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California Commercial Saturation Survey

Prepared for California Public Utilities Commission

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Executive Summary

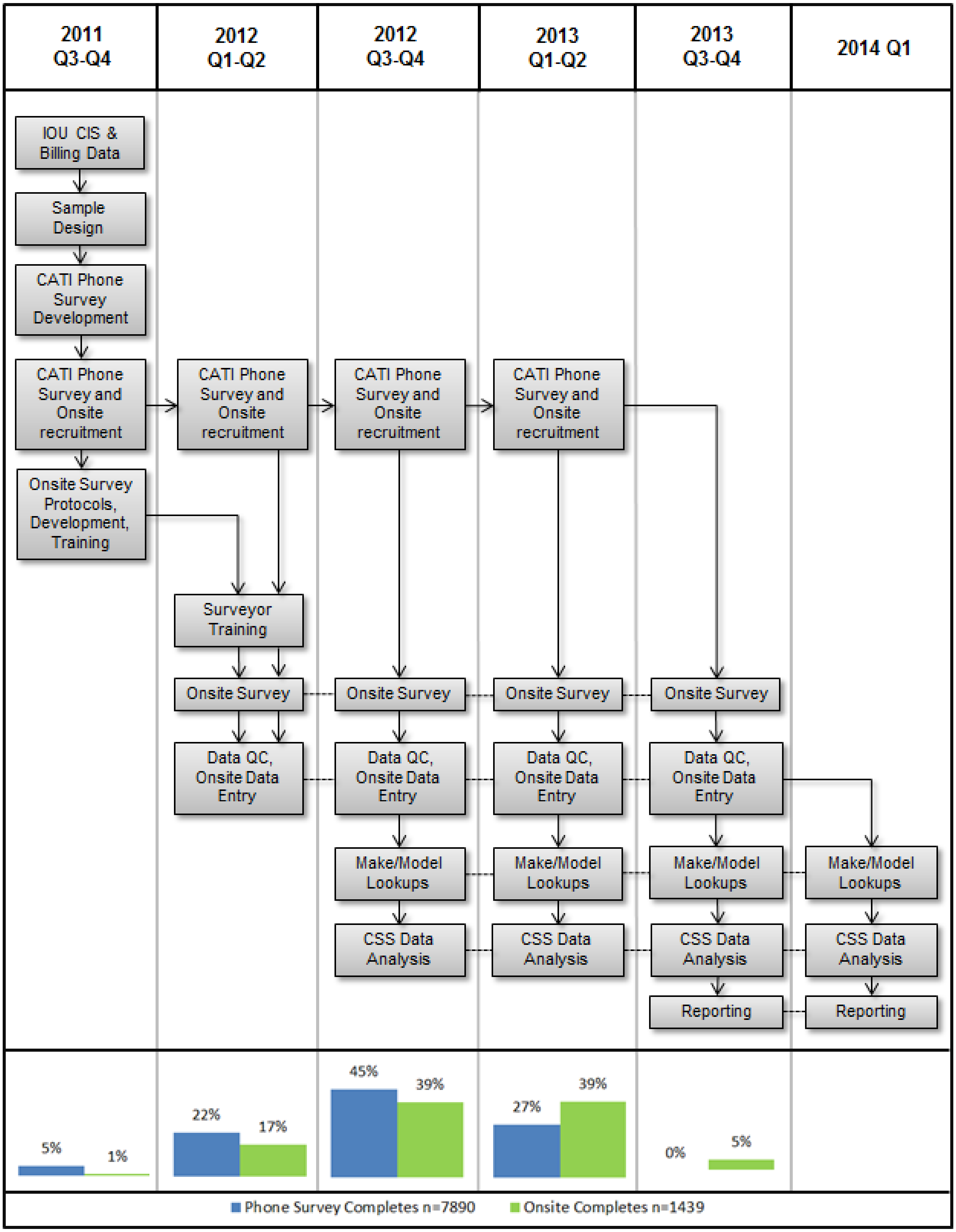
ES.1 Introduction

The Commercial Saturation Survey (CSS) study was designed to collect baseline information about energy consuming measures at commercial buildings in California. This report describes the saturation, age, condition and efficiency levels of electric consuming measures in businesses in the electric service territories of Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E), along with information regarding building characteristics and relevant firmographic data.

The research objectives of the CSS study center around determining the current baseline of equipment in commercial businesses and to provide insight into the saturation of high efficiency measures. The CSS focuses on the whole building and business characteristics and many of the electric end uses within commercial businesses. End uses analyzed include lighting, televisions (TV), office equipment, refrigeration, HVAC, energy management systems (EMS), and distributed generation systems (DG). Extensive information was collected during on-site visits to develop a baseline of businesses and equipment. The data collected on-site was combined with data from the utilities' Customer Information Systems (CIS), billing data, and energy efficiency (EE), demand response (DR), and distributed generation (DG) program tracking data. This report presents a high level explanation of the detailed data collected on-site combined with the information provided by the utilities. The Study provides the CPUC with a database containing the on-site information. The data collected by this Study provides the CPUC, IOUs and evaluators with a better understanding of the saturations and efficiency distributions of many high priority electric end uses in California businesses.

The CSS study spanned the period from November 2011 to May 2013 and was a large scale data collection and analysis effort. Subsequent to the finalization of the research plan, data collection devices, and test survey findings were reviewed by the CPUC and IOUs and comments received were incorporated into the final versions. The careful development of the research and the data collection devices led to a more efficient collection of the desired information and the study got underway with a clear vision of study objectives. Figure ES-1 provides a description of the activities that were undertaken during this study timeframe.

Figure ES-1: CSS Study Timeline



The Commercial Market Share Tracking Study (CMST) and the Commercial Saturation Survey (CSS) research projects were designed to be a coordinated effort to collect the data necessary to describe current baseline purchases of select high priority equipment and the current baseline saturation of measures in businesses in the commercial population. The CMST Study provides information on the baseline of recent purchases of these technologies, while the efficiency distribution within the CSS provides information on the full stock of technology within businesses, regardless of when they were purchased. Having the ability to analyze these data sets, which were collected over the same time period, provides two sources of baseline data and a unique and informative source of information for program planners, evaluators, and future potential studies.

This report represents one of three reports developed from the CSS/CMST study focusing on the data collected during the CSS on-site surveys. Additional reports include the Commercial Saturation and Commercial Market Share Tracking Study Telephone Survey Findings (Oct, 2013)[1] and the California Commercial Market Share Tracking Study (April, 2014). The Study will also provide the CPUC and IOUs with searchable databases enabling additional analyses. A web site will also provide interested parties with the ability to review the study findings in a manner that maintains the study participants' anonymity.

ES.2 Sample Design and CSS Recruitment

The research team worked with the CPUC and the IOUs to develop the necessary databases. The sample of sites needed for this study was drawn from the population of electric customers in the Non-residential Frames (NRF) of PG&E, SCE and SDG&E (collectively referred to as the IOUs). The IOU data used for the study included the Non-residential CIS, the Non-residential Billing data, and the EE, DR, and DG Program Tracking Data. The program participation data were used to characterize the efficiency distribution of installed measures by program participation, determine the share of DR program participation for sites with EMS, and review the DG data collected during the on-site visit.[2]

The telephone survey's primary objective was to help develop an on-site sample for estimating a wide range of commercial customer characteristics. Given that the primary purpose of the telephone survey was to recruit a representative sample for the CSS and CMST on-site surveys, planned phone survey sample sizes were exceeded for some strata where the phone survey was achieving responses but a sufficient number of sites could not be recruited for on-site visits to achieve the CSS on-site sample design objectives. The telephone survey sample design

[1] The telephone survey report included limited information comparing the customers' telephone survey responses to data collected during on-site visits.

[2] Information on the distribution of sites in the nonresidential frame is available in Chapter 3 of the CSS/CMST telephone survey report.

incorporates 14 business types, three IOUs and five usage strata (very small, small, medium, large, and unknown).[3] The telephone survey asks respondents about installation of linear lighting, TVs, and packaged HVAC. Sites that had recently purchased linear technologies, TVs, or HVAC units were recruited to participate in the CMST on-site survey.[4] Sites in the eight CSS business types were recruited to participate in the CSS on-site study.

ES.3 Summary of CSS On-Site Survey Results

The CSS on-site data collection effort assembled information from 1,439 on-site visits with businesses in eight commercial business types: Food/Liquor stores, Health/Medical Clinics, Miscellaneous businesses, Offices, Restaurants, Retail, Schools, and Warehouses. For many types of equipment, make and model numbers were collected and for Linear Lighting, TVs, and Packaged and Split Single Zone Cooling systems the make and model numbers were looked up to determine efficiency. The technologies with efficiency look ups mirror the technologies analyzed in the Commercial Market Share Tracking Study (CMST 2014). CSS on-site surveys collected data on businesses, buildings, and electric end use technologies. The CSS on-site effort included eight business types in three IOUs and five usage strata to produce 120 unique strata. The distribution of recruited sites, quota, and completed sites is presented in Section 3 of this report.

The data collected during the CSS on-site included data on the saturation and number of electric measures at the facility, the self-reported year of purchase, information on the size and condition of the equipment, make and model numbers, and hours of operation for select measures. For high priority measures, the make and model lookups served to verify manufacturer names, model numbers, system types, and efficiency ratings. The measure level efficiency information was used to develop efficiency distributions for the high priority measures. The data for many of the end uses and measures were analyzed in conjunction with site level data and information from IOU program tracking databases to help determine relationships between the information found on site and program participation.

The results presented in this report have been weighted by site weight. The analysis has also been completed using weights based on kWh. For consistency and to maintain a manageable size to the report, site based weights were chosen. Results using kWh weights will be available on the CSS web site.

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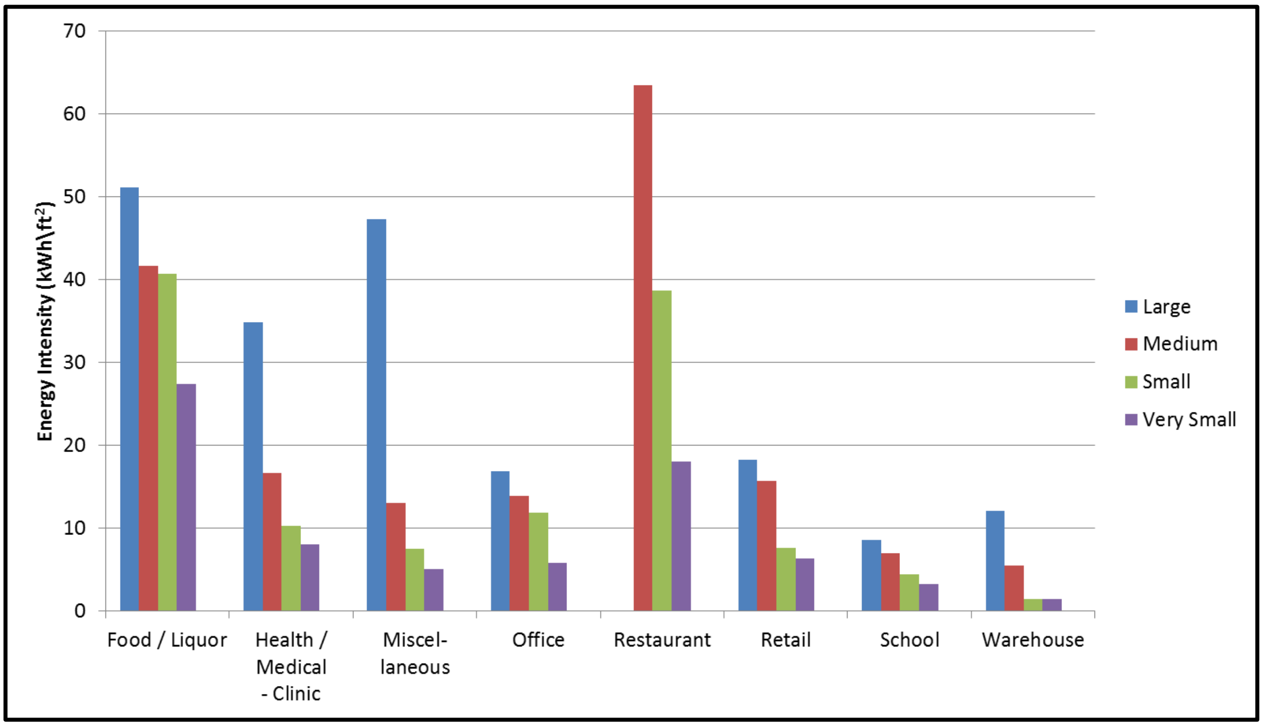
[3] The unknown usage category represents accounts found in the CIS that do not have a matching record in the billing data. As part of the on-site data collection effort, meter numbers were collected and unknown business size was resolved during the meter lookup process. This effort resulted in the on-site analysis representing four business size strata.

[4] Linear technologies, TVs, and HVAC units were chosen as high priority measures for the CMST on-site survey following a prioritization process that incorporated comments from the CPUC, DEER team, and evaluation contractors. It was necessary to limit the scope of the measures analyzed in the CMST due to budgetary limits.

ES.3.1 CSS Business Characteristics

The CSS study collected information that contributes to a better understanding of business and building characteristics in California. The Business Characteristics section of this study includes information on annual electricity consumption, square footage, energy intensity (EI), building age, and number of employees. The data presented on CSS businesses show that Offices consume more electricity than any of the other seven CSS business types while Warehouses occupy the largest share of CSS commercial floor stock. Combining electricity consumption and floor stock, Figure ES-2 illustrates the estimated EI by business type and size. These data indicate that Medium sized Restaurants have the highest average EI closely followed by Large Food/Liquor Stores and Large Miscellaneous businesses. In the Business Characteristics section of the report, the CSS EIs are compared with those from the California Commercial End Use Study (CA CEUS 2006).[5] The whole business EIs are found to be similar across the two studies, with many of the comparable business type EIs declining from the CEUS to the CSS.

Figure ES-2: Average Energy Intensities by Business Type and Size



* **The results presented above have been weighted by site weight.**

The whole business average Energy Intensity for CSS businesses is 10.2 kWh/Sqft. The whole business EI for the CA CEUS 2006 was 13.6 kWh/Sqft. The decline in whole business

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5 CA CEUS Project Final Report completed on behalf of the California Energy Commission. Report # CEC-400-2006-005. CA CEUS is also available at: http://capabilities.itron.com/CA CEUSWeb/Default.aspx . For more information on how the CSS whole building energy intensities were developed see Section 4.

average EI varies by business type.[6] The CSS whole business average EI is likely lower than the CEUS whole business average EI due in part to differences in the study objectives and surveyed business types. The similarities and differences between the CSS and CEUS are discussed in more detail in Section 2 and 4 of the report.[7]

Business types with substantial declines in average whole business EI from the CEUS (2006) to the CSS include Offices, Retail, Schools and Warehouses.[8] Table ES-1 shows the average change in EI between the CEUS and the CSS. The EI for Offices has fallen from 16.1 kWh/Sqft in the CEUS to 13.2 to 13.4 kWh/Sqft in the CSS and Retail has fallen from 14.1 kWh/Sqft to 11.2 to 11.0 kWh/Sqft. The substantial decline in whole building EI for these business types is likely due in part to their substantial improvement in lighting efficiency combined with the importance of the lighting end-use within these business types.

Table ES-1: Mean Energy Intensities by CSS and CA CEUS Building Types

CSS Business Type	Mean Energy Intensity from CSS, Site Weighted	Mean Energy Intensity from CSS, kWh Weighted	CA CEUS Business Type	Mean Energy Intensity from CA CEUS, kWh Weighted	Change in EI from CEUS to CSS
Food/Liquor	43.4	43.4	Grocery	41.0	6%
Miscellaneous	10.5	9.8	Miscellaneous	9.8	7% to 0%
Office	13.2	13.4	Office[9]	16.1	-16.8% to -18%
Restaurant	40.9	39.1	Restaurant	40.2	-3% to 2%
Retail	11.0	11.2	Retail	14.1	-21% to -22%
School	6.1	6.1	School	7.5	-19%
Warehouse	3.1	3.4	All Warehouse	6.7	-49% to -54%

* **The CSS results are presented both weighted by site weight and kWh.** The CA CEUS results are kWh weighted. The right most column shows the percentage change in EI between the CEUS and the CSS where a negative number represents a decrease in EI and a positive represents an increase.

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6 See Section 4 of this report for more information on how the CSS and CEUS development of business type and whole building energy intensities differ and how they are the same.

7 The CEUS whole business average EI includes values for business types that were not surveyed in the CSS including Colleges, Hospitals, and Hotels. The whole business EI for these business types may be larger, contributing to a lower average EI for the CSS. Examining EI by business type presents a more direct comparison.

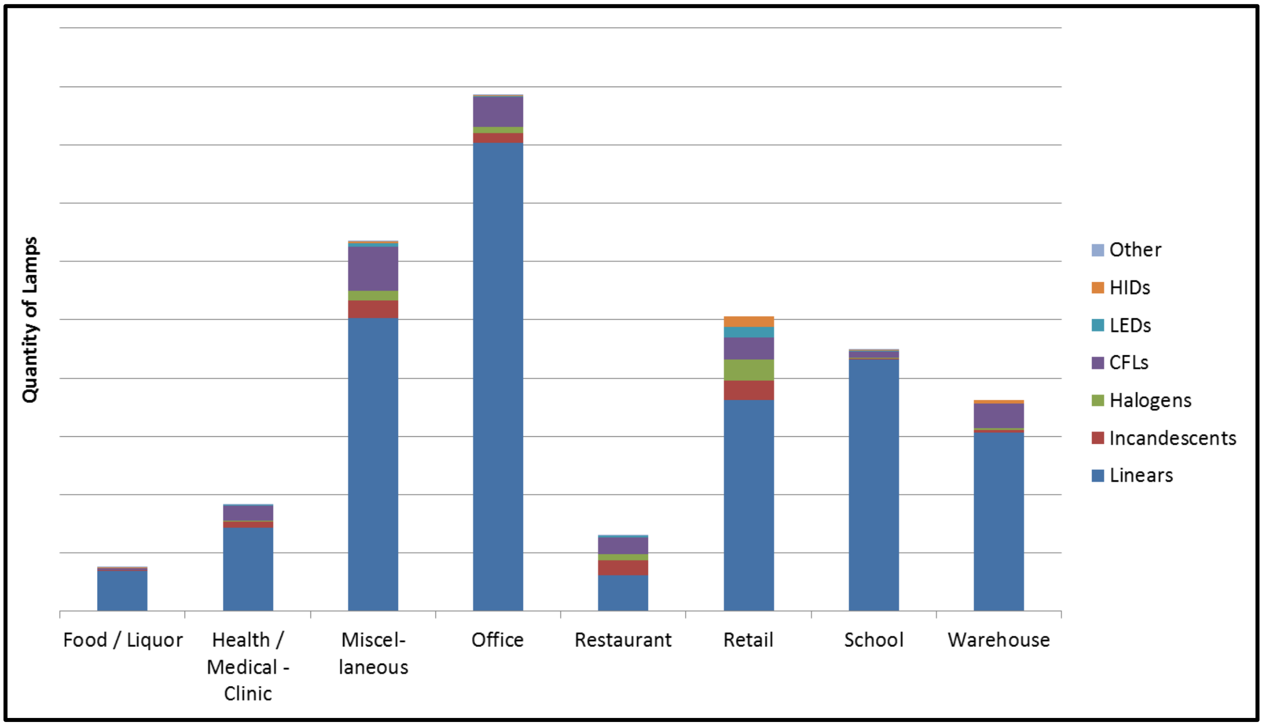
8 The business type definitions between the CSS and CEUS are not exactly the same. The CEUS sample design was based on SIC codes. The CSS sample design was based on NAICs codes. Both studies include appendices with a business type to NAICS/SIC code mapping. Additional information on business type differences in provided in Sections 2 and 4. For example, the CSS Food/Liquor business type includes Grocery stores and the CEUS Grocery category includes businesses that would be characterized as Food/Liquor, but while these two business types are largely comparable they do not overlap 100%.

9 The CEUS analysis calculated separate EI for Large and Small Offices. The Large Office EI was 17.7 and the Small Office was 13.1. Combining these two strata, results in an Office EI of 16.1.

ES.3.2 CSS Lighting

A central goal of the CSS study is to document the baseline distribution of lighting measures within commercial businesses. The CA CEUS (2006) estimated that indoor lighting accounted for approximately 29% of commercial electricity usage in California. Findings from the CSS study indicate that lightings share of commercial electricity usage in CSS businesses has fallen relative to the CEUS findings. The CSS on-site survey effort included a full inventory of indoor and outdoor commercial lighting measures. For analysis, the lighting technologies have been grouped into linear technologies, lighting that is indoor and Incandescent, CFL, LED, or Halogen (ICLH), Exit Signs, Advertising lighting, and outdoor lighting. The study also analyzed indoor and outdoor lighting controls. Figure ES-3 illustrates the distribution of interior lighting within CSS businesses. These data indicate that Offices have the highest quantity of lamps and that Linear technologies are the dominate type of lighting in Offices.

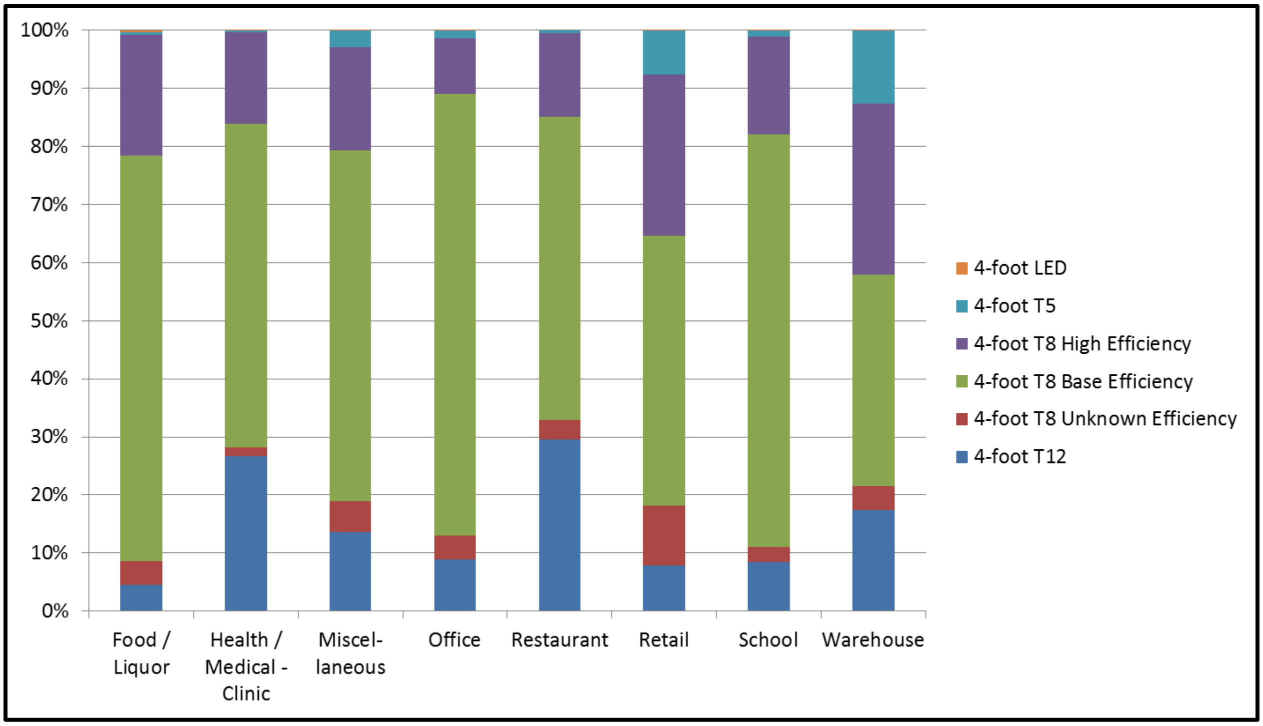
Figure ES-3: Interior Lamp Type Distribution by Business Type



* **The results presented above have been weighted by site weight.**

Commercial lighting programs have targeted the replacement of T12 linear fluorescent lighting with higher efficiency alternatives for over 20 years. More recent programs have also attempted to replace Standard 700-Series T8s with higher efficiency T8s and Linear LEDs. Determining the efficiency of installed T8s was a high priority objective of the CSS study, and to this end, make and model lookups were conducted and merged with information collected on-site to enable the disaggregation of T8 lighting into multiple efficiency levels. During the on-site data collection, make and model numbers were collected for most lighting technologies. The analyses of Linear technologies included a make and model lookup to determine the efficiency distribution of T8 lamps. Figure ES-4 illustrates the distribution of Linear technologies by T12, disaggregated T8 groupings, T5, and LEDs. These data indicate that Restaurants and Health/Medical Clinics have a higher share of inefficient T12s than other business types. These data also indicate that the Linear lamps in Offices, the business type with the highest number of Linear lamps, are dominated by first generation or Standard 700-Series T8s. Also seen here, Retail stores and Warehouses have a relatively high share of High Performance and Reduce Wattage T8s and T5s, which are high efficiency Linear technologies.

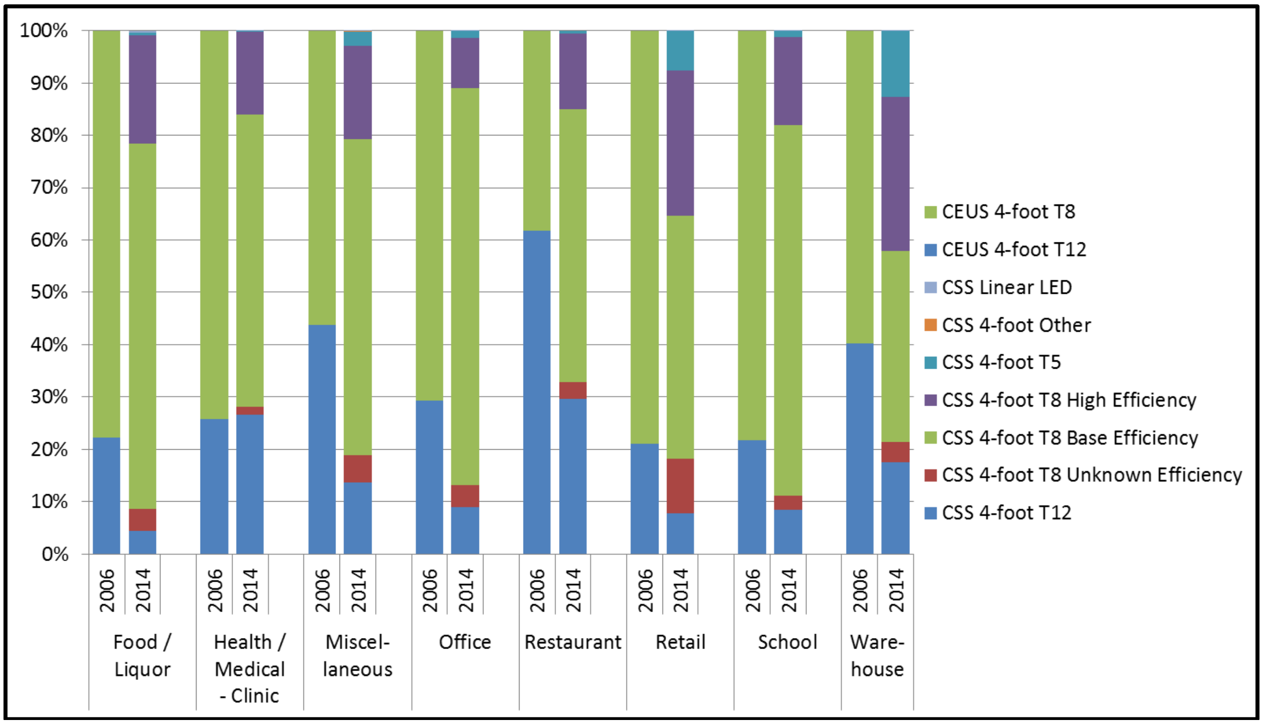
Figure ES-4: Interior Four Foot Linear Lamp Efficiency Distribution by Business Type



* **The results presented above have been weighted by site weight.**

Figure ES-5 illustrates the distribution of four-foot Linear technologies for the 2014 CSS and the 2006 CEUS study**.** For each business type, the first bar represents the 2006 CEUS distribution of linear technologies and the second bar represents the 2014 CSS distribution. The distribution of T12 technologies is directly comparable between the two studies. For T8s, the CSS study provides a finer level of detail than the CEUS study, disaggregating T8s into High Efficiency, Base Efficiency, and Unknown Efficiency. It is likely, however, that the majority of T8s found in the 2006 CEUS study are first and second generation T8s, i.e. Base Efficiency T8s. Therefore, the CEUS 4-foot T8s presented in Figure ES-5 are roughly comparable to CSS 4-foot T8 Base Efficiency lamps. The data indicate that the share of T12 Linear lamps has fallen substantially for most business types.

Figure ES-5: 2014 CSS and 2006 CEUS Linear Fluorescent Lamp Efficiency Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

The on-site and efficiency data for Linear lamps was combined with information on participation in IOU EE lighting programs from 2009 to 2012. Table ES-2 presents information on the efficiency distribution of Linear lamps for businesses that did and did not participate in the IOU EE lighting programs. For this analysis, a participant is a business that installed Linear Technologies under an IOU EE program as designated by the Linear High Impact Measure designation.[10] As anticipated, businesses that had participated in EE lighting programs from 2009 to 2012 were statistically significantly less likely to have T12 lamps and 700 series T8s and more likely to have High Performance and Reduced Wattage T8s and T5s than non-participants.

[10] The Linear High Impact Measure designation used for this analysis included EE program participants from 2009 to 2012 whose program tracking data indicated that they installed a Linear Technology under the program.

Table ES-2: Interior Linear Lamp Efficiency Distribution by EE 2009-2012 Linear Fluorescent Program Participation

Performance Group	EE LF HIM Non-Participant	EE LF HIM Participant
Base Efficiency	83%	51% ***
High Efficiency	17%	49% ***
Total	**100%**	**100%**
Base Efficiency Tiers Distribution		
4-foot T12	13%	6% ***
4-foot Other	0%	0.1% **
4-foot Unknown T8	4.5%	6%
4-foot Std 700 T8	48%	23% ***
4-foot Std 800 T8	18%	15%
High Efficiency Tiers Distribution		
4-foot High Performance T8	10%	18% ***
4-foot Reduced Wattage T8	4.0%	24% ***
4-foot T5	2.9%	7% ***
4-foot LED	0.1%	0.1%
n	**1,067**	**305**

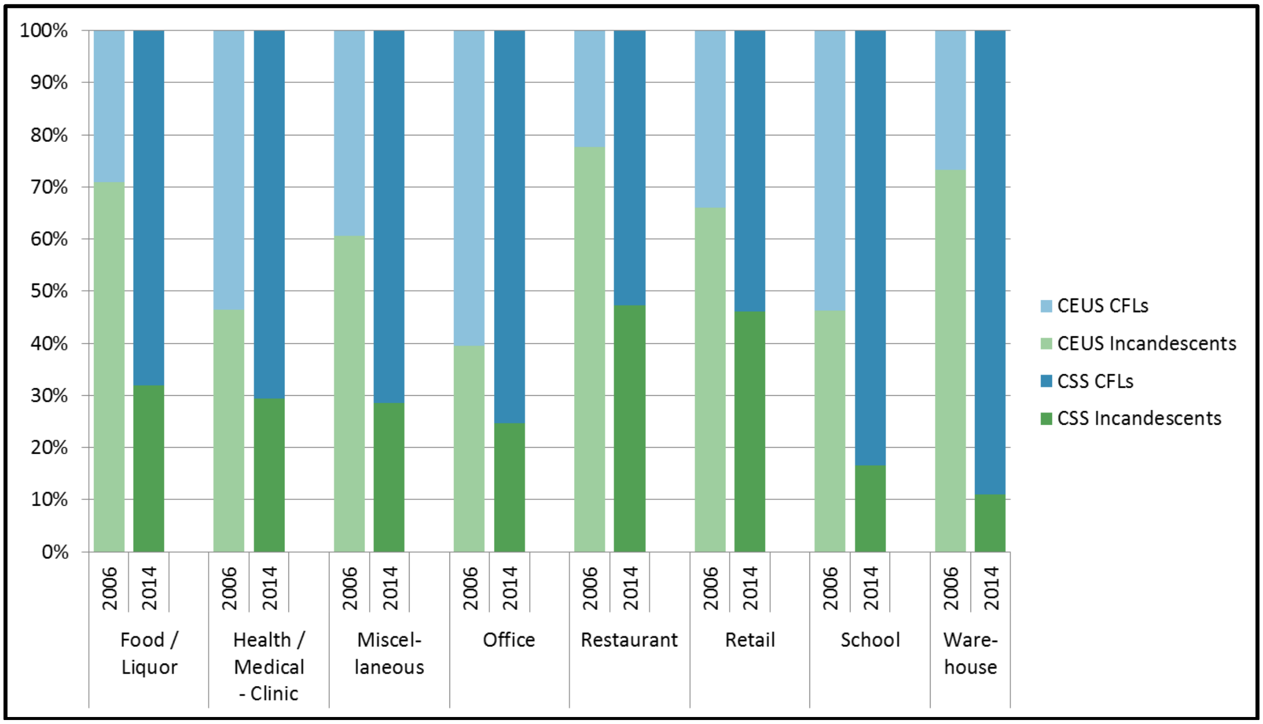
* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

The CSS analyzed lighting found in High Bay applications. The High Bay data presented in Section 5 clearly indicates that EE participants are substantially less likely to use T12 and HID lighting in their High Bay applications than non-participants. EE program participates were found to have a higher share of high efficiency linear technologies than non-participants.

The CSS on-site survey collected extensive information about indoor Incandescent, CFL, LED, and Halogen (ICLH) lamps. These data help to describe the distribution of high efficiency and base efficiency lighting for non-linear applications. The CSS data indicate that when medium screw based and pin based lighting is combined, CFLs are the most common type of ICLH lighting for all business types. For Warehouses, 87% of ICLH lighting is CFLs, while 81% of ICLH lighting in Schools is CFLs. Retail has the lowest share of CFL lighting at 37% of their ICLH, but Retail also has the highest share of LEDs (13%) in their ICLH lighting. The share of LEDs in CSS businesses is relatively low. While Retail businesses use LEDs for slightly over 13% of their ICLH lighting, the other business types in the CSS use LEDs for 0.5% to 5% of their ICLH lighting.

Figure ES-6 provides the distribution of Incandescent and CFL lamps found in the CSS study and the 2006 CEUS study. For each business type, the first bar represents the 2006 CEUS distribution of Incandescents and CFLs and the second bar represents the 2014 CSS distribution. Comparing the distribution of Incandescent and CFL bulbs in the CSS and the CEUS, businesses in California clearly have a lower instance of installation of Incandescent lighting during the period between the 2006 CEUS and the 2014 CSS.[11]

Figure ES-6: 2014 CSS and 2006 CEUS Incandescent and CFL Lamp Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

The data collected as part of the on-site survey were also used to develop an estimate of the average watts and lumens per square foot of commercial space. These data, combined with self-reported lighting schedules, provide information that is used to develop an estimate of lighting energy usage within CSS businesses. The estimates of lighting energy usage were compared with the whole business energy usage to develop estimates of the lighting energy usage shares. Table ES-3 presents information on the lighting share of the whole business electricity usage by business size. These data indicate that the lighting share for Very Small businesses is higher than the lighting share for Medium and Large businesses. More information on the estimates of lighting's share of whole business electricity usage is presented in Section 5.

[11] The majority of the data collected for the 2014 CSS occurred during 2012 and 2013, while the data collected for the 2006 CEUS occurred during 2002-2005.

Table ES-3: Lighting kWh Share of Whole Business Usage by Business Size

Business Size	*n*	Percent Lighting kWh
Large	97	13%
Medium	460	20%
Small	478	20%
Very Small	369	31%

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

The CSS study also collected information on the control type for interior and exterior lighting. Table ES-4 presents information on the distribution of interior lamps by control type and the business's participation in IOU EE lighting, EE lighting control, and DR registration. These data show that participants have a statistically significant smaller share of their lamps manually controlled than non-participants and a higher share of their lamps controlled by EMS, Occupancy sensors, motion sensors, and photocells and time clocks than non-participants.

Table ES-4: Distribution of Indoor Lamps by Control Type and EE/DR Participation

Control Type	Non-Participants	EE Lighting Participants	EE Lighting Control Participants	DR participants
Manual	82%	69% ***	65%	53%
Manual w/ Occ. Sensor	0.7%	1.4% *	1.1%	2.3%
EMS	6%	13% ***	11%	20%
Photocell & Motion Sensor	1.9%	0.8%	1.4%	1.5%
Motion Sensor	8%	11% **	14%	15%
Continuous On	0.4	1.0% ***	1.7%	0.9%
Photocell and/or Timeclock	1.4%	3.0% ***	3.0%	4.7%
Daylighting & Other	0.1%	1.4% **	2.9%	2.1%
n	**1,076**	**360**	**139**	**155**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Analysis of the CSS lighting data yielded a number of interesting findings, some which conformed to trend and expectation, and others that showed opportunities for greater potential for efficiency. This study examined the data collected from various angles, technology adoptions by size, utility service areas; EE/DR/DG program participation. A few key findings are listed below.

- **Only 12% of Linear lamps in CSS businesses are T12s. In the CA CEUS 2006, 36% of Linear lamps in businesses similar to CSS businesses were T12s.** The substantial decline in the share of Linear lamps that are inefficient T12s over the six to ten year time period represented by these two sets of data show significant improvements in the efficiency of Linear lamps in CSS businesses.
- **T12s are found in 42% of CSS businesses**. The relatively high share of businesses with T12s and low share of lamps is due to three factors: To be included in the 42% of businesses with T12s, a business only needed to have a single T12 lamp, a very low hurdle to reach. In addition, T12s represent 29% of the Linear lamps at Very Small businesses but only approximately 4% of the Linear technologies at Large businesses and many businesses with T12s also have more efficient T8 or T5 lighting.
- **First generation or Standard 700-Series T8s are the most common type of Linear lamp.** Standard 700-Series T8s account for 45% of four-foot Linear lamps and Standard 800-Series T8s represent 18% of four-foot Linear technologies. High Performance T8s, Reduced Wattage T8s, and T5 account for only 21% of Linear lamps in CSS businesses.
- **Businesses that have participated in IOU Lighting Energy Efficiency Programs from 2009-2012 have a larger share of high efficiency lighting and a lower share of base efficiency lighting.** Businesses that have participated in EE programs have a lower share of T12s and Standard 700-Series T8s and a higher share of High Performance T8s, Reduced Wattage T8s, and T5s than non-participants. A similar pattern is observed in High Bay lighting where program participants have fewer T12 and HID lamps and more high efficiency T8 and T5 lighting.
- **Pin- and medium screw-based CFLs account for 60% of lamps identified as Incandescent, Halogen, CFL, and LEDs.** There has been a significant increase in the use of CFLs in businesses in California in the last eight to ten years. In the CA CEUS 2006, CFLs accounted for only 48% of lamps identified as Incandescent or CFLs.
- **The estimated lighting share of CSS business electricity usage ranges from 11% in Restaurants to 34% in Retail.** The CSS estimated lighting's share of electricity using information on lighting watts and self-reported activity area schedules that were adjusted at the business type and day type level based on data from the *Small*

Commercial Contract Group Direct Impact Evaluation Report.[12] The adjustments used for the CSS analysis could be further refined using additional data from the *Small Commercial Contract Group Report.*

- Comparing the lighting efficiency distributions between the CSS and the CA 2006 CEUS, CSS businesses have made substantial strides toward improving their lighting efficiency. The share of inefficient lighting (T12s and Incandescent bulbs) has fallen substantially. The estimate of lightings share of whole business electricity consumption has also declined.

ES.3.3 CSS HVAC

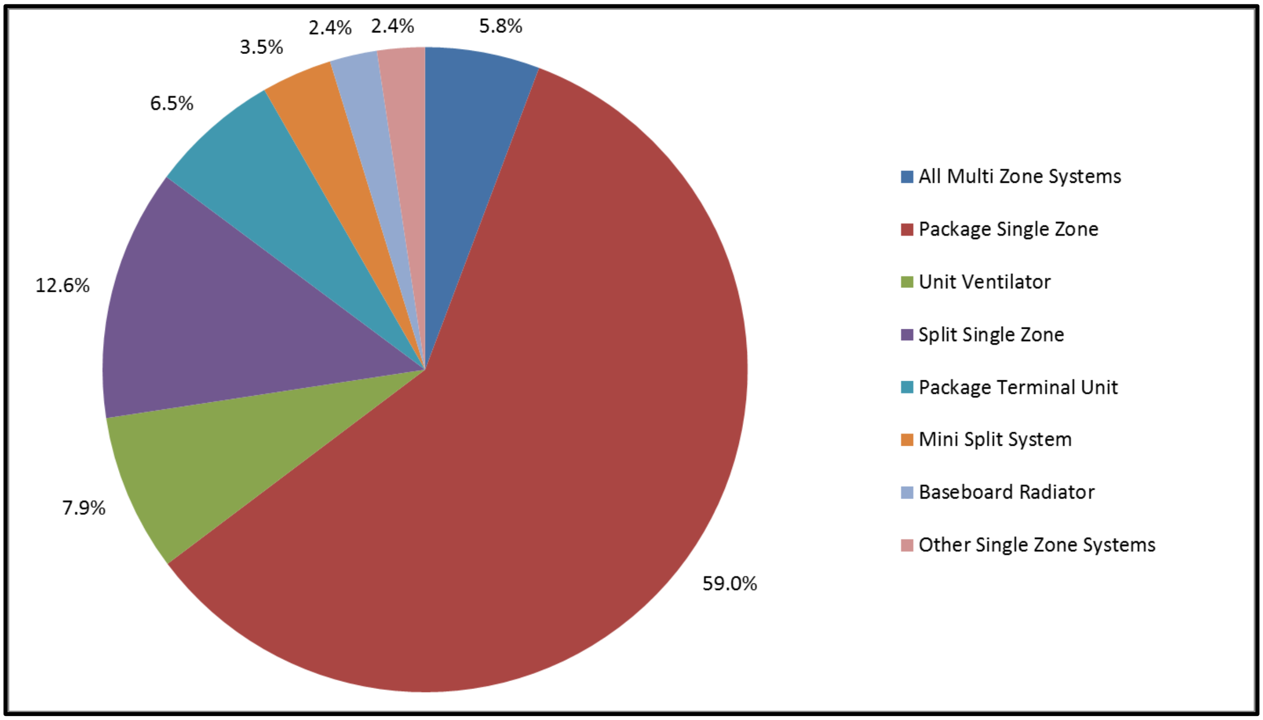
Heating, ventilation, and air conditioning (HVAC) systems represent a significant fraction of energy use and peak demand within the commercial sector. The 2006 California Commercial End Use Survey (CA CEUS) estimated that HVAC end uses account for approximately 29% of the electricity use in the commercial sector.[13] The CSS on-site survey collected extensive information on HVAC systems, with a focus on air conditioning systems, specifically direct expansion (DX) space cooling systems. The data collected during these surveys provides a baseline from which it will be possible to measure progress toward achieving the goal of improved HVAC efficiency in the commercial sector.

The HVAC on-site survey collected information on numerous characteristics of the HVAC system. Figure ES-7 illustrates the distribution of HVAC units by system type within CSS businesses. Packaged Single Zone (PSZ) and Split Single Zone (SSZ) are the most common type of system found, representing over 70% of the systems. Multi zone systems represent approximately 6% of HVAC systems in CSS businesses.

[12] California Public Utility Commission, *Small Commercial Contract Group Direct Impact Evaluation Report*, prepared by Itron, Inc. February 9, 2010

[13] The CSS did not estimate end use usage or energy intensities. The CEUS end use energy usage shares are presented to provide information on the approximate share of California commercial energy usage associated with each end use.

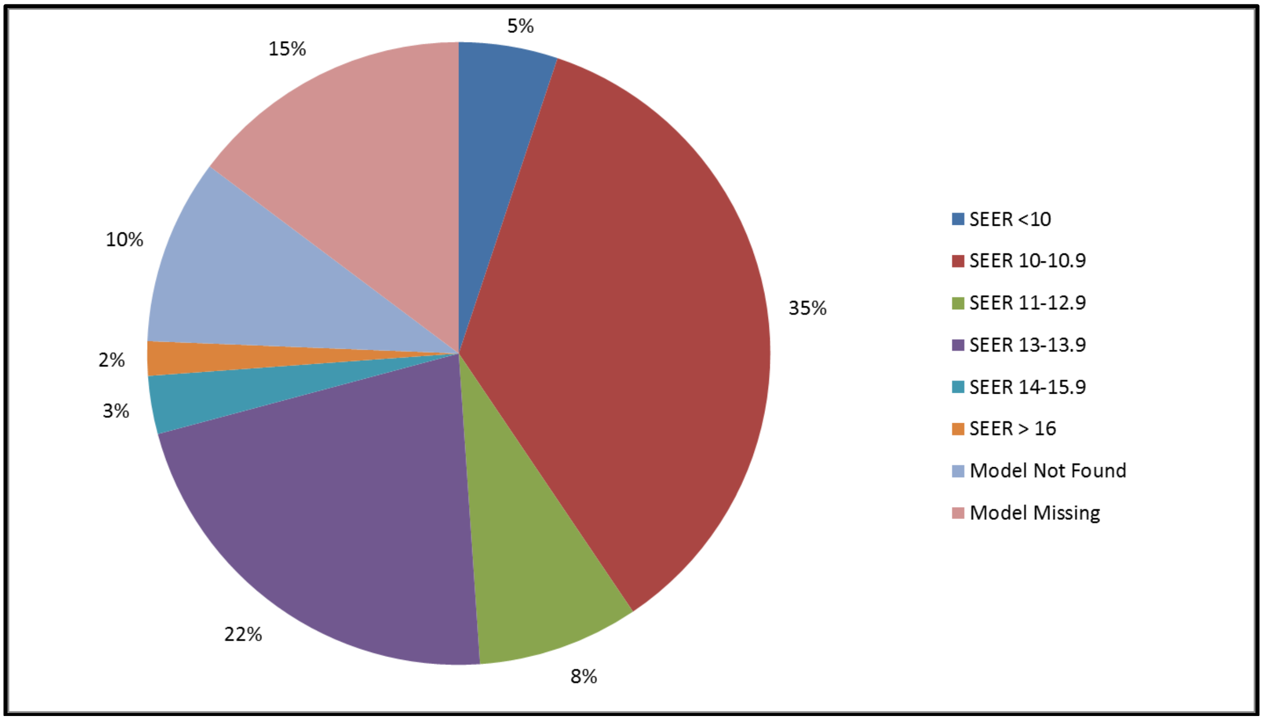
Figure ES-7: Distribution of HVAC Units by System Type



*** The results presented above have been weighted by site weight.**

Make and model numbers were collected for many HVAC systems. For PSZ and SSZ systems, the make and model numbers were looked up to determine capacity (tons or Btuh) and efficiency (SEER or EER). This analysis found that 81% of PSZ and SSZ units installed in CSS businesses are small units with a Btuh <65,000, 17% are medium sized units with 65,000 <= Btuh < 240,000, and 3% of units are larger than 240,000 Btuh. Figure ES-8 illustrates the efficiency distribution for small PSZ and SSZ units. These data indicate that at least 40% of existing units have SEER 10.9 or less. Given that a large share of the units without SEER ratings are older units, it is likely that the share of units with SEER less than 10.9 exceeds 50%. Current standards for small PSZ and SSZ units require newly manufactured units to have a minimum efficiency rating of SEER 13. Only 5% of existing units are 14 SEER or above. Section 9 of the CSS report presents the efficiency distribution for medium and large sized PSZ and SSZ units. The medium and large sized units have a higher share of units meeting current efficiency standards than was found for small sized units.

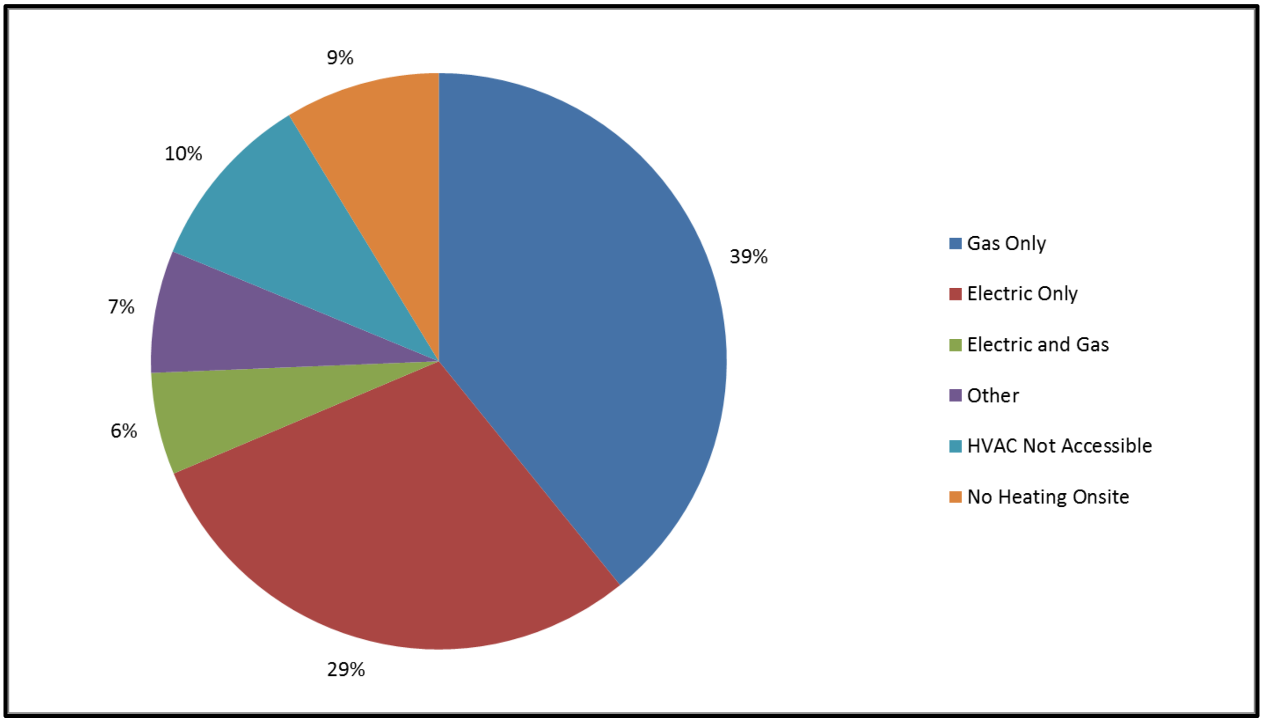
Figure ES-8: Efficiency Distribution for CSS Small PSZ and SSZ Units



*** The results presented above have been weighted by site weight.**

The CSS study also collected information on heating fuel types. Figure ES-9 illustrates the heating fuel type for CSS businesses. Thirty nine percent of businesses are heated solely by natural gas whereas 29% of businesses are heated only by electric. Six percent of businesses use a combination of electric and gas heating systems, 7% of businesses use other fuel types, and approximately 9% of all CSS businesses do not have HVAC systems that provide heating. The majority of the HVAC systems that do not provide heating are in Very Small and Small businesses in the southern part of California.

Figure ES-9: Distribution of Heating Fuel Type for Businesses



*** The results presented above have been weighted by site weight**

The CSS study also collected information on the HVAC systems condition, controls, age, and the HVAC maintenance practices of the site. The maintenance data clearly indicate that Large and Medium sized businesses commonly practice periodic maintenance on their HVAC systems while 46% of Very Small sized businesses self-report that they never perform HVAC maintenance and 25% of Very Small businesses only undertake HVAC maintenance when there is a problem.

The HVAC analysis yielded the following results:

- **Within CSS businesses, 94% of HVAC units are single zone and only 6% are multi-zone.** The most common type of single zone systems were Packaged Single Zone (59%) and Split-System Single Zone (13%). Make and model lookups were undertaken for Packaged and Split-System Single Zone units to determine their capacity and efficiency.
- **The Packaged and Split-System Single Zone HVAC units are 72% of HVAC units in CSS businesses.** Eighty one percent of these units are under 65 kBtuh (Small), 17% are 65 kBtuh to less than 240 kBtuh (Medium), and 3% are greater than or equal to 240 kBtuh (Large). For Small Packaged and Split-System units, the Study was unable to determine the efficiency level for 25% of units but these units were largely older units with an efficiency level less than 13 SEER. Forty eight

percent of Small units have an identified efficiency level less than SEER 13 and 22% have a SEER level 13-13.9. From the CSS data it can be concluded that over half of current Small HVAC units have a SEER level lower than the current standard of 13 SEER and only 5% of units are SEER 14 or higher.

- **Within CSS businesses, 49% of heating units are fueled by natural gas and 33% are electric.** For natural gas fueled units, furnaces are the dominant heating technology while electric heating is largely heat pumps. For CSS businesses, a larger share of PG&E businesses use natural gas heating, in SCE the distribution is approximately equal, and businesses in SDG&E's territory are more likely to heat with electricity.
- **HVAC maintenance at CSS business is undertaken regularly for approximately 30% of businesses and only when problems occur for 25% of businesses.** Regular HVAC maintenance is common for Large sized businesses (84%) but relatively uncommon for Very Small businesses (21%). These findings reinforce the importance of educating smaller business owners about the benefits from on-going HVAC maintenance.

ES.3.4 CSS Televisions

For the CSS/CMST studies TVs were designated a high priority measure. Prior to the CSS/CMST studies, there was considerable uncertainty surrounding the share of businesses with TVs, the types of TVs in commercial settings, the age of existing TVs, the size of TVs, and growth of TVs within the commercial sector. The CMST analysis found that the prevalence of TVs in the commercial sector is growing. Data collected as part of the CMST study showed that 60% of newly purchased TVs are purchased as new, additional TVs not as replacement TVs.

The CSS analysis provides a better understanding of all TVs within the commercial sector, both those that are recently purchased (from 2009-2012) and older TVs. The analysis looked at the TV type (LCD, LED, and CRT), age, size, and efficiency level using ENERGY STAR rating information. Table ES-5 presents information on the distribution of TV type, age, and screen size. These data indicate that TVs are nearly evenly split between CRT older TVs and newer LCD TVs. The average size of the newer LCD TV is 35 inches while older CRT TVs average 25 inches.

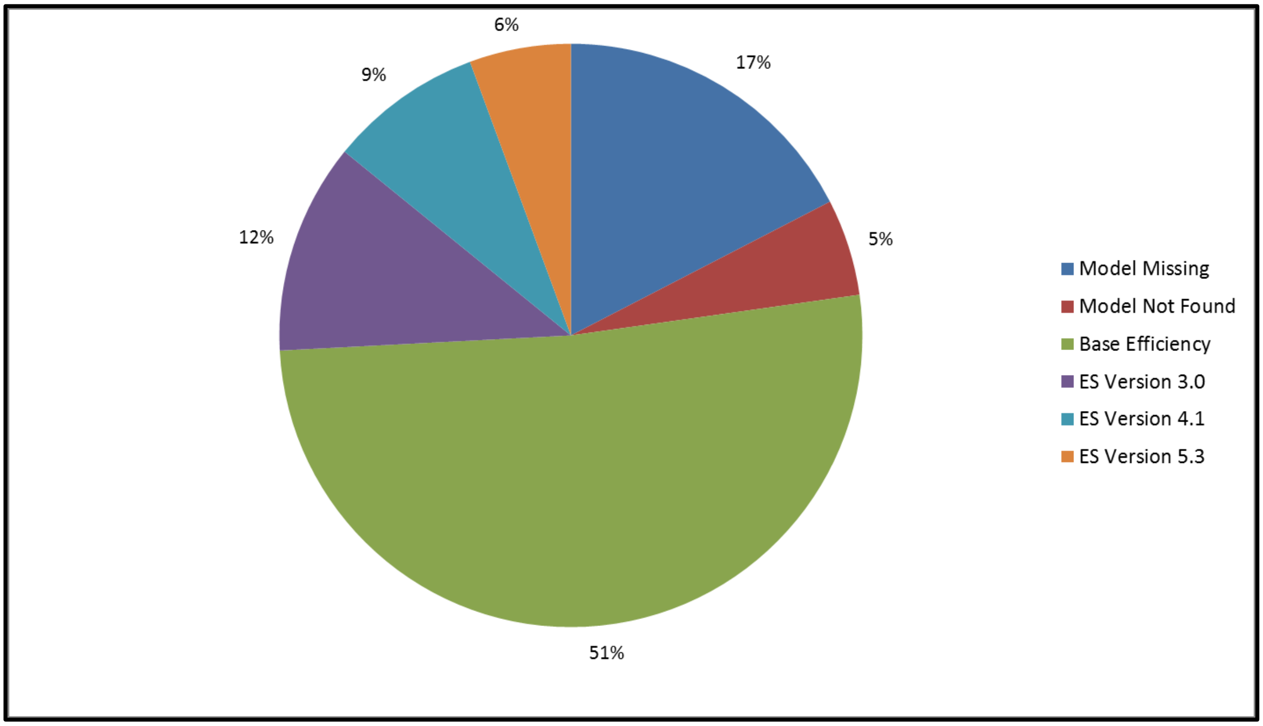
Table ES-5: TV Type Distribution, Average Age, and Screen Size

TV Type	Share of TVs	Average TV Age (Years)	Average Screen Size (Inches)
CRT	42%	12	25
LCD	43%	3	35
LED	8%	3	41
Other	6%	4	46
n	**10,322**	**7,119**	**9,910**

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Rapid technology improvements have led to dramatic reductions in energy usage for newer LCD and LED TVs. To better understand the energy efficiency of TVs, make and model numbers were collected to determine the efficiency level of existing and newly purchased TVs. ENERGY STAR rating information was used to classify TVs as not ENERGY STAR or ENERGY STAR Version 3.0, 4.1, or 5.3. Data presented in Section 6 indicate that 47% of commercial sites have TVs and that larger businesses are significantly more likely to have TVs than smaller businesses. Figure ES-10 presents information on the distribution of efficiency levels for sites with TVs. These data indicate that more than half of commercial TVs are base efficiency. This is consistent with finding that 42% of TVs are inefficient CRT TVs. CRT TVs do not qualify for ENERGY STAR.

Figure ES-10: CSS TV Efficiency Distribution, Unit Count Shares



*** The results presented above have been weighted by site weight.**

To summarize, **Televisions are found in 47% of CSS businesses and their saturation is growing.** The CMST (2014) found that 60% of recently purchased TVs are new, not replacement TVs. The average age of TVs in CSS businesses is approximately 6 years, with the distribution of TVs nearly evenly split between older, smaller, less efficient CRT (average 13 years) and newer, bigger, more efficient LCD TVs (average age 3 years).

ES.3.5 CSS Office Equipment

The CSS on-site data collection effort collected information on the saturation of multiple type of office equipment. The office equipment technologies were grouped into Copiers, Printers, Computers, and Servers. The Study finds that some form of office equipment exists in nearly all businesses. Section 7 of this report discusses the distribution of office equipment across CSS business types. Offices are found to have the highest share of all four types of office equipment. In Section 7, the data for office equipment is also analyzed by business size, IOU, and within activity areas designated to be offices or computer rooms.

Within CSS businesses, over 50% of printers and computers are found in office activity areas and over 90% of servers are found in areas designated as network, server, or data center rooms. Office equipment is found in nearly every business, but the concentration of computers, printers, and servers varies substantially across activity areas within businesses.

ES.3.6 CSS Refrigeration

Refrigeration is a significant source of electricity usage within commercial businesses. The CA CEUS (2006) estimated that refrigeration systems account for 13% of electricity usage in the commercial sector and 54% of the electricity usage in Food/Liquor store, 67% in Refrigerated Warehouses, and 25% of electricity usage in Restaurants. The CSS study collected extensive information on ice makers, refrigerated cases, and the distribution of self-contained versus remote refrigeration systems by business type and customer size.

Of the 1,439 sites visited during the on-site data collection effort, 649 sites had commercial refrigeration on-site. Table ES-6 shows that all Food/Liquor stores, 97% of Restaurants, and 84% of Schools have commercial refrigeration equipment at their facility. The incidence of refrigeration equipment at other business types is significantly lower than in these three business types.

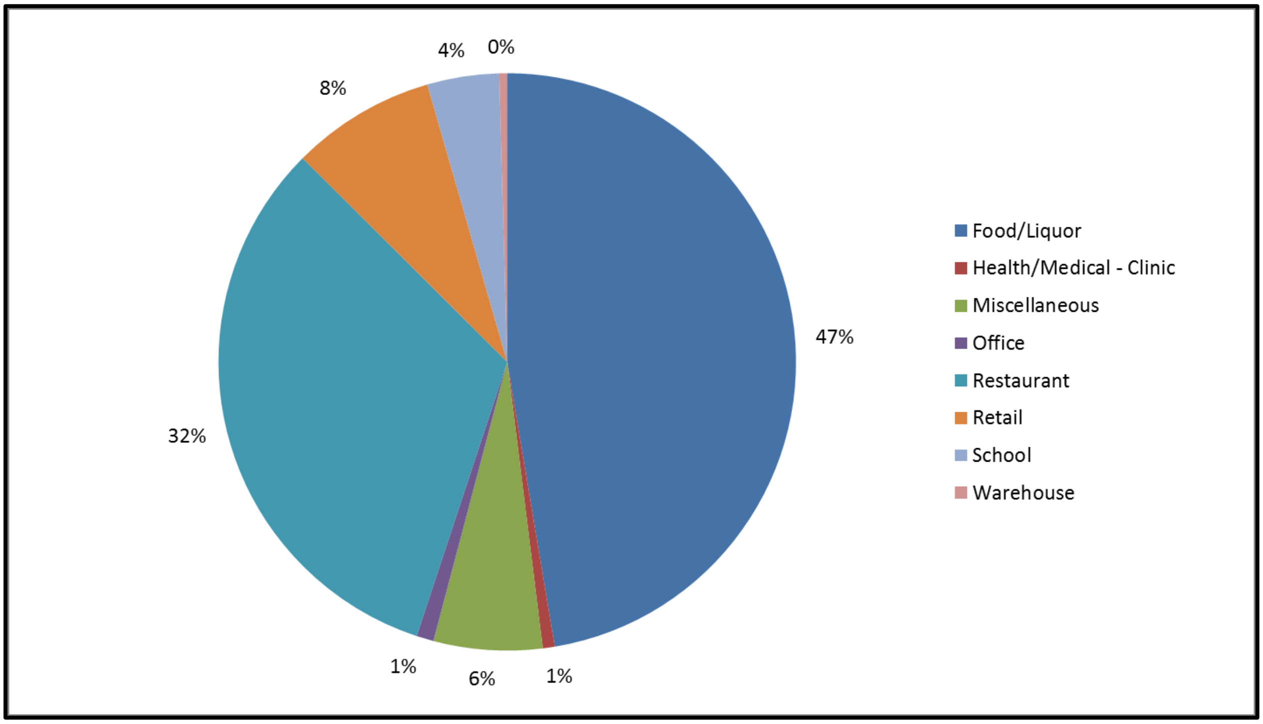
Table ES-6: Distribution of Businesses with Different Types of Refrigeration

Business Type	Businesses with Refrigeration Equipment	Remote Refrigeration	Self-Contained Refrigeration	Ice Makers
Food/Liquor	100%	13%	100%	46%
Health/Medical - Clinic	4%	0%	4%	3%
Miscellaneous	13%	0%	13%	3%
Office	3%	0%	3%	1%
Restaurant	97%	0%	96%	84%
Retail	13%	0%	13%	1%
School	84%	0%	84%	12%
Warehouse	3%	1%	2%	<1%
n	**649**	**65**	**637**	**350**

*** The results presented above have been weighted by site weight.**

The CSS analyzes refrigerated cases using linear feet of cases as the unit of analysis. Within CSS businesses, Glass Door Cases and Solid Door Cases represent 32% and 33% of the linear feet of cases while Open Display Cases represent only 13% of cases. Figure ES-11 illustrates the distribution of the linear feet of display cases across CSS business types. The data in Table ES-6 indicates that Food/Liquor stores, Restaurants, and Schools dominate the incidence of commercial refrigeration. The data in Figure ES-11 illustrates that Food/Liquor stores and Restaurants have 47% and 32% of the linear feet of refrigerated cases respectively while Schools have only 4%.

Figure ES-11: Share of Total Linear Feet of Display Cases by Business Type



*** The results presented above have been weighted by site weight.**

Section 8 of the CSS report also presents information on the distribution of cases by temperature, distinguishing refrigerator and freezer cases by case type. Walk-ins are also analyzed by case temperature. The report also presents information on efficiency measures including strip curtains and auto-door closers. For Remote Refrigeration systems, information is presented on the self-reported age of compressors and condensers, leading to the conclusion that this equipment is significantly newer in large Supermarkets and Retail/Variety stores than in smaller Grocery stores and Warehouses.

Lighting in Walk-ins and Refrigeration Cases was also analyzed in the CSS. Table ES-7 presents information on the lighting efficiency distribution for Refrigerated Cases. Lighting in most types of display cases has been retrofit to high efficiency lighting (CFL, LED, High Pressure Sodium, T8, and T5). The majority of Solid Door and Island/Coffin Cases have no lighting, but when these cases have lighting, a high share of the lighting is inefficient.

Table ES-7: Lighting Efficiency by Refrigerated Display Case Type

Lighting Efficiency Group	Glass Door Case	Solid Door Storage Case	Open Display Case	Island/ Coffin Case	Service Case	Beverage Merchan-diser	Other/ Unlisted Case
High Eff.	66%	7%	82%	21%	62%	48%	16%
Low Eff.	21%	31%	12%	13%	20%	23%	23%
No Lighting	13%	61%	4%	66%	17%	22%	61%
Unknown	1%	1%	3%	0%	1%	7%	0%

*** The results presented above have been weighted by site weight and display case length (linear feet).**

In summary, the highlights of the Refrigeration study are:

- **Nearly all Food/Liquor Stores and Restaurants have commercial refrigeration equipment.** The refrigerated display cases in Food/Liquor stores represent 47% of the linear feet of cases while cases in Restaurants have 32% of the case linear feet in CSS businesses. The distribution of cases in these two business types is substantially different with Glass Door cases dominant in Food/Liquor stores and Solid Door cases the primary type of case in Restaurants.
- **The lighting in refrigerated cases varied substantially by case type.** Solid Door cases represent 33% of case linear feet. Sixty percent of Solid Door cases were found to have no lighting while 30% of these cases had incandescent lighting. Glass Door cases are the second most common type of case with 32% of case linear feet. Thirty three percent of glass door cases are lit with LEDs, 31% with T8s, and 20% with T12s.
- **Warehouses have 84% of the floor area of Walk-in Coolers/Freezers followed by 8% in Food/Liquor stores and 4% is Restaurants.** Ninety nine percent of the freezer Walk-ins at Warehouses have strip curtains and 91% have door auto-closers. In comparison, 65% of Food/Liquor store freezer Walk-ins have strip curtains and 35% have door auto-closers. Warehouse Walk-ins have larger doors for the movement of large equipment and people, potentially leading these businesses to be more aware of energy efficiency measures.

ES.3.7 CSS Energy Management Systems

Energy Management Systems (EMS) consist of a network that combines local distributed control with centralized coordination and management to monitor, control, and optimize the energy usage throughout a business facility. EMS can be used to control and monitor the energy use of appliances and equipment at a site including lighting, HVAC, water heating and process equipment. EMS systems can also be used to control systems during demand response events. The CSS on-site survey collected multi-faceted data on EMS including the end uses controlled by the system. The CSS on-site EMS data was combined with information on business registration for IOU Demand Response (DR) programs. Using this information, the CSS study analyzed the share of sites with EMS that also participated in IOU DR programs.

The CSS data indicates that 2-4% of business by IOU have EMS. Fifteen percent of schools were found to have EMS, a substantially higher share than any other CSS business type. The likelihood of having EMS is very dependent on the size of the business; 60% of Large businesses have EMS while only 22% of Medium businesses are found to have this type of control.

Results of interest from the EMS study are: **Sixty percent of Large businesses have EMS, 22% of Medium sized businesses, 2% of Small and 0.2% of Very Small businesses.** Large businesses with EMS are more likely to participate in IOU demand response (DR) programs, with 74% of Large businesses with EMS signed up to participate in DR while only 42% of Medium sized business with EMS participate in DR.

ES.3.8 CSS Distributed Generation

The state of California has a long history of investing in distributed generation programs and technologies. The California Self Generation Incentive Program (SGIP) was designed in response to the energy crisis of 2001, initially conceived as a peak-load reduction program. The California Solar Initiative (CSI) began in 2007 as a program designed to rebate the installation of solar technologies on residential and commercial facilities. These programs, in combination with others offered by the California IOUs have encouraged the installation of distributed generation technologies. To help provide information on distributed generation technologies within the commercial sector, the CSS study collected information on the distributed generation technologies found during the on-site data collection efforts.

The CSS collected information on primary PV systems and back-up generation systems. Primary generation systems accounted for 40% of the systems found in CSS businesses while back-up generation systems represented 60% of the systems. The primary generation PV systems were most commonly found in Miscellaneous businesses and Schools while back-up systems were most often found in Offices. The average size of distributed generation systems increased with the annual consumption at the site and back-up systems averaged 147 kW while PV systems were smaller, averaging 92 kW. Self-reported information on the age of the systems also found that most PV systems are recent additions to the business while approximately 40% of the back-up systems were installed prior to 2000.

ES.4 CSS Conclusions and Recommendations

ES.4.1 Energy Intensities

The business level Energy Intensities developed in the CSS indicate that progress has been made in reducing whole business EI of some business types but additional progress will need to be made to meet the Strategic Plan goals of 50% of existing buildings being equivalent to zero net energy by 2030. The Strategic Plan estimates that 250 million square feet of commercial floor stock needs to approach zero net energy per year starting in 2010 for the state to meet the goal of 50% zero net energy by 2030. For CSS businesses, approximately 500 million square feet of commercial floor stock is associated with businesses that have installed photovoltaic panels (PV). The average IOU energy usage for CSS businesses with PV, however, does not approach zero net usage. To achieve zero net usage, businesses need to install more energy generation equipment or more efficiency measures to reduce their energy usage. The evaluation of businesses participating in the California Solar Initiative and the Self Generation Incentive Program should incorporate a review of the IOU electricity consumption of installing businesses during the 12 month pre and post installation to develop a better understanding of the influence of installed distributed generation systems on business IOU electricity consumption and energy intensity. This information would provide information on the share of electricity provided by DG systems and the size of the energy reduction needed from energy efficiency measures to achieve the Strategic Plan goals.

ES.4.2 Lighting

Substantial improvement has been made in lighting efficiency between the CEUS (2006) and the CSS. In the CEUS, 35% of the linear technologies were found to be T12s while only 12% of the linear lamps in CSS were T12s. The dominance of Standard 700- and 800-Series T8s in CSS businesses, however, indicates that substantial Linear lighting potential remains, though the cost effectiveness of achieving this savings potential will be less than the cost effectiveness of T12 retrofits. The CSS found that 82% of indoor lighting in CSS businesses that have not participated in EE Lighting programs is controlled manually, while 69% of EE participant lighting is controlled manually. Further advances in the saturation of lighting controls will provide additional lighting savings. The CPUC, IOUs, and evaluators should determine the potential and cost-effectiveness of expanding lighting controls.

ES.4.3 Other End-uses

The majority of CSS businesses have small packaged or split system single zone HVAC systems. Over half of these systems have an efficiency rate below current standards of 13 SEER. Less than 10% of systems have efficiency ratings of 14 SEER or higher. Programs need to be designed to cost-effectively encourage the installation of high efficiency small HVAC systems in the business segment.

The majority of Small and Very Small CSS businesses do not schedule periodic maintenance for their HVAC equipment. Additional outreach, education, and updates to program design need to be considered to help increase the share of Small and Very Small businesses using periodic maintenance to improve and maintain the operational efficiency of their HVAC systems.

Businesses with EMS controls had a higher share of their lighting controlled than other businesses. Businesses with EMS controls are highly likely to have their HVAC systems controlled by the EMS system. Businesses with EMS controls were also more likely to be registered for DR events. EMS controls provide an opportunity to better improve energy efficiency and responses to DR events. These controls should be analyzed for their cost effective inclusion in EE and DR programs or as an integrated DSM measure.

Data collected during the CSS provides preliminary support for the conclusion that the refrigeration equipment in small grocery and convenience stores is often older then in larger super markets. Small grocery and convenience stores also appear to have fewer refrigeration energy efficiency measures. A more complete evaluation of the make and model numbers collected during the CSS, but not looked up for efficiency purposes, could lead to a better understanding of the efficiency distribution of commercial refrigeration equipment.

ES.4.4 Additional Research Opportunities Building on Data Collected

The CSS on-site data were combined with the IOU billing data for telephone and on-site participants. Combining these two data sets allowed for comparisons by customer size and the development of information on whole business energy intensities. The CSS data, however, could also be combined with IOU AMI hourly electricity consumption for the telephone and on-site survey participants. Combining the CSS data with data on hourly electricity consumption has the potential to expand our understanding of many facets of the relationship between business' and their electricity consumption and peak demand. These data could lead to a better understanding of load shapes by business type, geographic location, and firmographic characteristics. The hourly electricity consumption information could allow for a better understanding of the relationship between energy consumption and demand by multiple business characteristics. The combination of CSS on-site and load consumption data could also be used in models of load disaggregation, to calibrate the DEER prototypes, and as inputs to future potential studies.

The Huffman bill requires that commercial indoor and outdoor lighting usage to decline by at least 25% from 2007 to 2018. The CEUS study provides an engineering estimate of the baseline of lighting usage for the 2002-2004 time period. The CSS study uses lighting wattage, self-reported schedules and adjustments from CPUC 2006-2008 Small Commercial lighting logger studies to develop an estimate of the baseline interior lighting usage for the 2012-2013 time period. To our knowledge, however, no estimate of commercial lighting usage for 2007 exists to help determine the success or failure of the Huffman bill or to help legislators, policy implementers, and the IOUs determine where additional programs are needed to help achieve the Huffman bill's requirements. Using data from the CEUS, CSS, and IOU program achievements during the 2004-2012 time period, it should be possible to develop a reliable estimate of the lighting energy usage in 2007 that could be used to help determine if commercial businesses have achieved the legislation's goals.

Make and model number lookups added to the value of the CSS analysis for Linear Lamps, TVs, and Packaged and Split-System Single Zone HVAC. Additional technologies in the CSS have make and model numbers collected but not looked up or analyzed. Technologies where make and model numbers were collected but were not looked up to determine the efficiency distributions include Photo Voltaic Panels, Emergency Generators, Ice Makers, Self-Contained Refrigerated Cases, Self-Contained Walk-ins, Mini cooling systems, Packaged Terminal Unit (PTU) cooling systems, some Heating Equipment, Chillers and Boilers, and several lighting technologies. The lighting technologies were make and model numbers were collected but efficiency were not looked up include HIDs, LEDs, CFLs, Incandescent, Halogens, and Exit Signs. These technologies and the information collected for them represent opportunities to extend the value of the CSS study, but analyzing the efficiency distribution of these technologies was not included in the original scope or budget.

The data collected in the CSS provide the opportunity for additional analyses not undertaken for this report. These data have been combined with information on EE, DR, and DG program participation. The data have been linked to the business electric billing data for 2009-2012. These data are a rich source of information on the electric using equipment in CSS businesses in California. The research team sees potential for further analyses building on both, the data gathered here, and the processes and methods that have been developed to support a large scale saturation study. Findings regarding technology adoptions in small businesses for instance, may be used to inform hard-to-reach programs with regards to market and technology potential. Information gathered in this study may also be analyzed to determine what share of existing equipment would conform to new standards of efficiency. Comparisons of CSS results with past studies would enable a longitudinal analysis of technology adoptions. As stated, even though electric consumption continues to be dominated by Lighting, the CSS study revealed that in comparison to the 2006 CEUS findings, the share of commercial electricity usage attributable to the lighting end-use in CSS businesses has fallen. This brings into focus other and newer end-uses where aggregate consumption has increased, and which therefore demand more program focus and provide greater potential for savings.

1

Introduction

The California Commercial Saturation Survey (CSS) Study collected data on-site from 1,439 commercial businesses. These data are analyzed to describe the saturation of high priority electric end uses, systems, and measures within the commercial sector in the California IOU service territories. End uses included in the study include lighting, HVAC, refrigeration, office equipment, TVs, energy management systems, and distributed generation equipment. The study also collects extensive information about the buildings occupied by CSS businesses and the energy consumption and floor stock of these businesses. The energy consumption and floor stock information are analyzed to calculate whole building energy intensities for CSS business types.

The baseline for electric systems and measures is analyzed using on-site data, make and model number efficiency look ups, program participation data, information from the utility Customer Information System, and billing data. The CSS and Commercial Market Share Tracking (CMST) telephone survey was used to collect self-reported information from telephone survey participants and to recruit for the on-site survey. The CSS on-site data collection effort led to the development of precise information on the saturation and distribution of many electric systems and measures.[1] The information collected and analyzed by the CSS study will provide the CPUC, IOUs, and the evaluation community with a baseline estimate of the saturations and quantity of these technologies and information on the efficiency distribution for select measures. Combining the on-site data with IOU energy efficiency (EE) program tracking data enables the analysis to determine if the efficiency distribution of high priority measures differs if the business participated in IOU energy efficiency programs from 2009 to 2012.

The CSS study collected on-site information from the following business types:

- Food and Liquor Stores
- Health and Medical Clinics
- Miscellaneous
- Office

[1] The telephone and on-site CSS data collection efforts was coordinated with the CMST data collection effort. The combination of the CSS and CMST telephone and on-site surveys works to increase efficiencies and the number of sites available for each study.

- Restaurant
- Retail
- School
- Warehouse

During the on-site data collection effort, data was collected on the businesses, buildings, and the equipment in the businesses. These data will be used to develop an up-to-date understanding of the electric consuming equipment in California businesses.

The sections of the CSS report include the following:

- A description of the objectives of the CSS surveys and approaches taken to develop additional data needed for the CSS analysis
- A description of the sample and CSS on-site weighting
- Presentation of the CSS business and building characteristics
- Presentation of the CSS Lighting results
- Presentation of the CSS Television results
- Presentation of the CSS Office Equipment results
- Presentation of the CSS Refrigeration results
- Presentation of the CSS HVAC results
- Presentation of the CSS Energy Management System results
- Presentation of the CSS Distributed Generation results

The report also includes four appendices:

- Appendix A presents the NAICS to business type mapping
- Appendix B presents additional information on the telephone survey and on-site survey sample design
- Appendix C is the on-site survey form
- Appendix D is the on-site survey training handbook

2

Commercial Saturation Survey Objectives

The Commercial Saturation Survey and the Commercial Market Share Tracking Survey are designed to answer an extensive list of baseline research objectives. The research objectives for the studies differ and overlap for the three components of the study: the CSS/CMST telephone survey, the CMST on-site data collection, and the CSS on-site data collection. The following sections highlight the different and overlapping surveys of the multiple data gathering efforts while focusing on the research objectives of the CSS study.

2.1 Telephone Survey Research Objectives

The telephone survey interviewed approximately 8,000 non-residential customers in the three California electric IOU service territories, providing the evaluation team with the unique opportunity to collect baseline information on a large number of customers. The team collected information on firm demographics, the customer's environmental consciousness, their awareness of DSM programs, and their current participation in these programs. The survey also collected information on the types of technologies currently used in the customer's business and whether the customer had purchased high-priority new technologies since 2009. The CSS/CMST telephone survey also recruited for both the CSS and CMST end user on-site data collection effort.

2.2 Commercial Market Share Tracking Research Objectives

Commercial market share tracking information was collected using three approaches: Telephone and on-site surveys with end users and telephone surveys with contractors. The CMST telephone and on-site survey with end users were undertaken with businesses in the non-residential population, including Colleges and Universities, Food and Liquor Stores, Non-hospital Health Care, Hospitals, Hotels and Motels, Industrial, Offices, Property Managers, Restaurants, Retail, K-12 Schools, Warehouses, Miscellaneous business, and businesses designated as unclassified in the IOU CIS.[1] See Section 3 and 4 of this report for more

[1] The business activity at sites were updated as part of the telephone survey. To be included in the on-site survey, the business activity at a site was required to be in the list of CMST businesses. Sites that were classified as Property Managers and Unclassified in the CIS were updated and included in the on-site sample frame if the updated business type was a CMST business.

information on businesses in the CMST. Information on recent purchases of Linear Fluorescents, Televisions, and small HVAC systems was collected from non-residential customers during the telephone survey. The on-site data collection efforts verified recent purchases identified during the telephone survey, collected information on additional recent purchases of these technologies that were not identified during the telephone survey, and collected make and model number information that is used to develop detailed descriptions of the efficiency of recent purchases. Telephone surveys of lighting and HVAC contractors are used to develop a high level understanding of the efficiency distribution of recent sales and installations by contractors in non-residential sites in California.

2.3 Commercial Saturation Survey Research Objectives

CSS data was collected using telephone and on-site surveys with CSS businesses. The CSS telephone survey was undertaken in combination with the CMST telephone survey. The research objectives of the CSS study center around describing commercial businesses in California including square footage, whole business energy usage, and the current baseline of electric equipment in commercial businesses. The data collected on-site, combined with additional information on the business' billing history and IOU EE, DG, and DR program participation, will lead to the development of a better understanding of electricity usage and electricity using equipment within CSS businesses. This information will help with future program plans, will be used to help update measure specific baselines and energy saving estimates and will be used as inputs to future energy efficiency potential studies.

The CSS on-site data collection effort assembled information from 1,439 on-site visits with businesses in 8 commercial business types: Food/Liquor stores[2], Health/Medical Clinics, Miscellaneous businesses, Offices, Restaurants, Retail, Schools, and Warehouses. Sections 3 and 4 of this report provide more information on the CSS Sample Frame.[3] The CSS data collection effort focuses on the whole building and business characteristics and many of the electric end uses within commercial businesses. End uses analyzed for the CSS study include Lighting, Televisions, Office Equipment, Refrigeration, HVAC, Energy Management Systems, and Distributed Generation systems.

Extensive information was collected during on-site visits to develop a baseline of businesses and equipment. The data collected included information on the saturation, age, and condition of equipment. To determine the efficiency level of equipment, the make and model numbers were collected. For high priority measures, these data were used in look ups to determine efficiency

[2] Food/Liquor stores include small specialty food stores, convenience stores, liquor stores, and small and large grocery stores.

[3] Appendix B presents additional information on the CSS/CMST telephone survey and the CSS on-site survey sample designs.

distributions. In the CSS report, efficiency distributions are presented for Linear Lighting technologies, Televisions, and Packaged and Split Single Zone Cooling units.

Technologies where make and model numbers were collected but were not looked up to determine the efficiency distributions include Photovoltaic Panels, Emergency Generators, Ice Makers, Self-Contained Refrigerated Cases, Self-Contained Walk-ins, Mini cooling systems, Packaged Terminal Unit (PTU) cooling systems, some Heating Equipment, Chillers and Boilers, and several lighting technologies. The lighting technologies where make and model numbers were collected but efficiency were not looked up include HIDs, LEDs, CFLs, Incandescent, Halogens, and Exit Signs. These technologies and the information collected for them represent opportunities to extend the value of the CSS study, but analyzing the efficiency distribution of these technologies was not included in the original scope or budget.

2.3.1 Comparison of the CSS and CMST

Table 2-1 presents a high level comparison of the CSS and CMST studies. The CMST and CSS have unique objectives, though the study implementation used a joint telephone survey and overlapping on-sites. The business types included in the two studies were identical for the joint telephone survey, but the types of businesses included in the CSS on-site data collection was more limited than for the CMST on-site data collection effort. The CSS on-site data collection and analysis, however, incorporated more technologies than the CMST study. The technologies with efficiency look ups in the CSS mirror the technologies analyzed in the CMST. The CMST Study provides information on the baseline of current purchases of these technologies while the efficiency look ups within the CSS provide information on the baseline of current technology distributions within businesses. Having the ability to analyze both of these data sets, which were collected over the same time period, provides a description of where the market is currently heading (CMST) and what the efficiency of equipment in businesses currently is (CSS). The combination of these two sources of baseline data provides a unique and informative source of information for program planners, evaluators, and future potential studies.

Table 2-1: CSS and CMST Comparison

CSS Study	CMST Study
Joint Phone Survey	Joint Phone Survey
On-sites Implemented in Select Commercial Business Types	On-sites Implemented in Select Non-Residential Business Types
	Contractor Telephone Survey
Analyzed Existing Baselines for Lighting, HVAC, Refrigeration, TV, Office Equipment, EMS, and DG	Analyzed Recent Purchases for Linear Lighting, TV, and Select HVAC
Analyzed Efficiency Distribution of Equipment for Lighting, TV, and Select HVAC	Analyzed Efficiency Distribution of Equipment for Linear Lighting, TV, and Select HVAC
Disaggregated the analysis by IOU EE Participation, Customer Size, IOU, and Building Type	Disaggregated the analysis by IOU EE Participation, Customer Size, IOU, and Building Type

2.3.2 Comparison of CSS and Commercial End Use Survey Objectives

The CSS and the Commercial End Use Survey (CEUS, 2006[4]) are both large commercial end use surveys undertaken in California. Given that both the CSS and the CEUS are large commercial population studies, it is natural to compare the findings from the studies. Prior to comparing the results of the studies, however, it is important to understand that the objectives of the two studies overlap, but each study has high priority objectives that are not included in the other study.

Primary achievements of CEUS include:

- The development of whole building energy intensities
- End-use fuel shares
- Energy intensities by end use
- Hourly load profiles for commercial market segments and end uses
- A web based tool to present high priority results

CSS objectives and achievements include:

- The development of whole business energy intensities
- Measure level saturations
- Efficiency distributions for high priority measures by multiple domains of interest
- The construction of a web site to support the delivery of these data

[4] CA CEUS Project Final Report completed on behalf of the California Energy Commission. Report # CEC-400-2006-005. CA CEUS is also available at: http://capabilities.itron.com/CeusWeb/Default.aspx.

The estimation of end use intensities and hourly load profiles were not an objective of the CSS study[5] while developing a better understanding of measure level efficiency distributions was not a high priority for the CEUS study.

The CEUS was managed by the California Energy Commission (CEC) and was designed to satisfy Title 20 requirements which mandate the development of fuel shares and end use energy usage information. The CSS was managed by the CPUC and was focused on developing information on measure saturations and baseline data on efficiency distributions that provide the CPUC, DEER, IOUs, and evaluators with information to better understand the current energy efficiency market.

The CEUS and the CSS have different primary objectives and were managed by different regulatory agencies. The implementation and data gathered from the two studies, however, was similar. The CSS on-site survey forms and procedures were developed from the CEUS and the California Small Commercial Group Direct Impact Evaluation (2010) on-site survey forms and procedures. The CSS lighting form was largely derived from the forms used to collect lighting information during the 2006-2008 California Small Commercial Group Direct Impact Evaluation. The CSS lighting forms are more extensive and collect additional lighting detail when compared to the lighting forms used during the CEUS. The CSS forms were designed to collect additional lighting detail due to the CSS's focus on analyzing the efficiency distributions for high priority lighting measures. Lighting has been a primary focus of commercial energy efficiency programs, recent code updates, and lighting accounts for a substantial share of commercial energy usage. These three factors, contributed to CSS's emphasis on collecting and analyzing more detailed lighting information than was incorporated into the CEUS.

In contrast to the lighting forms, the CSS simplified the CEUS HVAC forms. During the study development, the research team chose to focus the CSS HVAC research on the collection and analysis of information on split and packaged HVAC systems and chose to eliminate the collection of information on thermal zones. The focus on split and packaged systems is due to their primary role in providing heating and cooling in California businesses and recent code updates to these systems enhance the need to better understand their efficiency distribution. Focusing the HVAC data collection on spilt and packaged systems provided the Study with the

5 Given the data collected during the CSS and the availability of AMI hourly load data for nearly all commercial businesses in the California IOU territories, the CSS data, in combination with the hourly load data, load profiles could be developed for CSS businesses. The end use data collected during the CSS could also be used in statistical models to disaggregate the load data. Given data collected, this load disaggregation could lead to the development of weather sensitive or HVAC load shapes, lighting shapes, time sensitive shapes, and base loads. Using starter shapes adjusted for the information collected on-site, could lead to additional load disaggregation. Combining AMI data with on-site data to disaggregate loads is a relatively new approach to estimating end use load shapes, a full understanding of the possibilities of these data is yet to be developed.

information needed to describe the efficiency distribution of the primary cooling systems for businesses included in the CSS study.

The CSS study augmented the refrigeration forms relative to the CEUS and the CSS study added a form to collect information on televisions and their peripherals. The collection of information on televisions was deemed high priority due to the high degree of uncertainty associated with the saturation and efficiency level of televisions in commercial settings. As discussed below, the CSS did not collect data on water heating, cooking, and addition end uses.

The sample frames for both studies were based on the commercial sites within the electric frames for the three California IOUs. Both studies collected extensive information on measure saturation, business hours and area schedules, building shells, and firm demographics. The similarities between these two studies allow for the development of select information on how energy usage and measure saturations have stayed the same and where they have changed. Some of these opportunities are highlighted in this report; other opportunities are outside the scope of this report.

Business Types Studied

The CEUS collected and analyzed data for ten business types:

- Large and Small Offices
- Retail
- Refrigerated and Non-Refrigerated Warehouses
- Colleges
- Health Care
- Restaurants
- Grocery
- Schools
- Hotel/Motel
- Miscellaneous

In the CEUS, the sample design and reporting for Large and Small Offices and Refrigerated and Non-Refrigerated Warehouse was separated, leading to the presentation of results by twelve business types. The development of the CEUS business types was undertaken under the management of the CEC, the consultation with the IOUs, and to fulfill the Title 20 requirements.

The CSS focused on eight business types:

- Large and Small Offices
- Retail
- Refrigerated and Non-Refrigerated Warehouses
- Colleges
- Health Care – Non-Hospital
- Restaurants
- Grocery
- Schools
- Hotel/Motel
- Miscellaneous

The CSS did not include Colleges or Hotel/Motel segments in its data collection and analysis. In addition, the CSS did not include Hospitals. Colleges, Hospitals, and many Hotel/Motels represent business types that are generally large and difficult to survey. These businesses often have energy facility management personnel that direct the maintenance and upgrading of their business shell and energy equipment. During the research planning phases of the CSS, it was determined, in consultation with the CPUC, DEER team, and IOUs, that the collection of data in these three business types could be more efficiently undertaken in a study that focused on these three larger types of businesses, enabling the CSS to use its resources to focus on the remaining eight business types. Using information from the three IOUs' Customer Information Systems, the three business types not included in the CSS account for 0.78% of the non-residential sites and 6.4% of the non-residential energy consumption. These data are presented in Table 4.1 in Section 4. Neither the CSS nor the CEUS included industrial, agricultural, mining, street lighting, parking lots, or TCU sites in their frame of eligible sites.[6]

The CSS and the CEUS both include Large and Small Offices in their sample frames. In the CEUS, large and small offices are developed as separate strata. In the CSS, Offices are developed as a single business type with multiple size strata. For both the CSS and the CEUS, the Office strata divisions were originally developed based on the business' billing data. In the CEUS, the final designation of Office analysis size was based on the square footage observed on-site while the CSS Office analysis size is based on the business' annual energy consumption.[7]

End Uses Studied

The high priority measure data collection and analysis differed across the two studies. The CEUS collected information and analyzed both electric and gas measures while the CSS focused on electric measures. The CEUS was designed to satisfy the Title 20 requirements that include

[6] Hospitals, Colleges, and Hotel/Motel represent 1% of non-residential sites not including industrial, agricultural, mining, street lighting, parking lots and TCU and 10.6% of kWh consumption.

[7] Section 4 describes the development of business annual electricity consumption for businesses in the on-site data collection effort. The business annual consumption values are updated following on-site data collection and meter lookups.

both gas and electric end uses. The CSS was designed to provide information to the CPUC, DEER team, and IOUs to help understand electric energy using equipment.

The CEUS collected data for 13 end uses including:

- Space Heating
- Space Cooling
- Ventilation
- Water Heating
- Cooking
- Refrigeration
- Interior Lighting
- Exterior Lighting
- Process Equipment
- Motors (non-HVAC)
- Air Compressors
- Office Equipment
- Miscellaneous

The CEUS collected and analyzed comprehensive on-site survey information on equipment stocks, operating schedules, and shell characteristics of commercial buildings. For many types of equipment, the CEUS collected efficiency information, including make and model numbers, but the study did not include resources to analyze much of the efficiency data.

The CSS collected and analyzed information on 8 end uses including:

- Space Heating
- Space Cooling
- Ventilation
- TVs
- Office Equipment
- Refrigeration
- Interior Lighting
- Exterior Lighting
- Miscellaneous

The CSS collected and analyzed comprehensive on-site survey information on equipment stocks, operating schedules, efficiency information, and shell characteristics of commercial buildings. For many types of equipment, the CSS collected make and model numbers. Within the CSS, the make and model numbers for Linear Technologies, packaged HVAC units, and TVs were looked up to determine the efficiency distribution of these measures. Technologies where make and model numbers were collected but were not looked up to determine the efficiency distributions include Photo Voltaic Panels, Emergency Generators, Ice Makers, Self-Contained Refrigerated Cases, Self-Contained Walk-ins, Mini cooling systems, Packaged Terminal Unit (PTU) cooling systems, some Heating Equipment, Chillers and Boilers, and several lighting technologies. The lighting technologies whose make and model numbers were collected but whose efficiency information was not looked up include HIDs, LEDs, CFLs, Incandescent, Halogens, and Exit

Signs. These technologies and the information collected for them represent opportunities to extend the value of the CSS study, but analyzing the efficiency distribution of these technologies was not included in the original CSS scope or budget.

CEUS collected more extensive information on HVAC end uses than were collected during the CSS. The CSS focused data collection and analysis on cooling, heating and control information for direct expansion (DX) systems. The CSS model number lookups focused on the cooling data providing extensive information on capacity and efficiency level that were not available in CEUS. The data collected for packaged cooling systems within the CSS provide information on the distribution of efficiency and capacity for these systems within CSS businesses, providing detailed data on the current packaged system baselines. The CSS ventilation information was limited to the fan control type and outdoor air percentages. For large built-up (non-DX) systems, the CSS limited data collection to the information needed to identify the system type and cooling/heating sources (chiller, boiler, etc.). The CSS study focused on collecting and analyzing data for small packaged and split HVAC systems that dominate cooling equipment found in the business types studied in the CSS. See Section 9 for more information on the HVAC data collected and analyzed in the CSS.

The CSS collected and analyzed extensive information on interior lighting. The CSS collected and analyzed make and model information for linear fluorescents to distinguish between four different types of T8 technologies: Disaggregating T8s into 700 series, 800 series, High Performance, and Reduced Wattage. Within the CEUS, all T8 technologies were classified as high efficiency linear lighting while T12 were classified as standard equipment. Both the CEUS and CSS collected extensive information about lighting wattages, lumens, and lighting schedules.

The CSS end use data collection focused on the end uses representing the majority of electricity consumption within CSS businesses, and those end uses with extensive energy efficiency programs and/or codes and standards updates. The CSS did not collect information for water heating, cooking, process, motors, air compressors or miscellaneous end uses. The CSS collected information for TVs which were not an explicit end use within the CEUS. The CEUS data imply that the end uses that were not analyzed in the CSS account for approximately 10-16% of electric energy usage. The end uses included in the CSS study, therefore, likely account for 84-90% of the electric energy usage for business types included in the CSS study.

The CEUS and the CSS studies relied on data collected from buildings and measures observed on-site. Both studies, however, also collected information from the site manager during the on-site survey. Information collected from the site manager was extensive for both studies. These data include, but are not limited to, business hours and operating schedules, age of equipment if not observable on the equipment nameplate, age of building, DR and DG program participation, and information on energy management systems (EMS) and their controls.[8] The CSS database includes information on EE, DR, and DG program participation allowing the study to validate self-reported participation with information from the 2009-2012 IOU program tracking databases.

CSS and CEUS Lighting Load Shapes

The CSS and the CEUS both estimate lighting load shapes and the share of commercial energy consumption associated with indoor lighting. The approaches to estimating indoor lighting usage for the two studies employed many of the same lighting elements collected during the on-site survey. The two studies, however, used different approaches to modify the self-reported lighting schedules collected on-site to develop a final site specific lighting schedule and an estimate of the lighting load shape and lighting energy usage.

The CSS combined information on technology wattages and self-reported lighting schedules to develop base lighting load shapes for each lighting technology element at a site. The base lighting load shapes were then adjusted to develop final site specific lighting schedules using ratio adjustments derived from the 2006-2008 California Small Commercial Contract Group Direct Impact Evaluation (SCCG 2010). The SCCG ratio adjustments were developed using self-reported lighting schedules and data from over 7,000 lighting loggers installed at over 1,200 California businesses. The ratios represent the observed relationship between self-reported schedules and the observed hours of lighting usage developed during the SCCG lighting logger study. The SCCG ratios were used to adjust the CSS self-reported lighting schedules. The adjusted schedules and lighting wattage data are used to develop a final, site specific lighting load shape and an estimate of lighting electricity consumption for each business included in the CSS on-site analysis. The information on the development of the CSS estimate of lighting energy usage is available in Section 5 of this report.

The CEUS also developed an estimate of lighting energy usage using similar on-site data. The CEUS study combined information on technology wattages and self-reported lighting schedules with "starter" lighting load shapes developed from previous metering studies to develop an estimate of site specific lighting load shapes. The information on wattages was used to develop estimates of lighting energy usage. The self-reported lighting schedules were used to modify the "starter" lighting load shapes that had been derived from other studies.[9] The updated base lighting load shapes were combined with the site specific information on wattages to determine the load or magnitude associated with the site specific load shape. The lighting load shapes were

[8] Hardware based EMS systems were often observable to surveyors, but surveyors also asked site personnel about the presence of control systems to ensure the collection of information on hardware and software based systems.

[9] The base CEUS lighting load shapes were derived from other metering studies and were specific to the site's business type.

combined with shapes developed from other end uses and the final lighting load shape was developed through a top-down calibration to the site's monthly bills.

Throughout the report various comparisons of the CSS and CEUS findings are reported. In these sections, additional information will be presented to help with the data comparison. For some end uses and measures, the data are very similar while for others differences between the CSS and CEUS objectives make the comparison of information less direct. As with all large studies separated by an eight to ten year time period, updates to technologies, definitions, and the macro economy have transpired to change the measures and energy usage of commercial customers. Comparison across these studies are informative, but must be undertaken with care, realizing that the studies had different objectives, different survey forms, and they represent different time periods.

2.3.3 CSS Business Characteristics

The CSS study collected information on-site that contributes to a better understanding of business and building characteristics within the CSS businesses in California. Characteristics described in the Business Characteristics section of this study include average electricity consumption, square footage, energy intensity, building age, and number of employees. These characteristics are presented by CSS business type, business size, and/or utility. This information is helpful in describing commercial businesses in California, their square footage, and their energy consumption. These data may contribute to future energy and energy efficiency forecasts.

- The CSS study collected information on business square footage. This information is used to describe the total square footage by business type and IOU. Producing an updated picture of the commercial floor stock is important to better understand the commercial energy intensity and the remaining DSM potential.
- The CSS collected information on utility account and meter numbers while on-site. These data allowed the research team to develop a more accurate summation of the utility meters and accounts associated with the business. With these data the research team developed annual electricity consumption for CSS businesses visited as part of the on-site survey. Using the annual electricity consumption information, the Study developed a weighted estimate of the energy usage for the population of CSS businesses.
- The CSS estimates of floor stock and annual consumption are used to develop estimates of energy intensity by business type and customer size. These data can be used in program planning, future energy efficiency potential studies, and to better understand how energy is used in different business types. Comparing estimates of energy intensity across time within the same business type can also help to develop an understanding of how changes in technology are changing energy usage patterns. Energy intensities are

one of several energy indicators that can be used to evaluate energy usage and progress toward using energy efficiently.[10]

- The CSS estimates of whole business energy intensities are presented with the energy intensity estimates from the California Commercial End Use Study (CA CEUS, 2006).[11]

2.3.4 CSS Commercial Lighting

A central goal of the CSS study is to document the baseline distribution of lighting measures within commercial businesses. The 2006 CEC Commercial End Use Study (CEUS)[12] estimated that lighting accounted for approximately 35% of commercial energy usage in California. In addition, lighting measures represent technology long targeted by commercial energy efficiency programs and recent technology code updates. The CSS on-site survey effort included a full inventory of indoor and outdoor commercial lighting measures. The data collected through this study provide an indication of the progress achieved in replacing inefficient measures with newer, more efficient technologies.

The data collected for commercial lighting will help the CPUC, program planners, and DSM evaluators better understand the current distribution of lighting in the commercial sector. This information will help with baseline development. The data collected during the CSS study will help with the development of energy savings estimates for high efficiency lighting through the information presented on the current baseline for efficient and inefficient lighting. These data will contribute to discussions of lighting market transformation. The analysis of the lighting data will also help with the development of a better understanding of average lighting energy usage and the shape of this usage.

- The CSS lighting data collection included information on the types of technologies present in the facility, the quantity of these technologies, the hours of operation of technologies, the watts of technologies, and make and model numbers for many types of technologies. For Linear technologies, the make and model numbers were looked up to determine the efficiency level of the technology, to verify the wattage information, and to collect information on lumens.
- Using the data collected on-site and information from model look ups and other lighting studies, the CSS study developed estimates of the lighting power density by business type, business size, and energy efficiency program participation.

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[10] Energy intensities should not be used exclusively to describe progress toward using energy efficiently. If the intensity of production for a given floor space also changes over time, the energy intensity could rise or fall with improvements in efficiency. See Section 4 of this report of a larger discussion of energy intensity.

[11] CA CEUS Project Final Report completed on behalf of the California Energy Commission. Report # CEC-400-2006-005. CA CEUS is also available at: http://capabilities.itron.com/CeusWeb/Default.aspx.

[12] California Commercial End-Use Survey; Prepared for California Energy Commission by Itron Inc.; March 2006

- The CSS collected data on the lighting employed in commercial businesses through a full inventory of commercial lighting. The study collected information on Linear Fluorescents, Incandescent bulbs, Halogens, CFLs, LEDs, and HIDs.
- The CSS lighting data provides a baseline distribution of the commercial usage of Incandescent lighting, CFLs, and LEDs. These data can contribute to the determination of energy savings associated with the installation of CFLs and LEDs.
- The CSS lighting analysis used information on lighting wattage and hours of use by activity area to develop an estimate of energy usage by business type.

2.3.5 CSS Commercial Televisions

The prevalence of TVs within the commercial sector is highly uncertain. Until recently, TVs were seldom analyzed within the commercial sector; TVs were primarily viewed as an energy-consuming end use within the residential sector. Anecdotal evidence, however, indicates that the number of TVs within the business sector is rising. The CMST analysis of recently purchased TVs found that 60% of the TVs purchased by businesses from 2009 to 2012 represented new or additional TVs not replacement TVs.

Recent advances in TV technology have created a push toward increased energy efficiency. The ENERGY STAR rating for TVs has been updated three times during the 2009-2012 time period. Modern LCD and LED TVs can use less energy than older CRT TVs even though they tend to be substantially larger. This study provides a better understanding of the saturation of TVs within the commercial sector and a characterization of the types of TVs. The data collected on-site includes the television technology (CRT, LED, LCD), the size of the televisions, the usage of the television, and the make and model number of the television. With these data, the Research Team is able to characterize the saturation of TVs within the commercial sector by TV type, size, and energy efficiency. The distribution of TVs can be characterized by business type, IOU, and business size, helping to reduce the uncertainty associated with a growing commercial end use.

- The CSS study determined the number and type of televisions currently used in commercial businesses.
- The CSS study used make and model numbers collected during the on-site data collection effort to determine the energy efficiency of televisions in commercial facilities. These data help to describe the distribution of TVs and provide information about business types that have likely seen recent growth in their TV saturation.

2.3.6 CSS Office Equipment

The CSS study collected extensive information on the saturation of multiple types of office equipment. Some form of office equipment exists in nearly all businesses. The ubiquitous nature of office equipment helps to clarify the importance of developing a better understanding of the saturation and distribution of these technologies. Various types of office equipment are experiencing rapid technological changes. The energy usage and cost of office technologies has generally been falling while the functionality has generally improved. Given the rapid technological change of office equipment, it is likely that these technologies experience a relatively rapid turnover or have a short expect life. Given the level of rapid technological change, potentially short life, and ubiquitous nature of office equipment, collecting information on these technologies is important to update our understanding of the current distribution of office equipment.

The CSS on-site data collection effort collected information on the presence of different types of office equipment. The study collected information on a wide variety of equipment including Copiers, Printers, Computers, and Servers. Using this information the Research Team characterizes the distribution of office equipment by business type and IOU. The equipment is also further disaggregated to determine the types of office equipment commonly found in activity areas classified as offices and computer rooms. These data will help the CPUC and evaluators better understand the distribution of different types of office equipment.

2.3.7 CSS Refrigeration

Refrigeration systems represent a significant source of energy usage within the commercial sector. The 2006 CEUS[13] estimated that refrigeration systems account for approximately 13% of the electricity usage in the commercial sector. Within select commercial segments, however, refrigeration usage accounts for a significantly higher share of usage. Refrigeration systems account for approximately 54% of electricity usage within food and liquor stores, 67% of the usage within refrigerated warehouses and 25% of electricity usage for restaurants.[14]

The CSS on-site study collected extensive information about commercial refrigeration. These data collected on-site includes information on the refrigeration system type (self-contained or remote), the refrigeration cases present in commercial facilities and refrigeration measures commonly included in energy efficiency programs. Using these data, the Research Team characterizes the current distribution of systems, technologies, and measures. This information will help the CPUC, IOUs, and evaluators better understand the current baseline of refrigeration measures. This information will be used to help develop future programs and as inputs into future potential studies.

- The CSS study collected information on the type of refrigeration cases present in businesses and the size of these cases. With these data the team developed estimates of

[13] Ibid; March 2006

[14] Ibid.

the total linear feet of refrigeration cases by case type, case temperature, and refrigeration system type. These data will help program planners better understand the current distribution of refrigeration equipment.

- The CSS study collected information on Ice Makers. With these data the Team developed information on the distribution of Ice Makers across business types and customer sizes.
- The CSS study collected extensive information on Walk-in refrigeration units. These data clearly describe the difference in Walk-in size and the distribution of age and efficiency equipment by business type.

2.3.8 CSS Commercial HVAC

Heating, ventilation, and air conditioning (HVAC) systems represent a significant source of energy usage and peak demand within the commercial sector. The 2006 CEUS[15] estimated that HVAC systems account for approximately 29% of the electricity usage in the commercial sector. The California Strategic Plan emphasizes the importance of achieving dramatic improvements in the efficiency of HVAC systems. In the Strategic Plan one of the four Big Bold Energy Efficiency Strategies (BBEES) states that HVAC will be transformed to ensure that its energy performance is optimal for California's climate. The BBEES targets a 50% improvement in efficiency in the HVAC sector by 2020. The data collected as part of the CSS study provide the CPUC, IOUs, and the state of California with information on the efficiency of HVAC within the commercial sector as of 2012.

The CSS on-site data collection effort collected extensive information about the HVAC systems present at commercial facilities.

- The HVAC data collected on-site classifies the HVAC systems in CSS businesses into HVAC system (single and multi-zone) and equipment types. Given that the majority of HVAC systems found in CSS businesses are Single-Zone systems, the Research Team worked to collected complete information on these systems to better understand the efficiency distribution of Single-Zone systems.
- Information collected for Single-Zone HVAC systems included information on the heating and cooling technology type, the heating fuel, the age of the technology, the efficiency and capacity of the technology (if available on the name plate), and the make and model number of equipment.
- The study also provides interested parties with a better understanding of the efficiencies of Packaged and Split Single-Zone systems and how these efficiency levels differ by

[15] California Commercial End-Use Survey; Prepared for California Energy Commission by Itron Inc.; March 2006

business type, business size, and system capacity. The report also presents information on the average square foot per ton for these systems.

- The CSS study also collected self-reported information on HVAC system maintenance. These data provide the CPUC and evaluators with a better understanding of current maintenance practices as the states introduces programs to encourage quality installation and maintenance of HVAC equipment.

2.3.9 CSS Energy Management Systems

An Energy Management System (EMS) is a network that combines local distributed control with centralized coordination and management to monitor, control, and optimize the energy usage throughout the facility. EMSs can be used to control and monitor energy use of appliances and equipment at a site including lighting, HVAC, water heating and process equipment. EMS systems can also be used to control systems during demand response events. The California Strategic Plan notes that EMSs are important for the achievement of the Big, Bold, Energy Efficiency Initiatives and integrated energy solutions. The CSS data on EMSs provides the IOUs and the CPUC with a better understanding of the current baseline of EMS saturation. This information is useful for future program planning for energy efficiency, demand response, and future potential studies.

The CSS on-site survey collected multi-faceted data on energy management systems.

- The EMS data provides information on the current saturation of EMSs. Providing a better understanding of the business types and business sizes with EMS.
- The CSS collected data on the end uses controlled by the system. The survey collected information on the number of points and the number of controllers.
- The CSS survey data was merged with the demand response tracking data to determine if sites with EMS were participating in IOU Demand Response programs. These data help the CPUC and IOUs better understand where EMS and demand response program participation has led to needed demand reduction and where demand response opportunities remain.

2.3.10 CSS Distributed Generation Systems

The state of California has a long history of investing in distributed generation programs and technologies. The California legislature implemented laws creating incentives for grid-tied PV systems in 1996 and Californians participated in the national Million Solar Roofs program begun in 1997. The California Self Generation Incentive Program (SGIP) initially implemented in 2001 is one of the longest-running and most successful distributed generation programs in the country. The California Solar Initiative (CSI) began in 2007 as a program designed to rebate the installation of solar technologies on residential and commercial facilities. In addition, the

California Strategic Plan calls for improved integration of DSM, including distributed generation, as it strives to reach the goal of having 50% of existing buildings with the equivalent of zero net energy by 2030. To help provide information on distributed generation technologies within the commercial sector, the CSS study collected information on the distributed generation technologies found on-site. The study collected information on the types of technologies, the number of technologies, and if the technology is used primarily as a back-up system or a primary generation system.

- The CSS presents information on the share of sites with primary and backup generation systems and the average system size.
- Using data collected on DG systems and the business level annual energy consumption, the CSS presents information on the average energy intensity by business type for sites with and without PV systems.

3

CSS Approach, Sample, and Weighting

The CSS/CMST telephone surveys gathered self-reported customer information regarding commercial business type, installed measures, and utility program participation decisions and experience, where relevant.[1] One of the phone survey's primary purposes, however, was to recruit for the CSS and CMST on-site surveys and to inform the on-site verification effort. The telephone surveys helped to refine the sample design for on-site data collection by gathering better information on business types. The telephone survey enabled the surveyor to approach each on-site survey equipped with better information about the establishment's size, measure specifications, baseline information, and dates of installation. This section briefly discusses the on-site sample design for CSS.

3.1 Sample Design

The development of the CSS on-site sample design followed an approach similar to the telephone survey sample design. Specifically, the design was based equally on the number of sites and the usage of sites. For many of the medium and large sized businesses, the on-site sample quota resulted in a census of the phone survey sites that agreed to participate in the on-site data collection.

3.1.1 CSS/CMST Telephone Survey Sample Design

The primary goal of the telephone survey was to develop a representative sample of the non-residential population for the CSS on-site sample that would provide the desired level of statistical precision for estimating a wide range of commercial customer characteristics. Given that the primary purpose of the telephone survey is to recruit for the on-site surveys, the final telephone survey sample design was adjusted during the survey process to successfully fulfill this objective.

The telephone survey sample design incorporated 14 business types:

[1] The sample design and findings for the CSS/CMST telephone survey are available in the telephone survey report, Commercial Saturation and Commercial Market Share Tracking Study Telephone Survey Findings, Sept. 2013.

- Colleges and Universities
- Food and Liquor Stores
- Non-hospital Health Care
- Hospitals
- Hotels and Motels
- Industrial
- Offices
- Property Managers
- Restaurants
- Retail
- K-12 Schools
- Warehouses
- Miscellaneous
- Unclassified and Undefined

The business type strata were further disaggregated by the three electric IOUs and five energy usage size strata (Large, Medium, Small, Very Small, and Unknown)[2] to produce 210 unique strata.

- **Large –** Sites whose annual usage was over 1,750,000 kWh.
- **Medium –** Sites with usage from 300,000 kWh to 1,750,00 kWh.
- **Small –** Sites with usage from 40,000 to 300,000 kWh.
- **Very Small –** Sites with usage less than 40,000 kWh.
- **Unknown –** Sites with no kWh in 2010. (Some of these sites were later found to have usage reported in the 2011 billing data. If no usage was found in the 2010 or 2011 billing data, the site had no kWh usage.)

The telephone survey quota was originally developed based equally upon the usage and number of unique sites. In other words, two separate quotas were calculated by strata based first, on kWh, and then by counts. These two quotas were then averaged for each stratum. The sample design was also dependent upon ensuring that there was an adequate number of sites, but not too many, for each IOU/business type combination and the design allocated a target number of sites by IOU. Over time, some strata were oversampled in order to achieve sufficient survey recruits for the on-site survey in those strata. As additional sites were needed to ensure adequate on-site strata, the quota for the telephone survey was simply increased. The CMST/CSS telephone survey resulted in 7,994 completed surveys.

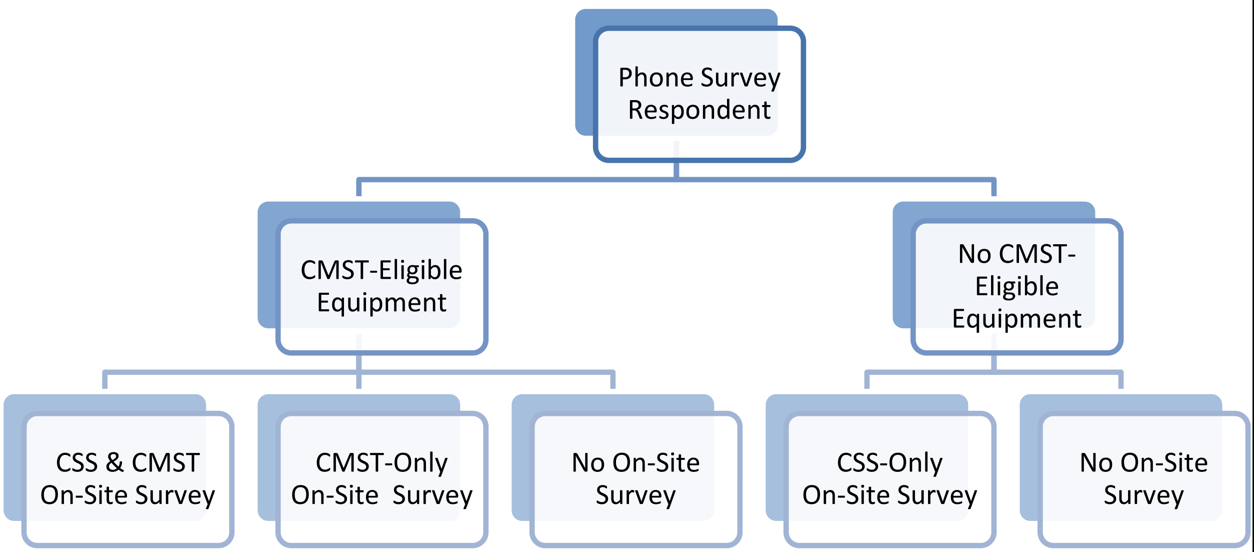
3.2 On-Site Recruitment

The last set of questions in the phone survey involved the on-site recruitment battery. The respondent confirmed that he or she is the one most knowledgeable about the energy usage at their facility. The respondent was first asked if they were willing to participate in a full CSS on-

2 The unknown usage category represents accounts found in the CIS that do not have a matching record in the billing data.

site survey.[3] The CSS survey collected information on both CMST-eligible and non-CMST-eligible equipment. If the respondent initially refused to participate in the CSS they were offered a small incentive gift card to participate in the CSS survey. If a site agreed to participate in the CSS on-site survey and they reported purchasing CMST eligible equipment, they were a dual (CSS and CMST) recruited sites. If, following the incentive offer, a site again preferred not to participate in the CSS on-site data collection effort, they were then asked to participate in the CMST on-site data collection effort (as long as they confirmed that they had recently installed CSMT-eligible equipment). Figure 3-1 illustrates the on-site recruitment effort.

Figure 3-1: Phone Survey Recruitment Options



3.3 CSS On-Site Sample Design

The sample design for the CSS on-site survey effort was developed from the telephone survey completes using the following methodology:

- The number of telephone survey completes by strata,
- The annual usage of those telephone survey completes,
- A desired number of completes per utility, and

[3] Hospitals, Colleges and Universities, and Hotels and Industrial sites were not recruited for the CSS survey. These types of sites were not eligible for the CSS survey and were skipped directly to the CMST recruit script if they had self-reported during the telephone survey that they recently purchased one of the three types of measures in the CMST analysis.

- A minimum and maximum number of completes per utility and business type combination.

The methodology was very similar to the approach used as part of the telephone survey sample design. This process worked to ensure that each stratum was represented by a minimum number of on-site surveys and that the more populous strata did not overwhelm the smaller strata. Given that the phone survey and on-site survey were undertaken in a staged but overlapping time frame, the on-site quota was frequently updated to account for updates in the telephone survey completes. As the telephone survey was approaching completion the quota for the on-sites were reviewed for adjustment based on the number of on-site recruits.

The CSS on-site sample design incorporated 8 business types: Food and Liquor Stores, Health and Medical Clinics, Miscellaneous, Offices, Restaurants, Retail, K-12 Schools, and Warehouses. The sample design business type designation was based on the detailed business type information collected as part of the telephone survey and post telephone survey internet searches. The on-site sample design was also stratified by IOU and customer size. The stratification led to 120 unique strata. Not all of the strata had quota, Restaurants did not have quota within the large size strata. The customer size designations used the same groupings as those used for the telephone survey sample design. The CSS phone survey completes, the number of sites agreeing to participate in an on-site survey, and the on-site quota are presented in Table 3-1. The information presented in Table 3-1 is by business type and IOU.[4] The sample design was also stratified by business size. The size specific quotas are presented in Appendix B due to the size of these tables.

[4] For all data presented in Table 3-1 the business type represents the business type determined during the telephone survey and post-survey Internet searches.

Table 3-1: Phone Survey Completes, CSS On-site Recruits, and On-Site Quota

Business Type	Utility	Phone Survey Completes	CSS Recruited	CSS On-Site Quota
Food/Liquor	PG&E	188	72	55
Food/Liquor	SCE	219	127	54
Food/Liquor	SDG&E	79	38	26
Health/Medical - Clinic	PG&E	251	70	64
Health/Medical - Clinic	SCE	267	78	55
Health/Medical - Clinic	SDG&E	115	42	27
Miscellaneous	PG&E	578	212	103
Miscellaneous	SCE	750	224	113
Miscellaneous	SDG&E	309	113	48
Office	PG&E	500	175	113
Office	SCE	583	168	107
Office	SDG&E	230	67	37
Restaurant	PG&E	217	98	64
Restaurant	SCE	243	105	62
Restaurant	SDG&E	135	60	31
Retail	PG&E	370	156	81
Retail	SCE	471	177	121
Retail	SDG&E	178	52	41
School	PG&E	210	104	78
School	SCE	203	93	71
School	SDG&E	66	28	27
Warehouse	PG&E	255	54	64
Warehouse	SCE	402	97	74
Warehouse	SDG&E	88	23	26
Not in CSS Study	PG&E	379	0	0
Not in CSS Study	SCE	508	1	0
Not in CSS Study	SDG&E	200	2	0
n		**6,907**	**2,433**	**1,542**

Table 3-1 includes a “Not in CSS Study” business type. These sites represent sites whose business type was college/university, hospital, hotel/motel, or industrial. These business types were included in the CMST telephone and on-site survey but were not included in the CSS on-site survey. The three sites recruited to participate in the CSS on-site survey that are listed as “Not in CSS Study” are sites where the phone surveyor incorrectly asked the site if they wanted to participate in the CSS on-site study instead of the CMST on-site study.

Table 3-2 lists the CSS on-site quota and completes by business type and IOU.[5] The on-site completes are presented by their business type as determined during the phone survey and their business type as determined during the on-site survey. The analysis business type, which represents the business type presented in the rest of this study, is the on-site business type. The weighting business type is the phone survey business type. Using the phone survey business types, the study completed 1,462 on-site surveys. Some of these surveys, however, were determined during review of the on-site data to be with businesses that did not meet the CSS on-site business criteria. Two of the completed on-sites were also with businesses that were gas IOU sites but not electric IOU sites. Sites that were not in CSS business types or were not in the electric IOU service territories were not included in the CSS on-sites analysis data set that includes 1,439 sites.

[5] The quota and completes are developed and tracked by business size where size is designated by annual consumption. The breakout of the quota and the on-site completes by business size are available in Appendix B.

Table 3-2: On-Site Quota and Completes

Business Type	Utility	CSS On-Site Quota	CSS On-Sites, Phone Survey Business Types	CSS On-Sites, On-Site Business Types
Food/Liquor	PG&E	55	55	54
Food/Liquor	SCE	54	56	54
Food/Liquor	SDG&E	26	21	19
Health/Medical - Clinic	PG&E	64	52	51
Health/Medical - Clinic	SCE	55	53	54
Health/Medical - Clinic	SDG&E	27	22	23
Miscellaneous	PG&E	103	106	98
Miscellaneous	SCE	113	116	104
Miscellaneous	SDG&E	48	49	44
Office	PG&E	113	101	105
Office	SCE	107	101	108
Office	SDG&E	37	33	33
Restaurant	PG&E	64	65	65
Restaurant	SCE	62	69	71
Restaurant	SDG&E	31	33	34
Retail	PG&E	81	84	84
Retail	SCE	121	119	114
Retail	SDG&E	41	32	35
School	PG&E	78	76	77
School	SCE	71	66	66
School	SDG&E	27	19	18
Warehouse	PG&E	64	45	39
Warehouse	SCE	74	67	71
Warehouse	SDG&E	26	17	18
Not in CSS Study	PG&E	0	2	0
Not in CSS Study	SCE	0	1	0
Not in CSS Study	SDG&E	0	2	0
n		**1,542**	**1,462**	**1,439**

The original CSS/CMST telephone survey sample design envisioned approximately 8,000 telephone surveys with a recruit rate of approximately 25-30%, allowing the study to gain access and collect on-site data at approximately 1,800 sites. The CSS/CMST telephone survey completed 7,994 telephone surveys. The on-site quota was reduced from 1,800 to 1,542 because the recruit rate for the on-site survey was less than planned for many strata.

The CSS on-site quota was developed using the businesses that completed the telephone survey and agreed to participate in an on-site survey. The Study experienced difficulty contacting and recruiting Large and Medium sized businesses. During the telephone survey phase of the CSS/CMST study, the Research Team requested that the utilities provide the Study with updated contact information for the Large and Medium sized sites. The Study requested the contact name and telephone number associated with the contact used by the utility account representatives to advise customers on DSM opportunities. The Study received updated contact information from all three utilities, though the list for SCE was complete, PG&E was extensive, and SDG&E was only able to provide limited information. The Study completed 1,462 sites of which 1,439 sites were usable for the analysis. Given the distribution of sites across business type, IOU, and size categories, the Study was not able to meet the designated quota largely due to inabilities to contact Large and Medium sized sites.

Within SCE's service territory, the CSS Study quota was 657 sites and the study completed 647 or 98% of the quota. The quota for PG&E sites was 622 and the study completed 584 on-sites or 94% of the quota.[6] Within SDG&E's territory, the quota was 263 sites and the study completed 226 of 86% of the quota. The inability to reach the desired quota was largely due to the Study's inability to complete telephone surveys with Large and Medium sized sites. In addition, the Study failed to complete the on-site quota within Warehouse sites. The telephone survey was successful completing phone surveys with Warehouses, but these sites were consistently more difficult to recruit for the on-site study.

The goal of the on-site sample design was to develop a representative sample that provides the desired level of statistical precision for estimating a wide range of commercial customer characteristics largely represented by the share of sites with various energy consuming technologies. The goal of the sample design outlined in the Study Research Plan called on the Study achieving a 90/10 relative precision at the IOU level and 90/15 at the business type level.

The relative precision estimate calculated for proportions within the study is based on the following calculation:

$$RP = \frac{Z * SE(\hat{P})}{\hat{P}} \tag{1}$$

Where the standard error is calculated as follows.

6 The quota for the on-site survey was developed from the telephone survey recruits. SCE's ability to provide the study with the requested information for Large and Medium sized sites led to an increased ability to recruit these sites. PG&E also provided Itron with addition, though less complete contact information for Large and Medium sized sites.

$$SE(\hat{P}) = \sqrt{\frac{n}{n-1}}\sqrt{\frac{\sum w_i^2(d_i - \hat{P})^2}{(\sum w_i)^2}} \qquad (2)$$

In the above relative precision calculation

Z = 90 percentile of the cumulative Standard Normal distribution

n = the number of sites surveyed.

w_i = the site specific weight.

d_i = the site specific indicator for having the technology of interest.

$\hat{P}$ = the weighted proportion of sites within the sample with the technology.

3.4 On-Site Weighting Methodology

This section describes the development of weights that were applied to each sample point from the CSS on-site surveys. The on-site survey findings presented in this report were aggregated to the frame using site weights though kWh weights were also developed.

The on-site sample was stratified and weighted in a way to most accurately represent the population in order to reduce any potential response bias. Key parameters that are known for the population, that are believed to potentially have some correlation to the values being measured, are IOU, business type, and customer size. In addition, the sample was also stratified by whether or not a customer had recently participated in an energy efficiency program (EE participants). For example, someone that had recently participated in a program would have a significantly greater likelihood of installing higher efficiency equipment (particularly, linear fluorescents since many of customers installed linear fluorescents under the program). Although the sample was selected randomly within IOU, business type and size, we found that past EE participants were much more likely to be willing to respond to the phone survey and willing to have an on-site visit. Therefore, it was very important to stratify the sample by EE participation to make sure that EE participants were not over-represented in the final results.

To summarize, the on-site sample was stratified by IOU and size and EE participation. Using a combination of CIS data (for IOU, NAICS codes and size), program tracking data (EE participation) and the phone survey (business type), population values were estimated for the number of sites and the amount of annual kWh consumption in every segment. Furthermore, every on-site participant was also classified into one of these various segments. By doing so, weights were developed so that the on-site sample represented the population with respect to both the number of sites and annual kWh consumption within strata.

In order to classify a customer into one of the business types of interest for this study, customers were first placed into a business type classification based on the NAICS code from the CIS data. During the telephone survey, customers were asked more about their business, and some customers were reclassified into a different business type. When the phone survey site and kWh weights were developed, they were based on the stratum a customer was initially classified as based on the CIS NAICS data.

The weights developed are referred to as case weights, where the weight is equal to either the number of sites or the amount of kWh that a given phone survey respondent represents in the population. For a given stratum, the sum of the case weights for all phone survey respondents within that stratum will equal the number of sites or kWh in that stratum's population. When a phone survey respondent's business type is reclassified based on their response, they maintain the original weight. Therefore, summing up all weights within a reclassified business type will represent the number of sites or kWh in the population with that business type.

The phone survey site weight for an individual 'j' in IOU 'I', business type 'B'[7], size 'S', and EE participation 'E' is:

$$PhoneSurvey\_SiteWeight_{I,B,S,E,j} = \frac{numSitePop_{I,B,S,E}}{numSitePhone_{I,B,S,E}} \tag{3}$$

Where:

> $numSitePop_{I,B,S,E}$ is the total number of sites in the population that are in IOU 'I', business type 'B', size 'S', and EE participation 'E'.[8]
>
> $numSitePhone_{I,B,S,E}$ is the total number of phone surveys conducted that are in IOU 'I', business type 'B', size 'S', and EE participation 'E'.

Note that every phone survey respondent within a stratum gets the same site weight, and each surveyed site is weighted up so that the surveyed sample represents the whole population in the stratum. In this sense, the weight is the so called expansion weight as it expands the sample to

7 The subscripts using a 'B' represent the business type based on NAICs codes from the CIS data. Below we introduce the subscript 'BT' which represents the business type determined during the phone survey.

8 The subscript E represents participation in an IOU EE program during the 2009-2012 time period. Incorporating EE program participation as a strata explicitly adjusts the weights for the finding that EE participants are more likely to respond to the telephone survey and agree to an on-site than non-participants.

the population. Across strata, however, the phone survey site weights differ, due to different probability of selection, and, more importantly, the different response rates for different strata.

The kWh weights are created in a similar spirit. However, rather than all sites within a strata having the same weight, the kWh weights are defined proportional to the customer's annual kWh consumption. The kWh weight for an individual 'j' in IOU 'I', business type 'B', size 'S', and EE participation 'E' is:

$$\text{PhoneSurvey\_kWhWeight}_{I,B,S,E,j} = \frac{kWh_j \times kWhPop_{I,B,S,E}}{kWh\text{Phone}_{I,B,S,E}} \tag{4}$$

Where:

> kWh_j is the total annual kWh for on-site customer 'j'
>
> $kWhPop_{I,B,S,E}$ is the total annual kWh for all sites in the population that are in IOU 'I', business type 'B', size 'S', and EE participation 'E'.
>
> $kWh\text{Phone}_{I,B,S,E}$ is the total annual kWh for all phone survey respondents in IOU 'I', business type 'B', size 'S', and EE participation 'E'.

As mentioned above, the number of sites and annual kWh for a given segment are determined using a variety of data source including CIS data (for IOU, business type and size) and program tracking data (EE participation). The phone survey is then used to reclassify respondents into a business type, which is the level of analysis for which the CSS is conducted.

For each stratum, the telephone survey respondents represented in aggregate a number of sites and an amount of kWh in the total population. The CSS sample that was drawn from a specific stratum then represents that same population in terms of both sites and kWh. The case weights developed are equal to either the number of sites or the amount of kWh that a given onsite represents in the population. For a given stratum, the sum of the case weights for all CSS onsites within that stratum will equal the number of sites or kWh in that stratum's population. Case weights developed above for the telephone sample can be used to determine the population site count or total kWh for the population in that stratum.

Using the telephone case weights, the site weights for the CSS on-site sample for an individual 'j' in IOU 'I', business type 'BT'[9], size 'S', and EE participation 'E' is:

$$\text{Onsite\_SiteWeight}_{I,BT,S,E,j} = \frac{\sum_k \left(\text{PhoneSurvey\_SiteWeight}_{I,B,S,E,k}\right)}{numSiteOS_{I,BT,S,E}} \tag{5}$$

[9] The Notation BT is used here to differentiate the use of phone survey based business type, rather than CIS based business type.

In the numerator, we are summing the telephone site case weights $\left(\text{PhoneSurvey\_SiteWeight}_{I,B,S,E,k}\right)$ over all phone respondents, 'k', in IOU 'I', business type 'BT', size 'S', and EE participation 'E'. This would equal the population count for the number of sites in this stratum. We divide this value by the number of CSS onsites performed in IOU 'I', business type 'BT', size 'S', and EE participation 'E' ($numSiteOS_{I,BT,S,E}$). Therefore, each site in IOU 'I', business type 'BT', size 'S', and EE participation 'E', represents an equal number of sites in that stratum's population, such that the sum of the site weights would now equal the total population count for that stratum.

The kWh weights, however, are not all equal within a stratum, and are proportional to the customer's annual kWh consumption. The kWh weight for a CSS individual 'j' in IOU 'I', business type 'BT', size 'S', and EE participation 'E' is:

$$\text{Onsite\_kWhWeight}_{I,BT,S,E,j} = \frac{kWh_j \times \sum_k \left(\text{PhoneSurvey\_kWhWeight}_{I,B,S,E,k}\right)}{kWhOS_{I,BT,S,E}} \qquad (6)$$

In the numerator, we are now summing the telephone kWh case weights $\left(\text{PhoneSurvey\_kWhWeight}_{I,B,S,E,k}\right)$ over all phone respondents, 'k', in IOU 'I', business type 'BT', size 'S', and EE participation 'E'. This would equal the population total annual kWh in that stratum. We then multiply this value by the customer's annual kWh (kWh_j) and then divide the total annual kWh for all on-sites conducted that fall into that stratum ($kWhOS_{I,BT,S,E}$). This ratio equals the percentage of kWh that customer 'j' represents in the sample for IOU 'I', business type 'BT', size 'S', and EE participation 'E'. By multiplying this ratio by the total annual kWh in IOU 'I', business type 'BT', size 'S', and EE participation 'E', the customer's case weight then represents the proportion of the population's total annual kWh in that stratum. Again, if we sum all of the kWh weights within a stratum, that value would equal the population total annual kWh for that stratum.

Finally, in order to limit the amount of influence a single site can have on the overall results, the weights were capped. The maximum site-level case weight a CSS on-site is allowed to have is 2,000 (meaning no single on-site can represent more than 2,000 customers in the population). Furthermore, the maximum kWh-level case weight a CSS on-site is allowed to have is 2,000 times their annual usage (meaning no single on-site can represent more than 2,000 times their annual usage in the population). These limits only affect 4% of the CSS on-site sample.

Each site in the on-site survey has a site weight and a kWh weight. The results presented in this report use the site weights. The kWh weights are available on the databases provided to the IOUs and the CPUC. Using the CSS web site, it will be possible to produce results using either site weights or kWh weights.

4

Business Characteristics

The CSS collected information about the businesses and the buildings that were surveyed by telephone and through on-site visits as part of this study. A variety of business and building characteristics is described in this section including average annual electricity consumption, square footage, whole business energy intensity, building age, number of employees, and exterior building characteristics such as window types and roof color. These characteristics are presented by CSS business type, business size, and/or utility in the subsections that follow.

4.1 CSS Study Domain Overview

The CSS/CMST study used the NAICS codes from the IOU Customer Information Systems (CIS) to group the businesses in PG&E's, SCE's, and SDG&E's non-residential frame into business types eligible for the CSS/CMST telephone survey, those eligible for the CSS on-site survey, and those not included in these studies. The CSS on-site survey included the following businesses:

- Food or Liquor Stores
- Health Care – Clinic (Non-Hospital)
- Miscellaneous
- Offices
- Restaurants
- Retail
- Schools
- Warehouses[1]

Using data from the 2010 IOU CIS and billing systems, Table 4-1 lists the total number of sites and annual electricity consumption of sites eligible for the CSS on-site study.[2] The table

[1] Many of the sites classified as property managers and unknown were reclassified during the telephone survey into business types that were eligible for the CSS on-site survey, as neither of these categories qualified. The phone survey business type determined if a site was eligible to be recruited for the CSS on-site survey.

includes sites whose business type in the CIS is non-descriptive, and those sites listed as Property Managers, College/University, Health Care Hospital, Hotel/Motel, Industrial, and Unknown. These site categories were included in the CSS/CMST telephone survey. For the sites categorized as Property Managers and Unknown, the business type description from the telephone survey determined if the site's business type was eligible for the CSS on-site survey. If a site's business type collected during the telephone survey was eligible for the CSS on-site survey, the business was recruited for on-site data collection.

The business types included in the CSS on-site study represented between 51 - 72% of the non-residential sites in the frames from the three IOUs and 44 - 54% of the annual electricity consumption (annual kWh). Ranges are presented to account for the fact that not all sites in the non-residential frame were included in the CSS study. The lower bound is calculated by removing all sites categories as Property Managers, College/University, Health Care - Hospital, Hotel/Motel, Industrial, and Unknown as well as those business types that were not included in the CSS/CMST telephone survey (Agriculture, Mining, Street Lighting, and TCU). The upper bound includes the sites categorized as Property Managers and Unknown as these may or may not fit in the listed CSS Business Types.

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[2] Additional information on the sites and annual electric usage of non-residential customers in the CIS for the three IOUs is available in Section 3 of the CSS/CMST telephone survey report. The NAICs code to business type mapping used for the CSS is presented in Appendix A.

Table 4-1: Non-Residential Population and Businesses Eligible for the CSS On-Site Study

Business Type	Total Number of Sites	Share of Non-Residential Sites	Total Usage 2010, MWh**	Share of Telephone Eligible Usage
Food/Liquor	24,885	2%	6,296,625	5%
Health Care – Clinic	40,075	3%	2,796,944	2%
Miscellaneous	242,726	19%	11,508,821	10%
Office	133,764	11%	9,595,069	8%
Property Managers	72,672	6%	8,025,888	7%
Restaurant	64,732	5%	6,179,456	5%
Retail	79,755	6%	7,877,868	7%
School	11,482	1%	3,391,931	3%
Unknown	193,902	15%	3,376,771	3%
Warehouse	39,580	3%	4,139,725	4%
College/University*	1,507	0%	1,816,925	2%
Health Care - Hospital*	1,133	0%	3,009,551	3%
Hotel/Motel*	7,157	1%	2,688,164	2%
Industrial*	41,363	3%	22,494,451	19%
Not in CSS/CMST Study	299,038	24%	24,266,973	21%
Non-Residential Frame Total	**1,253,771**		**117,465,161**	
Eligible for CSS**	**636,999- 903,573**	**51% - 72%**	**51,786,439 – 63,189,098**	**44% - 54%**

* Sites not eligible for CSS Study

** Sites classified as Property Managers and Unknown may or may not fit in the listed CSS Business Types. Site categories that are not included in the CSS on-site study are College/University, Health Care – Hospital, Hotel/Motel, and Industrial. College/universities, Health Care – Hospitals, Hotel/Motel, and Industrial were included in the CSS/CMST telephone survey and the CMST on-site survey. Ranges are presented to show an estimate of the lower and upper bounds of sites that are eligible for CSS. The lower bounds exclude all sites classified as Property Managers, College/University, Health Care – Hospital, Hotel/Motel, Industrial, Unknown, and Not in CSS/CMST Study. The upper bounds include Property Managers and Unknown sites, but do not include sites in the other categories that were excluded from the lower bound as these are not eligible for the CSS on-site survey.

The CSS/CMST telephone survey included the business types included in the CSS on-site survey and businesses designated as Property Managers, College/University, Health Care - Hospital, Hotel/Motel, Industrial, and Unknown businesses. The CMST study collected information on recent purchases of linear lighting technologies, small packaged HVAC, and TVs from a broader group of non-residential businesses than are incorporated in the CSS on-site study.[3] The

[3] The CSS on-site study focused on eight business types due to a desire to accurate characterize the commercial sector on a set budget. A focused baseline study of Hotels and Hospitals may be able to add information on these segments while information on Colleges may be more readily available directly for their energy managers.

business types included in the CSS/CMST telephone survey represented 76% of the non-residential sites and 79% of the annual electricity consumption.[4] Note that this is higher than the number of sites that were included in the CSS on-site study.

Table 4-2 presents the distribution of telephone survey and CSS on-site survey completes by business type and IOU for the CSS on-site business types.[5] Within the CSS on-site business types, the study completed 6,907 telephone surveys and 1,439 CSS on-site surveys.[6] In other words, the share of on-site surveys was 20% of the total telephone surveys completed for the CSS study. Across the utilities, this ratio of on-site surveys to telephone surveys was about the same. CSS business types with the largest number of CSS/CMST telephone surveys and CSS on-site surveys include Miscellaneous, Office, and Retail.

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4 These data are available in Section 3 of the CSS/CMST telephone survey report. Note that these percentages are based on data that have been revised since the telephone survey report was released. The number of total sites remains the same; however the number Health Care – Clinic and Health Care – Hospital sites have been redistributed between these categories.

5 The CSS on-site business type represents the business type observed and updated from the on-site survey. For phone survey completes, the business type is the business type updated from the phone survey.

6 The CSS/CMST study completed 7,994 telephone surveys. Of the 7,890 completed surveys, 1,090 surveys were completed in business types that are not eligible for the CSS on-site study. The CSS/CMST on-site effort completed 1,556 on-site surveys; however 1,439 of these were usable for the CSS study due to how sites were categorized and whether there was enough information to include the on-site survey in the evaluation.

Table 4-2: Phone and On-Site Survey Completes by CSS Business Type and Utility

CSS Business Type	Survey Type	Total	PG&E	SCE	SDG&E
Food/Liquor	Phone	486	188	219	79
	On-site	132	55	56	21
Health/Medical - Clinic	Phone	633	251	267	115
	On-site	126	51	53	22
Miscellaneous	Phone	1,637	578	750	309
	On-site	263	101	113	49
Office	Phone	1,313	500	583	230
	On-site	233	100	101	32
Restaurant	Phone	595	217	243	135
	On-site	166	65	69	32
Retail	Phone	1,019	370	471	178
	On-site	234	83	119	32
School	Phone	479	210	203	66
	On-site	160	75	66	19
Warehouse	Phone	745	255	402	88
	On-site	125	43	65	17
n	Phone	**6,907**	**2,569**	**3,138**	**1,200**
	On-site	**1,439**	**573**	**642**	**224**

The telephone and on-site surveys collected additional information to further disaggregate the eight CSS business types into 22 categories (see Table 4-3). These categories are presented below with the number of on-site visits and the share of on-site visits that were carried out by CSS business type. Certain CSS businesses types have relatively equal shares of on-site visits across the disaggregated business categories. For example, on-site visits to Restaurants were equally divided between Fast Food and Sit-Down/Table Restaurants (35% versus 36%), and Other Food (29%). Food/Liquor businesses were divided in relatively similar shares between Convenience Stores (45%) and Groceries Stores – both Large and Small (55%). Business types with less equal distributions of on-site visits when disaggregated business types are used include Health/Medical and Retail. For the Health/Medical – Clinic business type, about 77% of businesses are Medical/Dental offices or Clinics while 23% of these businesses are for Rehabilitative Services. On-site visits to Retail locations were more heavily weighted towards Retail businesses (68%) compared to Auto Sales (11%) and Variety Retail businesses (21%).

Table 4-3: Number and Share of On-site Visits by Disaggregated Business Type

CSS Business Type	Disaggregated Business Type	Number of Onsite Visits	Share of On-site Visits by Disaggregated Business Type
Food/Liquor	Convenience Store	57	45%
	Large Grocery	41	32%
	Small Grocery	29	23%
Health/Medical - Clinic	Medical/Dental	98	77%
	Rehabilitative Services	30	23%
Miscellaneous	Assembly	89	36%
	Laboratory	24	10%
	Multi-Family[7]	32	13%
	General Miscellaneous	36	15%
	Services	65	26%
Office	Office	246	100%
Restaurant	Fast Food Restaurant	59	35%
	Table Restaurant	62	36%
	Other Food	49	29%
Retail	Auto Sales	25	11%
	Retail	159	68%
	Variety/Warehouse	49	21%
School	School	161	100%
Warehouse	Conditioned Warehouse	25	20%
	Unconditioned Warehouse	81	63%
	Storage	12	9%
	Refrigerated Warehouse	10	8%

4.2 Electricity Consumption by CSS Business Type

Table 4-4 lists the total, average and median annual electricity consumption by CSS business type for sites in the California IOU electric frame and sites visited as part of the CSS on-site data collection effort.[8] The total annual energy consumption by CSS business type in Table 4-4 is not

[7] The data included in this report for Multi-Family locations represents the commercial or common area of these locations. The data does not include the equipment or technologies in residential units. The square footage and energy usage reported in this section, and the whole building energy intensities, represent the values calculated from common areas within these locations.

[8] The total annual consumption by business type has been compared with the annual consumption for similar business types from the California Commercial End Use Study (CA CEUS, 2006). While our total consumption

directly comparable with the total annual energy consumption by business type that was reported from the IOU frame in the CSS/CMST Telephone Survey Report. Two significant updates have been made to these data since the CSS/CMST Telephone Survey Report: Both the site level electric meter aggregation and the CSS business types have been updated with information collected on-site.

Prior to beginning the sample design and the phone survey for the CSS/CMST Study all of the records in the utility CIS were aggregated into sites and their meters and annual usage were aggregated together to develop an estimate of the site's annual usage. CSS/CMST sites were developed to represent a business not a building. Businesses can occupy a part of a building, a building, or multiple buildings.[9] While some smaller businesses may be associated with only one account or meter, many larger businesses are associated with multiple meters. To determine business energy usage, it is necessary to aggregate meters and accounts into a business site. The site aggregation process used information from the utility CIS including the address, phone number, and name associated with the account in the CIS to group records into a single business site. The aggregation process begins by looking at all three forms of identification and progresses through alternative combinations to determine if CIS records should be grouped together as a site.

During the CSS on-sites, the surveyors collected electric and gas meter number information and requested to see copies of utility bills to record account number information. With these updated sources of information, the sites' original meter aggregation was reviewed and updated where necessary. The updating helps to assure that the energy usage for the CSS businesses is correctly accounted for in the analysis.[10] The method of meter matching and updating the business level energy usage employed during the CSS is very similar to the approach used during the California Commercial End Use Survey (CA CEUS) to verify site aggregation and the correct mapping of

exceeds the consumption for these business types in the California Commercial End Use Survey (CA CEUS), the distribution of energy consumption across business types is very similar. The CA CEUS Project Final Report was completed on behalf of the California Energy Commission. Report # CEC-400-2006-005.

[9] Multi-tenant office buildings are classified as a single business if the CIS information indicates that a single company pays the utility bills. Multi-tenant spaces where the CIS information indicates that the individual businesses pay the utility bills are classified as separate businesses.

[10] During the original site aggregation, there were records in the IOU CIS that were not associated with billing data; these sites were grouped into strata with unknown usage. Due to the on-site collection of meter information and the matching of these data to billing records, the study was able to assign usage to all on-site surveyed businesses. For analysis purposes, sites originally in unknown usage strata are reported in the strata associated with their post-meter match up usage. Their weights, however, are based on their unknown usage strata.

meters and electricity consumption to a business.[11] Both studies collected meter information on-site and updated site aggregation with the on-site information where necessary.

The CSS business level annual energy usage information presented in this report is based on billing data from 2009-2012. To determine a business' annual energy usage, the Study reviewed the site level aggregated annual consumption across the years 2009-2012. If the business had billing records for all four years, and the range of annual consumption in the records was such that the maximum annual consumption did not exceed twice the minimum annual consumption, the business' energy usage was set to the average of observed annual consumption across the years 2009-2012. Average annual consumption across four years works to eliminate any extremes in consumption that may not represent the business' likely future consumption. For sites that did not have billing records for all four year and for sites with higher variability in consumption, manual reviews of the site level annual consumption was undertaken. Many of these sites were newer businesses, with no or limited consumption during 2009 and 2010. For these sites, their annual energy usage was set to their observed value for either 2011 or 2012. In comparison, the CEUS business level energy usage information was developed using calibrated building simulation models that were run with normalized weather data. The models were calibrated with actual year consumption and weather data which varied from 2002-2004. For CEUS, the annual business energy usage was then developed using the calibrated models and normalized weather.

The business types used for the CSS on-site study and all analysis presented for this report represent business types that have been updated with information that the surveyor collected during the on-site survey. Many of the business types included in the utility CIS were updated, including all sites labeled as Unknown or Property Managers within the CIS. The total annual energy consumption by business type listed in Table 4-4 represents the Study's estimate of total, average, and median annual consumption for businesses types in the CSS. The analysis incorporates the updated on-site business type designations and the updated annual consumption.

The data presented in Table 4-4 shows that Offices use the most electricity of CSS businesses, consuming 27% of the total annual electricity within CSS businesses.[12] Offices also have the third highest average annual energy consumption at approximately 131,000 kWh annually. Schools have the highest average annual consumption at approximately 291,000 kWh while Food/Liquor Stores are second at approximately 268,000 kWh. The Health/Medical – Clinic segment consumes the least amount of electricity of CSS businesses at 5% of total CSS business

[11] The CA CEUS Project Final Report was completed on behalf of the California Energy Commission. Report # CEC-400-2006-005. CA CEUS is also available at: http://capabilities.itron.com/CA CEUSWeb/Default.aspx

[12] When restricting the CA CEUS (2006) businesses to the business types analyzed in the CSS Study, Offices (combined large and small) in the CA CEUS analysis are also estimated to account for 27% of the electric energy consumption.

annual electricity consumption.[13] Per business average annual electricity consumption of Health/Medical – Clinics is also the lowest at approximately 60,000 kWh.

Table 4-4: Total, Mean and Median Annual Electricity Consumption by CSS Business Type

CSS Business Type	Total Annual MWh	Average Annual kWh	Median Annual kWh
Food/Liquor	5,872,385	267,888	110,238
Health/Medical - Clinic	3,181,519	60,087	16,696
Miscellaneous	13,883,575	62,875	15,928
Office	19,026,992	131,324	11,541
Restaurant	8,089,191	108,197	71,460
Retail	9,090,172	75,765	16,193
School	4,339,918	291,148	181,342
Warehouse	6,248,334	90,197	21,273

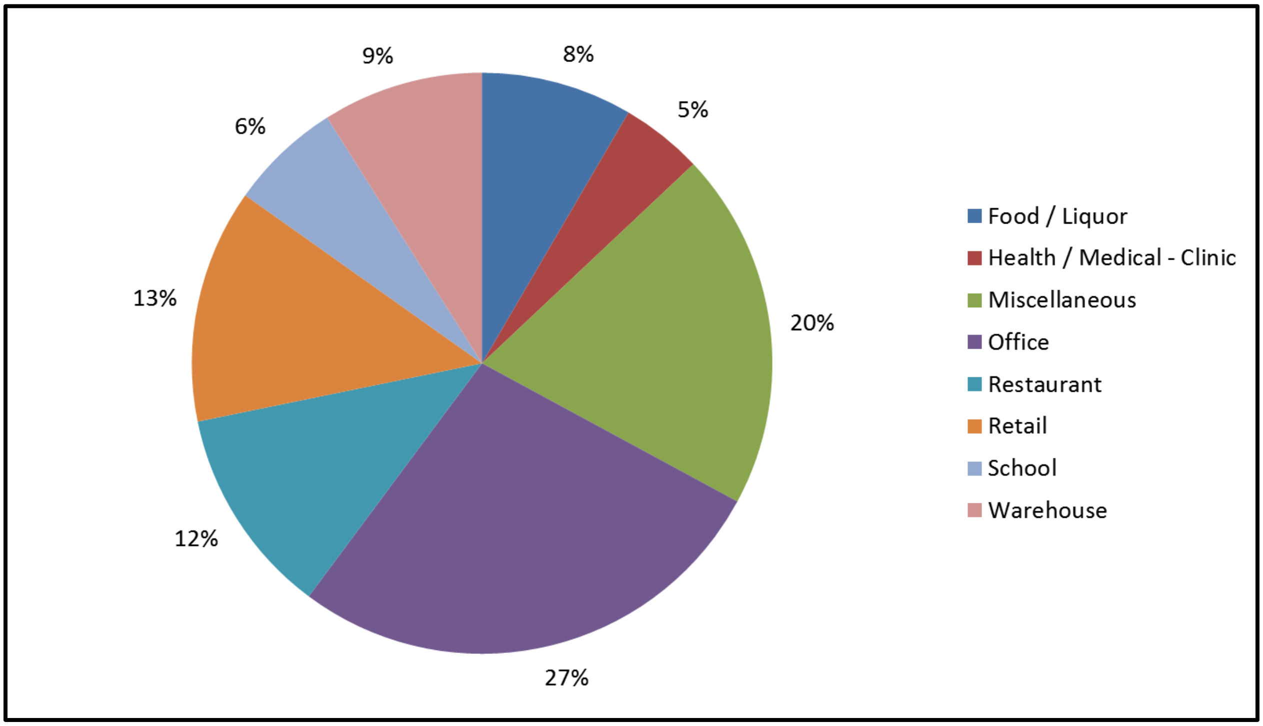
*** The results presented above have been weighted by site weight.**

A substantial difference between the average and median annual electricity consumption for a business type implies that the business type has several smaller sized businesses contributing to a lower median consumption while the larger mean consumption level is pulled higher by sites with a substantial level of electricity consumption. Mean electricity consumption levels of Offices and Retail businesses are substantially higher than their median consumption levels, while Restaurants and Schools display the closest relationships between median and mean annual consumption.

Figure 4-1 presents the share of total annual electricity consumption by business type. This pie chart shows the total annual electricity consumed by businesses included in the CSS study. As noted earlier, Offices use approximately one-quarter of the electricity (27%) consumed by CSS business types. The business type that uses the next largest share is Miscellaneous at 20%. CSS business types that use smaller shares of the total annual electricity consumed are Warehouses (9%), Food/Liquor (8%), Schools (6%), and Health/Medical (5%).

[13] The CSS Health/Medical – Clinic business type does not include hospital energy usage. Hospitals were not included in the CSS on-site study.

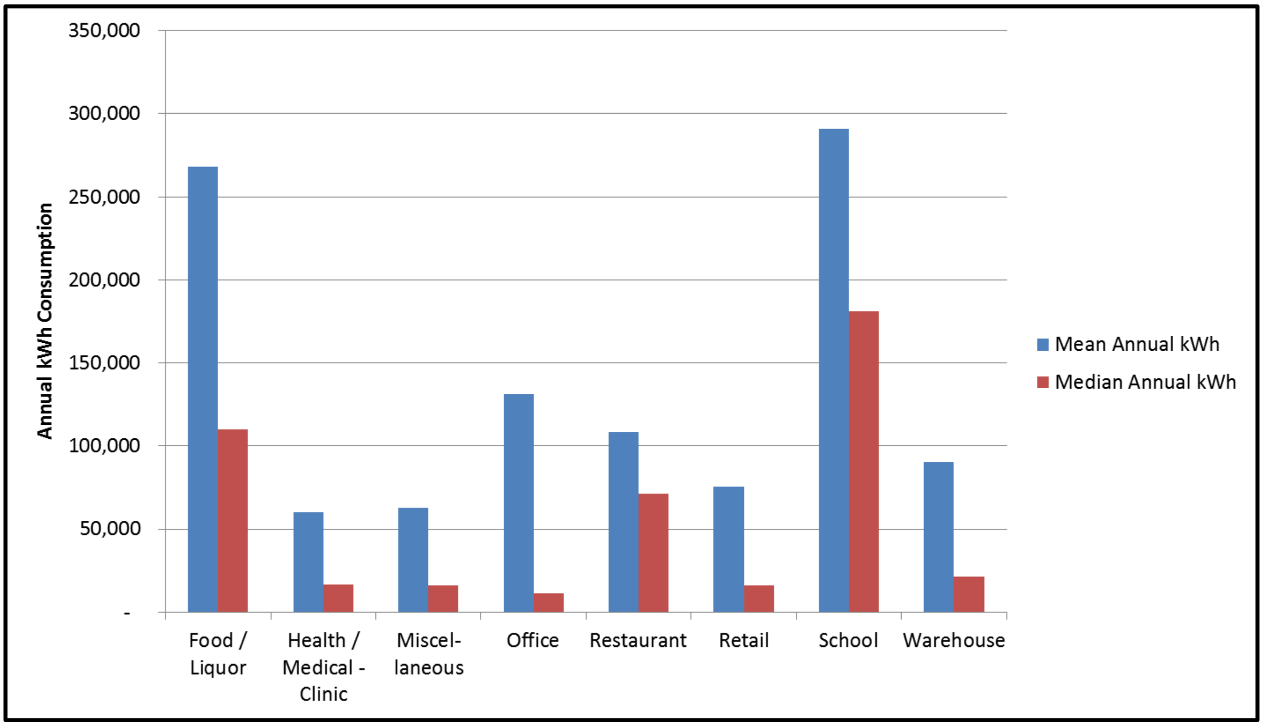
Figure 4-1: Share of Total Annual Consumption (kWh) by CSS Business Type



*** The results presented above have been weighted by site weight.**

Figure 4-2 illustrates the mean and median annual electricity consumption data. The CSS business types with the highest mean annual consumption are Schools and Food/Liquor Stores. Those with the lowest means are Health/Medical and Miscellaneous. Offices have the smallest median consumption closely followed by Miscellaneous, Health/Medical, and Retail businesses. Schools are found to have the highest median consumption across all business types followed distantly by Food/Liquor businesses.

Figure 4-2: Mean and Median Annual Electricity Consumption by CSS Business Type

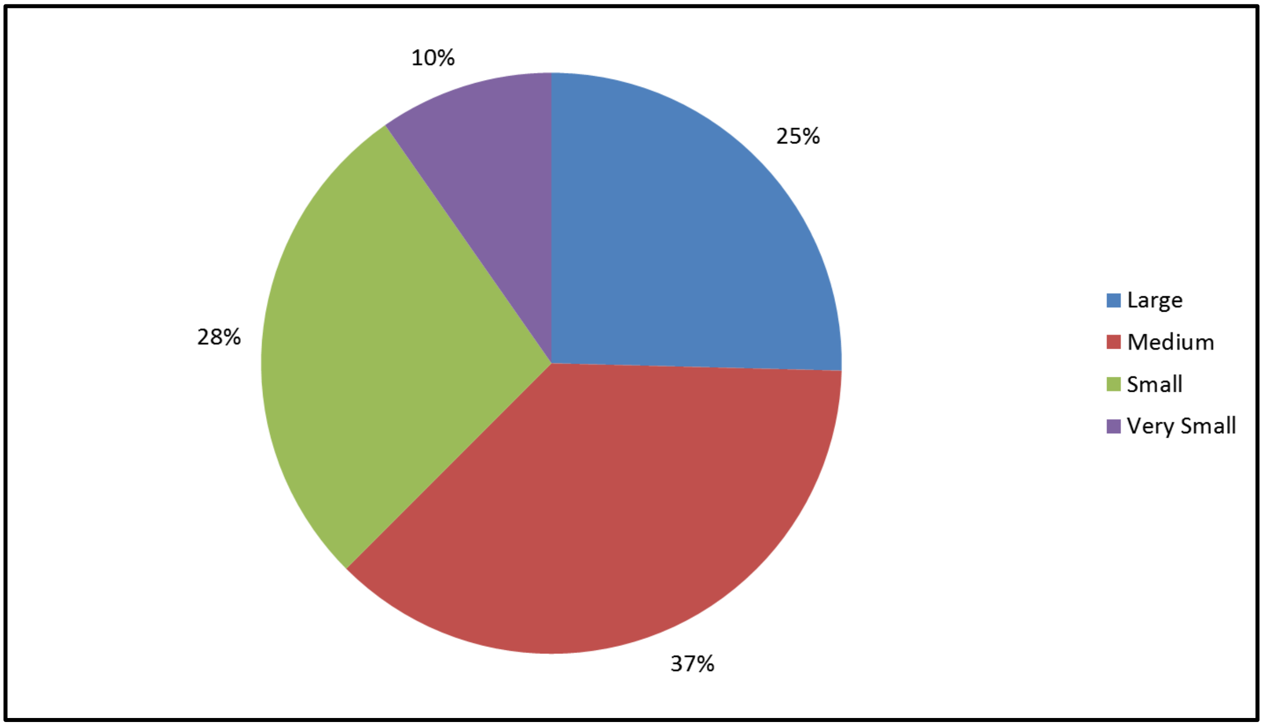


* **The results presented above have been weighted by site weight.**

4.2.1 Electricity Consumption by Business Size

The amount of electricity consumed by a business is likely affected by its size. For the CSS study, size categories were created based on annual electricity usage. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have a maximum annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small sites have annual usage less than or equal to 40,000 kWh. Figure 4-3 displays the share of electricity consumption by CSS business size. According to the information presented in the figure, businesses classified as Medium consume the largest share of electricity (37%). The shares of electricity consumed by Small and Large businesses are similar, with Small businesses consuming 28%, and Large businesses accounting for 25% of the consumption of CSS businesses. Very Small businesses, not surprisingly, consume the smallest share of electricity at just 10% of total annual electricity consumed by all CSS businesses.

Figure 4-3: Share of Total Annual Consumption (kWh) by CSS Business Size



*** The results presented above have been weighted by site weight.**

4.2.2 Electricity Consumption by CSS Business Type and Business Size

The CSS study gathered data to estimate the average annual electricity consumption by CSS business type and business size. Sites are categorized based on their annual electricity usage, as described in Section 4.2.2. Looking at the Large businesses, it is clear that those categorized as Miscellaneous have the highest average annual electricity consumption at close to 7,500 MWh followed distantly by Offices at approximately 4,400 MWh. There are no Restaurants in the population that were categorized as Large. The average annual electricity usage of Very Small businesses ranges from a low of 9,528 kWh for Offices to a high of 30,006 kWh for Food/Liquor businesses.

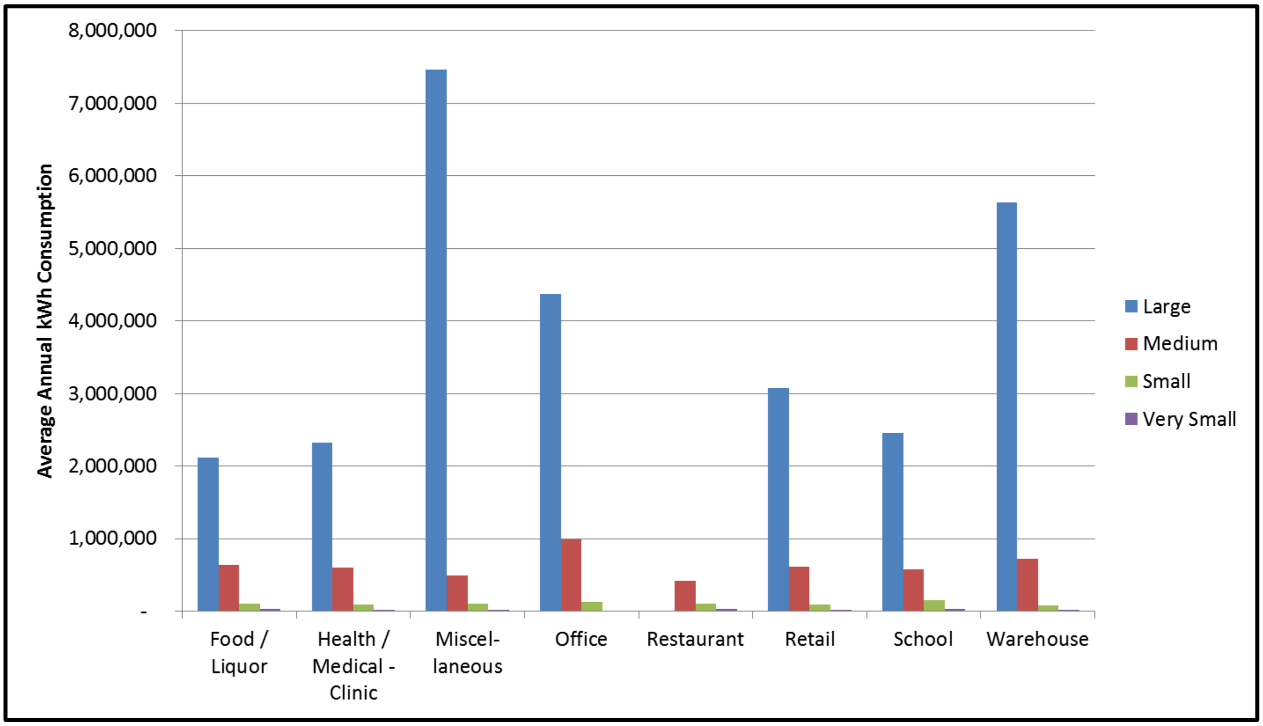
Not surprisingly, the range between average electricity consumption by business type is much larger for Large sites than it is for those sites categorized as Very Small. This is because there is no upper average annual electricity consumption limit for Large sites. The difference in ranges can be seen in Figure 4-4 by looking at the minimal difference in height of the Very Small sites across business types and the larger difference in height of the average electricity usage of the Large sites.

Table 4-5: Average Annual Electricity Consumption (kWh) by CSS Business Type and Business Size

CSS Business Type	Large	Medium	Small	Very Small
Food/Liquor	2,115,376	637,487	108,755	30,006
Health/Medical - Clinic	2,325,144	600,574	86,242	15,529
Miscellaneous	7,467,183	493,680	100,066	13,860
Office	4,374,919	985,017	131,650	9,528
Restaurant	N/A	416,150	99,757	26,808
Retail	3,074,895	613,346	88,564	15,433
School	2,454,768	572,354	156,151	27,454
Warehouse	5,627,743	723,949	84,745	13,360

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh**.**

Figure 4-4: Average Annual Electricity Consumption (kWh) by CSS Business Type and Business Size



* **The results presented above have been weighted by site weight.**

4.2.3 Electricity Consumption by CSS Business Type and Utility

Table 4-6 presents the average electricity consumption by CSS business type and IOU. An examination of this table shows that Schools in SCE's service territory have the highest average annual electricity consumption of all utility/business type categories, followed by Schools in SDG&E's service territory (474,841 kWh and 374,718 kWh, respectively). Schools in PG&E's territory have an average annual kWh consumption that is 45% of SCE territory Schools. Business types with the lowest average annual kWh consumption are Warehouses in SDG&E's territory (38,437 kWh) followed very closely by Health/Medical businesses (39,927 kWh) and Offices in SDG&E's territory (41,465 kWh) as well.

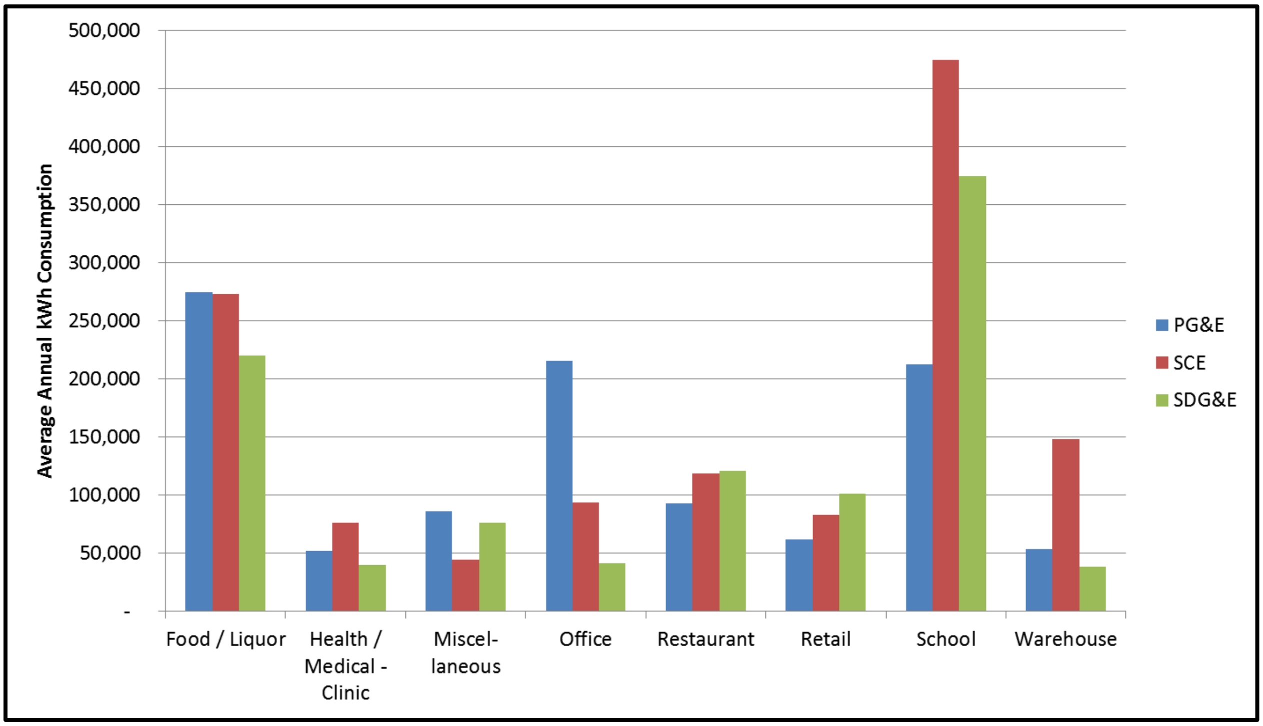
Table 4-6: Average Annual Electricity Consumption by CSS Business Type and Utility

CSS Business Type	PG&E Average Annual kWh	SCE Average Annual kWh	SDG&E Average Annual kWh
Food/Liquor	274,973	273,209	220,266
Health/Medical - Clinic	51,902	75,879	39,927
Miscellaneous	85,920	44,434	76,452
Office	215,403	93,286	41,465
Restaurant	93,137	118,303	120,823
Retail	61,723	83,073	101,350
School	212,270	474,841	374,718
Warehouse	53,807	148,200	38,437

*** The results presented above have been weighted by site weight.**

Figure 4-5 is a graphical presentation of the data listed in Table 4-6. Upon examination, it appears as if the average annual electricity consumption is lower in a majority of business types in SDG&E's territory. Five of the eight CSS business types have lower average annual electricity consumption in SDG&E's territory than they do in SCE's or PG&E's service territories. That is not to say the CSS business types in one service territory uniformly has higher or lower average annual electricity consumption, but rather it is meant to point out a general trend.

Figure 4-5: Mean Annual Electricity Consumption by CSS Business Type and Utility



* **The results presented above have been weighted by site weight.**

4.3 Business Type Floor Space

The average business square footage is highly dependent upon the activity at the business. For example, the typical School or Warehouse requires substantially more space than the typical Restaurant. Table 4-7 presents that total, average, and median square footage by CSS business type. Based on the data in this table, the average school is over fifteen times larger than the average restaurant. In addition, they are the largest of the business types included in the CSS study with an average square footage of almost 48,000 sq. ft. The median square footage of Schools is 33,600 sq. ft. The relative similarity of the average and median square footage for Schools indicates that the square footage of schools is not as variable as the square footage for many business types. The average square footage of Schools is only 45% larger than the median. In comparison, the average square footage of Offices is over six times larger than the median square footage of Offices.

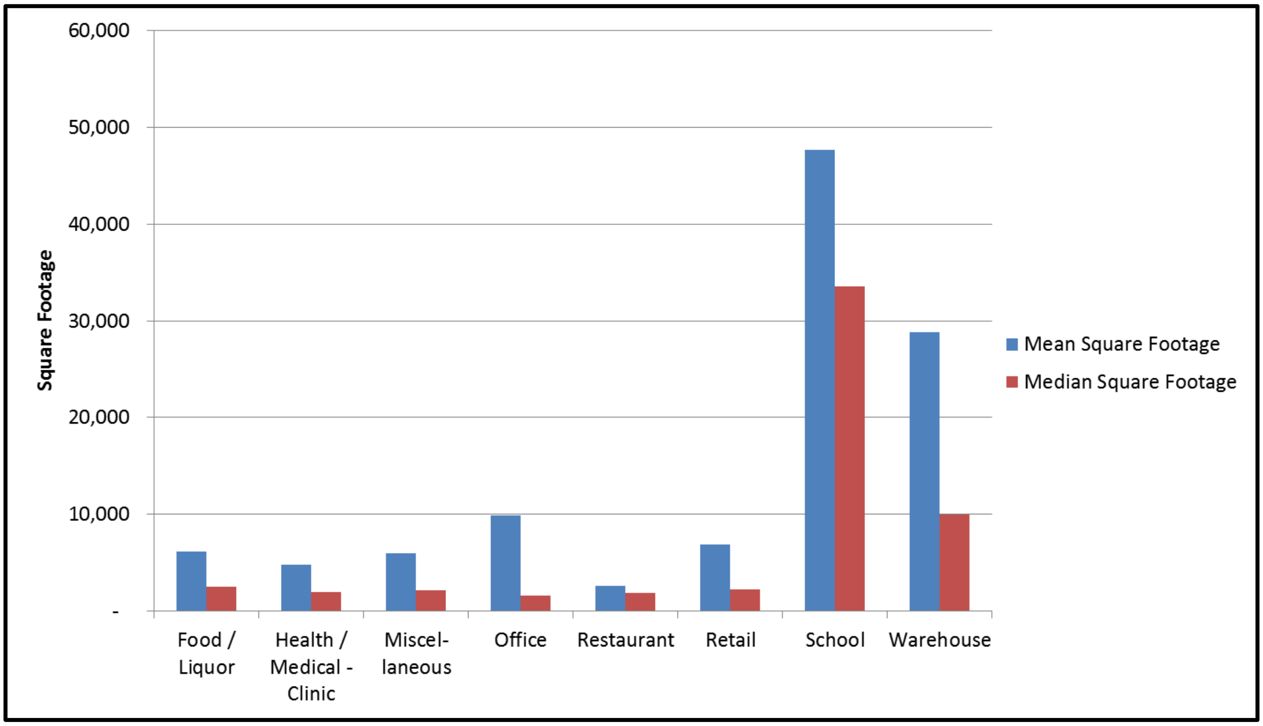
The smallest business type by average square footage is Restaurants, at an average size of 2,646 sq. ft. and a median square footage of 1,920. As Figure 4-6 shows, the range in floor space is clearly evident when the average square footage and median square footage are examined across the CSS business types included in the analysis.

Table 4-7: Total, Mean and Median Square Footage by CSS Business Type

CSS Business Type	Total Square Footage (in 1,000s of sq. ft.)	Average Square Footage	Median Square Footage
Food/Liquor	135,296	6,172	2,500
Health/Medical – Clinic	254,814	4,812	1,980
Miscellaneous	1,320,860	5,982	2,130
Office	1,438,655	9,930	1,580
Restaurant	197,856	2,646	1,920
Retail	825,124	6,877	2,246
School	711,206	47,712	33,600
Warehouse	1,996,311	28,817	10,000

*** The results presented above have been weighted by site weight.**

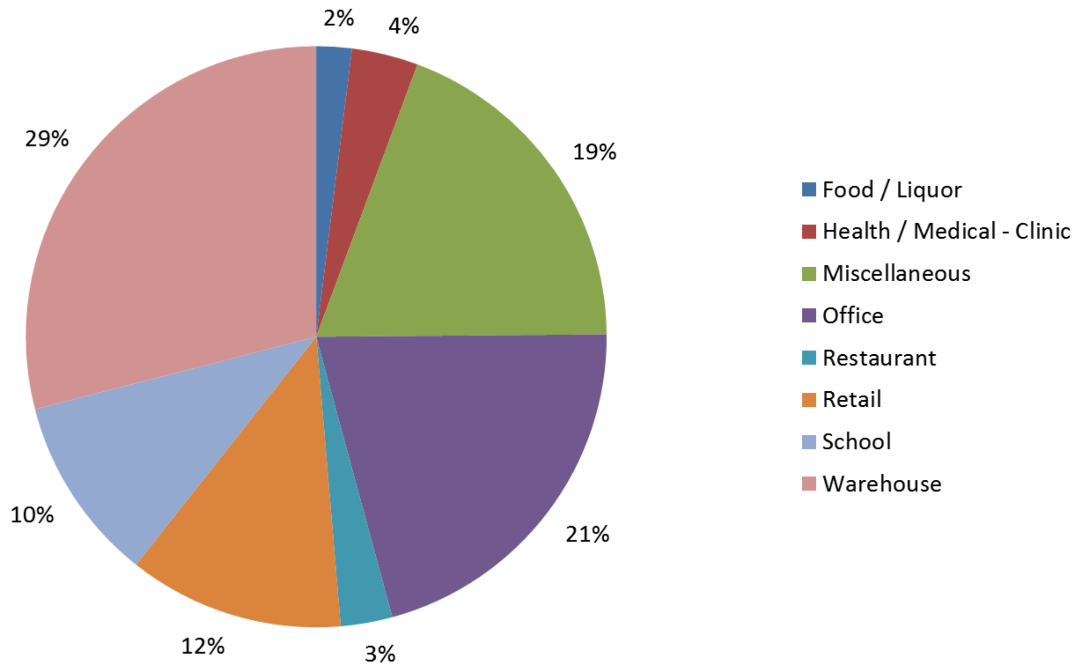
Figure 4-6: Mean and Median Square Footage by CSS Business Type



*** The results presented above have been weighted by site weight.**

The shares of total square footage of businesses by CSS business types are presented in Figure 4-7. Warehouses occupy almost 30% of all square footage of businesses included in the CSS study. The next largest business type by share of total square footage is Offices at 21% followed by the Miscellaneous business type at 19%. Those business types that take up the least amount of total space by square footage are Food/Liquor (2%), Restaurants (3%), and Health/Medical (4%) businesses.

Figure 4-7: Share of Total Square Footage by CSS Business Type

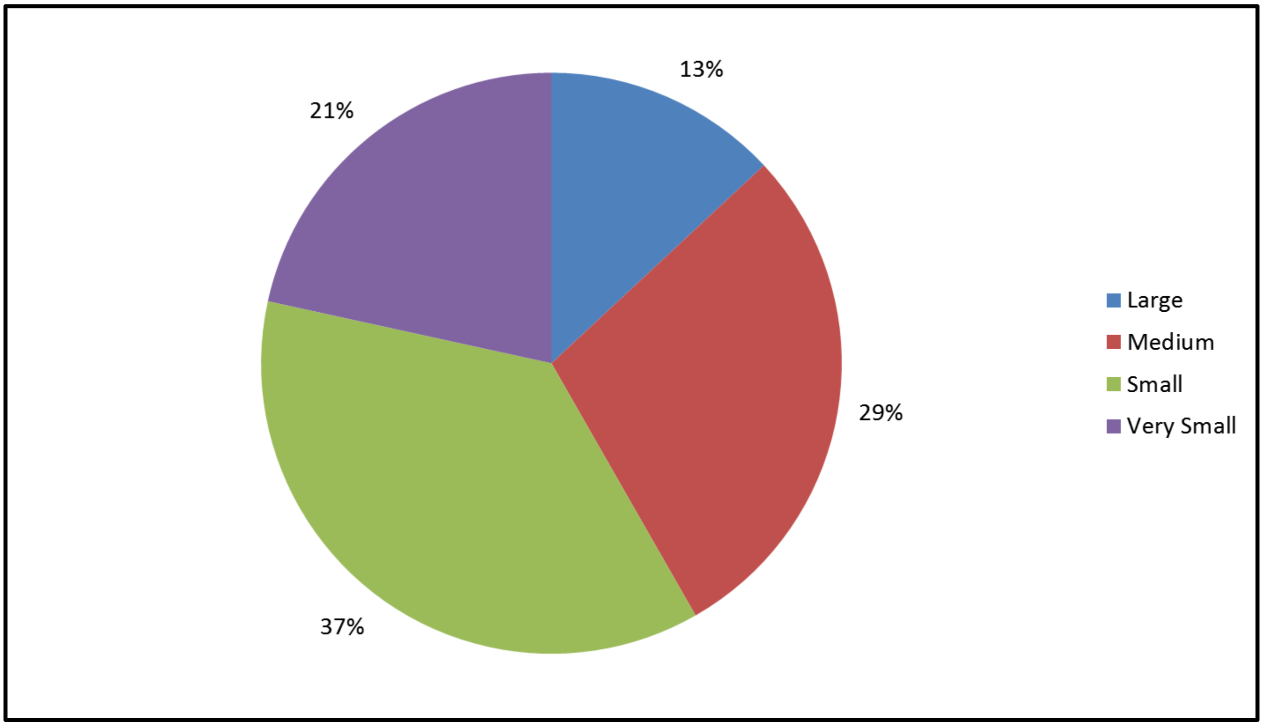


*** The results presented above have been weighted by site weight.**

4.3.1 Business Square Footage by Business Size

Figure 4-8 displays the share of square footage occupied by Large, Medium, Small, and Very Small CSS businesses. Recall that the business size categories are defined by total annual kWh usage and not by square footage in the CSS study. As the figure shows, Small businesses occupy 37% of total floor space, followed by Medium sized businesses that occupy 29%. What is most interesting is that Large businesses, which are defined as those businesses that exceed 1,750,000 kWh usage annually, occupy only 13%, the smallest share of square footage. This is likely due to the fact that there is not a large quantity of businesses that are considered Large relative to the number of Medium, Small, and Very Small businesses. Note that Very Small businesses occupy more floor space than Large businesses (21%).

Figure 4-8: Share of Total Square Footage by Business Size



*** The results presented above have been weighted by site weight.**

4.3.2 Business Square Footage and by Business Type and Business Size

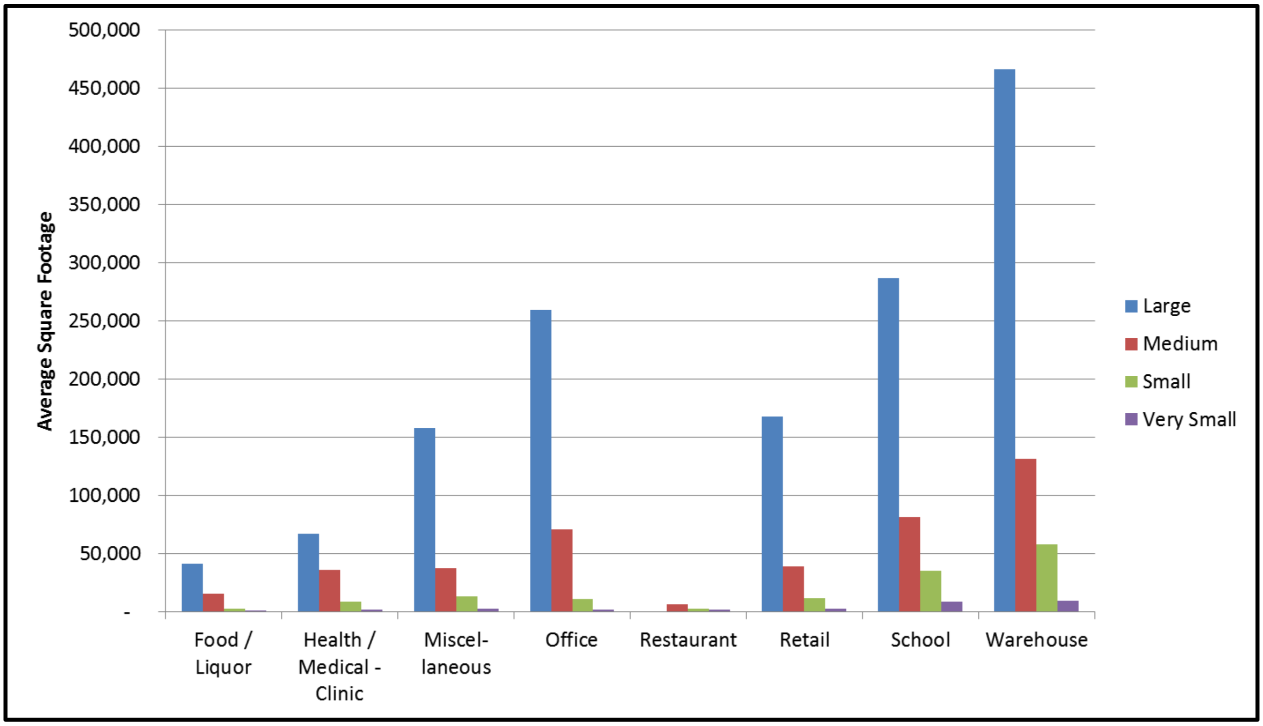
Business square footage is also presented in this study by business size, where, as a reminder, business size is based on kWh usage per year (see Table 4-8 and Figure 4-9). This stratification of square footage provides more detail about the amount of floor space occupied by differently sized businesses within the same CSS business type as well as across business types. An examination of the data shows that the largest difference across business sizes exists in Warehouses. The average square footage of Large Warehouses exceeds 460,000 sq. ft. and the average for Very Small Warehouses is just under 9,200 sq. ft. This is followed by Schools which range from an average square footage of Large Schools equal to 286,700 sq. ft. to 8,400 sq. ft. for Very Small Schools. The range of average square footage is much smaller for Restaurants as can be seen in Figure 4-9. There are no Restaurants in the CSS study that are classified as Large; however the average square footage of Medium sized Restaurants is 6,552 sq. ft. For Very Small Restaurants, the average square footage is 1,484 sq. ft.

Table 4-8: Average Square Footage by CSS Business Type and Size

CSS Business Type	Large	Medium	Small	Very Small
Food/Liquor	41,371	15,285	2,672	1,093
Health/Medical - Clinic	66,791	35,911	8,366	1,935
Miscellaneous	157,825	38,483	13,319	2,748
Office	259,331	70,997	11,075	1,643
Restaurant	N/A	6,552	2,580	1,484
Retail	167,857	38,952	11,652	2,425
School	286,679	81,680	34,953	8,398
Warehouse	466,365	131,658	58,187	9,185

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, medium have greater than 300,000 kWh and less than or equal to 1,750,000, small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, very small have annual usage less than or equal to 40,000 kWh.

Figure 4-9: Average Square Footage by CSS Business Type and Size



* **The results presented above have been weighted by site weight.**

4.3.3 Business Square Footage and Utility

In Table 4-9, the average business square footage by CSS business type and utility is listed. The average square footage of Restaurants does not vary a great deal across IOU service territories. It ranges from a low average of 2,484 sq. ft. in PG&E territory to a high average of 2,808 in SCE's territory. In contrast, the average square footage for Schools ranges from 40,943 sq. ft. in

PG&E's territory to 61,781 sq. ft. in SCE's territory. Schools in SDG&E's territory have a similar average size as those in SCE's territory at 61,624 sq. ft. What is notable is that the substantially larger Schools in both SCE's and SDG&E's territories are also observable in their higher average annual electricity consumption (see Table 4-6 and Figure 4-5 above) relative to Schools in PG&E's territory. Note however that though the average size of schools in SCE and SDG&E territories are similar, the average annual electricity consumption is higher for Schools in SCE's territory relative to SDG&E's territory.

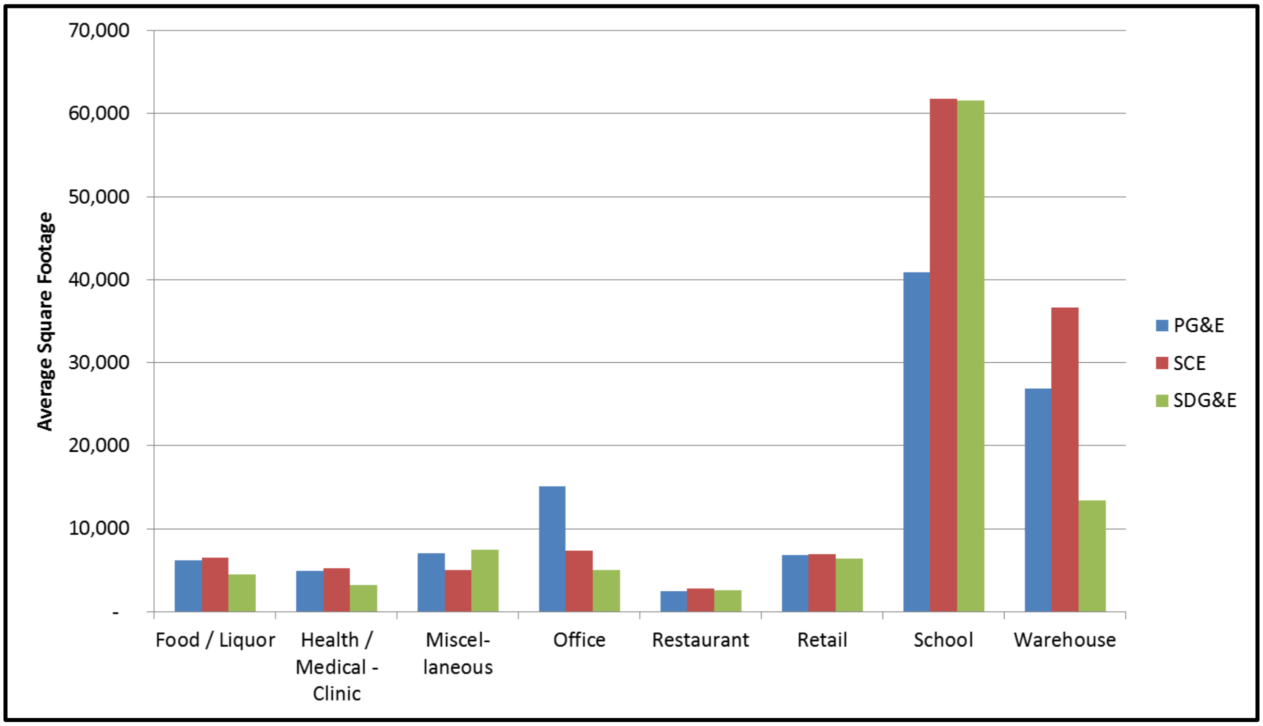
The square footage of Offices also varies substantially by IOU, with PG&E's average Office square footage more than double the average for Offices in SCE and SDG&E's territories. PG&E's territory includes many high rise offices in San Francisco while many of the large offices in Los Angeles are not included in SCE's territory and offices in San Diego are smaller than those in San Francisco.

Table 4-9: Average Square Footage by CSS Business Type and Utility

CSS Business Type	PG&E Average Square Footage	SCE Average Square Footage	SDG&E Average Square Footage
Food/Liquor	6,235	6,510	4,483
Health/Medical - Clinic	4,906	5,238	3,173
Miscellaneous	7,035	5,014	7,480
Office	15,059	7,371	5,022
Restaurant	2,484	2,808	2,595
Retail	6,877	6,982	6,369
School	40,943	61,781	61,624
Warehouse	26,901	36,645	13,449

*** The results presented above have been weighted by site weight.**

Figure 4-10: Average Square Footage by CSS Business Type and Utility



* **The results presented above have been weighted by site weight.**

4.3.4 Conditioned Business Square Footage

Business square footage can be conditioned through the operation of heating and/or cooling equipment, or unconditioned. Unconditioned square footage typically uses less energy than conditioned square footage due to the lack of heating and cooling energy. Table 4-10 shows the share that is conditioned by business type and business size. As can be seen below, the share of business square footage that is conditioned in Warehouses is systematically lower than the other CSS business types, regardless of business size. This lower share for the Warehouse business type is not surprising, considering this category includes Unconditioned Warehouses and Storage Facilities, which are not always conditioned.

The range of conditioned square footage shares is larger as business decreases. For example, the share of conditioned space for Large businesses ranges from a low of 92% for Schools and for Retail to a high of 100% for Health/Medical (this excludes Large Warehouses, whose share is 19%). The share of Very Small businesses that are conditioned range from a low of 48% for Food/Liquor businesses to a high of 96% for Schools (again, excluding Very Small Warehouses).

A deeper look at Table 4-10 shows that the share of conditioned square footage is never less than 95% for Health/Medical businesses and never less than 92% for Schools across all business sizes. Both these business types serve specific populations that may be more sensitive to large variations in temperature. Health/Medical businesses treat the ill and Schools are where children under the age of 18 gather for long periods of time.

Table 4-10: Share of Business Square Footage that is Conditioned by CSS Business Type and Business Size

CSS Business Type	Large	Medium	Small	Very Small
Food/Liquor	95%	88%	65%	48%
Health/Medical - Clinic	100%	99%	96%	95%
Miscellaneous	95%	77%	80%	65%
Office	97%	99%	94%	87%
Restaurant	N/A	92%	87%	60%
Retail	92%	86%	71%	73%
School	92%	97%	94%	96%
Warehouse	19%	25%	18%	19%

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, very small have annual usage less than or equal to 40,000 kWh.

Table 4-11 shows the share by business type and utility service territory. One would expect that the share of square footage that is conditioned is not only dependent on business type, but also partially dependent on the climate zone of the service territory in which the business is located. However, an examination of the table below shows that the share of conditioned space does not vary significantly across service territories. There are some noticeable differences in the percentage of conditioned space by business type and IOU. For example, the share of conditioned space in Warehouse businesses ranges from a high in SCE's and PG&E's territory at 20% and a low of 15% in SDG&E's territory. Health/Medical – Clinic and Office have higher percentage of conditioned space in by PG&E and SCE's territories then it does in SDG&E's territory as well. However, for other business types, SDG&E does not have the lowest percentage of conditioned space. For example, 85% of the space in Restaurants in SDG&E's territory is conditioned, while 82% of Restaurant space is conditioned in PG&E's territory. SDG&E's Schools also have a higher percentage of conditioned space than SCE's Schools do (95% versus 93%).

Table 4-11: Share of Business Square Footage that is Conditioned by CSS Business Type and Utility

CSS Business Type	Total	PG&E	SCE	SDG&E
Food/Liquor	82%	81%	84%	74%
Health/Medical - Clinic	97%	98%	97%	92%
Miscellaneous	75%	79%	72%	71%
Office	96%	97%	96%	92%
Restaurant	85%	82%	87%	85%
Retail	79%	82%	76%	78%
School	95%	97%	93%	95%
Warehouse	19%	20%	20%	15%

*** The results presented above have been weighted by site weight.**

4.4 Business Energy Intensity

Combining the business energy consumption and the square footage leads to the development of the business's energy intensity or the consumption of energy per square foot. Changes in business energy intensity over time can be used to illustrate improvements in the efficiency of energy usage. Care must be taken when interpreting energy intensity as a measure of improved energy efficiency. If the productivity of a business's square footage is changing over time, changes in the energy intensity may reflect changes in productivity, changes in efficiency, or likely a combination of both change in productivity and efficiency. For example, comparing the modern office with an office of 10 years ago, the modern office likely includes more work stations and cubicles than the office of a decade ago. The higher density of workers and their computing needs may lead to a higher measure of energy intensity. Rapid improvements in the energy usage of computers and office lighting technologies, however, may lead to lower energy intensity.

Data collected for the CSS study was used to develop energy intensity measures for business types. The mean energy intensities (EIs) for the eight CSS business types are listed the first three columns of Table 4-12. The CSS EIs are presented weighted by site weights and kWh. For comparison purposes, the CA CEUS was consulted to find mean EIs for commercial business types developed using data from 2002-2004. Though the business types are not identical across these studies, they are similar and can therefore be used to assess whether the mean EIs estimated for CSS are in the ball park of what other studies have found.[14] The EIs for CA CEUS business types are also listed in Table 4-12 in the last two columns. Details of what types of sites

[14] The business types included in the studies differ due to design (the CSS did not include all of the business types analyzed in the CEUS) due to different SIC/NAICs to business type mappings.

were included in these categories can be found in the Commercial End Use Survey Final Report published in 2006.

Before making comparisons across CSS and CA CEUS, initial observations about the energy intensities calculated for CSS business types can be made by examining Table 4-12. CSS business type EIs range across business types from a low of 3.1 kWh per square foot for Warehouse to a high of 43.4 kWh per square foot for Food/Liquor businesses. This range is expected as the amount and type of energy using equipment and amount of space required is directly related to business type. For example, Offices and Health/Medical – Clinic have similar EIs. The CSS EI for Offices is 13.2/13.4 (site/kWh weighted) and for Health/Medical it is 12.5/13.1. Many of the sites included in the CSS Health/Medical business type are medical and dental offices, contributing to their similar EI. Other business types with similar EIs are Restaurants and Food/Liquor businesses. Similar EIs for Restaurants and Food/Liquor businesses result from the requirement of both business types maintaining perishable food items with refrigeration and food storage equipment.

Table 4-12: Mean Energy Intensities by CSS and CA CEUS Building Types

CSS Business Type	Mean Energy Intensity from CSS, Site Weighted	Mean Energy Intensity from CSS, kWh Weighted	CA CEUS Business Type	Mean Energy Intensity from CA CEUS, kWh Weighted	Change in EI from CEUS to CSS
Food/Liquor	43.4	43.4	Grocery	41.0	6%
Health/Medical – Clinic (does not include Hospitals)	12.5	13.1	Health (includes Hospital)	19.6	NA
Miscellaneous	10.5	9.8	Miscellaneous	9.8	0 to 7%
Office	13.2	13.4	Office[15]	16.1	-16.8% to -18%
Restaurant	40.9	39.1	Restaurant	40.2	-3% to 2%
Retail	11.0	11.2	Retail	14.1	-21% to -22%
School	6.1	6.1	School	7.5	-19%
Warehouse	3.1	3.4	All Warehouse	6.7	-49% to -54%

* **The CSS results are presented both weighted by site weight and kWh.** The mean energy intensity measures for CA CEUS business types were calculated using weather normalized annual electricity consumption. The right most column presents the change in EI between the CEUS and CSS where a negative value represents a decline in EI.

When the EIs are compared across the CSS study and the CA CEUS project, it is important to understand both the similarities and the differences between the CSS and the CEUS. First, the CSS's EI are usually based on the average of the business' energy consumption from 2009-2012 and the business square footage as observed on-site. For businesses with high variability in

[15] The CEUS analysis calculated separate EI for Large and Small Offices. The Large Office EI was 17.7 and the Small Office was 13.1. Combining these two strata, results in an Office EI of 16.1.

annual consumption or newer businesses, energy consumption may be based on their annual consumption for 2011 or 2012. The CEUS EI are based on a calibrated model estimate of weather normalized consumption from 2002-2004 and the business square footage as observed on-site.

Business type descriptions were updated between the CSS and the CEUS. The business types for the CSS were based on NAICs to business type mappings developed through discussions with the CPUC, IOUs, and DEER at the start of the CSS research study. The CSS to business type mappings are available in Appendix A. The CEUS business types are based on a SIC to business type mapping developed during the CEUS study. While many minor differences are likely to exist, some known differences include the following:

- The CSS Health/Medical – Clinic does not include Hospitals. This business type is largely medical offices and common areas for rehabilitation and nursing homes. The CEUS Health Care business type included hospital and the common are of rehabilitation and nursing homes but did not include medical offices. Medical offices in the CEUS were included in the Office business type. Given the substantial differences in the businesses included in the CSS Health/Medical and the CEUS Health Care, the EIs for this business type will not be directly compared.
- The CSS Food/Liquor business type includes all sizes of grocery, food, and liquor stores including convenience stores. The CEUS Grocery business type includes all sized of grocery, food and liquor stores, but convenience stores in gas stations are allocated to Miscellaneous in the CEUS. In the CSS, gas stations with convenience stores are designated as Food/Liquor during the NAICs to business type mapping.
- The CEUS Office business type was analyzed separately for large and small offices. In the CSS, may of the analyses of office results are undertaken by size, but many are presented at the all office level. In CEUS, the analysis of large and small offices is described by square footage. In CSS, size designations are based on annual electricity consumption.
- The CSS Warehouses include storage unit businesses. In the CEUS, storage unit businesses were classified with Miscellaneous. The CSS study did not sample refrigerated warehouses as a separate stratum. Given that the CEUS included refrigerated warehouses as a separate stratum, the CEUS may have a larger number of these businesses than the CSS.

For a number of business types, the energy intensities in the CSS and the CEUS are similar. For example, the energy intensity measure for the CSS Restaurant business type is 40.9/39.1 and from CA CEUS, the energy intensity for the Restaurant business type is 40.2. Energy intensity measures across these studies are most similar for Food/Liquor (CA CEUS business type is grocery), Miscellaneous, and Restaurant business types.

For Offices, the CA CEUS study calculated EIs disaggregated by size. For the comparison of the CSS and CEUS Office business type EI, Itron has combined the CEUS Small and Large business types, to develop a CEUS Office EI. The CSS Office EI is 13.2/13.4 while the CEUS Office EI is 16.1. Using these results, the Office EI has fallen by approximately 17 to 18% from 2002-2004 to 20010-2012.

Other business types with EIs that have declined across the two studies include Retail, Schools, and Warehouses. The estimated EI from Retail businesses has fallen from 14.1 in the CEUS to 11.0/11.2 in the CSS, a 21-22% decline in energy intensity. The estimated EI for Schools has fallen from a 7.5 to a 6.1, a 19% decline. These declines in energy intensity are substantial, representing a substantial decline in energy consumption per square foot of commercial space.

The decline in the Warehouse EI between the CEUS and the CSS appears substantial, but it is likely that a significant share of this reduction is due to changes in the composition of the Warehouse business type across the two studies. It is very likely that the All Warehouse category in CA CEUS included more Refrigerated Warehouses than were surveyed in the CSS. For the CA CEUS, the Refrigerated Warehouses category was a separate stratum from Warehouses. In the CSS however, Warehouses and Refrigerated Warehouses are combined into one Warehouse strata. As seen in Table 4-13 below, Refrigerated Warehouses have a substantially higher EI than the other disaggregated business types included in the CSS Warehouse category. Therefore, if the CEUS Warehouse category incorporated more Refrigerated Warehouses than the CSS Warehouses, it is likely that the substantially lower EI observed CSS Warehouses is due in part to fewer Refrigerated Warehouses.

One should not be surprised that the EIs from the CSS study and CA CEUS differ. These studies were carried out at different times and may include different businesses that have closed and opened in the interim. Different business types are included in each of the overall energy intensity measures presented as well. In addition, the types of energy using equipment have changed over time. These factors would result in different EIs.

4.4.1 Energy Intensities for Disaggregated Business Types

Table 4-13 presents the calculated energy intensities for the 22 disaggregated business types that were aggregated up to the 8 CSS business types presented throughout this study. These business type disaggregated-level energy intensities are presented to provide more perspective as to which business types have higher energy intensities at the more refined level. The business type with the highest energy intensities are Fast Food Restaurant (60.6), Convenience Store (55.8), Laboratory (48.9), and Large Grocery (44.0). Those with the lowest are Storage (0.9), Unconditioned Warehouse (2.6), and Conditioned Warehouse (4.9).

Looking at the EIs of the disaggregated business types that constitute the Food/Liquor and Restaurant stratum, shows clearly why these two categories have the highest EIs. For the Restaurant business type, Fast Food Restaurants are energy intensive, with an EI of 60.6. The high EI is because a lot of the cooking equipment is electric in these locations, relative to a mix of electric and gas equipment that is found in Table Restaurants. The mean energy intensities of the disaggregated business types that constitute Food/Liquor are all relatively high. Convenience Stores that are located at gasoline stations can have high energy intensities especially if they are co-located with drive through car washes. In addition, Large Grocery Stores require energy intensive equipment such as dependable refrigeration equipment for the amount of space they occupy.

The disaggregated business types that make up the CSS business type Warehouse have very low energy intensities. Storage and Unconditioned Warehouse have very low energy intensities while refrigerated warehouses have a relatively high EI for the Warehouse stratum.

Table 4-13: Mean Energy Intensities for Disaggregated Business Types

CSS Business Type	Disaggregated Business Type	Mean Energy Intensity
Food/Liquor	Convenience Store	55.8
	Large Grocery	44.0
	Small Grocery	30.2
Health/Medical - Clinic	Medical/Dental	11.7
	Rehabilitative Services	15.5
Miscellaneous	Assembly	6.8
	Laboratory	48.9
	Multi-Family	15.9
	General Miscellaneous	10.7
	Services	7.2
Office	Office	13.2
Restaurant	Fast Food Restaurant	60.6
	Table Restaurant	33.0
	Other Food	33.1
Retail	Auto Sales	19.5
	Retail	7.7
	Variety/Warehouse	14.2
School	School	6.1
Warehouse	Conditioned Warehouse	4.9
	Unconditioned Warehouse	2.6
	Storage	0.9
	Refrigerated Warehouse	14.5

*** The results presented above have been weighted by site weight.**

4.4.2 Business Energy Intensity by Size

The energy intensity will vary by business type and by business size. The EIs calculated for the CSS study are ratios of kWh to square footage. Since larger businesses within the same business type may have different types of energy using equipment than smaller ones, this would have an effect on the amount of electricity used per square foot. For example, Large Grocery Stores may have more sophisticated equipment related to refrigeration, lighting, food storage, and service relative to Very Small Grocery Stores. Large Schools may have classrooms with computers in each classroom and audio/video equipment while Very Small and Small Schools may be less equipped.

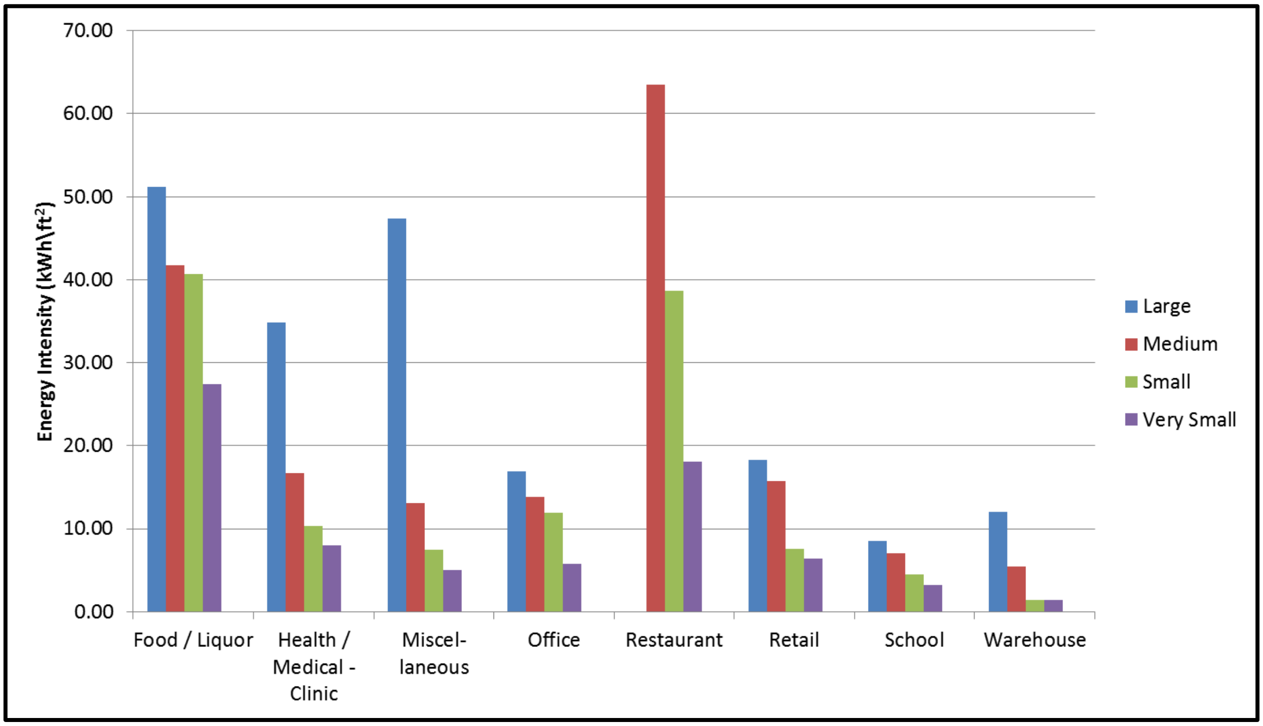
As shown in Table 4-14 and in Figure 4-11, there is a clear trend of declining EIs with business size in each CSS business type. Some business types have EIs that are not drastically different across business size while others do. For example, the EIs of Large Schools and Offices, and to some degree, Retail businesses and Warehouses, are not sizably different than the EIs of their Very Small counterparts. However, the EIs of Large Health/Medical and Miscellaneous businesses are much larger than the EIs of Medium, Small, and Very Small of these same business types. Note that while there are no Restaurants that are classified as Large, the Medium Restaurants have a much higher EI than Small and Very Small Restaurants do.

Table 4-14: Average Energy Intensity by CSS Business Type and Business Size

CSS Business Type	Large	Medium	Small	Very Small
Food/Liquor	51.13	41.71	40.70	27.46
Health/Medical - Clinic	34.81	16.72	10.31	8.02
Miscellaneous	47.31	12.83	7.51	5.04
Office	16.87	13.87	11.89	5.80
Restaurant	N/A	63.51	38.67	18.07
Retail	18.32	15.75	7.60	6.36
School	8.56	7.01	4.47	3.27
Warehouse	12.07	5.50	1.46	1.45

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 4-11: Average Energy Intensity by Annual Consumption Size



* **The results presented above have been weighted by site weight.**

4.4.3 Business Energy Intensity by Utility

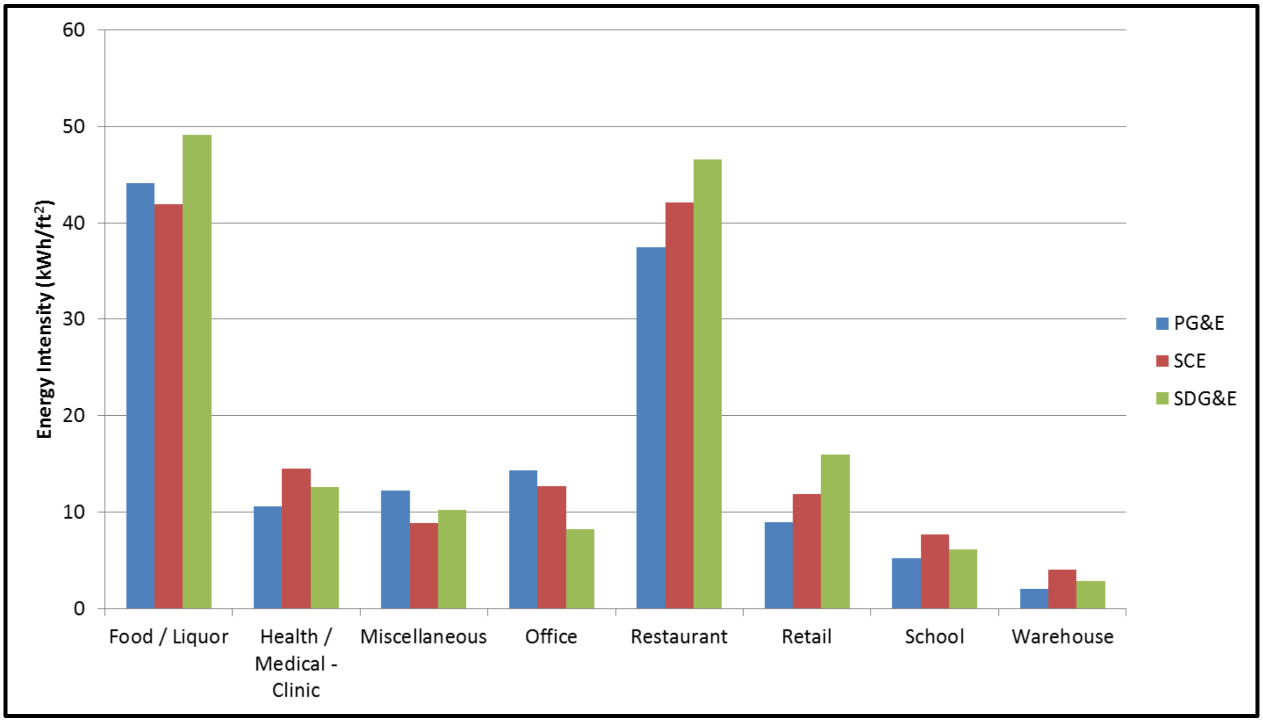
Given the different climates associated with the different utility service territories, energy intensities may also vary for the same business type by IOU. The overall climate is cooler in parts of PG&E and warmer in parts of SCE which may lead to more heating in the northern part of California and more air conditioning in southern California. Table 4-15 presents the energy intensities by CSS business type and IOU. This information is also displayed graphically in Figure 4-12. Examination of both does not show a noticeable trend with regard to lower or higher energy intensities by utility. The energy intensities are relatively similar for the different business types. However, the energy intensities for the business types that are highest, Food/Liquor and Restaurant, are greater in SDG&E service territory than in either PG&E's or SCE's territories. It is also higher for Retail businesses in SDG&E's territory compared to the other two. Other than this observation, there do not seem to be IOU related trends in the energy intensity measures calculated for the CSS business types.

Table 4-15: Average Energy Intensity by CSS Business Type and Utility

CSS Business Type	PG&E	SCE	SDG&E
Food/Liquor	44.10	41.97	49.13
Health/Medical - Clinic	10.58	14.49	12.58
Miscellaneous	12.21	8.86	10.22
Office	14.30	12.66	8.26
Restaurant	37.49	42.13	46.57
Retail	8.98	11.90	15.91
School	5.18	7.69	6.08
Warehouse	2.00	4.04	2.86

*** The results presented above have been weighted by site weight.**

Figure 4-12: Average Energy Intensity by CSS Business Type and Utility



*** The results presented above have been weighted by site weight.**

4.5 Business Characteristics

The CSS on-site survey collected a variety of information about businesses, including data about the year the business was established and the number of employees working for the business. In this subsection of the report the share of businesses established before the 1990s, during the 1990s, and between the years 2000-2003, 2004-2008, and 2009-2012 are presented by business type and by IOU. The number of businesses used to develop these results is equal to the number of usable CSS on-site surveys completed, which equals 1,439. There was a very small fraction of businesses that were unable to provide information regarding the year in which they were established. For this reason, a category of Unknown is included in the tables and figures in this subsection.

Table 4-16 lists the share of businesses established in the above listed year buckets by business type. Based upon the information presented, it appears that the largest shares of businesses included in the CSS on-site survey were before the 1990s. One result that stands out is that almost 80% of the Schools included in the on-site survey were established before the 1990s. Very few Schools were established after the year 2000.

Figure 4-13 presents a stacked bar chart with the shares of businesses established by year buckets and business type. This shows that Restaurants were established fairly equally across the year categories defined above. Between 20% and 26% were established in each of the year buckets with the exception of 2000-2003. The share of Restaurants established was only 12% in this year bucket. Warehouses were established in fairly equal shares across the year categories as well, ranging between 19% and 24%. The exception for this business type was in the 1990s where only 13% of existing Warehouses were established.

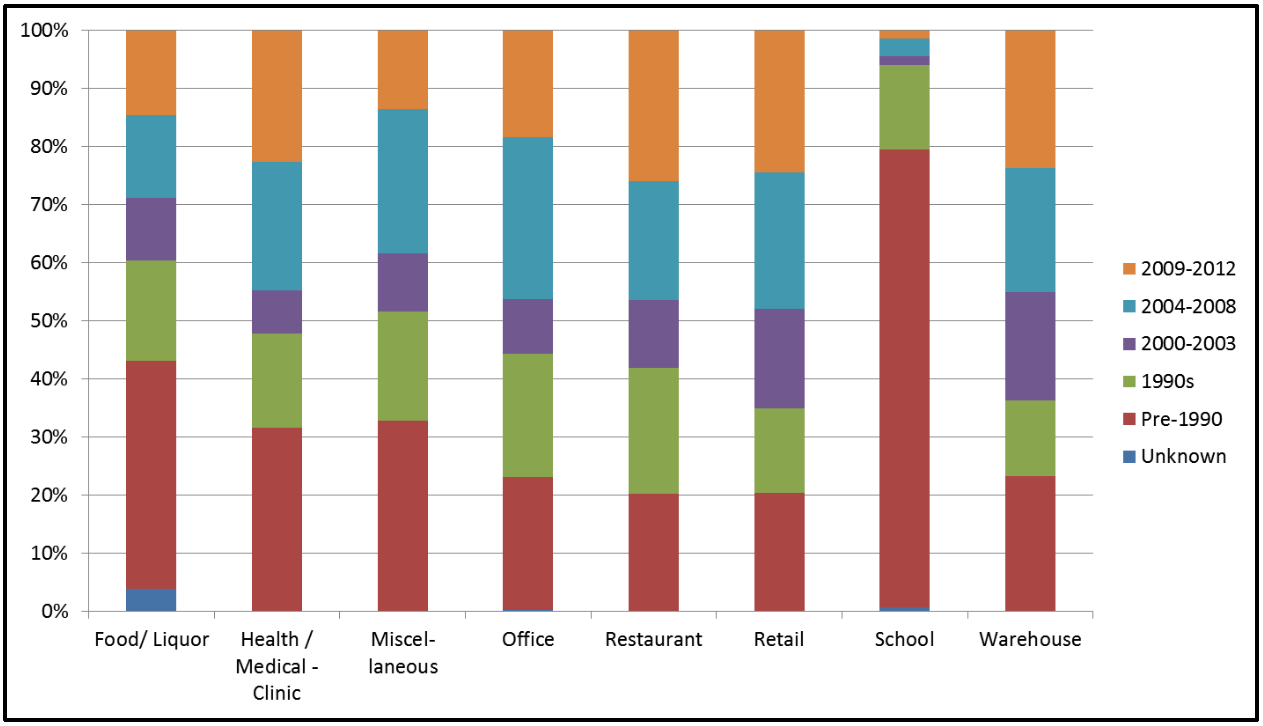
Further examination of Table 4-16 and Figure 4-13 shows that the shares of businesses established across several business types, such as Food/Liquor, Health/Medical, Miscellaneous, Office, and Restaurants, were lower during 2000-2003 than those established in the year buckets immediately before and after. This is perhaps is due to the existence of a nationwide recession during the early 2000s.

Table 4-16: Share of Businesses Established by Year and CSS Business Type

Date Business Established	Food / Liquor	Health / Medical - Clinic	Miscel-laneous	Office	Restaurant	Retail	School	Warehouse
Unknown	4%	N/A	N/A	N/A	N/A	N/A	1%	N/A
Pre-1990	39%	32%	33%	23%	20%	20%	79%	23%
1990s	17%	16%	19%	21%	22%	14%	15%	13%
2000-2003	11%	7%	10%	9%	12%	17%	2%	19%
2004-2008	14%	22%	25%	28%	21%	24%	3%	21%
2009-2012	15%	23%	14%	18%	26%	24%	1%	24%
n	**127**	**128**	**246**	**246**	**170**	**233**	**161**	**128**

*** The results presented above have been weighted by site weight.**

Figure 4-13: Share of Businesses Established by Year and CSS Business Type



*** The results presented above have been weighted by site weight.**

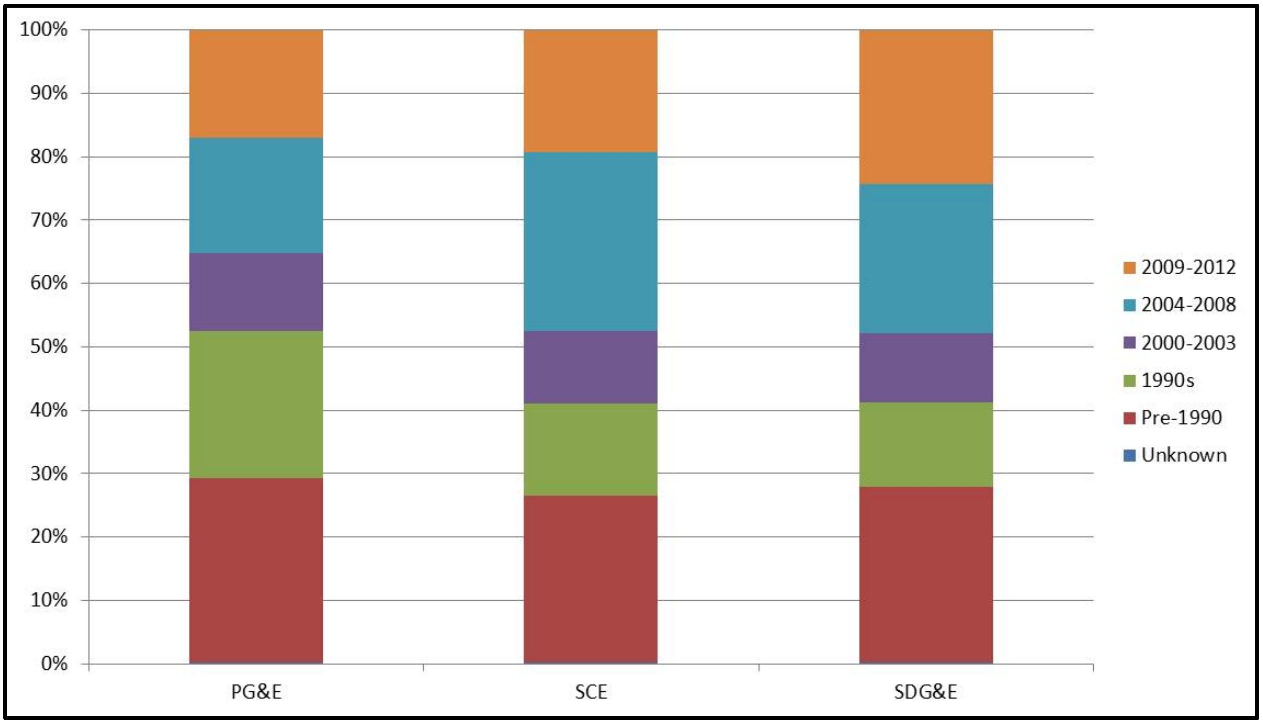
Table 4-17 presents information on the year the businesses in the CSS were established by IOU. A stacked bar chart of these data is also included in Figure 4-14. A few differences across utilities are observable about the share of businesses established over the years. The share of businesses established before the 1990s is relatively equal across the IOUs, however in the 1990s, the share of businesses established in PG&E's territory greatly exceeds the shares established in both SCE's and SDG&E's territories. In the 1990s, approximately 23% of businesses surveyed on-site for CSS in PG&E's territory were established. In contrast, the share of SCE businesses and SDG&E businesses that were established in the 1990s was closer to 15% and 13%. This trend reverses in the 2004-2008 time period; 18% of businesses in PG&E's territory were established while 24% and 28% of businesses in SCE's and SDG&E's territories were established. Note that these findings are limited to sites surveyed for the CSS study.

Table 4-17: Share of Businesses Established by Year and Utility

Date Business Established	PG&E	SCE	SDG&E
Unknown	0.1%	0.2%	0.1%
Pre-1990	29.2%	26.2%	27.7%
1990s	23.1%	14.7%	13.3%
2000-2003	12.3%	11.4%	11.0%
2004-2008	18.1%	28.1%	23.5%
2009-2012	17.1%	19.4%	24.3%
n	**573**	**642**	**224**

***   The results presented above have been weighted by site weight.**

Figure 4-14: Share of Businesses Established by Year and Utility



***   The results presented above have been weighted by site weight.**

The CSS study collected information from site contacts about the number of employees working for the business at the locations that were surveyed on-site. Table 4-18 presents data on the average number of full time employees by business type and the size of the business measured by annual electricity consumption. As expected, the average number of employees within a business type declines as the business size decreases from Large to Very Small. There is a large drop in the average number of employees when going from Large to Medium business size across all CSS business types. This trend is seen clearly in Figure 4-15.

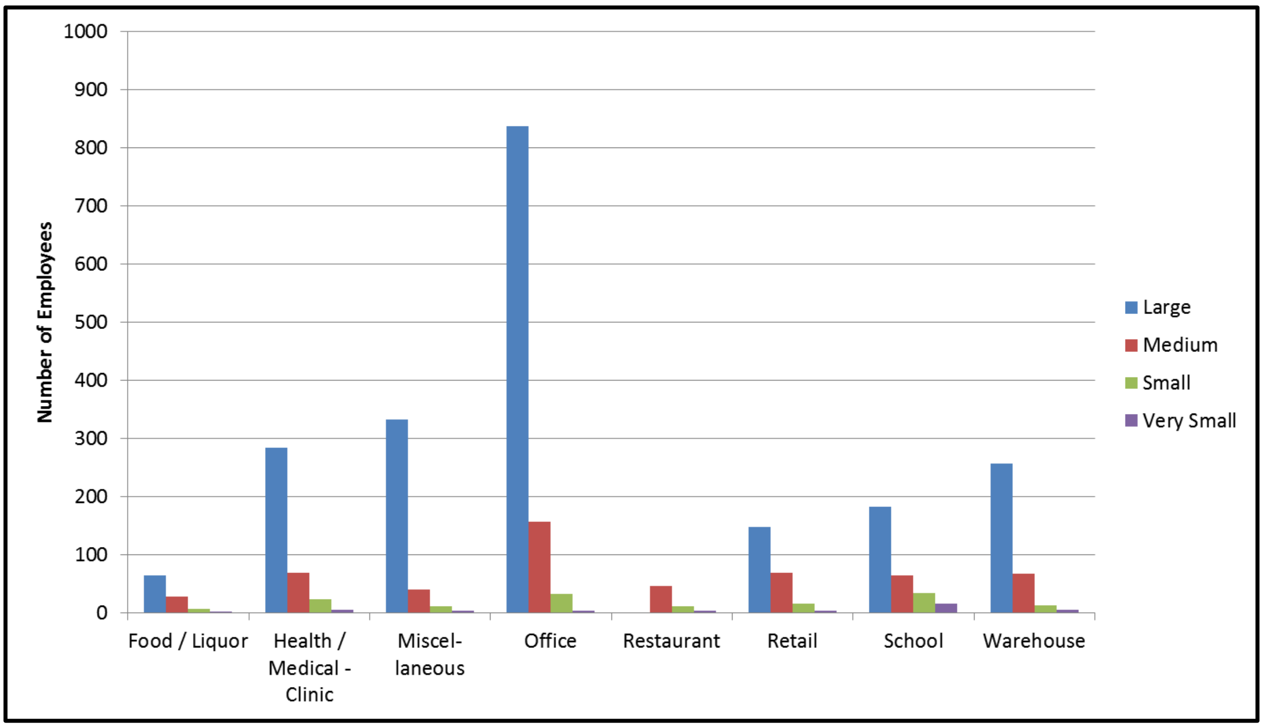
Of the Large sized businesses, Offices have the highest average number of employees with 837.7 employees per office. This is an outlier relative to the rest of the data presented. This is distantly followed by the average number of employees in Large Miscellaneous and Large Health/Medical businesses with 332.7 and 284.7 employees. Businesses that are considered Very Small have an average number of employees that range from a low of 1.9 for Food/Liquor businesses to a high of 15.4 employees for Schools.

Table 4-18: Average Number of Employees by Business Type and Size

Business Size	Food / Liquor	Health / Medical - Clinic	Miscel-laneous	Office	Restaurant	Retail	School	Warehouse
Large	63.9	284.7	332.7	837.7	N/A	147.8	182.2	256.5
Medium	28.0	69.2	40.2	156.4	46.3	68.5	64.4	66.5
Small	6.2	23.6	11.5	32.7	10.7	15.6	33.4	12.1
Very Small	1.9	5.4	3.9	3.7	4.3	3.3	15.4	5.2

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 4-15: Average Number of Employees by Business Type and Business Size



* **The results presented above have been weighted by site weight.**

4.6 Building Information

The businesses studied as part of the CSS study occupy buildings of various configurations and ages. Businesses can be located at sites that occupy a portion of a building or may be large enough to require several buildings. Businesses may be located in buildings that are older or newly constructed. The following subsection presents information about the different types of premises occupied by CSS businesses, the age of buildings they occupy, building envelope characteristics, and the presence of external amenities such as parking garages or swimming pools.

4.6.1 Number of Buildings

The businesses surveyed for the CSS study occupy a variety of premises. Some occupy a part of a building, others occupy an entire building, and yet others may be in several buildings or even have their own campuses. Table 4-19 lists the share of businesses included in this study that occupy these premise types. Also included are the premise types by average square footage and the average annual electricity consumption. The most common premise type of is single buildings with almost 45% of all businesses included in the CSS study occupying this type of premise. An extremely small share of businesses is located on campuses (2%). Not surprisingly, average square footage increases by premise type with businesses occupying less than 1 building averaging approximately 3,000 sq. ft. and campuses using an average of over 49,000 sq. ft.

The average annual kWh used by businesses increases by premise type as well, with those businesses in less than 1 building using an average of 39,000 kWh a year and campuses using just under 238,000 kWh per year. It is interesting to note that the average square footage of single buildings occupied by CSS businesses uses less than 40% of the space of small multi-building businesses but that the average annual electricity consumption is 93% of the average annual consumption of small multi-building businesses. This could be due to the types of businesses that are located in single buildings versus small multi-buildings. If the business types located in single buildings are more energy intensive than those that occupy small multi-building premises, then this result is not surprising.

Table 4-19: Premise Type Share, Size, and Average Annual Electricity Consumption

Premise Type	Share of Total	Average Square Footage	Average Annual kWh
Less than 1 building	44%	2,972	39,372
Single building	44%	11,836	136,176
Small multi-building	10%	22,297	146,188
Campus	2%	36,756	237,982

*** The results presented above have been weighted by site weight.**

To assess why single building CSS businesses use a proportionately higher amount of energy relative to square footage when compared with small multi-building CSS businesses, a further look at the types of CSS businesses by premise type is warranted. If these are business types with high average energy intensities, it may help to explain this phenomenon. Table 4-20 presents the share of CSS business types occupying the different premise types and from this information, it is clear that greater than half of all Food/Liquor and Miscellaneous businesses are located in single buildings. Food/Liquor is the CSS business type with the highest average annual electricity consumption (267,888 kWh per year), as shown in Table 4-4 as well as the highest EI (43.4, as shown in Table 4-12). Another CSS business type that has a high energy intensity is Restaurants, with an EI measure of 40.9.[16] About 40% of Restaurants in California are located in single buildings. This information may help to explain why the average square footage of single buildings occupied by CSS businesses is small relative to the amount of electricity consumed by them when compared to CSS businesses occupying small multi-building premises.

Table 4-20: Share of Premise Type by CSS Business Type

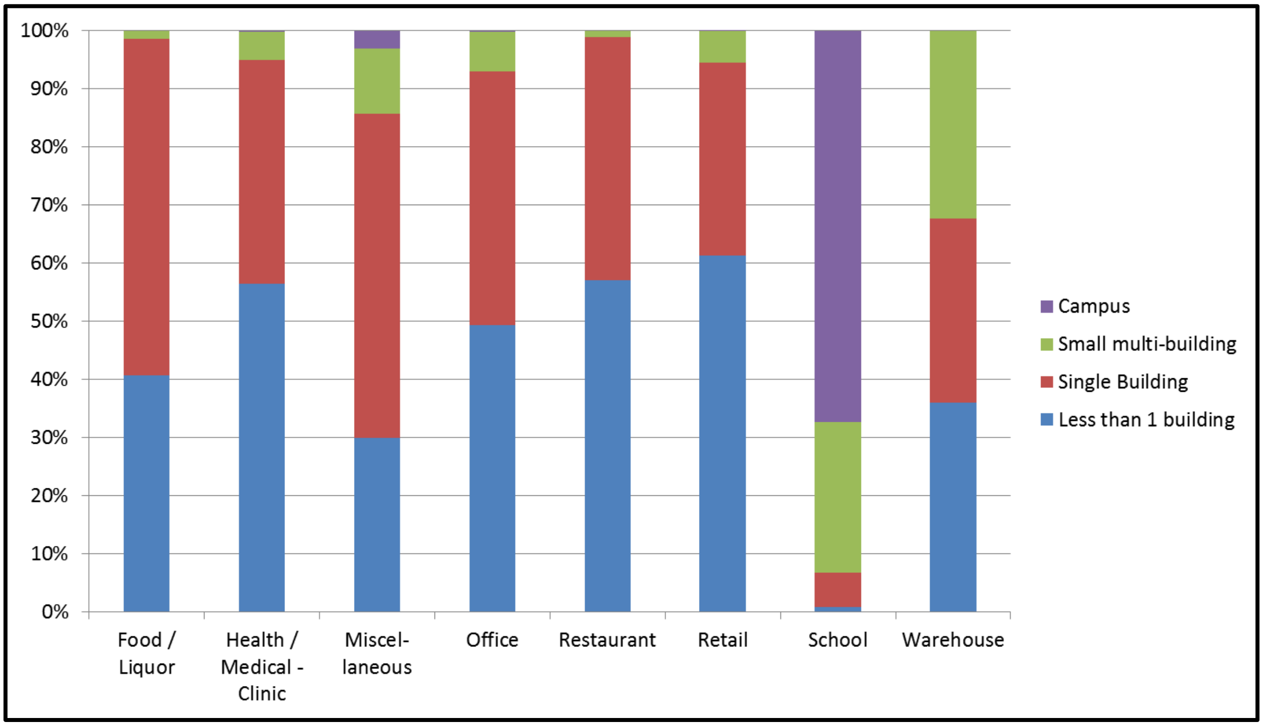
CSS Business Type	Less than 1 Building	Single Building	Small Multi-Building	Campus
Food/Liquor	41%	58%	1%	N/A
Health/Medical - Clinic	56%	39%	5%	0%
Miscellaneous	30%	56%	11%	3%
Office	49%	44%	7%	0%
Restaurant	57%	42%	1%	N/A
Retail	61%	33%	5%	0%
School	1%	6%	26%	67%
Warehouse	36%	32%	32%	N/A

*** The results presented above have been weighted by site weight.**

Certain premise types are more common for certain CSS business types as can be seen in Figure 4-16. Here we see that several CSS business types occupy single buildings most, with the exception of Restaurants, Retail, and Schools. Schools tend to occupy campuses with several larger buildings, while Restaurants and Retail businesses are located in a portion of buildings, such as malls.

[16] This high EI for Restaurants was driven upwards by the inclusion of the Fast Food Restaurant disaggregated business type, which has an EI of 60.6.

Figure 4-16: Share of Premise Type by CSS Business Type



*** The results presented above have been weighted by site weight.**

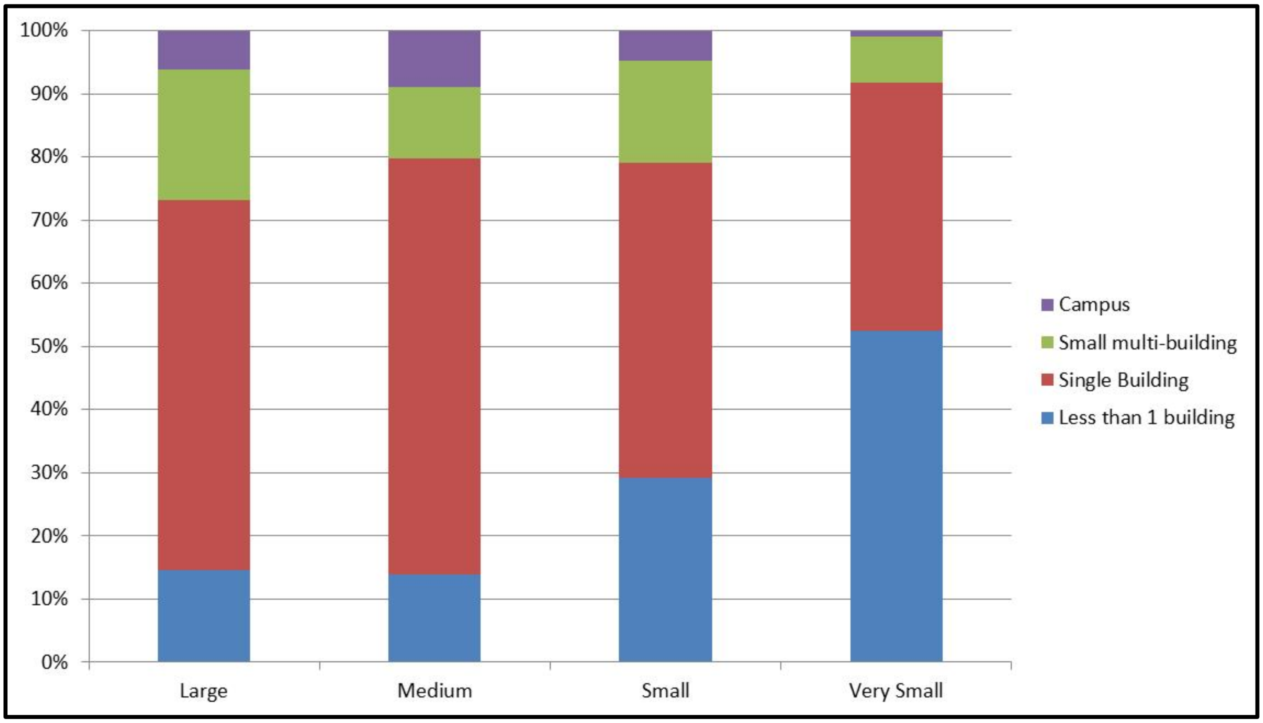
Table 4-21 below presents the shares of premise types by business size. According to the data, single buildings are the most common premise type for Large, Medium, and Small businesses. In fact, over 50% of Large, Medium, and Small businesses occupy single buildings. Very small businesses are located in a portion of a building just over 50% of the time. What is notable is that Medium businesses occupy campuses 9% of the time, while Large businesses occupy these types of premises 6% of the time. One would expect that perhaps the share of Large businesses in campuses would exceed the share of Medium businesses. These data that show the shares of premise types by business size are also presented graphically in Figure 4-17.

Table 4-21: Share of Premise Type by Business Size

Business Size	Less than 1 Building	Single Building	Small Multi-Building	Campus
Large	15%	59%	21%	6%
Medium	14%	66%	11%	9%
Small	29%	50%	16%	5%
Very Small	53%	39%	7%	1%

*** The results presented above have been weighted by site weight.**

Figure 4-17: Share of Premise Type by Business Size



*** The results presented above have been weighted by site weight.**

4.6.2 Building Age

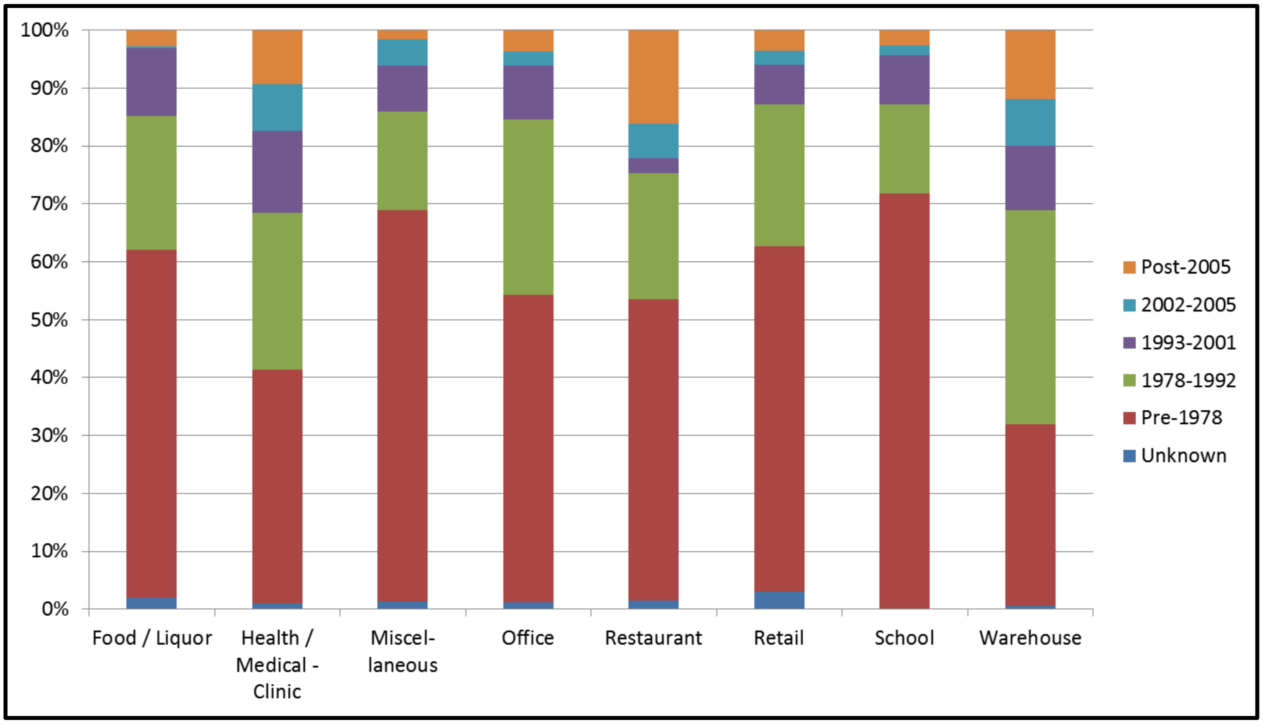
The year of building construction was gathered during the on-site survey effort to illustrate the average age of buildings occupied by the various CSS business types. Table 4-22 presents the share of each CSS business type constructed during various year categories. These data are also presented graphically in Figure 4-18. The most common year bucket during which buildings were constructed that are occupied by CSS business types are before 1978. This is followed distantly by the 1978-1992 year bucket, which was the second most common time period when buildings occupied by CSS businesses were built.

Table 4-22: Share of Buildings Built by Year and CSS Business Type

Date Ranges	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restaurant	Retail	School	Warehouse
Unknown	2%	1%	1%	1%	1%	3%	N/A	<1%
Pre-1978	60%	40%	67%	53%	52%	60%	72%	31%
1978-1992	23%	27%	17%	30%	22%	24%	15%	37%
1993-2001	12%	14%	8%	9%	3%	7%	9%	11%
2003-2005	<1%	8%	5%	2%	6%	2%	2%	8%
Post-2005	3%	9%	2%	4%	16%	4%	3%	12%

* **The results presented above have been weighted by site weight.**

Figure 4-18: Share of Buildings Built by Year and CSS Business Type



* **The results presented above have been weighted by site weight.**

Table 4-23 lists the average age of building construction by business type and IOU. These data are presented in graphical form in Figure 4-19 as well. An examination of both the table and the figure shows that Warehouses across all IOUs tend to have been built more recently relative to the other CSS business types. The average year of building construction for Warehouses ranges from 1983 for both PG&E and SDG&E to 1985 for SCE. The businesses located in the oldest buildings are Restaurants in SDG&E's territory and Retail businesses in PG&E's territory.

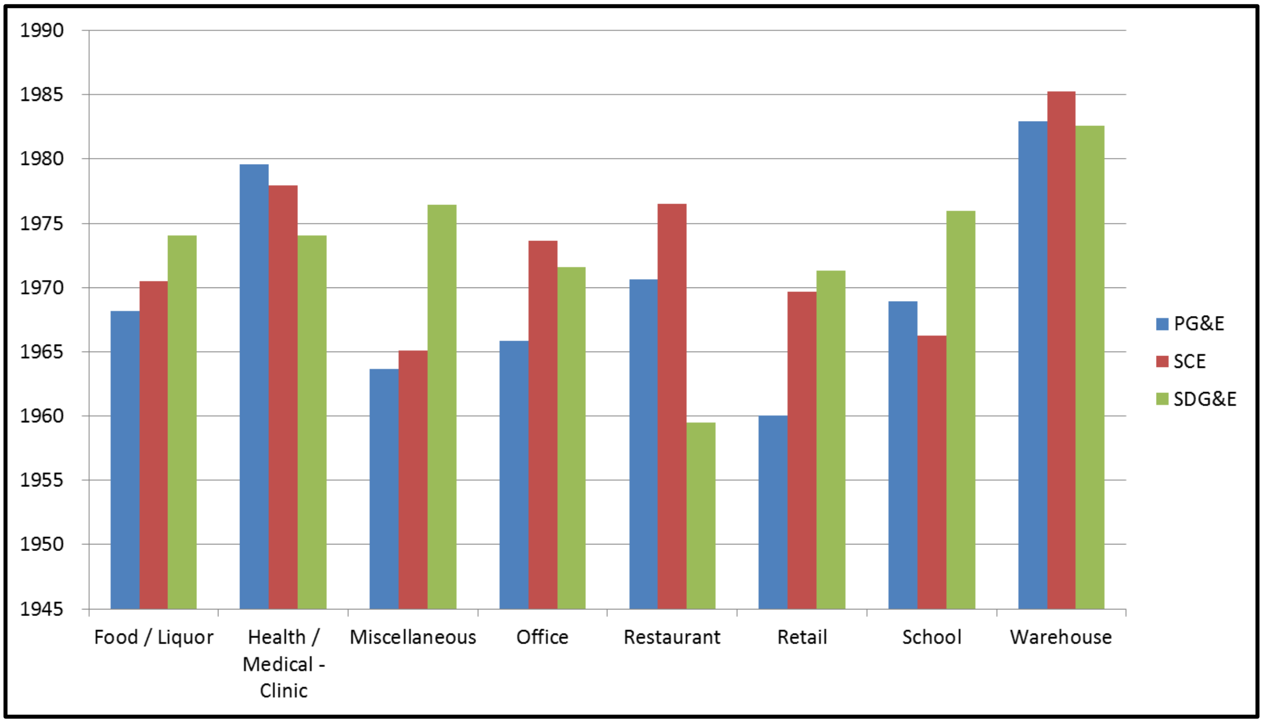
Table 4-23: Average Year of Building Construction by IOU

CSS Business Type	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
Food/Liquor	1968	0.26%	1971	0.29%	1974	0.47%
Health/Medical - Clinic	1980	0.42%	1978	0.38%	1974	0.38%
Miscellaneous	1964	0.37%	1965	0.24%	1976	0.45%
Office	1966	0.32%	1974	0.27%	1972	0.53%
Restaurant	1971	0.41%	1977	0.28%	1959	0.52%
Retail	1960	0.42%	1970	0.26%	1971	0.32%
School	1969	0.22%	1966	0.27%	1976	0.62%
Warehouse	1983	0.36%	1985	0.28%	1983	0.24%

*** The results presented above have been weighted by site weight.**

In some cases, one service territory has businesses located in buildings that are either much older or much newer than their counterparts in the other service territories. For example, the average year of construction of the buildings in which Miscellaneous businesses in SDG&E's territory is much later than it is in PG&E's and SCE's territories. The average year of construction for SDG&E Miscellaneous business buildings is 1976; for PG&E, the average year is 1964 and for SCE, this average year of construction is 1965. When looking at buildings in which Restaurants are located, the average year of construction in SDG&E's service territory is 1959. Buildings that house Restaurants in PG&E's service territory were have an average year of construction of 1971 and in SCE's territory, the average year of construction of Restaurant buildings was 1977.

Figure 4-19: Average Year of Building Construction by IOU



* **The results presented above have been weighted by site weight.**

4.6.3 Exterior and Building Envelope Characteristics

A number of building envelope and exterior characteristics about the buildings in which the CSS businesses are located are presented in this subsection of the report. First, information about the color of roofs is presented to determine the share of businesses with cool roofs or solar roof tiles. This is followed by data about window characteristics, such as the share of CSS business with single or multi-panes and with glazed windows. Last this subsection presents the share of CSS businesses with parking garages and pools by CSS business type.

The CSS on-site survey gathered data about the roof color of buildings occupied by CSS businesses. Table 4-24 shows that the most common roof color of buildings occupied by CSS businesses is light (55%) followed by medium (29%) colored roofs. Of most interest are cool roofs and solar roofs for their energy efficiency and renewable energy benefits. Also of interest are green roofs, which are roofs that are partially or completely covered by vegetation that serve to insulate buildings. Based on the information below, cool roofs are found on only 2% of buildings occupied by CSS businesses and neither green roofs nor solar tiles are present in large enough quantities to constitute even 1% of roofs of CSS businesses.

Table 4-24: Share of Buildings in CSS Study by Roof Color

Roof Color	Share of Buildings
Dark	11%
Green Roof	0%
Light	55%
Medium	29%
Other	0%
Solar Roof Tiles	0%
Cool Roof	2%
Unknown	3%

*** The results presented above have been weighted by site weight.**

The shares of buildings with multiple-paned windows and with glazed windows are listed in Table 4-25 by CSS business type. These results are also presented graphically in Figure 4-20. Multiple-paned windows and glazed windows are both more energy efficient than simple single paned windows and windows without glazing. Multiple-paned windows serve to better insulate homes than single paned windows. Glazed windows help to keep solar heat gain and loss down relative to unglazed windows. An examination of the data presented below shows that over 50% of Schools are equipped with multiple-paned windows. This far surpasses any other CSS business type. The business type with the second highest share of multiple-paned windows is Health/Medical at 39%. Aside from these CSS business types, about 25% of the remaining ones have multiple-paned windows.

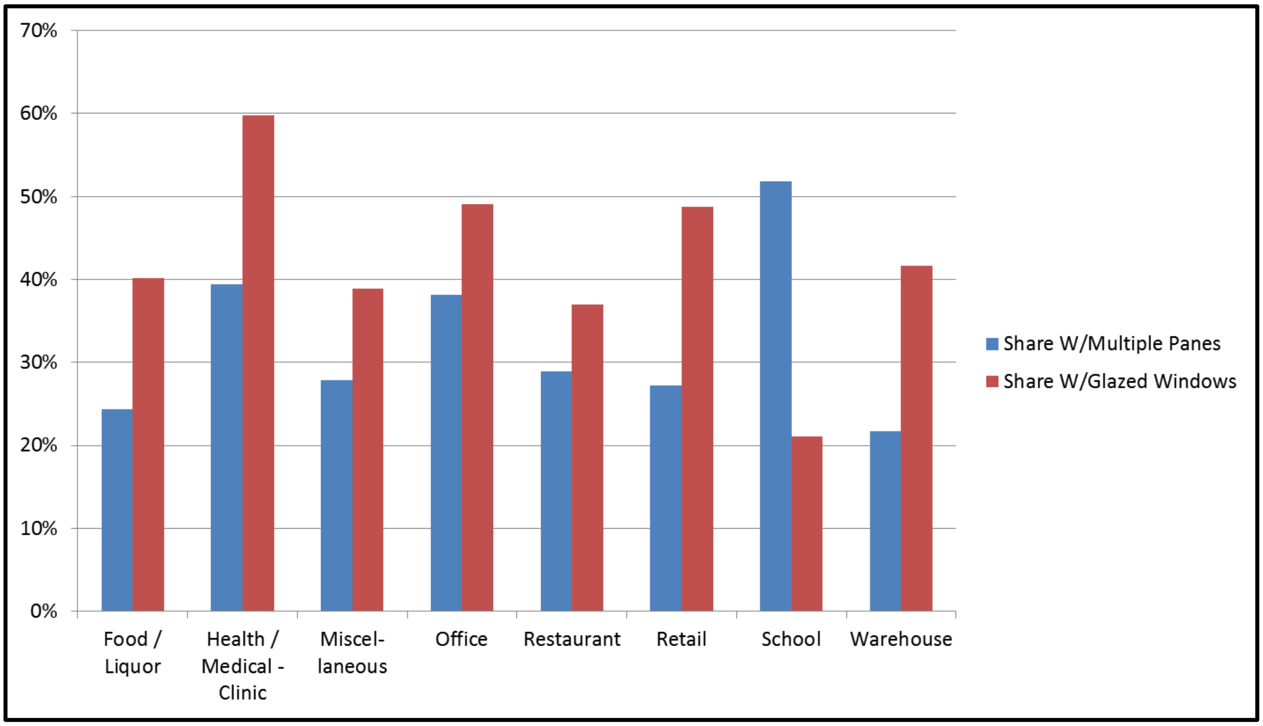
The findings with regard to window glazing show that larger shares of businesses across CSS business types have this feature, with the exception of Schools. Schools have the lowest share of businesses with glazed windows (21%). This may be because such a large share of Schools has multiple-paned windows to help with insulation. More than half of Health/Medical businesses have glazed windows (60%), followed by Offices (49%) and Retail (49%).

Table 4-25: Share of CSS Business Types with Multiple Window Panes and Glazed Windows

CSS Business Type	Share with Multiple Panes	Share with Glazed Windows
Food/Liquor	24%	40%
Health/Medical – Clinic	39%	60%
Miscellaneous	28%	39%
Office	38%	49%
Restaurant	29%	37%
Retail	27%	49%
School	52%	21%
Warehouse	22%	42%

*** The results presented above have been weighted by site weight.**

Figure 4-20: Share of CSS Business Types with Multiple Window Panes and Glazed Windows



*** The results presented above have been weighted by site weight.**

The shares of CSS business types with parking garages and pools are presented in Table 4-26. Both exterior characteristics are not very common in CSS businesses, based on this information. Parking garages are found in approximately 6% of Health/Medical businesses and Miscellaneous businesses. Pools are found in 10% of Miscellaneous businesses and in 4% of Health/Medical businesses and Schools.

Table 4-26: Share of CSS Business Types with Parking Garages and Pools

CSS Business Type	Percent with Parking Garage	Percent with Pool
Food/Liquor	0%	0%
Health/Medical - Clinic	4%	4%
Miscellaneous	1%	10%
Office	4%	0%
Restaurant	0%	0%
Retail	2%	1%
School	2%	4%
Warehouse	0%	0%

***   The results presented above have been weighted by site weight.**

5

Commercial Lighting Equipment

5.1 Introduction

A central goal of the CSS study is to document the baseline distribution of lighting measures within commercial businesses. The 2006 CEC CEUS[1] analysis estimated that lighting accounted for approximately 35% of commercial energy usage. In addition, lighting measures represent technology long targeted by commercial energy efficiency programs and recent technology code updates. The CSS on-site survey effort gathered a full inventory of commercial lighting measures. The data collected provide an indication of the progress achieved in replacing inefficient measures with newer, more efficient technologies. These data may also serve as inputs for future potential studies that could provide the CPUC and the IOUs with a detailed picture of the remaining achievable energy savings potential.

5.1.1 Lighting Equipment Overview

Each item of lighting fixture data collected on-site was classified as: Linear Fluorescent, Compact Fluorescent, LED, Halogen, Incandescent, High Intensity Discharge (HID), or Other Lighting. Lighting data installed in indoor and outdoor spaces was analyzed and has been reported separately for all of these lighting technologies. Additionally, advertising lighting, exit signs, and indoor and outdoor lighting controls are discussed separately in later sections of this chapter.

5.2 Data Sources

The extensive quantity of commercial lighting information collected through this study provides a greater awareness of the distribution of lighting technologies within commercial businesses in California. Information was gathered for lighting technologies and other relevant metrics to aid in developing an understanding of energy use for lighting and the distribution of lighting equipment within the commercial sector. Data collection on lighting technologies involved several distinct efforts through the different stages of the study.

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[1] California Commercial End-Use Survey; Prepared for California Energy Commission by Itron Inc.; March 2006

- The CSS/CMST phone surveys: A total of 7,890 telephone surveys were conducted as part of this study with utility customers across twelve business types. While the telephone survey's primary objective is to recruit businesses to participate in the on-site survey effort, it also provided information regarding business characteristics; attitude and knowledge of EE, DR, and DG; and the types of lighting installed at the site of the business.
- CSS on-site surveys: The CSS on-site survey collected information from a sub-set of sites included in the telephone survey. Information was collected on site about the quantity, technology specifications, location, and vintage of lighting technology found at the business. The CSS on-site data collection effort collected data from Food/Liquor stores, Health/Medical Clinics, Miscellaneous businesses, Offices, Restaurants, Retail, Schools, and Warehouses.[2]
- Make and model lookups were undertaken with Linear technologies to determine efficiency levels

Additionally, the study was informed by coordination with other 2010-12 commercial lighting evaluations, residential market share tracking studies, as well as data collected from former saturation studies to show the progress achieved in replacing inefficient measures with newer, more efficient technologies.

The CSS study collected an extensive list of information on commercial businesses, including but not limited to commercial firm demographics. These data were analyzed along with information collected regarding the saturation, age, condition, and efficiency level of commercial lighting measures, as well as building usage patterns and square footage to provide information on saturations and efficiency levels by IOU and business type.

Table 5-1 provides a count of phone survey and on-site survey completes by business type. The table also provides a count of on-site surveys completed for specific lighting technologies.

[2] The CSS on-site data collection effort did not collect data from industrial sites, colleges, hotels, and motels, or hospitals due to the cost of detailed data collection at these larger sites. These business types were included in the more limited CMST data collection effort.

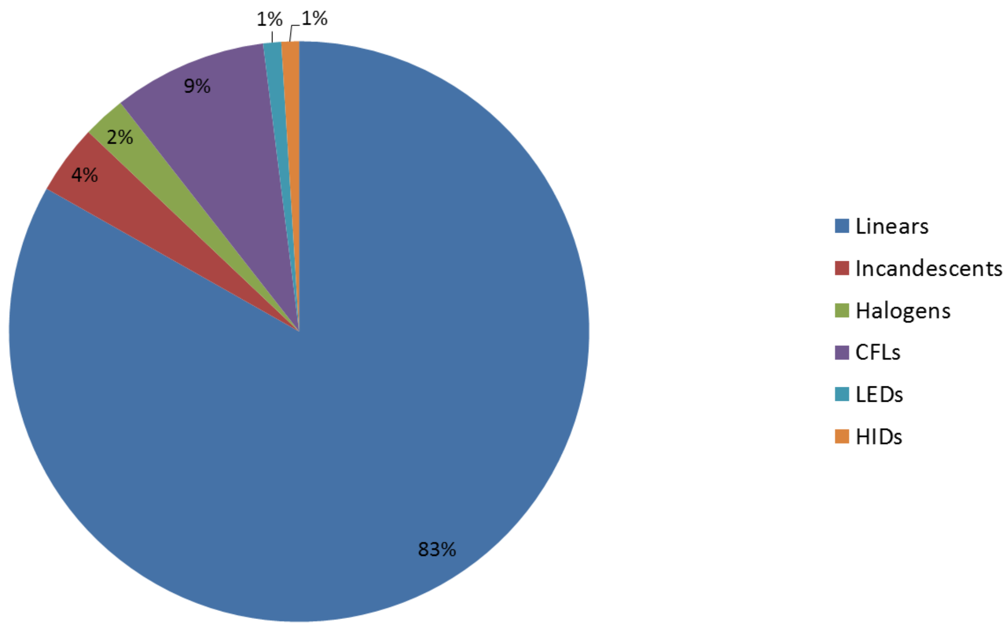
Table 5-1: Phone Survey and On-Site Survey Site Counts by Business Type – Indoor and Outdoor Lighting

Business Type	Total PS Count	Total CSS OS Count	OS with Linears	OS with CFLs	OS with Incan-descents	OS with Halo-gens	OS with LEDs	OS with HIDs	OS with Other Lighting
Food/ Liquor	486	127	126	79	35	18	12	58	3
Health/ Medical Clinic	633	128	126	111	73	36	9	42	3
Miscellaneous	1,637	246	239	205	137	65	22	109	7
Office	1,313	246	238	185	114	72	24	97	4
Restaurant	595	170	166	145	100	61	27	37	6
Retail	1,019	233	227	168	114	75	34	100	9
School	479	161	160	145	65	28	7	105	10
Warehouse	745	128	124	58	50	18	7	85	1
College	29	N/A							
Health/ Medical Hospital	59	N/A							
Hotel	199	N/A							
Industrial	696	N/A							
n	**7,890**	**1,439**	**1,406**	**1,096**	**688**	**373**	**142**	**633**	**43**

5.3 Indoor Lighting Analysis

We begin this section by focusing on the aggregate lighting in indoor areas of commercial businesses, presenting some information on the saturations of the different types of lighting. Figure 5-1 illustrates the site-weighted lamp shares of indoor lighting technologies as a percentage of total lamps found in commercial businesses. As depicted, 83% of all commercial indoor lamps are Linears. CFLs represent over half of the remaining share of indoor lamps, at 9% of the total, while HIDs comprise less than 1% of the total.

Figure 5-1: Distribution of Lamps by Technology Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

Later in this section of the report, a more in-depth analysis is provided of indoor Linear technologies and Incandescent, Halogen, CFL, and LED lighting. The distribution presented in Figure 5-2 provides perspective to the results presented in the Linear Lighting and Incandescent, CFL, LED, and Halogen Lamps (ICLH) subsections. Lighting saturations are reported by business type, business size, IOU, and Energy Efficiency (EE) program participation for detailed efficiency groupings within the individual lighting technologies.

5.3.1 Aggregate Indoor Lighting Saturations

This sub-section reports the results of the analysis of lighting technologies found in different business type and size groupings. Table 5-2 provides a distribution of businesses with a given lighting technology by business type. The percentages represent the share of businesses within a particular business type that has lamps of a particular lighting technology installed. For example, 91% of Miscellaneous businesses have at least one Linear lamp installed, while only 5% of Miscellaneous businesses have any HID lamps. Linear lamps have a high incidence in all business types with 100% of Food/Liquor stores and 92% of Offices having Linear technologies. CFLs are present in 59% of Food/Liquor stores, 49% of Offices, 34% of Warehouses, and over 60% of Health/Medical Clinics, Miscellaneous business types, Restaurants, Retail stores, and Schools. Comparing the share of businesses with CFLs to those with Incandescent lamps, all CSS business types other than Warehouses have a higher share of businesses with CFLs than Incandescent lamps.

Table 5-2: Share of Businesses with a Given Lighting Technology by Business Type – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Linears	100%	98%	91%	92%	98%	94%	100%	95%
Incandescents	26%	51%	47%	45%	53%	54%	29%	51%
Halogens	5%	20%	15%	17%	29%	32%	8%	9%
CFLs	59%	75%	68%	49%	84%	62%	60%	34%
LEDs	6%	8%	1.7%	1.8%	13%	8%	1.4%	1.7%
HIDs	3.0%	2.6%	5%	2.9%	0.1%	6%	16%	29%
Other	0.2%	0.4%	0.2%	0.1%	2.1%	0%	0.5%	0%
n	**126**	**128**	**245**	**246**	**170**	**233**	**161**	**127**

* **The results presented above have been weighted by site weight.** Percentages sum to more than 100% because, for any given business type, a business may have installed more than one type of lighting technology. *n*'s represent the number of surveyed sites included in the analysis.

Expanding on the data above, Table 5-3 presents the share of businesses with a given lighting technology by disaggregated business type. This provides a particularly useful look at the Miscellaneous business type, which is comprised of the following disaggregated business types: Assembly, Laboratory, Multi-Family, General Miscellaneous, and Services. Disaggregated business types within the Miscellaneous businesses type have the most variation of any business type in terms of installed lighting types and lighting applications. While Table 5-2 shows that 91% of total Miscellaneous businesses have at least one Linear lamp, Table 5-3 reveals that only 68% of Multi-Family[3] businesses have Linear lamps as compared to 100% of Laboratories. Shares of Multi-Family businesses with Halogens, LEDs, and HIDs are also low relative to other Miscellaneous disaggregated business types. The business type disaggregation also shows that a relatively high 82% of Assembly type businesses have CFLs, compared to 68% of all Miscellaneous businesses.

[3] The Multi-Family disaggregated business type represents the common areas of multi-family businesses.

Table 5-3: Share of Businesses with a Given Lighting Technology by Disaggregated Business Type – Indoor Lighting

Business Type	Disaggregated Business Type	*n*	Linears	Incan-descents	Halogens	CFLs	LEDs	HIDs	Other
Food / Liquor	Convenience Store	**57**	100%	24%	0%	49%	6%	1.8%	0%
	Large Grocery	**40**	100%	30%	21%	61%	3.9%	13%	1.4%
	Small Grocery	**29**	100%	27%	10%	83%	6%	0.5%	0%
Health / Medical – Clinic	Medical/Dental	**98**	97%	50%	21%	72%	9%	3.0%	0.3%
	Rehabilitative Services	**30**	100%	58%	9%	99%	0%	0%	0.5%
Miscel-laneous	Assembly	**89**	93%	60%	32%	82%	3.5%	7%	0.8%
	Laboratory	**24**	100%	42%	31%	48%	3.7%	22%	0%
	Multi-Family	**32**	68%	38%	1.5%	76%	0.3%	0.1%	0%
	General Miscellaneous	**35**	100%	35%	15%	71%	3.2%	2.3%	0%
	Services	**65**	97%	47%	10%	58%	0.9%	6%	0%
Office	Office	**246**	92%	45%	17%	49%	1.8%	2.9%	0.1%
Restaurant	Fast Food Restaurant	**59**	97%	35%	23%	87%	11%	0%	4.5%
	Table Restaurant	**62**	100%	78%	42%	84%	18%	0.4%	0%
	Other Food	**49**	97%	45%	22%	83%	9%	0%	2.0%
Retail	Auto Sales	**25**	100%	31%	16%	47%	4.8%	37%	0%
	Retail	**159**	94%	56%	32%	60%	7%	4.9%	0%
	Variety / Warehouse	**49**	88%	50%	33%	90%	15%	7%	0%
School	School	**161**	100%	29%	8%	60%	1.4%	16%	0.5%
Warehouse	Conditioned Warehouse	**25**	100%	46%	29%	13%	7%	40%	0%
	Unconditioned Warehouse	**81**	100%	45%	8%	28%	1.1%	36%	0%
	Storage	**11**	78%	71%	1.8%	66%	0%	0%	0%
	Refrigerated Warehouse	**10**	100%	34%	15%	64%	0%	37%	0%

* **The results presented above have been weighted by site weight.** Percentages sum to more than 100% because, for any given business type, a business may have installed more than one type of lighting technology. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-4 provides the distribution of businesses with specific lighting technologies across usage size categories. The data presented in Table 5-4 show that a 82% of Large businesses have CFLs while only 59% of Very Small businesses use CFLs. In contrast, 49% of Very Small businesses have Incandescent lamps while only 36% of Medium-sized businesses have Incandescent lamps.

Linear lamps have a near 100% share within the Large, Medium, and Small usage categories, with Very Small businesses having a 91% share.

Table 5-4: Share of Businesses with a Given Lighting Technology by Business Size – Indoor Lighting

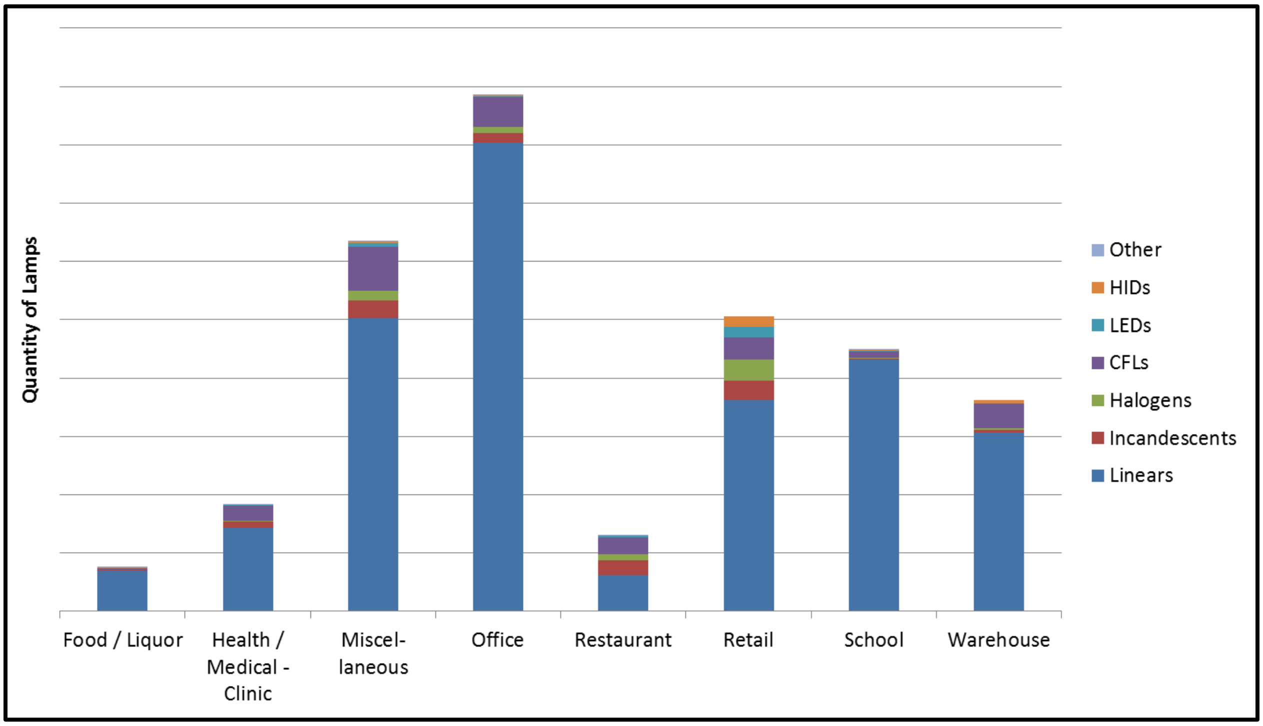
Technology Type	Large	Medium	Small	Very Small
Linears	100%	100%	99%	91%
Incandescents	38%	36%	48%	49%
Halogens	42%	22%	20%	18%
CFLs	82%	74%	67%	59%
LEDs	16%	13%	8%	2.2%
HIDs	32%	19%	9%	4.5%
Other	0.3%	1.0%	1.1%	0%
n	**97**	**463**	**484**	**392**

* **The results presented above have been weighted by site weight.** Percentages sum to more than 100% because, for any given business size, a business may have installed more than one type of lighting technology. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-2 below shows the distribution of the quantity of lamps for indoor lighting technologies across business types. This depiction is intended only to show the relative volume of lamps within each business type, as the site-weighted lamp counts do not reflect the actual quantity of lamps installed in commercial businesses. As shown, Offices have the largest quantity of indoor lamps, with Linear technologies representing the majority of indoor lamps in Offices. Miscellaneous business types have the second largest quantity of indoor lamps. The large Miscellaneous share is in part due to Miscellaneous businesses having the second highest total energy consumption of all CSS businesses and the third highest share of floor stock.[4]

[4] See Section 4 for information on the distribution of electricity usage and floor stock by business types. Offices have the largest share of electricity consumption for CSS businesses, and Warehouses have the highest share of floor stock.

Figure 5-2: Distribution of Lamps by Technology Type and Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.** This depiction is intended only to show the relative volume of lamps within each business type, as the site-weighted lamp counts do not reflect the actual quantity of lamps installed in commercial businesses.

Table 5-5 shows the share of lamps for individual lighting technologies by business type.[5] Linear lamps have an overwhelming presence with a 96% share of all indoor lamps in Schools, 92% in Food/Liquor stores, and a 91% share in Offices. The distribution of indoor lamps in Restaurants is significantly different than other business types with 47% Linear lamps and 53% ICLH lamps. This data helps to show the relative importance of each lighting technology that is discussed in the Linear and ICLH subsections within the context of the commercial market as a whole.

5 In Table 5-7, through Table 5-8, Incandescent, CFL, LED, and Halogen lamp shares have been aggregated into two rows: ICLH Pin- & Medium-Screw Based (the subset of ICLH lamps that is further analyzed in the ICLH section) and ICLH Other Base (which represents a minority share of lamps).

Table 5-5: Share of Lamps by Lighting Technology and Business Type – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Linears	92%	78%	79%	91%	47%	72%	96%	84%
ICLH Pin- & Medium Screw-Based	7%	21%	18%	9%	43%	20%	2.8%	13%
ICLH Other Base	0.5%	1.0%	1.7%	0.5%	10%	4.9%	0.6%	0.5%
HIDs	0.9%	0.1%	0.7%	0.1%	<0.1%	3.5%	0.3%	1.9%
Other	<0.1%	<0.1%	<0.1%	<0.1%	0.2%	0%	<0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**126**	**128**	**245**	**246**	**170**	**233**	**161**	**127**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-6 shows the technology type distribution of lamps by disaggregated business type. Comparing this data with Table 5-6 reveals the diversity of the Miscellaneous business type. Multi-Family businesses have a lower share of Linear lamps at 43% and a higher share of ICLH lamps at 57% compared the other Miscellaneous disaggregated business types.

Table 5-6: Share of Lamps by Lighting Technology and Disaggregated Business Type – Indoor Lighting

Business Type	Disaggregated Business Type	*n*	Linears	ICLH Pin- & Medium Screw-Based	ICLH Other Base	HIDs	Other	Total
Food / Liquor	Convenience Store	**57**	94%	4.2%	1.9%	0.4%	0%	**100%**
	Large Grocery	**40**	91%	7%	0.1%	1.5%	0.1%	**100%**
	Small Grocery	**29**	93%	7%	0.2%	<0.1%	0%	**100%**
Health / Medical – Clinic	Medical/Dental	**98**	83%	16%	0.8%	0.1%	<0.1%	**100%**
	Rehabilitative Services	**30**	49%	48%	2.5%	0%	<0.1%	**100%**
Miscel-laneous	Assembly	**89**	76%	23%	0.8%	0.6%	0.1%	**100%**
	Laboratory	**24**	89%	10%	0.3%	1.1%	0%	**100%**
	Multi-Family	**32**	43%	54%	3.7%	<0.1%	0%	**100%**
	General Miscellaneous	**35**	87%	11%	2.3%	0.3%	0%	**100%**
	Services	**65**	87%	8%	3.1%	1.1%	0%	**100%**
Office	Office	**246**	91%	9%	0.5%	0.1%	<0.1%	**100%**
Restaurant	Fast Food Restaurant	**59**	60%	37%	1.7%	0%	0.4%	**100%**
	Table Restaurant	**62**	35%	47%	18%	<0.1%	0%	**100%**
	Other Food	**49**	50%	42%	8%	0%	0.5%	**100%**
Retail	Auto Sales	**25**	89%	6%	0.3%	4.4%	0%	**100%**
	Retail	**159**	67%	24%	8%	0.6%	0%	**100%**
	Variety / Warehouse	**49**	74%	17%	0.8%	8%	0%	**100%**
School	School	**161**	96%	2.8%	0.6%	0.3%	<0.1%	**100%**
Warehouse	Conditioned Warehouse	**25**	95%	2.1%	0.5%	2.4%	0%	**100%**
	Unconditioned Warehouse	**81**	96%	1.8%	0.5%	1.8%	0%	**100%**
	Storage	**11**	32%	68%	0.4%	0%	0%	**100%**
	Refrigerated Warehouse	**10**	79%	9%	0%	12%	0%	**100%**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-7 shows the share of lamps for individual lighting technologies by IOU. PG&E has a higher share of Linear lamps than the other IOUs, but lower shares of both ICLH and HID lamps. The application of site weights to the on-site data accounts for differences in IOU territory size to allow for comparability across IOUs.

Table 5-7: Share of Lamps by Lighting Technology and IOU – Indoor Lighting

Technology Type	PG&E	SCE	SDG&E
Linears	87%	80%	77%
ICLH Pin- & Medium Screw-Based	12%	16%	17%
ICLH Other Base	1.1%	2.1%	4.3%
HIDs	0.4%	1.5%	1.5%
Other	<0.1%	<0.1%	<0.1%
Total	**100%**	**100%**	**100%**
n	**570**	**642**	**224**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-8 shows the share of lamps for individual lighting technologies by business size. Very Small businesses have the lowest share of Linear lamps, but the highest share of ICLH lamps than the other business sizes. Large businesses have a substantially higher share of HIDs than the other business types, at 4.4% of lamps.

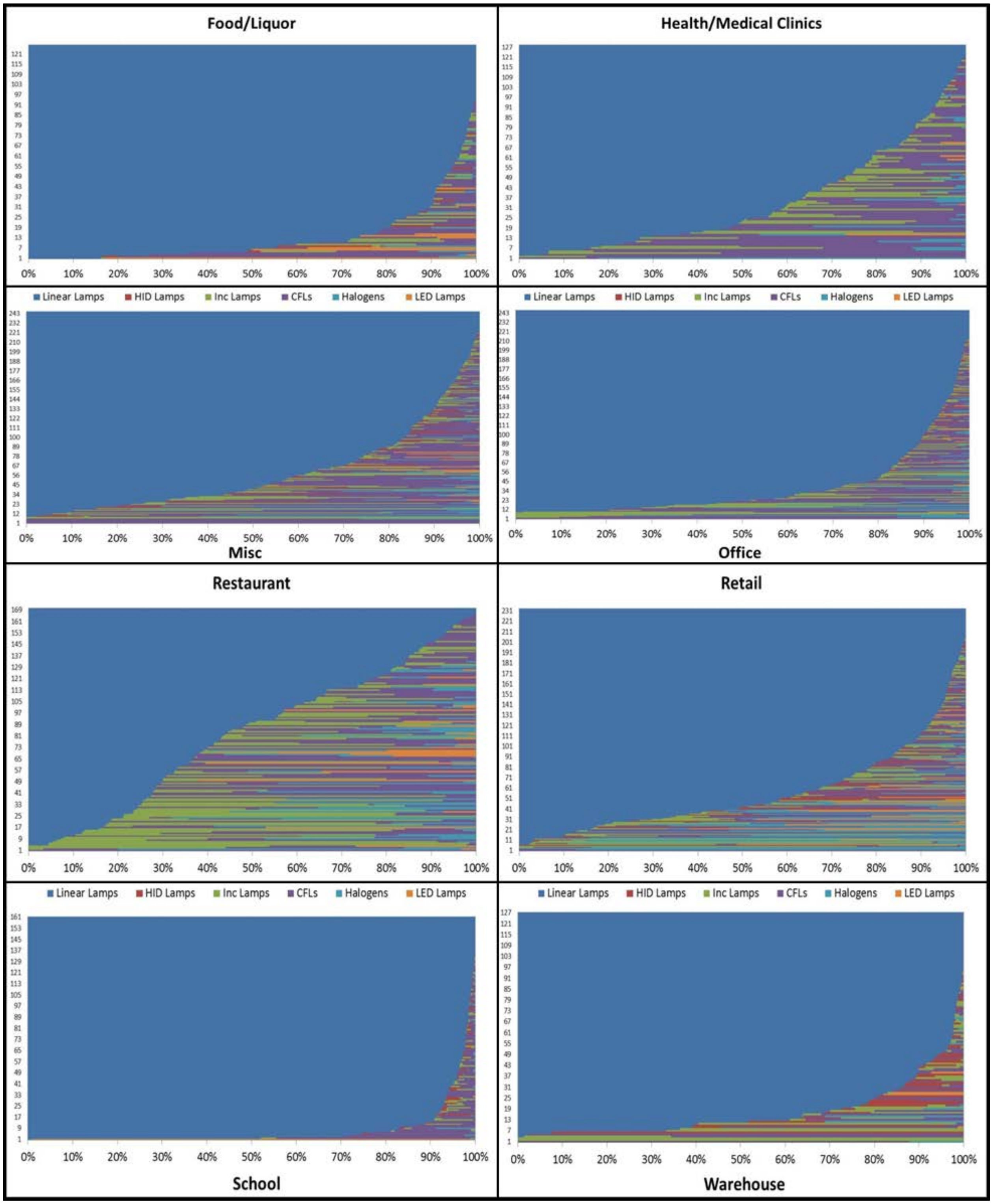
Table 5-8: Share of Lamps by Lighting Technology and Business Size – Indoor Lighting

Technology Type	Large	Medium	Small	Very Small
Linears	82%	90%	80%	76%
ICLH Pin- & Medium Screw-Based	13%	8%	16%	20%
ICLH Other Base	0.6%	0.8%	2.7%	2.8%
HIDs	4.4%	0.6%	0.5%	0.4%
Other	<0.1%	<0.1%	0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**
n	**97**	**463**	**484**	**392**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-3 illustrates the site-level distribution of aggregate indoor lamps by business type. The figure includes one chart for each of the eight business types. Each chart shows the unweighted distribution of lamps for every site surveyed in the given business type, where one row represents one surveyed site. Within each row, the different colors represent the various technology types found at that site, and the length of a color segment shows the share of lamps for the given technology type relative to the other technology types found on-site. The blue segments represent the share of Linear lamps at each site, the red segments represent HID lamps, the green represent Incandescent lamps, the purple represent CFLs, the turquoise segments represent Halogen lamps, and the orange represent LED lamps. A quick glance at the charts reveals that the blue area predominates all other colors. This blue area can be interpreted as the aggregate share of Linear lamps across all sites surveyed for a particular business type. For example, the blue area in the Restaurant chart is smaller than the blue area in the School chart, implying that on average Linear lamps make up a greater share of total lamps in Schools compared to the share of Linear lamps in Restaurants. This observation is confirmed by the site-weighted data presented above in Table 5-5, which shows that 96% of lamps in Schools are Linears but only 47% of lamps in Restaurants are Linears. The predominating blue area depicted in the charts further corroborates that Linear lamps are a significant proportion of indoor lighting in CSS businesses. In Schools, Food/Liquor stores, and Offices, there are very few sites where Linear lamps do not comprise the overwhelming majority of lamps. Restaurants are the only CSS business type where Linear lamps do not make up the majority of lighting in more than half of the sites surveyed. In Health/Medical Clinics and Retail stores, there are also a number of sites where Linear lamps are in the minority.

Figure 5-3: Site-Level Lamp Type Distribution by Business Type – Indoor Lighting



5.3.2 Aggregate Indoor Lighting Analysis

This sub-section focuses on the average connected load per business, Lighting Power Density (LPD), lumens per square foot of indoor space for the CSS business types, and efficacy. Average connected load is the per-business average of total lamp watts for a business type. Average LPD is the total lamp watts divided by the total square footage for the business type. The LPD represents the lighting load for a defined area. Many EE programs and standards target reductions in lighting loads or LPD to promote EE savings. LPD standards and objectives differ by business type and/or space usage category. Care must be taken, however, when trying to reduce LPD to ensure that quality lighting of interior and exterior spaces is maintained. Efficient lighting technologies work to reduce their power usage or watts while maintaining lumens or the amount of visible light emitted by the technology. Efficacy, calculated as the ratio of total lumens per square foot to total watts per square foot of indoor space, should increase as more efficient lighting technologies are installed.

Table 5-9 details the average connected load, average wattage and lumens per square foot, and efficacy for each CSS business type. As seen, Schools have the highest average total lamp wattage per business across all CSS business types. There are fewer Schools than other business types, yet Schools have a mid-range total square footage compared with the total square footage of other business types. This implies that Schools have higher square footage per business than other business types, causing the high average connected load per business seen in Table 5-9. Warehouses have the second highest average connected load. The LPD of Warehouses, however, is the lowest of all CSS business types. Warehouses have the highest share of total CSS business square footage, so the division of their total lamp wattage by their total business square footage leads to the drastically low average LPD that is observed. Warehouses also have the lowest average lumens of all CSS businesses, leading to a mid-range efficacy among all business types. Restaurants have the lowest average connected load of CSS businesses, but their relatively low total square footage causes Restaurants to have a midrange average LPD. Food/Liquor stores have the smallest share of total CSS business floor stock (2% of the total floor stock), causing Food/Liquor stores to have the highest average lumens per square foot of any business type while maintaining a mid-range average LPD. Schools also have a mid-range average LPD while achieving high lumens per square foot. These data may indicate that Food/Liquor stores and Schools have adopted energy efficient lighting with low wattage consumption relative to lumen output. This finding is supported by the high efficacies displayed by Food/Liquor stores and Schools.

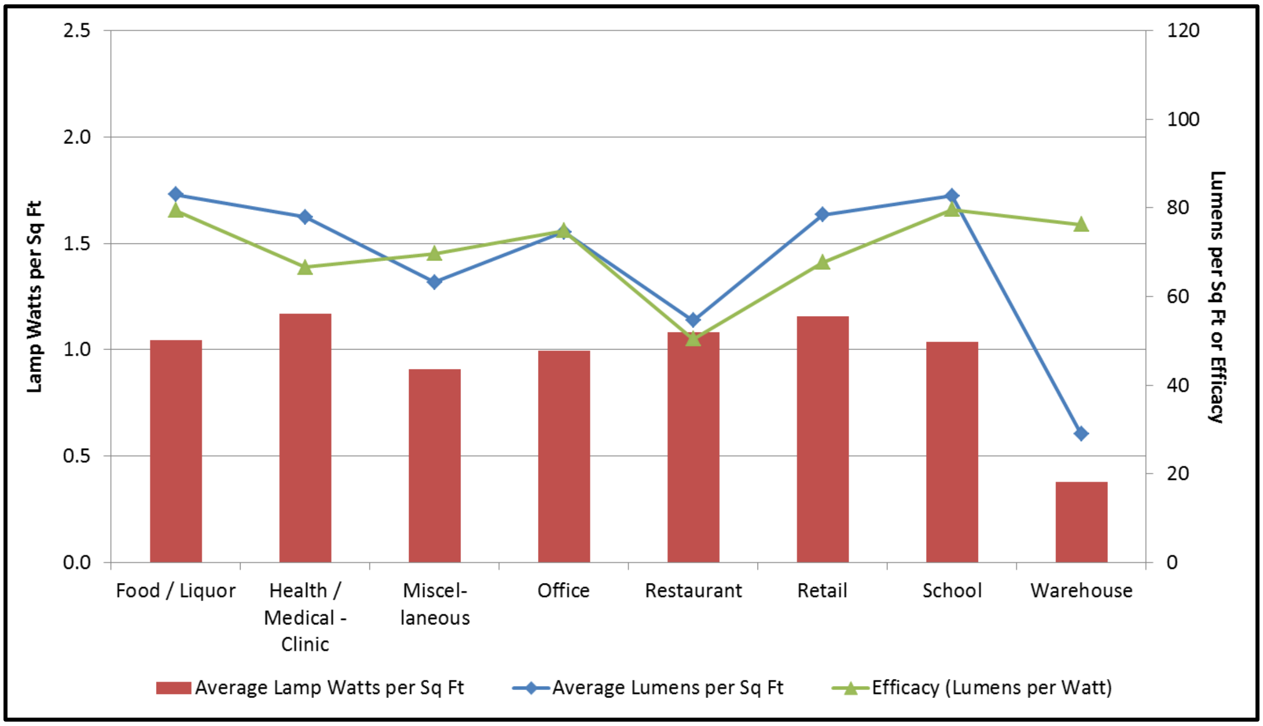
Table 5-9: Aggregated Averages by Business Type – Indoor Lighting

Business Type	*n*	Average Connected Load (Lamp Watts) per Business	Average LPD (Lamp Watts per Sq Ft)	Average Lumens per Sq Ft	Efficacy (Lumens per Watt)
Food/Liquor	126	6,390	1.04	83	79
Health/Medical – Clinic	128	5,638	1.17	78	67
Miscellaneous	245	5,322	0.91	63	70
Office	246	9,899	1.00	75	75
Restaurant	170	2,872	1.08	55	50
Retail	233	7,971	1.16	78	68
School	161	49,549	1.04	83	80
Warehouse	127	11,330	0.38	29	76
Total	**1,436**	**7,969**	**0.84**	**60**	**72**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Totals for Average Connected Load, Average LPD, Average Lumens per Sq Ft, and Efficacy represent weighted averages across all business types.

Figure 5-4 illustrates for each business type the average lamp watts per square foot of indoor space, average lumens per square foot, and efficacy calculated across all technology types as in Table 5-9 above. Average lamp watts per square foot are shown as bars plotted along the left-hand vertical axis. Average lumens per square foot and efficacy (lumens per watt) are shown as lines plotted along the right-hand vertical axis; both lines are measured in lumens and can therefore use the same scale. As depicted below, Restaurants have the lowest ratio of lumens to watts (efficacy), while Food/Liquor stores and Schools have the highest.

Figure 5-4: Average Lamp Watts per Square Foot, Average Lumens per Square Foot, and Efficacy by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

Table 5-10 shows the average connected load, the average wattage per square foot, and the average lumens per square foot by business size. These results show that average connected load grows with the size of the business, but they do not present a simple linear relationship between size and LPD or average lumens per square foot.

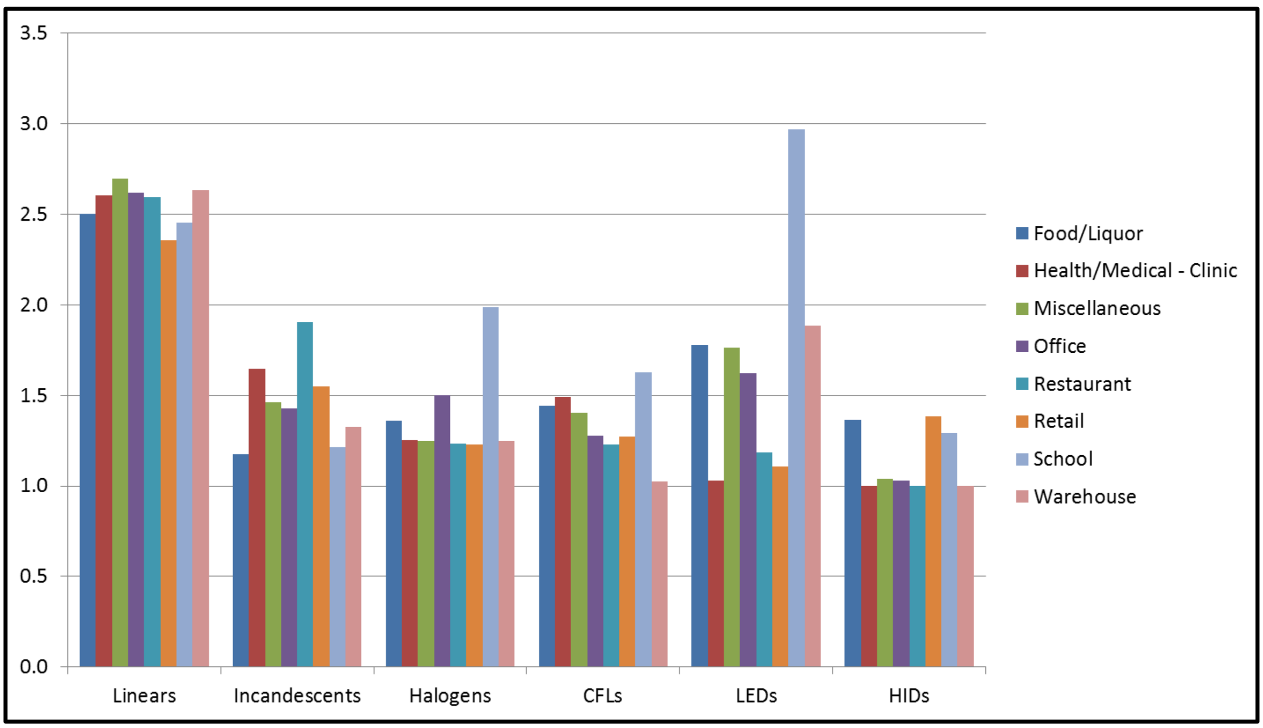
Table 5-10: Aggregated Averages by Business Size – Indoor Lighting

Business Size	*n*	Average Connected Load (Lamp Watts) per Business	Average LPD (Lamp Watts per Sq Ft)	Average Lumens per Sq Ft	Efficacy (Lumens per Watt)
Large	97	143,186	0.70	53	77
Medium	463	47,787	0.96	74	77
Small	484	9,983	0.73	52	71
Very Small	392	2,767	0.95	61	64
Total	**1,436**	**7,969**	**0.84**	**60**	**72**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Totals for Average Connected Load, Average LPD, Average Lumens per Sq Ft, and Efficacy represent weighted averages across all business types. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-5 depicts the average number of lamps per fixture found in indoor spaces by lighting technology. Linear fixtures are found to have the highest average number of lamps per fixture for all business types.

Figure 5-5: Average Number of Lamps per Fixture – Indoor Lighting



* **The results presented above have been weighted by site weight.**

5.4 Linear Lighting

The Linear lighting section presents information on Linear technologies currently installed in commercial businesses in California. The analysis incorporates some basic characteristics of Linear lamps, including the share of businesses with Linear lamps, the average age of these technologies, and the average number of lamps per square foot. This section will present saturations and densities of all Linear technologies and then focus on the efficiency distributions of 4-foot Linear technologies.

Linear technologies can be characterized by their diameter (typically T12, T8, or T5), by more disaggregated efficiency characteristics, and by lamp length. This analysis identifies seven performance groups, which are designated as either High or Base Efficiency. The performance groups are defined as follows, in order of highest to lowest efficiency:

- High Efficiency technologies:
  - Linear LED: LED replacements for Linear Fluorescents which will fit into the same fixture housing as the Linear Fluorescent bulbs
  - T5: T5 lighting systems
  - Reduced Wattage T8: Reduced Wattage T8s, as determined by the Consortium for Energy Efficiency (CEE); fourth-generation bulbs are 30W T8s, while fifth-generation bulbs are less than 30W (typically 28W or 25W).
  - High Performance T8: High Performance T8s, as determined by the CEE; the third generation of T8 bulbs, with an extended life of 4,000 hours over that of the 700- and 800-Series bulbs, a CRI in the 80s, and a higher lumen output (at least 3,100 initial lumens).
- Base Efficiency technologies:
  - Std 800 T8: Standard 800-Series T8 bulbs, the second generation of T8 bulbs; have a CRI in the 80s and are rated between 87-92 LPW
  - Std 700 T8: Standard 700-Series T8 bulbs, the first generation of T8 bulbs; have a CRI in the 70s and are rated at 84+ initial LPW
  - T12: T12 bulbs, which were phased out of production in July 2012

The CSS Linear lighting analysis uses data from several data sources. The primary sources of information are on-site surveys, make and model lookups to determine efficiency levels, and Energy Efficiency program participation information. During the on-site survey, data were collected on the year the technologies were purchased, the number of new Linear lamps at the site, and the make and model number of all Linear technologies. Looking up the make and model number information, the research team determined the type and efficiency level of the technology. Make and model lookups develop crucial secondary information needed to classify the efficiency level of Linear lighting measures. The on-site form allows for the collection of make, model, size specifications, and wattage information from the bulbs and ballasts. Additional information needed for a thorough analysis includes lumens, rated light, and light color. However, these are details that cannot be collected on site. Lookup tables were developed using the data collected on site to determine the efficiency level of the Linear lamps. The final step of the make and model lookups is allocating the Linear lamps to one of the seven aforementioned performance groups.

All Linear lamp counts and shares presented in this section include, in addition to lamps that are installed and operative, burnt out lamps and lamps installed in inoperable fixtures.

5.4.1 General Saturation and Density

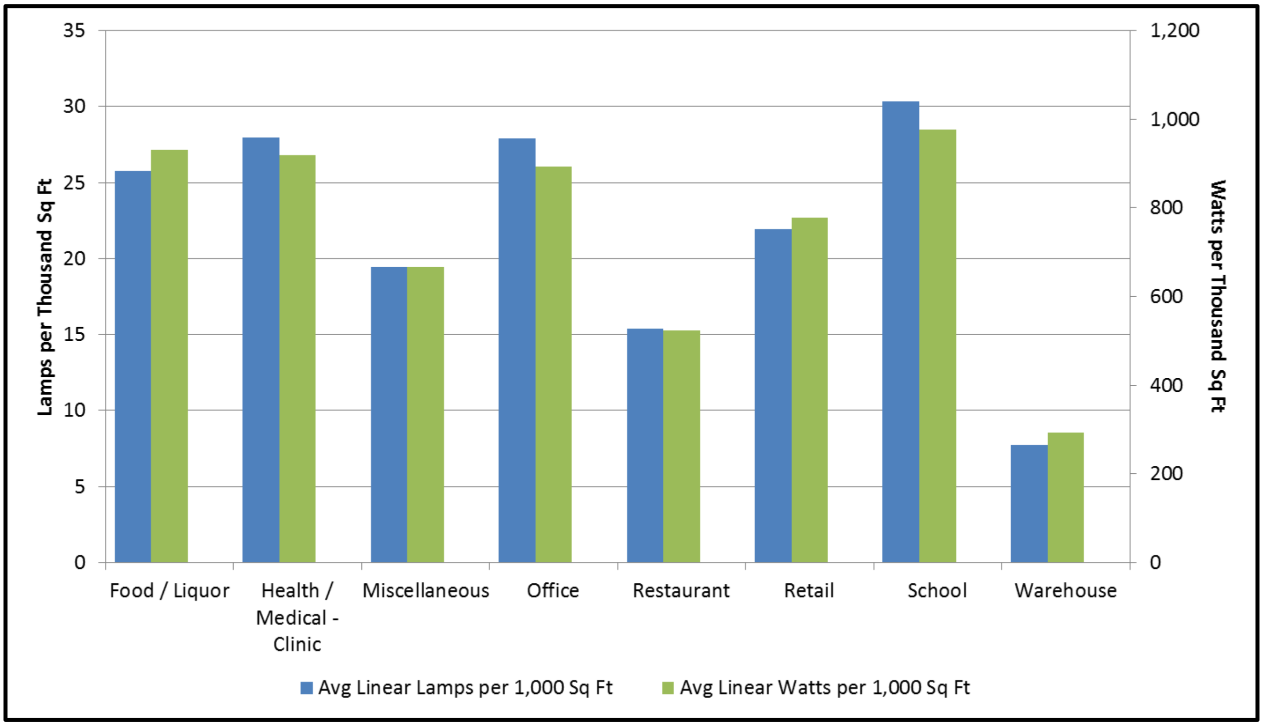
Table 5-11 shows the saturation of Linear technologies within CSS businesses in California. Linear lamps were found in nearly 98% of businesses. The data further shows the average density of Linear lighting within businesses by lamps per thousand square feet of floor area, watts per square foot, and lumens per square foot. Schools exhibit the highest density of Linear lighting across all three measures. While Health/Medical Clinics have the second highest incidence of Linear lamps per thousand square feet, Food/Liquor stores have higher average wattage and lumen output per square foot, indicating that on average Food/Liquor stores install Linear lighting with higher wattage and lumen output per lamp than Health/Medical Clinics. The relationship between lamp and wattage densities by business type is also depicted in Figure 5-6.

Table 5-11: Average Density of Linear Lamps by Business Type – Indoor Lighting

Business Type	Total Sites	Share of Businesses with Linear Lamps	Average Linear Lamps per 1,000 Sq Ft	Average Linear Watts per Sq Ft	Average Linear Lumens per Sq Ft
Food/Liquor	126	100%	25.7	0.93	78
Health/Medical - Clinic	128	98%	28.0	0.92	70
Miscellaneous	245	91%	19.5	0.67	54
Office	246	92%	27.9	0.89	71
Restaurant	170	98%	15.4	0.52	40
Retail	233	94%	22.0	0.78	66
School	161	100%	30.3	0.98	79
Warehouse	127	95%	7.7	0.29	24
Total	**1,436**	**98%**	**19.6**	**0.66**	**54**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Total Share of Businesses with Linear Lamps is the share across all business types. Totals for Average Linear Lamps per 1,000 Sq Ft, Average Linear Watts per Sq Ft, and Average Linear Lumens per Sq Ft represent weighted averages across all business types.

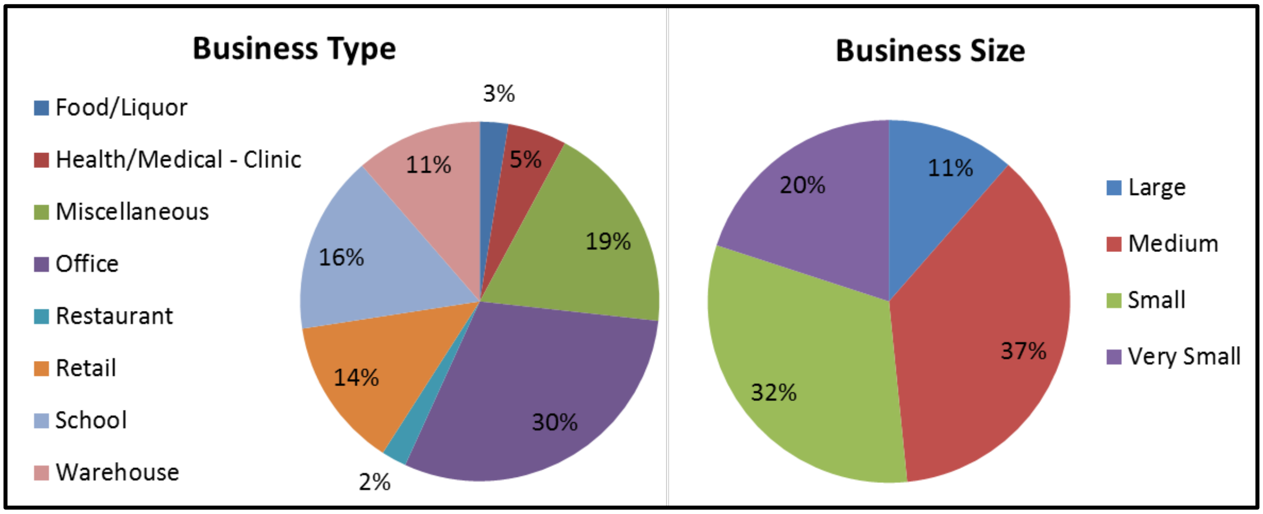
Figure 5-6: Average Linear Lamps and Watts per Thousand Square Feet by Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

Figure 5-7 illustrates the distribution of Linear lamps across business types and business sizes. This provides perspective on the relative magnitude of the distributions that follow. As shown below, Offices comprise the greatest share of Linear lamps of any business type, with 30% of all indoor commercial Linear lamps installed in Offices. Offices have a high density of Linear lamps and occupy 21% of the CSS business floor stock, leading to their high share of Linear lamps.[6] Within business size, Medium and Small businesses represent the greatest share of Linear lamps. While Large businesses tend to have a higher volume of lamps per business, there are sufficiently fewer Large businesses so that they only make up 11% of the total share of indoor commercial Linear lamps.

Figure 5-7: Distribution of Linear Lamps by Business Type and Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Age Distribution of Linear Technologies

The distribution of Linear lamps by system installation year and business type is presented in Table 5-12 and Figure 5-8. For a large proportion of Linear systems across all business types, the year of installation is unknown. For the remaining systems for which the installation year is known, the majority of lamps were installed between 2009 and 2012 across all business types. The prominence of Linear system installations between 2009 and 2012 is likely due to a high share of recent installations combined with the high share of Unknown system installation years. Health/Medical Clinics and Offices show a high proportion of Linear lamps in systems installed

6 Section 4 of this report presents information on the share of floor stock by CSS business type. Offices have the second highest share of CSS floor stock. Warehouses have the highest share of floor stock.

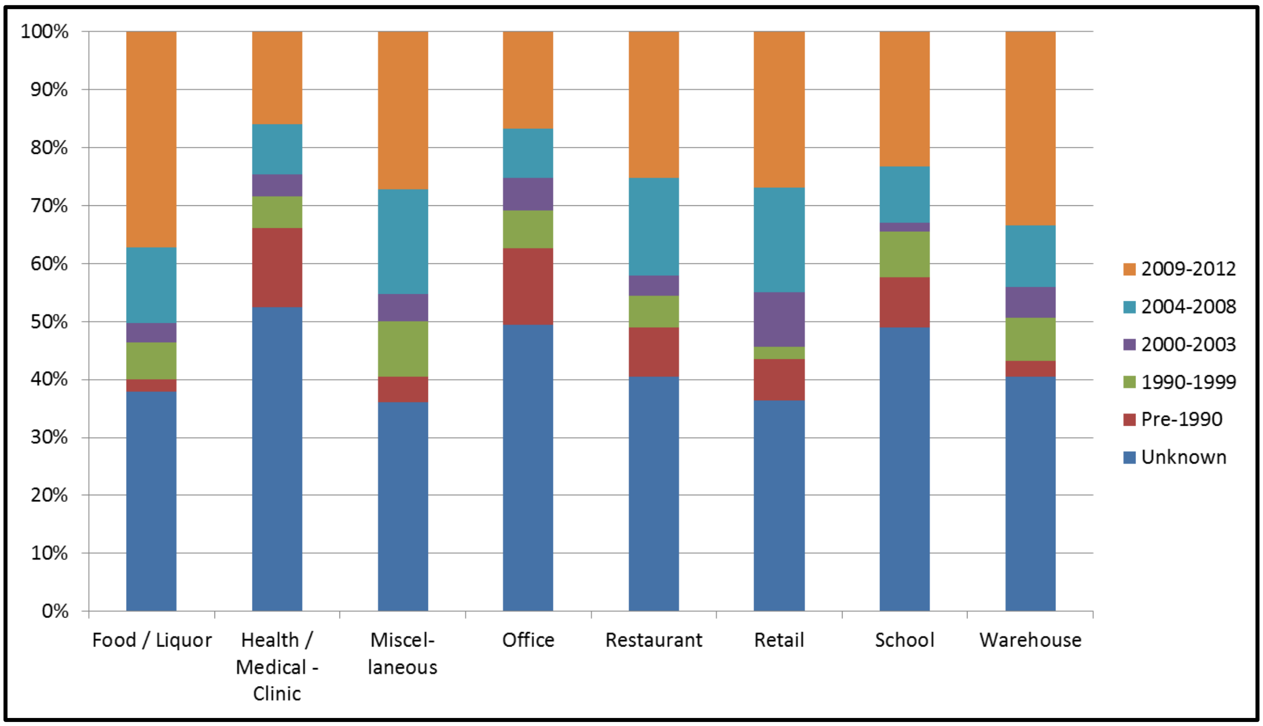
before 1990. As demonstrated later, these business types also have a large proportion of older T12 and Standard 700 T8 lamps relative to other business types.

Table 5-12: Distribution of Linear Lamps by System Installation Year and Business Type – Indoor Lighting

System Installation Year	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Unknown	38%	52%	36%	49%	41%	36%	49%	40%
Pre-1990	2.2%	14%	4.3%	13%	8%	7%	9%	2.8%
1990-1999	6%	6%	10%	7%	5%	2.1%	8%	7%
2000-2003	3.4%	3.7%	4.7%	6%	3.5%	9%	1.4%	5%
2004-2008	13%	9%	18%	8%	17%	18%	10%	11%
2009-2012	37%	16%	27%	17%	25%	27%	23%	33%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**126**	**126**	**237**	**238**	**166**	**227**	**160**	**124**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-8: Distribution of Linear Lamps by System Installation Year and Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

Length Distribution of Linear Technologies

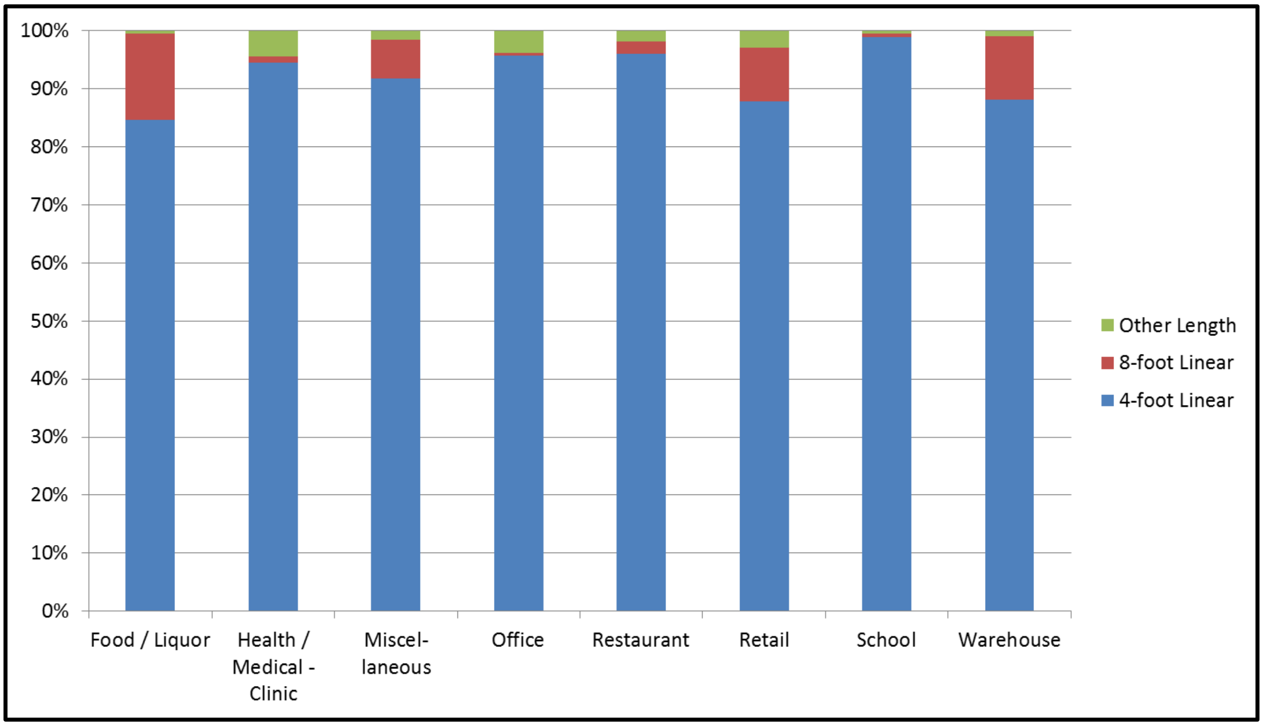
Table 5-13 and Figure 5-9 show the distribution of Linear technologies by lamp length and business type. As depicted, 4-foot Linear lamps are the most prevalent lamp length across all business types. Food/Liquor stores and Warehouses have higher proportions of 8-foot lamps than other business types. Lamp lengths other than 4 and 8 feet represent less than 5% of the Linear lamps installed in any business type.

Table 5-13: Length Distribution of Linear Lamps by Business Type – Indoor Lighting

Lamp Length	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot Linear	85%	94%	92%	96%	96%	88%	99%	88%
8-foot Linear	15%	1.0%	7%	0.4%	2.2%	9%	0.6%	11%
Other Length	0.6%	4.5%	1.6%	3.8%	1.8%	2.9%	0.5%	1.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**126**	**126**	**237**	**238**	**166**	**227**	**160**	**124**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-9: Length Distribution of Linear Lamps by Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

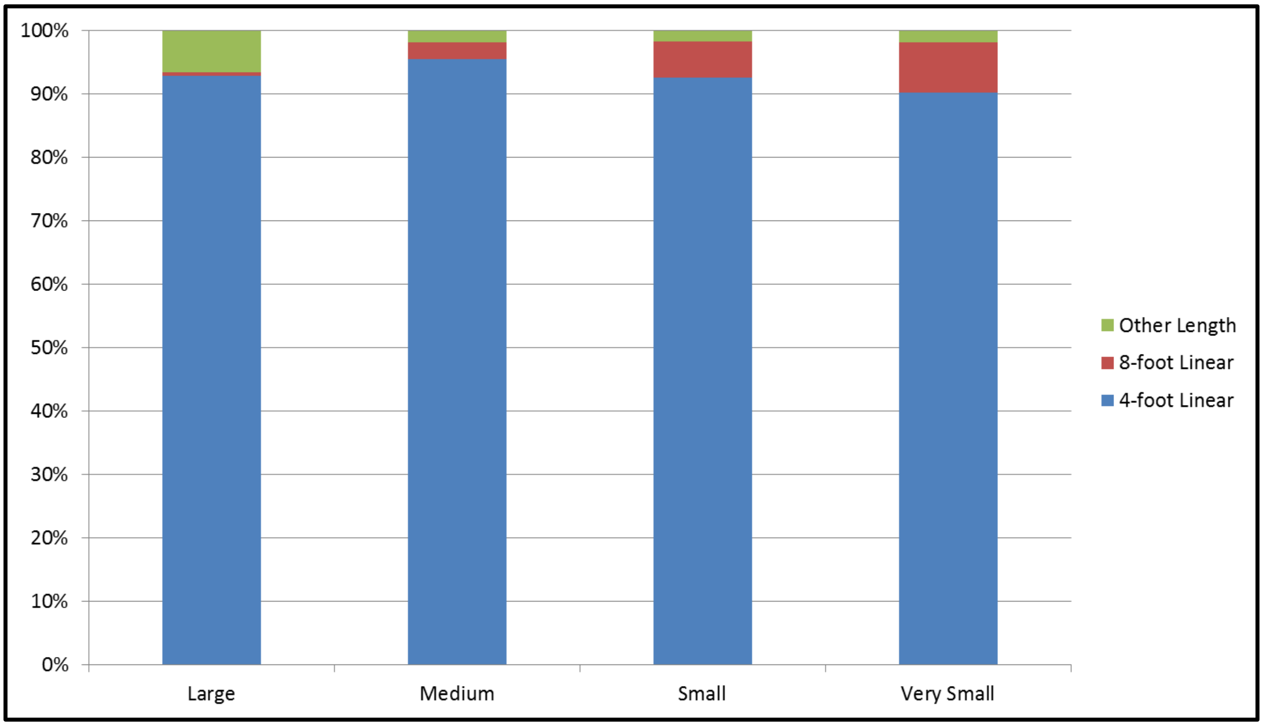
The length distribution of Linear lamps was also analyzed by business size, based on kWh consumption. Table 5-14 shows that in all size brackets, 4-foot lamps represent the largest share of Linear lamps. Small and Very Small businesses are shown to have a greater share of 8-foot lamps than Large and Medium businesses. Large businesses also tend to have a relatively higher share of Linear lamps of lengths other than 4 and 8 feet, relative to other business sizes. Figure 5-10 illustrates this length distribution of Linear lamps by business size.

Table 5-14: Length Distribution of Linear Lamps by Business Size – Indoor Lighting

Lamp Length	Large	Medium	Small	Very Small
4-foot Linear	93%	96%	93%	90%
8-foot Linear	0.6%	2.6%	6%	8%
Other Length	7%	1.8%	1.7%	1.8%
Total	**100%**	**100%**	**100%**	**100%**
n	**97**	**462**	**478**	**367**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-10: Length Distribution of Linear Lamps by Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Given that 4-foot Linear technologies are the dominate technology type, the Linear subsection will focus on 4-foot Linear technologies, presenting limited information on lamps of other lengths.

5.4.2 Saturations by Performance Group

Performance Group Distribution by Business Type

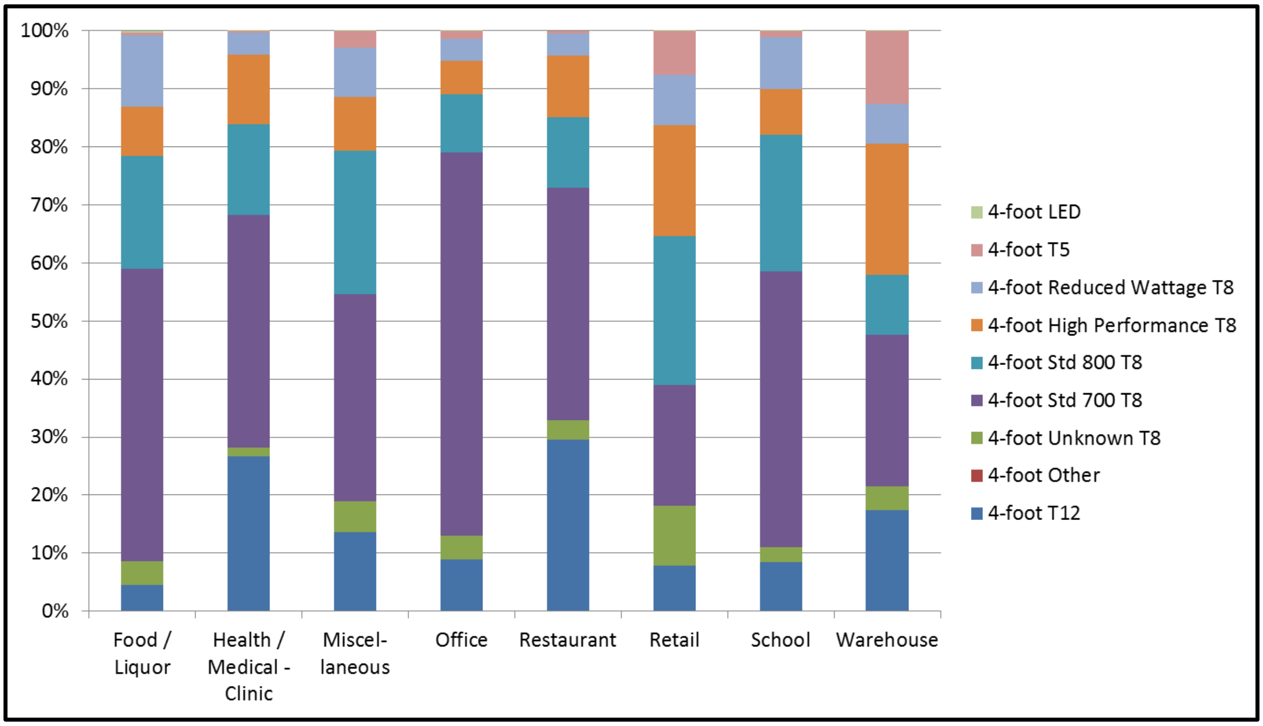
Table 5-15 and Figure 5-11 present the share of Linear lamps in each performance group by business type. As depicted, Offices have the greatest share of Base Efficiency lamps of any business type, with Base Efficiency lamps representing nearly 90% of the total Linear lamps installed in Offices. Conversely, Warehouses boast the highest share of High Efficiency lamps at 42%. Restaurants and Health/Medical Clinics have T12s in almost 30% of their Linear fixtures. Linear LEDs represent less than 1% of Linear lamps for all business types.

Table 5-15: Linear Lamp Efficiency Distribution by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Base Efficiency	78%	84%	79%	89%	85%	65%	82%	58%
High Efficiency	22%	16%	21%	11%	15%	35%	18%	42%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution								
4-foot T12	4.5%	27%	14%	9%	30%	8%	8%	17%
4-foot Other	0%	0%	<0.1%	<0.1%	0%	0%	0%	0%
4-foot Unknown T8	4.1%	1.5%	5%	4.2%	3.3%	10%	2.6%	4.0%
4-foot Std 700 T8	50%	40%	36%	66%	40%	21%	47%	26%
4-foot Std 800 T8	20%	16%	25%	10%	12%	26%	23%	10%
High Efficiency Tiers Distribution								
4-foot High Performance T8	8%	12%	9%	6%	11%	19%	8%	23%
4-foot Reduced Wattage T8	12%	3.8%	9%	3.8%	3.9%	9%	9%	7%
4-foot T5	0.5%	0.3%	2.8%	1.4%	0.5%	8%	1.1%	13%
4-foot LED	0.4%	<0.1%	0.1%	<0.1%	0%	0.1%	<0.1%	<0.1%
n	**120**	**124**	**228**	**237**	**163**	**219**	**160**	**121**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-11: Linear Lamp Efficiency Distribution by Business Type – Indoor Lighting

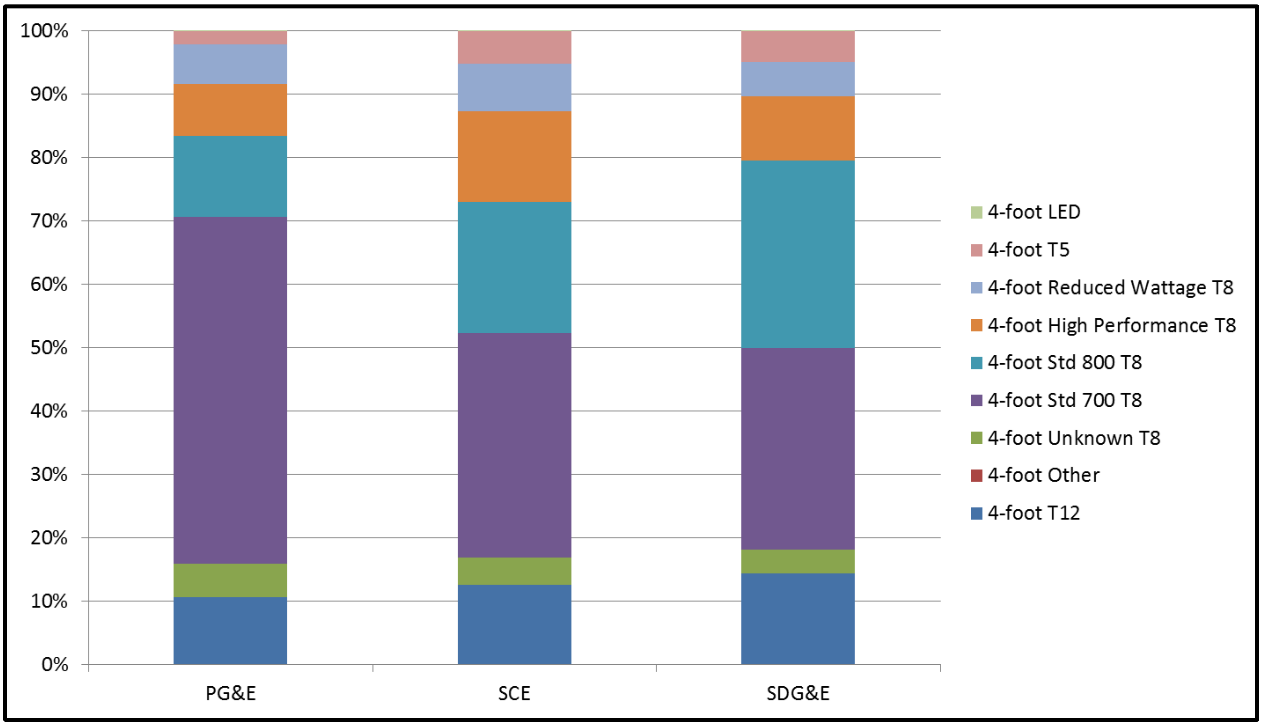


*** The results presented above have been weighted by site weight.**

Performance Group Distribution by IOU

Figure 5-12 illustrates the saturation of Linear technologies by performance group for each IOU. SCE has the highest proportion of High Efficiency lamps, with over a quarter of its Linear lamps High Performance T8s, Reduced Wattage T8s, T5s, or Linear LEDs. PG&E has a large proportion of Standard 700-Series T8s, causing High Efficiency lamps to constitute just 17% of its total.

Figure 5-12: Linear Lamp Efficiency Distribution by IOU – Indoor Lighting



*** The results presented above have been weighted by site weight.**

<u>Performance Group Distribution by IOU and Business Type</u>

Table 5-16, Table 5-17, and Table 5-18 detail the share of Linear lamps by business type for PG&E, SCE, and SDG&E, respectively. Standard 700-Series T8s represent the largest share of Linear lamps in Food/Liquor stores, Miscellaneous businesses, Offices, and Restaurants for all three IOUs. T12s represent the lion's share of lamps in Health/Medical Clinics in SDG&E, while Standard 700-Series T8s are favored in similar facilities in PG&E. In SCE, Health/Medical Clinics have roughly equal shares of T12s and Standard 700-Series T8s.

As illustrated previously, Offices have 30% of the Linear lamps in CSS businesses. In PG&E Offices, High Efficiency Linear lamps represent approximately 6% of Linear technologies. In SDG&E Offices, High Efficiency Linear lamps are only 4% of Linear technologies, while they constitute 23% of Linear technologies in SCE Offices. Turning to the least efficient Linear lamps, SDG&E Offices have 19% T12s, SCE Offices have 13%, and PG&E Offices have 6% T12s. Warehouses in PG&E have more High Efficiency Linear lamps than Base Efficiency (with 38% High Performance T8s), while Base Efficiency lamps prevail in Warehouses in SCE and SDG&E.

Table 5-16: Linear Lamp Efficiency Distribution by Business Type for PG&E – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel- laneous	Office	Restau- rant	Retail	School	Ware- house
Base Efficiency	86%	83%	85%	94%	96%	72%	86%	41%
High Efficiency	14%	17%	15%	6%	4.4%	28%	14%	59%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution								
4-foot T12	3.0%	16%	20%	6%	36%	7%	7%	21%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	2.9%	2.0%	3.8%	4.0%	2.6%	17%	3.2%	6%
4-foot Std 700 T8	47%	50%	38%	78%	49%	25%	61%	9%
4-foot Std 800 T8	33%	14%	23%	6%	8%	23%	14%	3.9%
High Efficiency Tiers Distribution								
4-foot High Performance T8	2.2%	17%	7%	2.7%	4.4%	9%	6%	38%
4-foot Reduced Wattage T8	11%	0%	6%	2.9%	0%	14%	7%	15%
4-foot T5	0.7%	0%	1.8%	0.9%	0%	5%	1.7%	6%
4-foot LED	0.1%	0%	0.2%	0%	0%	0%	<0.1%	0%
n	**49**	**50**	**94**	**101**	**61**	**76**	**77**	**35**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-17: Linear Lamp Efficiency Distribution by Business Type for SCE – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel- laneous	Office	Restau- rant	Retail	School	Ware- house
Base Efficiency	70%	85%	76%	77%	77%	58%	77%	67%
High Efficiency	30%	15%	24%	23%	23%	42%	23%	33%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution								
4-foot T12	4.1%	32%	8%	13%	27%	8%	12%	14%
4-foot Other	0%	0%	0.1%	<0.1%	0%	0%	0%	0%
4-foot Unknown T8	4.8%	0%	6%	5%	2.5%	6%	1.7%	2.5%
4-foot Std 700 T8	51%	34%	34%	44%	36%	17%	37%	37%
4-foot Std 800 T8	10%	19%	27%	15%	12%	27%	26%	13%
High Efficiency Tiers Distribution								
4-foot High Performance T8	15%	8%	10%	14%	17%	30%	7%	14%
4-foot Reduced Wattage T8	15%	6%	9%	7%	5%	6%	15%	1.3%
4-foot T5	0.4%	0.6%	4.3%	2.0%	1.0%	7%	0.6%	18%
4-foot LED	<0.1%	0.1%	<0.1%	<0.1%	0%	0.2%	0.1%	0.1%
n	**52**	**51**	**90**	**104**	**71**	**109**	**65**	**69**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-18: Linear Lamp Efficiency Distribution by Business Type for SDG&E – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Base Efficiency	85%	83%	69%	96%	85%	65%	77%	84%
High Efficiency	15%	17%	31%	4.3%	15%	35%	23%	16%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution								
4-foot T12	10%	61%	10%	19%	23%	11%	0.3%	21%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	6%	6%	4.9%	2.4%	8%	4.2%	2.5%	2.1%
4-foot Std 700 T8	60%	10%	33%	52%	27%	20%	12%	38%
4-foot Std 800 T8	9%	6%	21%	23%	26%	30%	62%	24%
High Efficiency Tiers Distribution								
4-foot High Performance T8	4.7%	0%	14%	0%	5%	16%	23%	3.7%
4-foot Reduced Wattage T8	8%	17%	17%	0.9%	10%	1.6%	0%	1.4%
4-foot T5	0%	0%	0.4%	3.4%	0%	17%	<0.1%	11%
4-foot LED	2.4%	0%	0%	0%	0%	0.1%	0%	0%
n	**19**	**23**	**44**	**32**	**31**	**34**	**18**	**17**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

<u>Performance Group Distribution by Business Size</u>

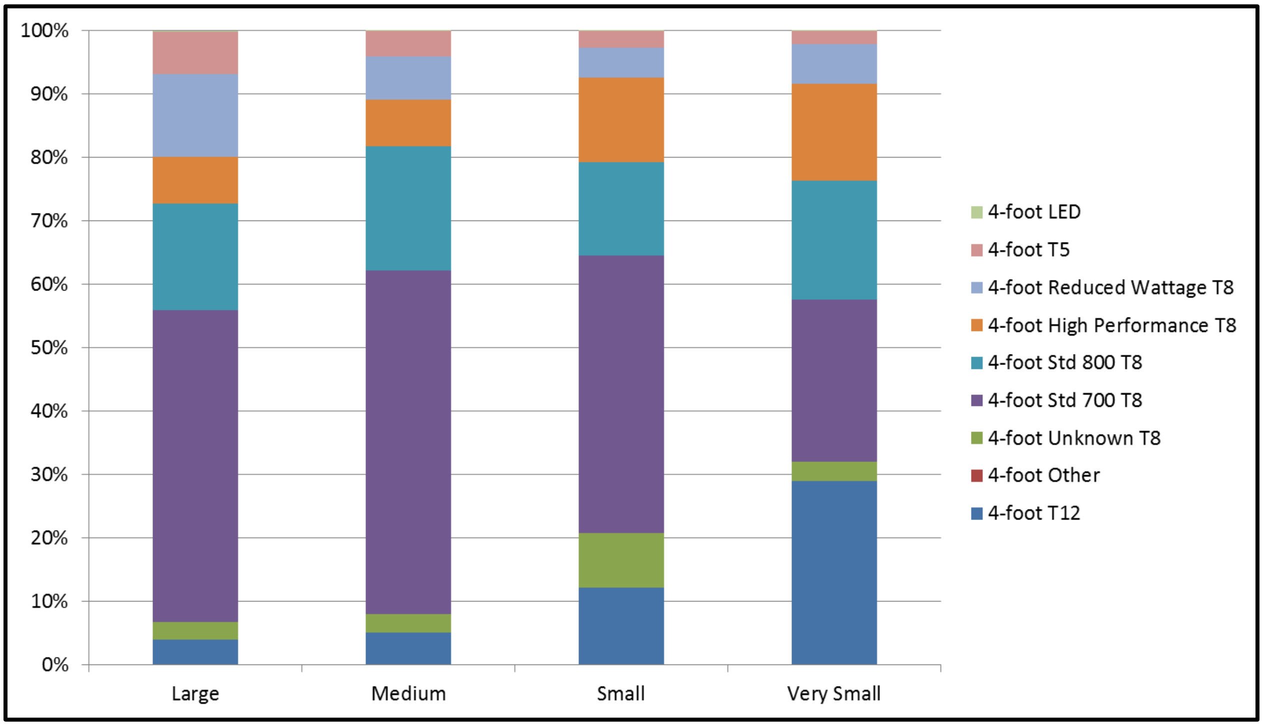
Table 5-19 and Figure 5-13 present the efficiency distribution of Linear lamps by business size, based on kWh consumption. Standard 700-series T8s represent the bulk of the lamps for Large, Medium, and Small businesses. Very Small businesses have a high share of T12 lamps, with a proportion of more than double that of Small businesses. Small and Very Small businesses have high shares of High Performance T8s than Large and Medium businesses.

Table 5-19: Linear Lamp Efficiency Distribution by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
Base Efficiency	73%	82%	79%	76%
High Efficiency	27%	18%	21%	24%
Total	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution				
4-foot T12	4.0%	5%	12%	29%
4-foot Other	0%	0%	0%	<0.1%
4-foot Unknown T8	2.8%	2.9%	9%	3.0%
4-foot Std 700 T8	49%	54%	44%	26%
4-foot Std 800 T8	17%	20%	15%	19%
High Efficiency Tiers Distribution				
4-foot High Performance T8	7%	7%	13%	15%
4-foot Reduced Wattage T8	13%	7%	4.7%	6%
4-foot T5	7%	4.0%	2.6%	2.1%
4-foot LED	0.2%	0.1%	<0.1%	<0.1%
n	**96**	**458**	**468**	**350**

* **The results presented above have been weighted by site weight.** *n*’s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-13: Linear Lamp Efficiency Distribution by Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by Business Size and IOU

Table 5-20, Table 5-21, and Table 5-22 provide the efficiency distribution of Linear lamps by business size for PG&E, SCE, and SDG&E, respectively. Across all three utilities, Large, Medium, and Small businesses have predominantly Standard 700- and 800-Series T8 lamps. For Very Small businesses in PG&E and SDG&E, T12 lamps capture the greatest share of total Linear lamps. The share of T12s for Very Small businesses in SCE is substantially lower than that of Very Small businesses in the other two IOUs. For Very Small SCE businesses, Standard 800-Series T8s and High Performance T8s are much more prevalent.

Table 5-20: Linear Lamp Efficiency Distribution by Business Size for PG&E – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	7%	0.7%	9%	42%
4-foot Other	0%	0%	0%	0%
4-foot Unknown T8	4.6%	3.0%	10%	1.5%
4-foot Std 700 T8	46%	71%	46%	34%
4-foot Std 800 T8	17%	13%	13%	9%
4-foot High Performance T8	2.6%	6%	14%	6%
4-foot Reduced Wattage T8	18%	4.8%	6%	4.1%
4-foot T5	4.5%	1.0%	1.7%	3.7%
4-foot LED	0.4%	<0.1%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**
n	**39**	**198**	**180**	**126**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-21: Linear Lamp Efficiency Distribution by Business Size for SCE – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	1.4%	12%	17%	15%
4-foot Other	0%	0%	0%	0.1%
4-foot Unknown T8	1.4%	2.7%	7%	4.8%
4-foot Std 700 T8	54%	33%	43%	17%
4-foot Std 800 T8	17%	24%	14%	27%
4-foot High Performance T8	13%	8%	13%	26%
4-foot Reduced Wattage T8	8%	11%	2.9%	9%
4-foot T5	5%	9%	3.4%	1.2%
4-foot LED	<0.1%	0.1%	0.1%	<0.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**47**	**202**	**209**	**153**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-22: Linear Lamp Efficiency Distribution by Business Size for SDG&E – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	1.1%	2.6%	13%	34%
4-foot Other	0%	0%	0%	0%
4-foot Unknown T8	1.6%	3.7%	6%	2.3%
4-foot Std 700 T8	39%	36%	31%	26%
4-foot Std 800 T8	15%	41%	29%	22%
4-foot High Performance T8	0%	13%	10%	11%
4-foot Reduced Wattage T8	15%	2.9%	6%	4.6%
4-foot T5	28%	1.8%	4.9%	0.5%
4-foot LED	0%	0.1%	0.1%	<0.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**10**	**58**	**79**	**71**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by Business Size and Business Type

Table 5-23, Table 5-24, Table 5-25, and Table 5-26 show the efficiency distribution of Linear lamps by business type for Large-, Medium-, Small-, and Very Small-sized businesses, respectively.[7] High Performance T8s make up over a quarter of the share of Linear lamps in Very Small Food/Liquor stores, compared to zero in Large stores, 8% in Medium stores, and 16% in Small stores. Large, Medium, and Small Offices have Standard 700-Series T8s as the greatest share of lamps, while Very Small Offices have a greater share of T12s. Regardless of size, Offices have on average more than four Base Efficiency Linear lamps for every one High Efficiency lamp. Restaurants in the Medium, Small, and Very Small categories tend to have a greater share of Base Efficiency lamps than High Efficiency lamps.[8] However, Very Small Restaurants have a greater share of High Performance T8s than any other performance group of Linear lamps. In Large Retail stores, Reduced Wattage T8s constitute nearly a quarter of the Linear lamps installed, a substantially greater share than any other business size. The Very Small Schools sampled had 0% High Efficiency Linear lamps, though Schools of other sizes had only about a quarter share of High Efficiency lamps or less. In Small Warehouses, High Performance T8s represented the greatest share of Linear lamps at nearly 40%, causing High Efficiency lighting to compose over half of the total Linear lamps in Small Warehouses.

[7] Results for Large businesses by business type represent a limited number of sites. See *n* values in Table 5-23 for site counts.

[8] No data was collected for Large Restaurants.

Medium-sized Warehouses have a 34% share of T5s, the leading share among T5s in any business type of any size.

Table 5-23: Linear Lamp Efficiency Distribution by Business Type for Large-Sized Businesses – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	0.4%	0%	3.1%	8%	0%	0.5%	0.6%	0.5%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	0%	0%	0%	4.8%	0%	3.3%	0.5%	0.5%
4-foot Std 700 T8	72%	100%	28%	69%	0%	12%	48%	60%
4-foot Std 800 T8	18%	0%	39%	6%	0%	27%	25%	0%
4-foot High Performance T8	0%	0%	4.0%	3.5%	0%	19%	11%	2.0%
4-foot Reduced Wattage T8	9%	0%	16%	6%	0%	23%	13%	26%
4-foot T5	1.0%	0%	9%	3.4%	0%	15%	1.3%	11%
4-foot LED	0%	0%	1.3%	0%	0%	0%	<0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**
n	**12**	**1**	**12**	**25**	**0**	**20**	**18**	**8**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh. Note, results for Large businesses by business type represent a limited number of sites. No data was collected for Large Restaurants.

Table 5-24: Linear Lamp Efficiency Distribution by Business Type for Medium-Sized Businesses – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	0.4%	24%	4.6%	1.1%	11%	3.1%	9%	7%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	2.6%	1.2%	2.1%	2.4%	1.6%	11%	2.0%	1.8%
4-foot Std 700 T8	44%	39%	54%	79%	45%	20%	34%	30%
4-foot Std 800 T8	27%	19%	22%	9%	32%	35%	31%	19%
4-foot High Performance T8	8%	13%	8%	4.3%	0%	13%	11%	3.8%
4-foot Reduced Wattage T8	18%	2.2%	6%	3.3%	10%	12%	12%	4.6%
4-foot T5	0.1%	0.8%	2.4%	1.0%	0.1%	6%	1.1%	34%
4-foot LED	0.3%	0.1%	<0.1%	<0.1%	0%	0.3%	<0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**52**	**43**	**63**	**83**	**36**	**51**	**96**	**34**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Medium sites have greater than 300,000 kWh and less than or equal to 1,750,000.

Table 5-25: Linear Lamp Efficiency Distribution by Business Type for Small-Sized Businesses – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	17%	17%	18%	10%	35%	9%	3.5%	10%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	10%	1.4%	8%	10%	4.2%	19%	4.2%	8%
4-foot Std 700 T8	46%	68%	32%	54%	40%	27%	70%	22%
4-foot Std 800 T8	5%	8%	21%	17%	8%	18%	12%	9%
4-foot High Performance T8	16%	4.9%	9%	5%	10%	22%	3.7%	39%
4-foot Reduced Wattage T8	4.0%	0.7%	10%	1.3%	2.1%	0.6%	5%	6%
4-foot T5	0.8%	0%	2.4%	1.8%	0.7%	4.6%	1.3%	6%
4-foot LED	0.7%	0%	<0.1%	0%	0%	0%	0.1%	0.1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**51**	**30**	**82**	**57**	**103**	**62**	**41**	**42**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Small sites have max annual usage greater than 40,000 kWh and less than or equal to 300,000.

Table 5-26: Linear Lamp Efficiency Distribution by Business Type for Very Small-Sized Businesses – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	0%	36%	16%	38%	26%	17%	68%	53%
4-foot Other	0%	0%	0.1%	<0.1%	0%	0%	0%	0%
4-foot Unknown T8	19%	1.9%	4.5%	2.8%	0.8%	3.5%	0%	0.2%
4-foot Std 700 T8	33%	19%	33%	27%	31%	20%	10%	18%
4-foot Std 800 T8	21%	18%	27%	10%	5%	24%	22%	5%
4-foot High Performance T8	27%	17%	11%	15%	33%	22%	0%	19%
4-foot Reduced Wattage T8	0%	8%	7%	7%	4.4%	5%	0%	4.2%
4-foot T5	0%	0%	2.1%	0.1%	0%	8%	0%	0.6%
4-foot LED	0%	0%	0%	0%	0%	0.1%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**5**	**50**	**71**	**72**	**24**	**86**	**5**	**37**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Very Small sites have annual usage less than or equal to 40,000 kWh.

<u>Performance Group Distribution by EE 2009-2012 LF HIM Participation</u>

For the purposes of this analysis, Energy Efficiency program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[9] Participation in Energy Efficiency programs for High-Impact Measure Linear Fluorescents (EE LF HIM) is not limited to one specific program, but rather includes any EE program for which an application identified the installation of Linear Fluorescents.[10]

Displayed in Table 5-27 is the efficiency distribution of Linear lamps by participation in 2009-2012 Energy Efficiency programs for High-Impact Measure Linear Fluorescents. For EE LF HIM program non-participants, Standard 700-Series T8s account for the largest share of Linear lamps. EE LF HIM participants, however, most commonly have Reduced Wattage T8s installed and have higher shares of all High Efficiency technologies than non-participants. Additionally, T12s represent less than half the share of EE LF HIM participant lamps compared to non-participant lamps. The differences between EE LF HIM participant and non-participant shares are statistically significant for all performance groups except LEDs and Unknown T8s. The

9 Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

10 A custom EE program application that did not specify the installation of Linear Fluorescents, but identified high efficiency lighting was not included in the LF HIM but was included in the more inclusive Lighting HIM. Upstream programs were not included in the analysis of EE LF HIM participation; however there were no substantial upstream programs for Linear Fluorescents.

differences between participant and non-participant shares of Base and High Efficiency technologies are statistically significant at the 1% level.

Table 5-27: Linear Lamp Efficiency Distribution by EE 2009-2012 LF HIM Participation – Indoor Lighting

Performance Group	EE LF HIM Non-Participant	EE LF HIM Participant
Base Efficiency	83%	51% ***
High Efficiency	17%	49% ***
Total	**100%**	**100%**
Base Efficiency Tiers Distribution		
4-foot T12	13%	6% ***
4-foot Other	0%	0.1% **
4-foot Unknown T8	4.5%	6%
4-foot Std 700 T8	48%	23% ***
4-foot Std 800 T8	18%	15%
High Efficiency Tiers Distribution		
4-foot High Performance T8	10%	18% ***
4-foot Reduced Wattage T8	4.0%	24% ***
4-foot T5	2.9%	7% ***
4-foot LED	0.1%	0.1%
n	**1,067**	**305**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Performance Group Distribution by EE 2009-2012 LF HIM Participation and IOU

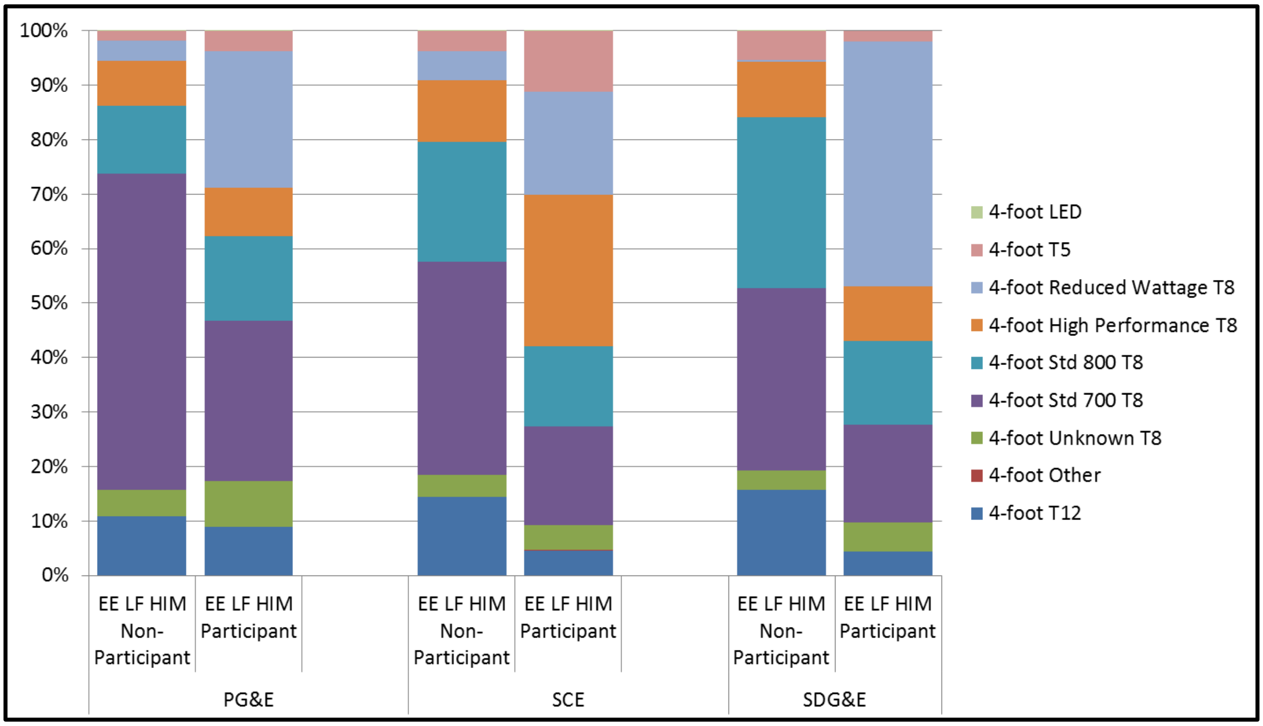
Table 5-28 and Figure 5-14 display the efficiency distribution of Linear lamps by participation in 2009-2012 Energy Efficiency programs for High-Impact Measure Linear Fluorescents (EE LF HIM) and by IOU. EE LF HIM program participants in all three utilities installed a greater share of High Efficiency Linear lamps than non-participants, with SDG&E program participants boasting a High Efficiency lamp share of three and half times that of non-participants. PG&E's EE LF HIM participants have a smaller share of High Efficiency Linear lamps than SCE and SDG&E's participants.

Table 5-28: Linear Lamp Efficiency Distribution by EE 2009-2012 LF HIM Participation and IOU – Indoor Lighting

Performance Group	PG&E		SCE		SDG&E	
	EE LF HIM Non-Participant	**EE LF HIM Participant**	**EE LF HIM Non-Participant**	**EE LF HIM Participant**	**EE LF HIM Non-Participant**	**EE LF HIM Participant**
4-foot T12	11%	9%	14%	4.6% ***	16%	4.4% ***
4-foot Other	0%	0%	0%	0.1% **	0%	0%
4-foot Unknown T8	4.9%	9%	4.1%	4.6%	3.5%	5%
4-foot Std 700 T8	58%	29% ***	39%	18% ***	34%	18% ***
4-foot Std 800 T8	12%	16%	22%	15% *	31%	15% ***
4-foot High Performance T8	8%	9%	11%	28% ***	10%	10%
4-foot Reduced Wattage T8	3.8%	25% ***	5%	19% ***	0.3%	45% ***
4-foot T5	1.8%	3.7%	3.8%	11% ***	5%	2.0%
4-foot LED	<0.1%	<0.1%	0.1%	0.1%	0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**448**	**95**	**440**	**171**	**179**	**39**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Figure 5-14: Linear Lamp Efficiency Distribution by EE 2009-2012 LF HIM Participation and IOU – Indoor Lighting



*** The results presented above have been weighted by site weight.**

5.4.3 Comparison with 2006 CEUS Study

Commercial lighting programs have targeted the replacement of T12 Linear Fluorescent lighting with higher efficiency alternatives for over 20 years. More recent programs have also attempted to replace 700-Series T8s with higher efficiency T8s and Linear LEDs. Table 5-29 presents the distribution of four-foot Linear technologies for the 2014 CSS and the 2006 CEUS study. The CSS results are presented by the CSS business types while the CEUS results are listed by similar CEUS business types. Prior to discussing the Linear lighting results, it is worth noting that the business type definitions have been modified across these two studies. Specifically, the CSS study does not include Hospitals in the Health/Medical Clinic business type, while the CEUS results include Hospitals. In addition, the CSS study does not disaggregate Offices into Small and Large Offices or Warehouses into Refrigerated and Other Warehouses. For the findings reported in Table 5-29, it was possible to combine CEUS Small and Large Offices and Refrigerated and Other Warehouses into single categories, but it was not possible to take Hospitals out of the Health/Medical Clinic category. Further, the CSS results are weighted by site, while the CEUS results are weighted by kWh.

For the CSS/CEUS comparison results presented in Table 5-29 the CSS T8 technologies have been grouped into T8s with Unknown Efficiency, Base Efficiency T8s, and High Efficiency T8s. For this comparison, Base Efficiency T8s are 700- and 800-Series T8s while High Efficiency

T8s are High Performance and Reduced Wattage T8s. The data collected as part of the CEUS was not subject to the make and model lookups that enable the development of T8 lighting efficiency distributions in the CSS. The CEUS, however, did collect information on Linear lighting wattage whenever possible. The CEUS wattage data indicates that nearly all T8s installed at the time of the CEUS were 700-Series, or Base Efficiency, T8s.

The data in Table 5-29 indicate that the share of T12 Linear lamps has fallen substantially for most business types. For Offices, the business type with the largest number of Linear technologies (see Figure 5-2), the share of Linear lamps that are T12s has fallen from 29% in the CEUS to 9% in the CSS, a reduction of 20 percentage points. The share of Restaurant T12s has fallen from 62% in the CEUS to 30% in the CSS; Miscellaneous business type T12s have fallen from 44% to 14%; and Warehouse T12s have declined from 40% to 17%. Health/Medical Clinics in the CSS have 27% T12s, while Health/Medical Clinics plus Hospitals in the CEUS have 26% T12s. The appearance of a one percentage point increase in the share of T12s in Health-related businesses is deceiving because the CEUS Health businesses include Hospitals. Hospitals are typically Large-sized businesses, which have a substantially smaller share of T12s than Small and Very Small businesses (see Table 5-19). The CSS Health/Medical Clinics likely have a higher share of T12s than the CEUS Health/Medical Clinics plus Hospitals due to the lack of Large-sized Hospitals in the CSS study.

Table 5-29: 2014 CSS and 2006 CEUS Linear Fluorescent Lamp Efficiency Distribution by Business Type – Indoor Lighting

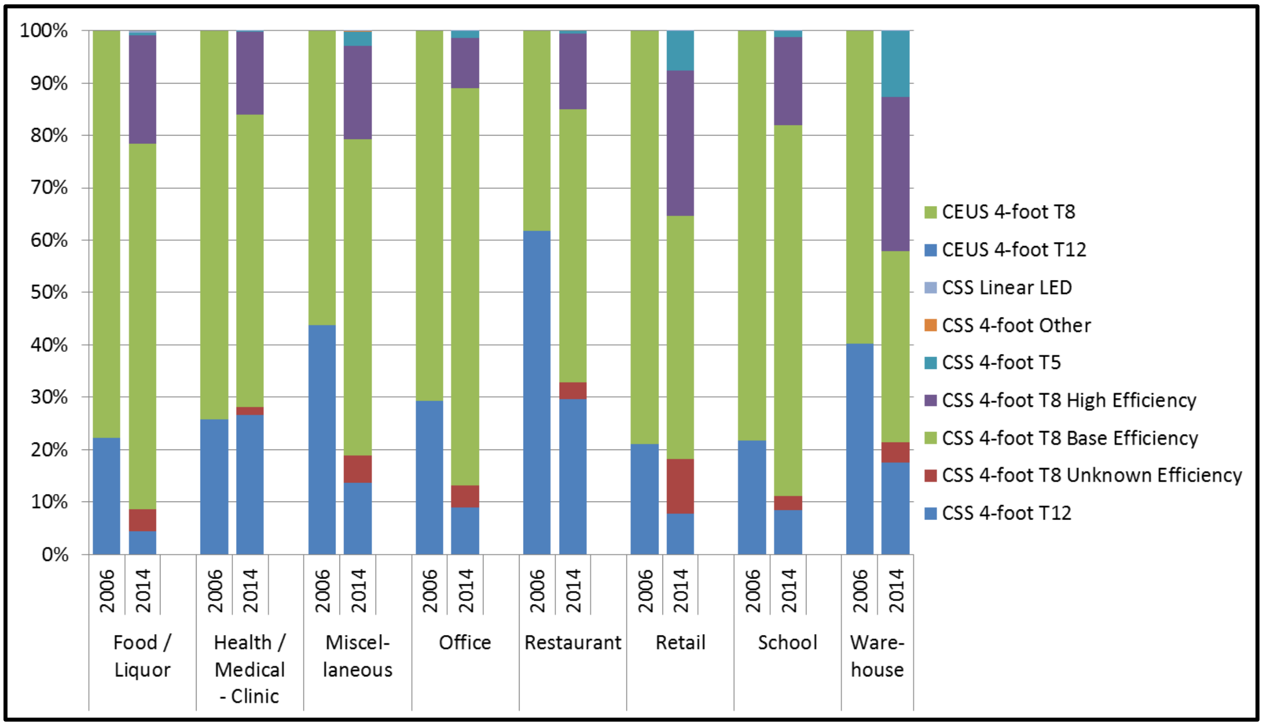
2014 CSS	Food/ Liquor	Health/ Medical – Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	4.5%	27%	14%	9%	30%	8%	8%	17%
4-foot T8 Unknown Efficiency	4.1%	1.5%	5%	4.2%	3.3%	10%	2.6%	4.0%
4-foot T8 Base Efficiency	70%	56%	60%	76%	52%	47%	71%	36%
4-foot T8 High Efficiency	21%	16%	18%	10%	14%	28%	17%	29%
4-foot T5	0.5%	0.3%	2.8%	1.4%	0.5%	8%	1.1%	13%
4-foot Other	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
4-foot LED	0.4%	<0.1%	0.1%	<0.1%	<0.1%	0.1%	<0.1%	<0.1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
2006 CEUS	**Food/ Liquor**	**Health/ Medical – Includes Hospitals**	**Miscel-laneous**	**Office – Large & Small**	**Restau-rant**	**Retail**	**School**	**Ware-house – Ref & Other**
4-foot T12	22%	26%	44%	29%	62%	21%	22%	40%
4-foot T8	78%	74%	56%	71%	38%	79%	78%	60%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

* **The CSSS results presented above have been weighted by site weight.** The CEUS results are kWh-weighted.

Figure 5-15 presents the data above in a bar graph to compare the findings from the 2006 CEUS with the 2014 CSS. T12s found during CEUS are directly comparable to T12s found during CSS. CEUS T8s are comparable to CSS Base Efficiency T8s because High Efficiency T8 technologies were not yet available during the CEUS data collection period. As illustrated, T12s represent a smaller share of lamps in CSS versus CEUS for all business types except Health/Medical Clinics, for which the T12 share is about the same in both time periods.[11] In conjunction with the lower T12 shares, T8s represent a higher share of lamps in CSS versus CEUS for all business types except Health/Medical Clinics, for which the T8 share is again roughly equal in both time periods. Retail stores and Warehouses have adopted High Efficiency T8 and T5 technologies at higher rates than other business types.

[11] The Health/Medical Clinic categories are not directly comparable between CSS and CEUS. The CSS study does not include Hospitals in the Health/Medical Clinic business type, while the CEUS results include Hospitals. It was not possible to take Hospitals out of the Health/Medical Clinic category in the presentation of the CEUS results.

Figure 5-15: 2014 CSS and 2006 CEUS Linear Fluorescent Lamp Efficiency Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

5.4.4 Burnt Out Linear Lamps

This subsection analyzes the distribution by performance group of Linear lamps that were found on site to be burnt out. The results presented in the tables represent Linear lamps burnt out as a percentage of total Linear lamps found at businesses within a performance group. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total burnt out Linear lamps as a percentage of total Linear lamps for each column.

Table 5-30 shows shares of burnt out Linear lamps relative to total Linear lamps in each performance group by business type. For example, the table shows that 2.1% of T12s installed in Food/Liquor stores were burnt out; this is not equivalent to the share of total Linear lamps across all performance groups that are burnt out. For Food/Liquor stores, the performance group with the highest share of burnt out lamps is T8s of unknown efficiency. Standard 800-series T8s have the highest share of burnt out lamps in Warehouses. For the remaining business types—Health/Medical Clinics, Miscellaneous, Offices, Restaurants, and Warehouses—T12s have the highest share of burnt out lamps. It is reasonable that T12s would have a relatively higher percentage of burnt out lamps compared to the other performance groups because they are an older technology. Not only are T12 lamps likely to be older than the other lamps at a given business, but T12s tend to have a shorter useful life than other technologies. No Linear LED lamps were found to be burnt out in any business and only a limited number of T5s were burnt out. In general, as efficiency increases, the share of burnt out lamps decreases.

Table 5-30: Burnt Out Linear Lamps as Shares of Total Linear Lamps by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	2.1%	1.9%	2.9%	2.4%	21%	3.5%	0.7%	6%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	3.4%	0.6%	1.5%	0.1%	2.1%	3.0%	1.1%	6%
4-foot Std 700 T8	2.0%	0.7%	0.8%	0.6%	2.4%	1.6%	0.9%	1.8%
4-foot Std 800 T8	0.9%	0.1%	1.0%	0.6%	3.2%	1.8%	1.9%	2.0%
4-foot High Performance T8	1.4%	0.6%	2.0%	0.4%	2.7%	1.3%	0.3%	1.0%
4-foot Reduced Wattage T8	0.9%	<0.1%	0.4%	1.2%	0.5%	0.7%	0.1%	0.4%
4-foot T5	0%	0%	<0.1%	0.2%	0%	<0.1%	0.6%	0.3%
4-foot LED	0%	0%	0%	0%	0%	0%	0%	0%
Total (Burnt Out / All Linear Lamps)	**1.6%**	**0.9%**	**1.2%**	**0.7%**	**8%**	**1.7%**	**1.0%**	**2.3%**
n	**120**	**124**	**228**	**237**	**163**	**219**	**160**	**121**
Sites with Burnt Out Linear Lamps	**36**	**31**	**66**	**55**	**44**	**67**	**59**	**42**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out Linear lamps as a percentage of total Linear lamps for each business type. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-31 shows the distribution of burnt out Linear lamps relative to total Linear lamps in each performance group by IOU. Across all three IOUs, T12s have the highest share of burnt out lamps relative to the other performance groups. As noted above, this result is unsurprising due to the old age and technology of T12 lamps. SCE has nearly twice the share of burnt out T12s as PG&E. This may be because SCE has a higher proportion of Restaurants and Warehouses with Linear lamps than the other IOUs, and these businesses have relatively high shares of burnt out T12s. Like the distribution by business type, the share of burnt out lamps tends to decrease as efficiency increases.

Table 5-31: Burnt Out Linear Lamps as Shares of Total Linear Lamps by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
4-foot T12	2.7%	5%	4.4%
4-foot Other	0%	0%	0%
4-foot Unknown T8	2.6%	1.3%	0.5%
4-foot Std 700 T8	0.9%	0.7%	1.4%
4-foot Std 800 T8	1.4%	1.1%	1.7%
4-foot High Performance T8	0.5%	1.3%	1.9%
4-foot Reduced Wattage T8	0.5%	0.6%	<0.1%
4-foot T5	0.2%	0.1%	0.8%
4-foot LED	0%	0%	0%
Total (Burnt Out / All Linear Lamps)	**1.2%**	**1.4%**	**1.9%**
n	**543**	**611**	**218**
Sites with Burnt Out Linear Lamps	**187**	**145**	**68**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out Linear lamps as a percentage of total Linear lamps for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-32 shows the distribution of burnt out Linear lamps relative to total Linear lamps in each performance group by business size. Small and Very Small businesses have a much greater proportion of burnt out T12s than Large and Medium businesses. There is a similar trend for Unknown T8s, Standard 700-Series T8s, and High Performance T8s. This may be a result of Large and Medium businesses having the resources to replace burnt out bulbs more frequently than Small and Very Small businesses.

Table 5-32: Burnt Out Linear Lamps as Shares of Total Linear Lamps by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	0.1%	0.7%	6%	4.2%
4-foot Other	0%	0%	0%	0%
4-foot Unknown T8	0.4%	1.8%	2.1%	2.8%
4-foot Std 700 T8	0.3%	0.8%	1.0%	1.4%
4-foot Std 800 T8	1.4%	1.4%	1.4%	1.2%
4-foot High Performance T8	0%	0.5%	0.6%	2.6%
4-foot Reduced Wattage T8	0.4%	0.8%	0.5%	0.1%
4-foot T5	<0.1%	0.2%	0.4%	0%
4-foot LED	0%	0%	0%	0%
Total (Burnt Out / All Linear Lamps)	**0.5%**	**0.9%**	**1.6%**	**2.3%**
n	**96**	**458**	**468**	**350**
Sites with Burnt Out Linear Lamps	**36**	**148**	**143**	**73**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out Linear lamps as a percentage of total Linear lamps for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.4.5 Inoperable Linear Fixtures

This subsection analyzes the distribution of Linear fixtures that were found on site to be inoperable. Note that this is an analysis of fixtures rather than lamps, as presented above. The following results represent inoperable Linear fixtures as a percentage of total Linear fixtures found at businesses within a performance group. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total inoperable Linear fixtures as a percentage of total Linear fixtures for each column.

Table 5-33 presents shares of inoperable Linear fixtures relative to total Linear fixtures in a performance group by business type. For example, the table shows that 3.3% of T12 fixtures installed in Food/Liquor stores were inoperable; this is not equivalent to the share of total Linear fixtures across all performance groups that are inoperable. Warehouses have a relatively high share of inoperable T12 fixtures, at 12% of all T12 fixtures. Ten percent of High Performance T8 fixtures in Food/Liquor stores are also inoperable, compared with just 3.7% in Restaurants. Interestingly, Restaurants have a high share of burnt out T12 lamps—21% of all T12 lamps in Restaurants, as shown in Table 5-30—but they do not have a high share of inoperable T12 fixtures. As with burnt out lamps, no Linear LED and very few T5 fixtures were found to be inoperable.

Table 5-33: Inoperable Linear Fixtures as Shares of Total Linear Fixtures by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel- laneous	Office	Restau- rant	Retail	School	Ware- house
4-foot T12	3.3%	0.6%	5%	4.1%	2.1%	1.0%	0.7%	12%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	2.9%	0.7%	0.4%	0%	7%	4.1%	0.2%	1.3%
4-foot Std 700 T8	0.9%	<0.1%	1.0%	0.5%	0%	3.8%	0.6%	2.6%
4-foot Std 800 T8	0.4%	0%	0.8%	<0.1%	0.8%	0.5%	1.1%	1.7%
4-foot High Performance T8	10%	<0.1%	0.5%	0.1%	3.7%	2.5%	0%	0.4%
4-foot Reduced Wattage T8	0.7%	0%	0%	0.1%	0%	1.2%	<0.1%	0%
4-foot T5	0%	0%	0%	0%	0%	0.4%	0.4%	<0.1%
4-foot LED	0%	0%	0%	0%	0%	0%	0%	0%
Total (Inoperable Fixtures / All Linear Fixtures)	**1.7%**	**0.2%**	**1.3%**	**0.6%**	**1.4%**	**2.0%**	**0.6%**	**3.6%**
n	**120**	**124**	**228**	**237**	**163**	**219**	**160**	**121**
Sites with Inoperable Linear Fixtures	**16**	**11**	**25**	**20**	**11**	**38**	**25**	**18**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable Linear fixtures as a percentage of total Linear fixtures for each business type. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-34 shows the distribution of inoperable Linear fixtures relative to total Linear fixtures in a performance group by IOU. T12 fixtures in PG&E represent the highest share of inoperable fixtures of any performance group in any IOU, at 6%. SDG&E shows low shares of inoperable fixtures, with less than 1% of fixtures across all performance groups.

Table 5-34: Inoperable Linear Fixtures as Shares of Total Linear Fixtures by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
4-foot T12	6%	3.4%	0.5%
4-foot Other	0%	0%	0%
4-foot Unknown T8	2.7%	0.2%	0.2%
4-foot Std 700 T8	1.1%	0.5%	0.3%
4-foot Std 800 T8	0.9%	0.3%	0.9%
4-foot High Performance T8	0.5%	1.5%	0.5%
4-foot Reduced Wattage T8	0.2%	0.4%	0.1%
4-foot T5	0.5%	<0.1%	0%
4-foot LED	0%	0%	0%
Total (Inoperable Fixtures / All Linear Fixtures)	**1.6%**	**0.9%**	**0.5%**
n	**543**	**611**	**218**
Sites with Inoperable Linear Fixtures	**92**	**52**	**20**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable Linear fixtures as a percentage of total Linear fixtures for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-35 shows the distribution of inoperable Linear fixtures relative to total Linear fixtures in a performance group by business size. Very Small businesses have a relatively high share of inoperable T12 fixtures, at 8%; this is by far the highest share of inoperable fixtures in any performance group and business size. As with burnt out bulbs, Small and Very Small businesses have higher shares of inoperable fixtures than Large and Medium businesses for several performance groups.

Table 5-35: Inoperable Linear Fixtures as Shares of Total Linear Fixtures by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	0.2%	0.5%	1.6%	8%
4-foot Other	0%	0%	0%	0%
4-foot Unknown T8	0%	0.1%	2.9%	0%
4-foot Std 700 T8	0.6%	0.4%	1.4%	1.9%
4-foot Std 800 T8	1.2%	0.5%	0.6%	0.6%
4-foot High Performance T8	0%	0.8%	0.5%	2.0%
4-foot Reduced Wattage T8	0.4%	0.1%	0%	0.8%
4-foot T5	0.2%	0.2%	0.1%	0%
4-foot LED	0%	0%	0%	0%
Total (Inoperable Fixtures / All Linear Fixtures)	**0.6%**	**0.4%**	**1.2%**	**3.4%**
n	**96**	**458**	**468**	**350**
Sites with Inoperable Linear Fixtures	**19**	**58**	**54**	**33**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable Linear fixtures as a percentage of total Linear fixtures for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.4.6 Linear Lamps in Storage

This subsection analyzes the distribution by performance group of Linear lamps that were found in storage on site. The results presented in the tables represent Linear lamps in storage as a percentage of total Linear lamps found at businesses within a performance group. Total Linear lamp counts include burnt out lamps and lamps installed in inoperable fixtures, but exclude lamps in storage. Instead, the shares presented below can be interpreted as the proportion of installed lamps that have replacement lamps in storage. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total Linear lamps in storage as a percentage of total Linear lamps for each column.

Table 5-36 displays the share of Linear lamps in storage relative to total Linear lamps in a performance group by business type. For example, the table shows that 4.2% of T12s installed in Food/Liquor stores have replacements in storage; this is not equivalent to the share of total Linear lamps across all performance groups that have replacements in storage. Miscellaneous businesses and Retail stores have relatively high shares of replacement T12s in storage, at 7% and 6% respectively, and are the only business types to have Linear LEDs in storage.

Health/Medical Clinics have an astounding 25% of T5 lamps with replacements in storage, and Food/Liquor stores similarly have a 24% share of T5 lamps with replacements in storage. It should be noted that the total number of T5 lamps at Food/Liquor stores and Health/Medical Clinics is substantially lower than the number of lamps in other performance groups across all business types.

Table 5-36: Linear Lamps in Storage as Shares of Total Linear Lamps by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
4-foot T12	4.2%	2.2%	7%	4.2%	3.2%	6%	1.4%	2.1%
4-foot Other	0%	0%	0%	0%	0%	0%	0%	0%
4-foot Unknown T8	0.1%	5%	0.4%	2.9%	4.0%	0.7%	1.8%	0.4%
4-foot Std 700 T8	2.3%	1.3%	3.8%	1.1%	2.2%	4.1%	0.7%	3.3%
4-foot Std 800 T8	2.7%	2.5%	1.3%	3.5%	1.2%	2.7%	1.6%	1.9%
4-foot High Performance T8	6%	0.4%	1.0%	1.4%	0.4%	1.0%	0.1%	<0.1%
4-foot Reduced Wattage T8	0.3%	0.9%	0.1%	2.8%	0%	1.5%	<0.1%	0.9%
4-foot T5	24%	25%	1.0%	5%	5%	1.0%	4.2%	4.1%
4-foot LED	0%	0%	2.7%	0%	0%	4.3%	0%	0%
Total (Lamps in Storage / All Linears)	**2.5%**	**1.7%**	**2.8%**	**1.8%**	**2.2%**	**2.5%**	**0.9%**	**2.0%**
n	**120**	**124**	**228**	**237**	**163**	**219**	**160**	**121**
Sites with Linear Lamps in Storage	**25**	**35**	**62**	**86**	**23**	**59**	**52**	**27**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total Linear lamps in storage as a percentage of total Linear lamps for each business type. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-37 shows the share of Linear lamps in storage relative to total Linear lamps in a performance group by IOU. Shares of replacement T12s in storage are high for all three IOUs relative to the other performance groups. SDG&E has higher shares of Unknown T8s and Linear LEDs with replacements in storage than the other IOUs, but a lower share of replacement T5s in storage.

Table 5-37: Linear Lamps in Storage as Shares of Total Linear Lamps by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
4-foot T12	5%	3.0%	2.6%
4-foot Other	0%	0%	0%
4-foot Unknown T8	1.1%	1.3%	5%
4-foot Std 700 T8	1.6%	2.1%	2.0%
4-foot Std 800 T8	3.0%	1.5%	2.2%
4-foot High Performance T8	1.2%	0.5%	0.4%
4-foot Reduced Wattage T8	1.3%	0.6%	0.8%
4-foot T5	3.1%	3.7%	0.5%
4-foot LED	2.7%	0%	7%
Total (Lamps in Storage / All Linears)	**2.1%**	**1.8%**	**2.0%**
n	**543**	**611**	**218**
Sites with Linear Lamps in Storage	**213**	**106**	**50**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total Linear lamps in storage as a percentage of total Linear lamps for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-38 presents the share of Linear lamps in storage relative to total Linear lamps in a performance group by business size. Very Small businesses have relatively high shares of T12s, Standard 700-Series T8s, and Reduced Wattage T8 lamps with replacements in storage compared to the other business sizes. Very Small businesses have 2% of Reduced Wattage T8s with replacements in storage compared to 1.1% in Large businesses, but have only 0.7% of replacement T5s compared to 7% in Large businesses.

Table 5-38: Linear Lamps in Storage as Shares of Total Linear Lamps by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
4-foot T12	0.6%	3.9%	3.1%	4.8%
4-foot Other	0%	0%	0%	0%
4-foot Unknown T8	5%	2.0%	0.9%	1.0%
4-foot Std 700 T8	2.9%	1.0%	1.7%	3.7%
4-foot Std 800 T8	2.4%	1.9%	3.0%	1.4%
4-foot High Performance T8	0.3%	0.9%	1.1%	0.4%
4-foot Reduced Wattage T8	1.1%	0.9%	0.1%	2.0%
4-foot T5	7%	2.3%	2.5%	0.7%
4-foot LED	0%	6%	0%	0%
Total (Lamps in Storage / All Linears)	**2.6%**	**1.4%**	**1.9%**	**2.8%**
n	**96**	**458**	**468**	**350**
Sites with Linear Lamps in Storage	**46**	**166**	**105**	**52**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total Linear lamps in storage as a percentage of total Linear lamps for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

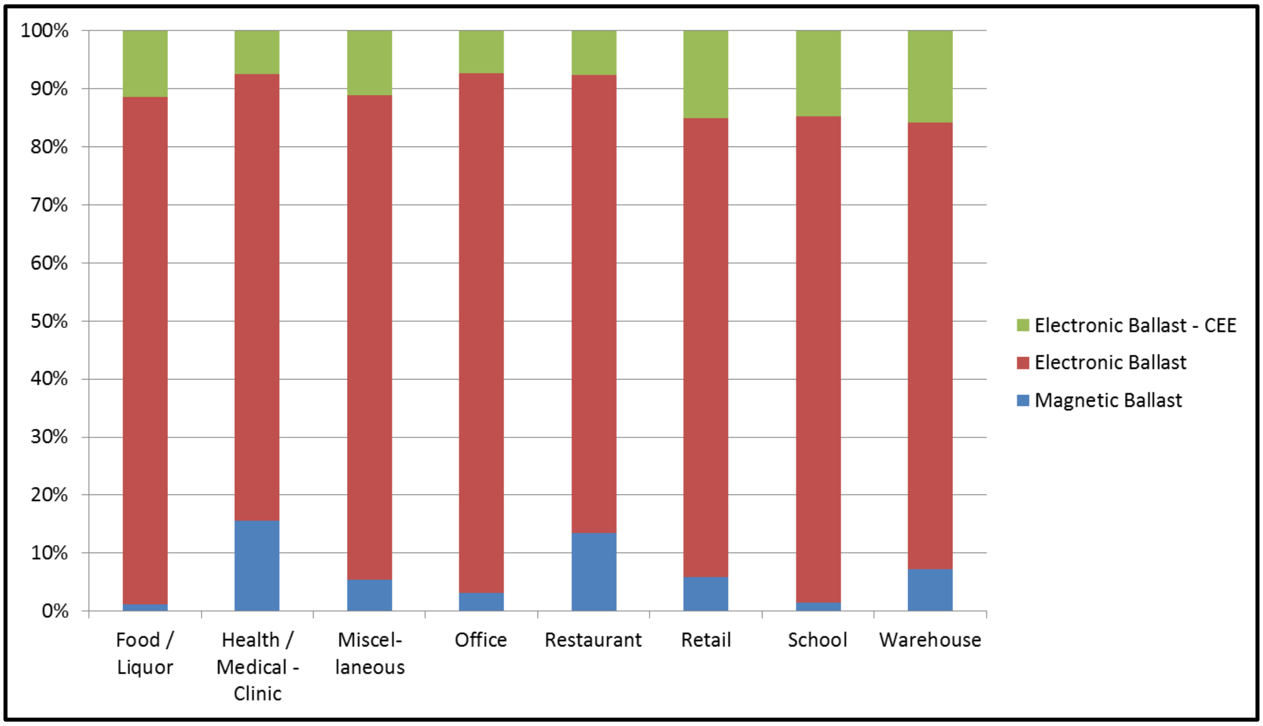
5.4.7 Linear Ballasts

As with inefficient T12 lamps, older magnetic ballasts are being phased out in favor of electronic ballasts. CEE-qualified electronic ballasts must meet certain specifications based on the type of ballast (instant-start or programmed rapid-start), the number of lamps driven by the ballast, and the ballast factor (a ratio measuring lumen output).[12]

Figure 5-16 displays the distribution of commercial Linear ballasts by business type. As evident, electronic ballasts predominate, with well over an 80% share in any given business type. Health/Medical Clinics and Restaurants have the highest share of magnetic ballasts, at 16% and 14%, respectively. CEE-qualified electronic ballasts are beginning to permeate the market, with greater instances of CEE electronic ballasts than magnetic ballasts in most business types. Warehouses have the highest relative saturation of CEE electronic ballasts, with an average of 15%.

12 CEE High-Performance T8 Specification. <http://library.cee1.org/sites/default/files/library/2743/CEE_ComLit_HP_Lighting_Spec.pdf>

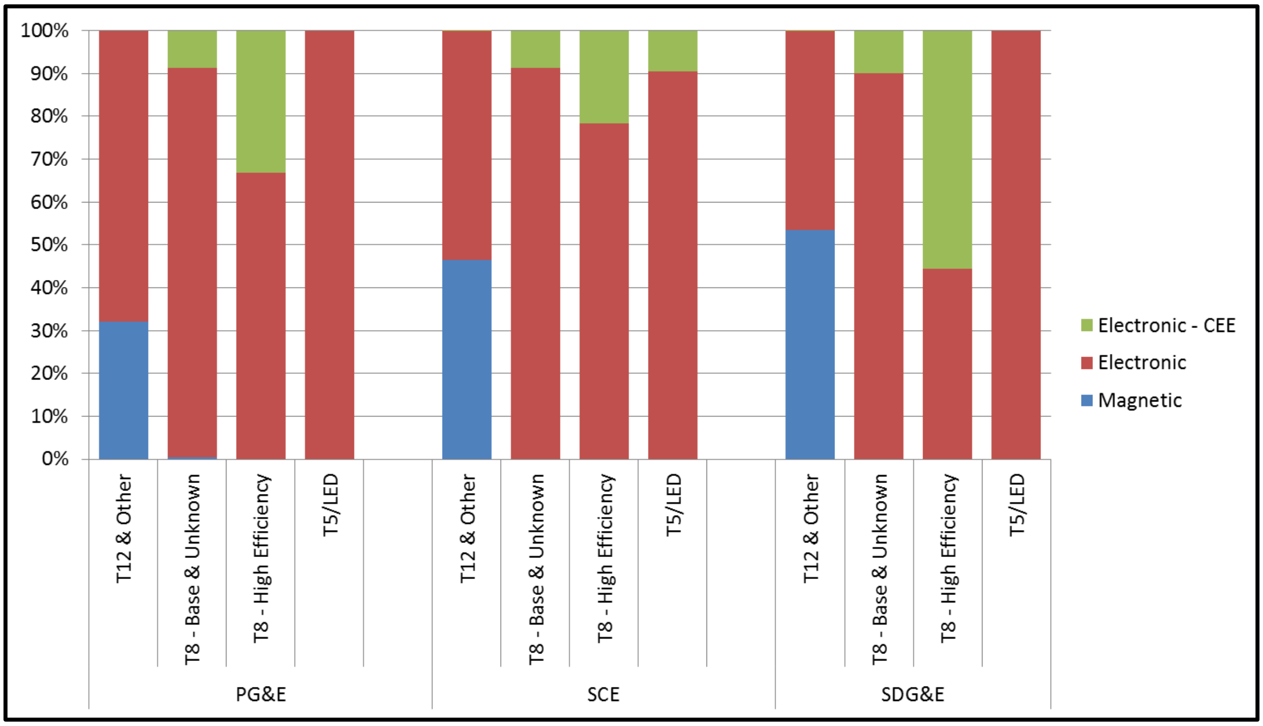
Figure 5-16: Linear Ballast Efficiency Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

The distribution of ballasts by Linear technology and IOU is displayed in Figure 5-17. Across all three utilities, High Efficiency T8s have the greatest incidence of CEE-qualified electronic ballasts. SDG&E's CEE electronic ballasts represent a staggering 56% of their total High Efficiency T8 ballasts. For all utilities, magnetic ballasts are found exclusively in older, inefficient Linear fixtures, such as T12s. No T5 or Linear LED fixtures are found with magnetic ballasts in any IOU. SCE and SDG&E have no High Efficiency T8s with magnetic ballasts, and PG&E's share of High Efficiency T8s with magnetic ballasts is less than 1%.

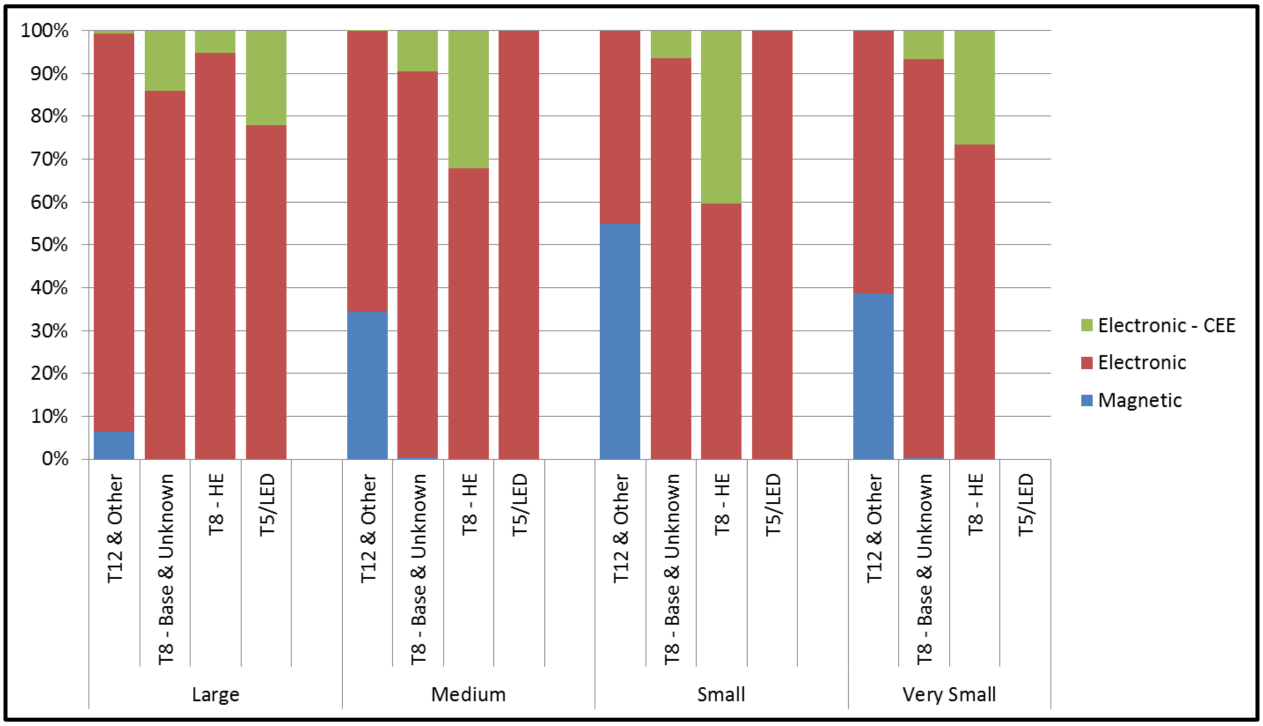
Figure 5-17: Linear Ballast Efficiency Distribution by Lamp Technology and IOU – Indoor Lighting



* **The results presented above have been weighted by site weight.**

Figure 5-18 depicts the distribution of ballasts by Linear technology and business size. At just 5%, Large businesses have a lower share of High Efficiency T8 lamps with CEE electronic ballasts than other business sizes. Other business sizes have higher shares of High Efficiency T8s with CEE electronic ballasts: 32% for Medium, 40% for Small businesses, and over 25% for Very Small businesses. T5 and Linear LED fixtures with CEE electronic ballasts are found exclusively at Large businesses.

Figure 5-18: Linear Ballast Efficiency Distribution by Lamp Technology and Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.5 Incandescent, CFL, LED, and Halogen Lamps

The ICLH section presents information on Incandescent, CFL, LED, and Halogen technologies currently installed in commercial businesses in California. These lighting technologies have been grouped together because each can be either pin- or medium screw-based, and the technologies have similar indoor lighting applications.

ICLH lamps can be characterized by their technology type and by their base type (pin or medium screw). This level of disaggregation identifies eight performance groups, listed as follows:

- Incandescent: Pin-Based and Medium Screw-Based
- Halogen: Pin-Based and Medium Screw-Based
- CFL: Pin-Based and Medium Screw-Based
- LED: Pin-Based and Medium Screw-Based

The analysis will look at some basic characteristics of ICLH lamps, including the share of businesses with these technologies and the average number of lamps per square foot. This section will provide saturations and densities of the ICLH performance groups.

Distributions in this section are presented as shares of indoor ICLH lamps. All ICLH lamp counts and shares presented in this section include, in addition to lamps that are installed and operative, burnt out lamps and lamps installed in inoperable fixtures. The analysis focuses on pin- and medium screw-based ICLH technologies because of their predominance in commercial indoor lighting. Table 5-39 shows that ICLH technologies with bases other than pin- or medium screw represent only 12% of indoor ICLH lamps and less than 2% of all indoor lamps. Other ICLH bases include: candelabra, GU24, other GU (e.g. GU10, GU6.5), hard-wired, intermediate, mogul, other, and unknown base types. ICLH lamps collectively represent nearly 16% of all commercial indoor lamps, as is also shown in Figure 5-2.

Table 5-39: ICLH Lamp Shares by Base Type – Indoor Lighting

	n	**Share of ICLH Lamps**	**Share of All Lamps**
ICLH Pin- & Medium Screw-Base	**1200**	88%	14%
ICLH Other Base	**231**	12%	1.8%
Total	**1217**	100%	16%

* **The results presented above have been weighted by site weight.** *n*’s represent the number of surveyed sites included in the analysis. Total *n* is greater than the sum of the *n*’s because some sites have both pin-/medium screw-based ICLH lamps and other base ICLH lamps. Other ICLH bases include: candelabra, GU24, other GU (e.g. GU10, GU6.5), hard-wired, intermediate, mogul, other, and unknown base types.

5.5.1 General Saturation and Density

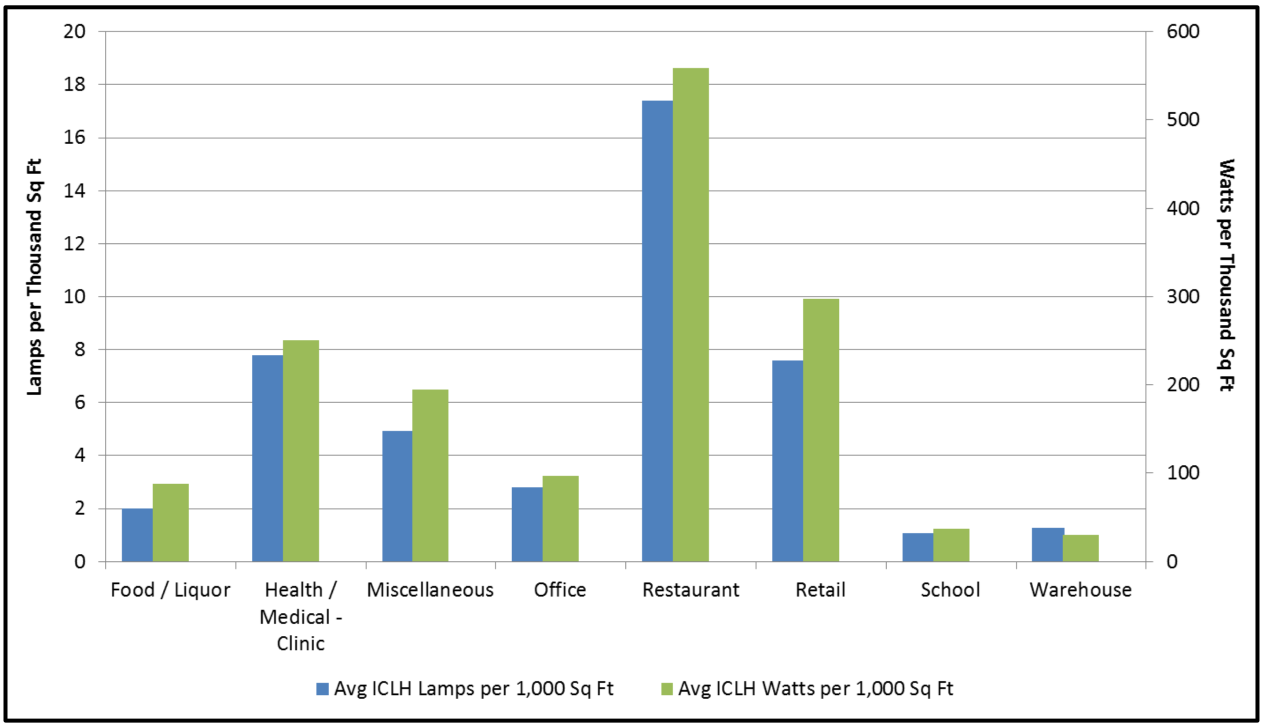
Table 5-40 shows the saturation of ICLH technologies within commercial businesses in California. ICLH lamps were found in 85% of businesses. The data further shows the average density of ICLH lighting within a business by lamps per thousand square feet of floor area, watts per square foot, and lumens per square foot. Nearly all Restaurants have these types of lamps. Restaurants also have the highest density of lamps, watts, and lumens of all business types. Health/Medical Clinics have the second highest incidence of ICLH lamps at 90% of businesses, but have less than half of the lamps per square foot as Restaurants. Although Health/Medical Clinics have a slightly higher average number of lamps per square foot than Retail stores, they have a lower average wattage per square foot. This suggests that Health/Medical Clinics install ICLH lamps with relatively lower wattages than Retail stores. The relationship between lamp and wattage densities by business type is also depicted in Figure 5-19.

Table 5-40: Average Density of ICLH Lamps by Business Type – Indoor Lighting

Business Type	*n*	Share of Sites with ICLH Lamps	Average ICLH Lamps per 1,000 Sq Ft	Average ICLH Watts per Sq Ft	Average ICLH Lumens per Sq Ft
Food/Liquor	126	71%	2.0	0.09	2
Health/Medical - Clinic	128	90%	7.8	0.25	8
Miscellaneous	245	88%	4.9	0.19	6
Office	246	79%	2.8	0.10	3
Restaurant	170	98%	17.4	0.56	15
Retail	233	88%	7.6	0.30	7
School	161	70%	1.1	0.04	2
Warehouse	127	70%	1.3	0.03	1
n	**1,436**	**85%**	**3.7**	**0.13**	**4**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Total Share of Businesses with ICLH Lamps is the share across all business types. Totals for Average ICLH Lamps per 1,000 Sq Ft, Average ICLH Watts per Sq Ft, and Average ICLH Lumens per Sq Ft represent weighted averages across all business types.

Figure 5-19: Average Number of ICLH Lamps and Watts per Thousand Square Feet by Business Type – Indoor Lighting

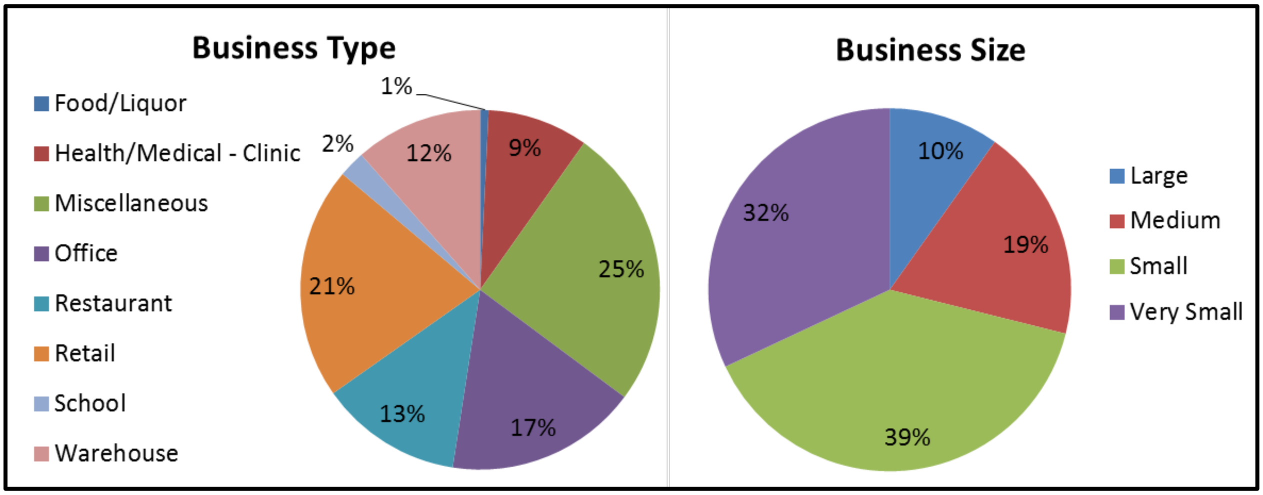


* **The results presented above have been weighted by site weight.**

Figure 5-20 illustrates the distribution of ICLH lamps by business type and size. Miscellaneous businesses account for 25% of ICLH lamps. Information presented in Figure 5-19 and Table

5-40 showed that Restaurants, Retail, and Health/Medical Clinics all have more ICLH lamps per thousand square feet than Miscellaneous businesses, but Miscellaneous businesses represent the largest share of total electricity consumption (20%) and the third largest share of total floor space (19%) of CSS businesses.[13] The high share of floor space and consumption contribute to Miscellaneous businesses representing the highest share of ICLH lamps even though their number of lamps per thousand square feet is only slightly higher than average. Regarding business size, Small-sized businesses have 39% of all ICLH lamps. The high share of ICLH lamps for Small-sized businesses is consistent with the finding that Small-sized businesses occupy 37% of the floor space of CSS businesses.

Figure 5-20: Distribution of ICLH Lamps by Business Type and Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.5.2 Saturations by Performance Group

<u>Performance Group Distribution by Business Type</u>

Table 5-41 presents the share of ICLH lamps in each technology/base group represented by business type. In Food/Liquor stores, 29% of ICLH lamps are pin-based CFLs, while 21% are medium screw-based CFLs. This is similar to Miscellaneous businesses, where pin-based CFLs make up 34% of ICLH lamps, while the screw-based CFLs comprise 30%. In Health/Medical Clinics, the proportions of pin-based and medium screw-based CFLs are 30% and 39%, respectively. Restaurants have a similar distribution: 19% pin-based CFLs and 33% medium screw-base CFLs. Offices and Schools heavily favor pin-based CFLs, which comprise 42% and

13 Information on total electricity consumption and floor space by business type is presented in Section 4 of this report.

59% of ICLH lamps, respectively. The vast majority of ICLH lighting in Warehouses is medium screw-based CFLs, which make up 84% of these lamps.

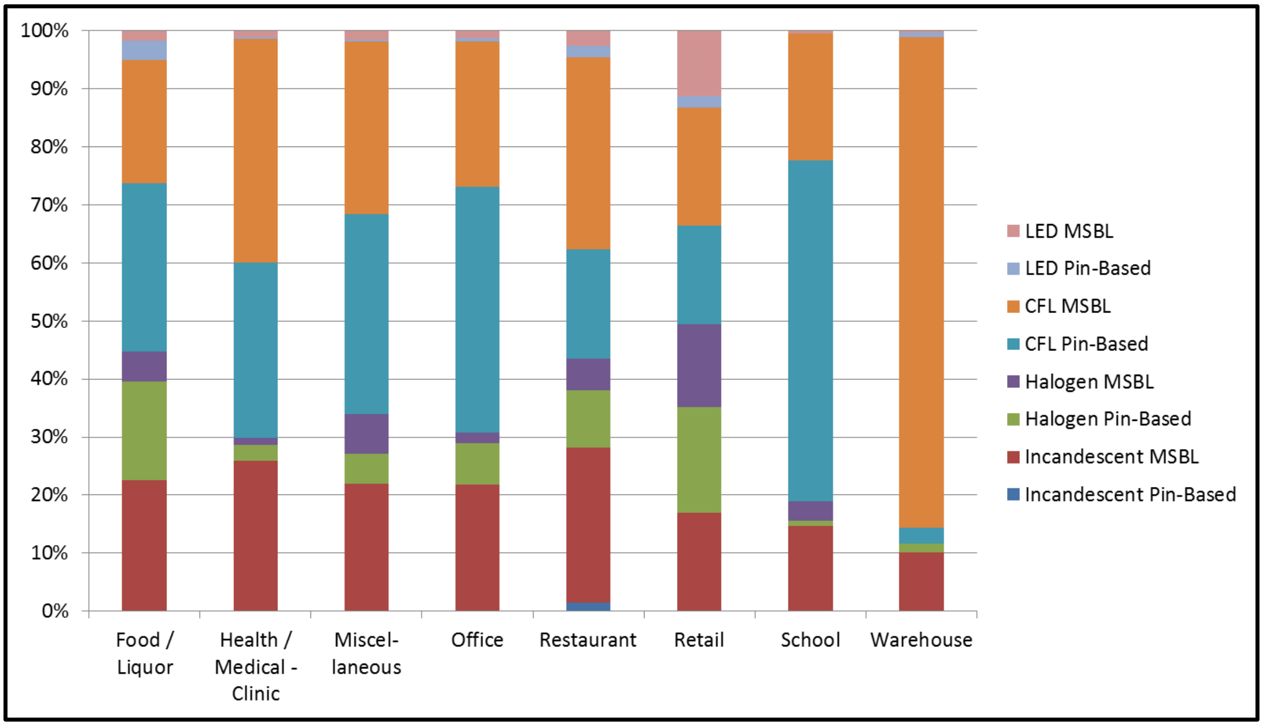
Table 5-41: ICLH Lamp Distribution by Business Type – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0.1%	0%	0%	1.5%	0%	0%	0%
Incandescent MSBL	23%	26%	22%	22%	27%	17%	15%	10%
Halogen Pin-Based	17%	2.7%	5%	7%	10%	18%	0.9%	1.6%
Halogen MSBL	5%	1.3%	7%	1.8%	5%	14%	3.4%	<0.1%
CFL Pin-Based	29%	30%	34%	42%	19%	17%	59%	2.7%
CFL MSBL	21%	39%	30%	25%	33%	20%	22%	84%
LED Pin-Based	3.3%	0.3%	0.3%	0.7%	1.9%	2.1%	0%	0.7%
LED MSBL	1.8%	1.2%	1.6%	1.2%	2.7%	11%	0.5%	0.4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**89**	**119**	**217**	**206**	**163**	**195**	**131**	**80**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Alternatively, Figure 5-21 illustrates the distribution of ICLH lamps within each business type. It is interesting to note that the ICLH lighting in Warehouses is largely comprised of medium screw-based CFL lamps, while pin-based CFL lamps make up most of the ICLH lighting in Schools. In each of the other business types, the ratio of the two types of CFLs is relatively even. Retail stores have the highest proportions of LED and Halogen lamps relative to the other business types. Pin-based Incandescent and LED lamps are virtually nonexistent throughout all businesses. Medium screw-based Incandescent bulbs represent 22-27% of the ICLH lamps in Food/Liquor stores, Health/Medical Clinics, Miscellaneous businesses, Offices, and Restaurants.

Figure 5-21: ICLH Lamp Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

Performance Group Distribution by Business Type and IOU

Table 5-42, Table 5-43, and Table 5-44 detail the share of ICLH lamps by business type for PG&E, SCE, and SDG&E, respectively. Interestingly, CFLs are the most common lamps found in each of the various business types across all utilities, except for PG&E Warehouses and PG&E and SDG&E Retail stores. For Miscellaneous businesses, which represent the greatest proportion of total ICLH lamps, pin-based CFLs are the most prevalent in PG&E and SDG&E territories. In SCE Miscellaneous businesses, medium screw-based CFLs are the most common. Figure 5-22 illustrates this information as well, organized by business type to show the differences in ICLH distributions between the three IOUs.

Table 5-42: ICLH Lamp Distribution by Business Type for PG&E – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0.2%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	12%	34%	27%	23%	25%	17%	11%	70%
Halogen Pin-Based	28%	3.7%	9%	7%	10%	23%	1.1%	1.0%
Halogen MSBL	0%	0.1%	9%	1.0%	2.8%	14%	1.3%	0%
CFL Pin-Based	39%	26%	30%	48%	28%	12%	62%	9%
CFL MSBL	18%	35%	25%	20%	33%	24%	25%	20%
LED Pin-Based	1.2%	0%	0%	0.5%	0.2%	0%	0%	0%
LED MSBL	2.4%	2.0%	0.3%	0.8%	1.3%	11%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**36**	**49**	**91**	**88**	**62**	**70**	**64**	**17**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-43: ICLH Lamp Distribution by Business Type for SCE – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	34%	16%	19%	17%	26%	16%	22%	5%
Halogen Pin-Based	12%	1.0%	3.3%	10%	10%	12%	0.8%	1.7%
Halogen MSBL	7%	1.9%	2.5%	3.1%	8%	15%	7%	<0.1%
CFL Pin-Based	24%	35%	30%	26%	17%	18%	46%	2.5%
CFL MSBL	23%	45%	42%	40%	31%	20%	23%	89%
LED Pin-Based	0%	0.7%	0.2%	1.1%	3.5%	4.2%	0%	0.8%
LED MSBL	1.6%	0.2%	3.2%	1.8%	4.1%	14%	1.2%	0.4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**40**	**50**	**87**	**92**	**69**	**95**	**51**	**49**

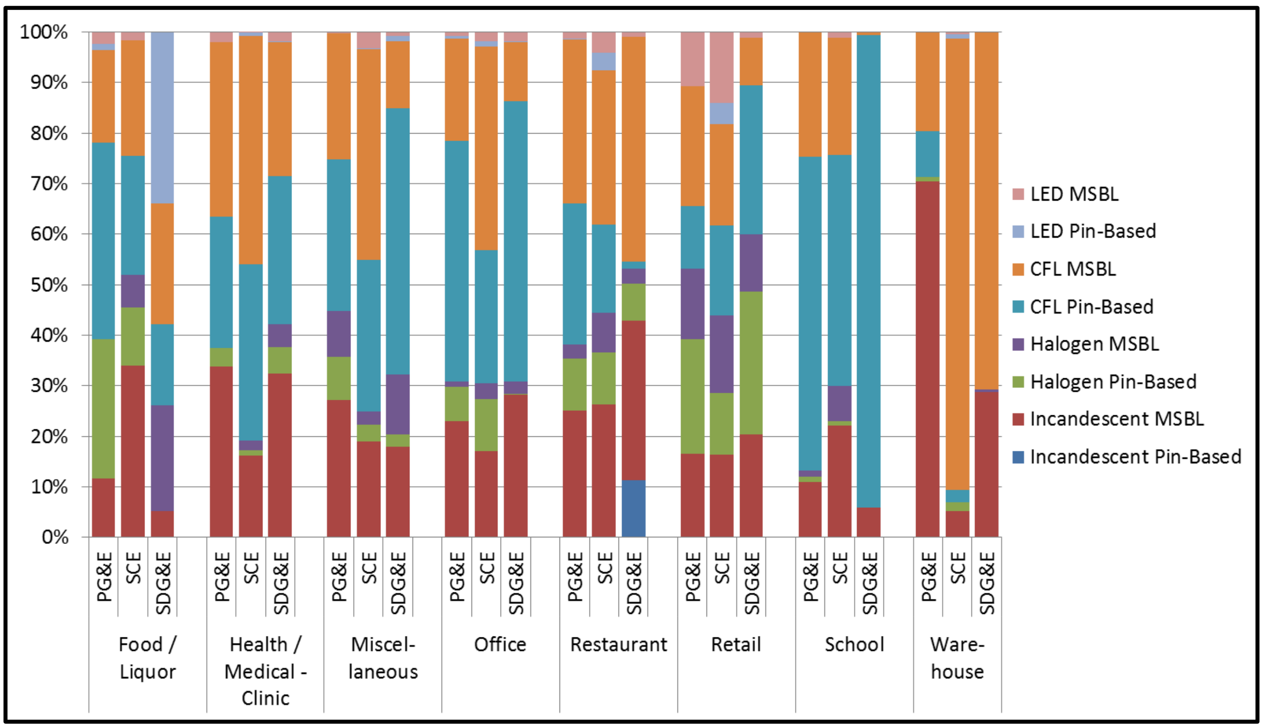
* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-44: ICLH Lamp Distribution by Business Type for SDG&E – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	11%	0%	0%	0%
Incandescent MSBL	5%	32%	18%	28%	32%	20%	6%	29%
Halogen Pin-Based	0%	5%	2.4%	0.1%	7%	28%	0%	0%
Halogen MSBL	21%	4.4%	12%	2.5%	3.1%	11%	0%	0.4%
CFL Pin-Based	16%	29%	53%	55%	1.4%	29%	94%	0%
CFL MSBL	24%	27%	13%	12%	45%	9%	0.5%	71%
LED Pin-Based	34%	0.1%	1.1%	0.1%	0%	0%	0%	0%
LED MSBL	0%	1.9%	0.7%	1.8%	0.9%	1.1%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**13**	**20**	**39**	**26**	**32**	**30**	**16**	**14**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-22: ICLH Lamp Distribution by IOU and Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

Performance Group Distribution by Business Size

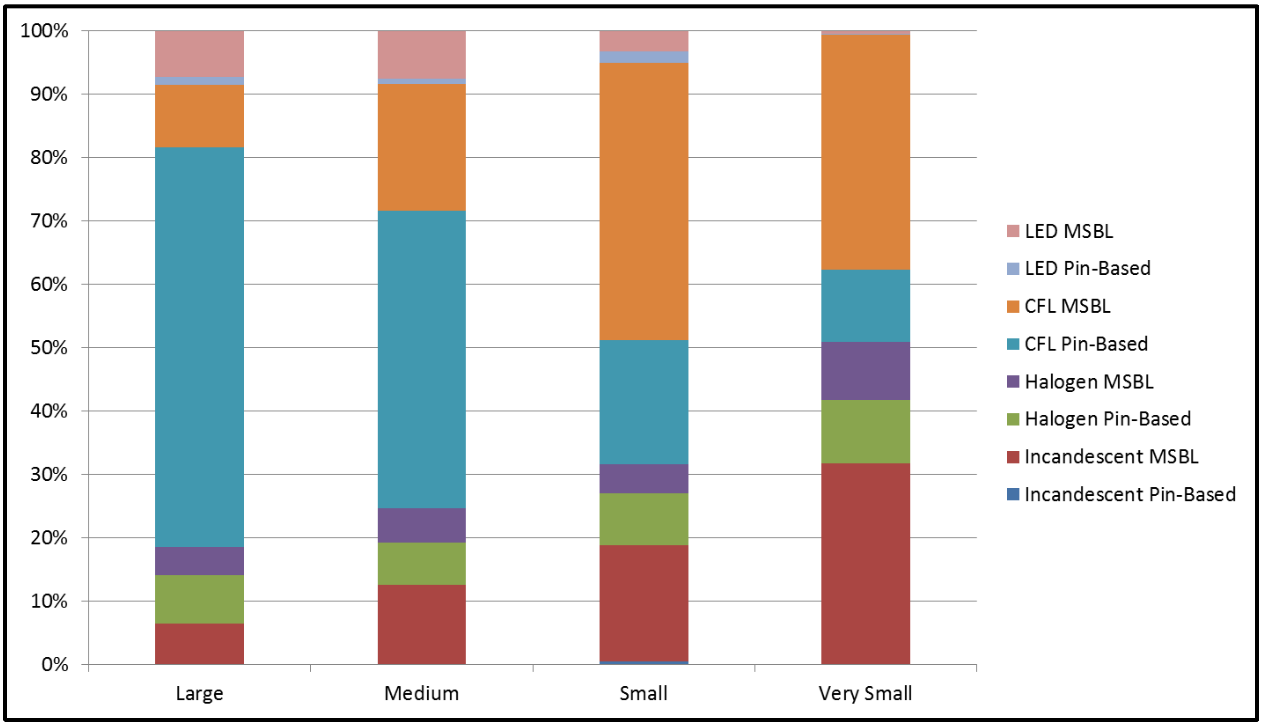
Table 5-45 and Figure 5-23 present the distributions of ICLH lamps by business size, which is determined by annual kWh usage. Overall, CFLs of both base types make up approximately 50% or more of the ICLH lamps in all business sizes. These data indicate that 63% of ICLH lamps in Large businesses are pin-based CFLs. Almost half of the ICLH lamps in Medium businesses are also pin-based CFLs. The most common type of ICLH lamp in Small and Very Small businesses is medium screw-based CFL, which makes up 44% and 37% of all ICLH lamps, respectively. Medium screw based Incandescent bulbs make up 32% of the ICLH lamps in Very Small, 18% in Small, and decline to 13% and 7% for Medium and Large businesses respectively.

Table 5-45: ICLH Lamp Distribution by Business Size – Indoor Lighting

Technology Type	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	<0.1%	0.5%	0%
Incandescent MSBL	7%	13%	18%	32%
Halogen Pin-Based	8%	7%	8%	10%
Halogen MSBL	4.5%	5%	4.5%	9%
CFL Pin-Based	63%	47%	20%	11%
CFL MSBL	10%	20%	44%	37%
LED Pin-Based	1.1%	0.8%	1.8%	0.2%
LED MSBL	7%	8%	3.3%	0.4%
Total	**100%**	**100%**	**100%**	**100%**
n	**85**	**378**	**407**	**330**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-23: ICLH Lamp Distribution by Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by Business Size and IOU

Table 5-46, Table 5-47, and Table 5-48 present the distribution of ICLH lamps by business size for PG&E, SCE, and SDG&E, respectively. CFLs remain the most popular ICLH lamp type found in businesses across all sizes and utilities, with the exception of Very Small businesses in SDG&E which favor Incandescent lamps. Pin-based CFLs are the most common type of lamp in Large, Medium, and Small businesses across all IOUs, with the exception of Small SCE businesses, where screw-based CFLs make up 60% of ICLH lamps. In Very Small businesses, medium screw-based Incandescent lamps and medium screw-based CFLs are the most common lamp types. Figure 5-24 summarizes these distributions by business size and IOU.

Table 5-46: ICLH Lamp Distribution by Business Size for PG&E – Indoor Lighting

Technology Type	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0.1%	0%	0%
Incandescent MSBL	1.5%	9%	25%	38%
Halogen Pin-Based	12%	1.1%	13%	13%
Halogen MSBL	8%	2.3%	5%	8%
CFL Pin-Based	59%	66%	29%	6%
CFL MSBL	7%	17%	26%	34%
LED Pin-Based	1.2%	<0.1%	0.1%	0%
LED MSBL	12%	4.5%	1.5%	0.7%
Total	**100%**	**100%**	**100%**	**100%**
n	**33**	**159**	**164**	**121**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-47: ICLH Lamp Distribution by Business Size for SCE – Indoor Lighting

Technology Type	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0%	0%	0%
Incandescent MSBL	16%	13%	14%	22%
Halogen Pin-Based	4.7%	12%	3.9%	7%
Halogen MSBL	2.5%	6%	2.7%	11%
CFL Pin-Based	59%	36%	11%	15%
CFL MSBL	14%	20%	60%	44%
LED Pin-Based	0.3%	1.2%	3.2%	0.4%
LED MSBL	4.0%	12%	4.8%	0.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**43**	**167**	**178**	**145**

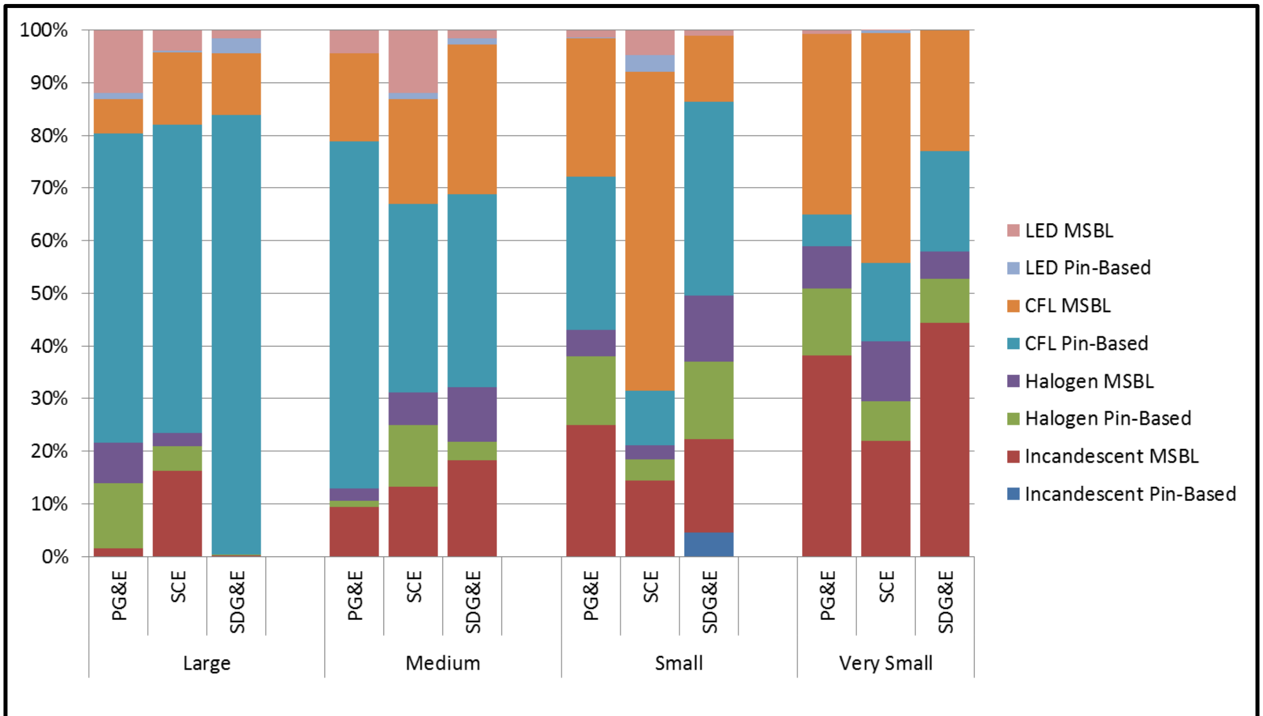
* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-48: ICLH Lamp Distribution by Business Size for SDG&E – Indoor Lighting

Technology Type	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0%	4.6%	0%
Incandescent MSBL	0.1%	18%	18%	44%
Halogen Pin-Based	0.2%	3.5%	15%	8%
Halogen MSBL	0%	10%	13%	5%
CFL Pin-Based	84%	37%	37%	19%
CFL MSBL	12%	28%	12%	23%
LED Pin-Based	2.8%	1.3%	0%	0%
LED MSBL	1.6%	1.5%	1.1%	0%
Total	**100%**	**100%**	**100%**	**100%**
n	**9**	**52**	**65**	**64**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-24: ICLH Lamp Distribution by Business Size and IOU – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by Business Size and Business Type

Table 5-49, Table 5-50, Table 5-51, and Table 5-52 present the saturation of ICLH lamps by business size and business type. In Large Health/Medical Clinics, Miscellaneous businesses, and Offices, over 80% of ICLH lamps are comprised of pin-based CFLs. In Medium businesses of the same types, pin-based CFLs still make up the majority of ICLH lamps, but in more modest proportions. Medium screw-based CFLs become more prevalent in smaller businesses. In virtually every Small and Very Small business type, these lamps make up a quarter to a half of ICLH lamps.

Table 5-49: ICLH Lamp Distribution by Business Type for Large-Sized Businesses – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel- laneous	Office	Restau- rant	Retail	School	Ware- house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	18%	0.1%	3.8%	2.7%	0%	6%	11%	71%
Halogen Pin-Based	42%	0%	0.8%	4.3%	0%	12%	0.3%	0.6%
Halogen MSBL	7%	0%	0.8%	1.2%	0%	10%	0.8%	0%
CFL Pin-Based	30%	88%	89%	81%	0%	40%	50%	23%
CFL MSBL	1.7%	12%	2.6%	4.8%	0%	16%	35%	5%
LED Pin-Based	0.9%	0%	2.7%	2.0%	0%	0%	0%	0%
LED MSBL	0%	0%	0.1%	3.7%	0%	16%	2.2%	0%
Total	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**
n	**8**	**2**	**11**	**23**	**0**	**17**	**18**	**6**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh.

Table 5-50: ICLH Lamp Distribution by Business Type for Medium-Sized Businesses – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0.4%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	22%	19%	14%	9%	19%	4.0%	12%	12%
Halogen Pin-Based	4.9%	1.1%	2.1%	2.8%	13%	14%	1.1%	41%
Halogen MSBL	6%	1.1%	7%	1.5%	11%	7%	1.9%	0%
CFL Pin-Based	41%	49%	49%	69%	24%	29%	76%	30%
CFL MSBL	20%	28%	24%	17%	27%	13%	8%	11%
LED Pin-Based	7%	1.3%	0.4%	1.2%	0%	0.2%	0%	6%
LED MSBL	0.5%	0.7%	3.2%	0.3%	6%	34%	0.2%	0%
Total	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**
n	**41**	**42**	**58**	**75**	**34**	**35**	**79**	**14**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Medium sites have greater than 300,000 kWh and less than or equal to 1,750,000.

Table 5-51: ICLH Lamp Distribution by Business Type for Small-Sized Businesses – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	2.4%	0%	0%	0%
Incandescent MSBL	34%	20%	24%	18%	31%	16%	19%	1.3%
Halogen Pin-Based	3.5%	5%	4.1%	14%	7%	26%	0.9%	0.4%
Halogen MSBL	0%	0.7%	9%	2.7%	3.6%	9%	6%	<0.1%
CFL Pin-Based	1.5%	27%	32%	37%	16%	10%	50%	1.6%
CFL MSBL	53%	47%	29%	25%	35%	17%	24%	96%
LED Pin-Based	0%	0%	0%	0.1%	2.9%	8%	0%	0%
LED MSBL	8%	0.2%	3.1%	2.1%	1.3%	13%	0%	0.5%
Total	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**
n	**37**	**29**	**74**	**45**	**104**	**55**	**32**	**31**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Small sites have max annual usage greater than 40,000 kWh and less than or equal to 300,000.

Table 5-52: ICLH Lamp Distribution by Business Type for Very Small-Sized Businesses – Indoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	0%	37%	28%	46%	16%	27%	0.9%	45%
Halogen Pin-Based	0%	1.9%	8%	7%	21%	17%	0%	0%
Halogen MSBL	0%	1.9%	6%	1.5%	0%	22%	0%	0.1%
CFL Pin-Based	0%	16%	19%	3.4%	20%	7%	0%	0%
CFL MSBL	100%	41%	39%	43%	40%	27%	99%	51%
LED Pin-Based	0%	0%	0%	0%	0%	0%	0%	3.5%
LED MSBL	0%	2.2%	0%	0%	2.4%	0.2%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**	**100%**
n	**3**	**46**	**74**	**63**	**25**	**88**	**2**	**29**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Very Small sites have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by EE 2009-2012 Lighting HIM Participation

For the purposes of this analysis, Energy Efficiency (EE) program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[14] The EE program participation analysis characterizes EE Lighting program participants as businesses who identified the installation of high efficiency lighting on any EE program application, including custom applications.[15] The ICLH analyses also present distributions for participants of EE CFL and/or EE LED programs.[16]

Displayed in Table 5-53 is the distribution of ICLH lamps by participation in 2009-2012 EE programs for High-Impact Lighting measures (EE Lighting). Included in this is the distribution of ICLH lamps for those businesses that participated in specific CFL and/or LED programs during this timeframe. For EE Lighting non-participants, medium screw-based CFLs account for the largest share of ICLH lamps. EE Lighting participants have similar proportions of CFLs compared to non-participants, but generally have lower shares of Incandescent lamps and greater

14 Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

15 EE LF HIM program participants are included as EE Lighting program participants.

16 Upstream rebate programs for CFLs and LEDs are not captured by this program participation analysis. The exclusion of these upstream rebate programs for CFLs and LEDs may explain the apparent similarities in the distributions of EE participants and non-participants in the ICLH analysis.

shares of LEDs. Participants in CFL and/or LED programs have relatively similar ICLH lamp distributions compared to overall EE Lighting participants.

Table 5-53: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0.2%	0.1%	0%
Incandescent MSBL	22%	13% ***	14%
Halogen Pin-Based	8%	12% *	10%
Halogen MSBL	6%	6%	4.8%
CFL Pin-Based	26%	29%	29%
CFL MSBL	34%	31%	35%
LED Pin-Based	1.1%	0.8%	1.4%
LED MSBL	2.8%	8% **	6%
Total	**100%**	**100%**	**100%**
n	**900**	**300**	**159**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Performance Group Distribution by EE 2009-2012 Lighting HIM Participation and IOU

Table 5-54, Table 5-55, Table 5-56, and Figure 5-25 show the saturation of ICLH lamps for each IOU by the EE participation groups defined above. In PG&E, EE Lighting participant businesses are much more likely to have LED lamps than non-participants, and non-participants are much more likely to have Incandescents than participants. Unexpectedly, EE Lighting participants in SCE territory are more likely to have medium screw-based Incandescent lamps than non-participants. In SDG&E territory, EE Lighting participants are more likely to have pin-based CFLs than non-participants, especially those who participated in a CFL/LED program. In SDG&E's territory, like in PG&E's, EE Lighting participants have a significantly smaller share of Incandescent lamps than non-participants.

Table 5-54: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation for PG&E – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0%	0.1% *	0%
Incandescent MSBL	28%	4.7% ***	4.9%
Halogen Pin-Based	9%	19% **	19%
Halogen MSBL	6%	5%	0.8%
CFL Pin-Based	30%	36%	34%
CFL MSBL	26%	22%	31%
LED Pin-Based	<0.1%	0.7% *	1.4%
LED MSBL	0.9%	12% ***	9%
Total	**100%**	**100%**	**100%**
n	**381**	**96**	**48**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-55: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation for SCE – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	15%	24% **	26%
Halogen Pin-Based	7%	6%	1.8%
Halogen MSBL	6%	7%	9%
CFL Pin-Based	21%	16%	15%
CFL MSBL	45%	42%	45%
LED Pin-Based	2.0%	0.4%	0.6%
LED MSBL	4.8%	5%	3.0%
Total	**100%**	**100%**	**100%**
n	**371**	**162**	**89**

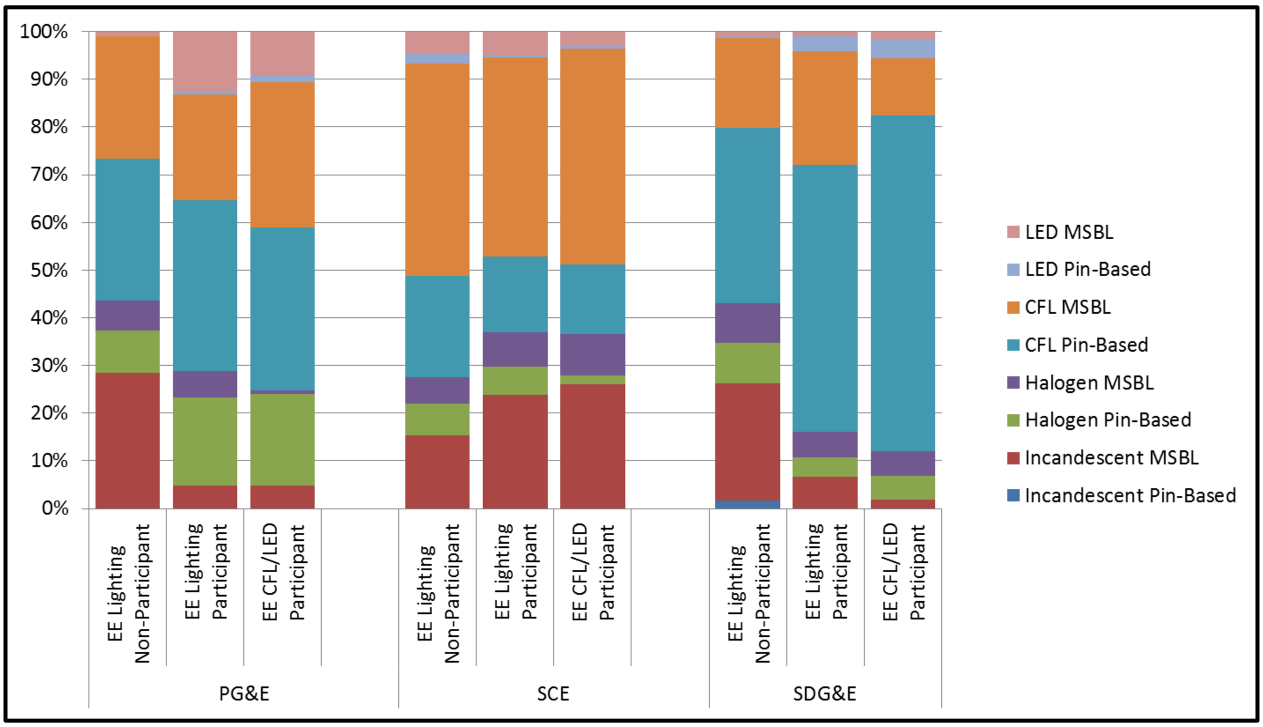
* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-56: ICLH Lamp Distribution EE 2009-2012 Lighting HIM Participation for SDG&E – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	1.7%	0%	0%
Incandescent MSBL	25%	7% ***	1.8%
Halogen Pin-Based	8%	4.1%	5%
Halogen MSBL	8%	5%	5%
CFL Pin-Based	37%	56% *	70%
CFL MSBL	19%	24%	12%
LED Pin-Based	0.5%	3.0% *	4.1%
LED MSBL	1.0%	1.1%	1.5%
Total	**100%**	**100%**	**100%**
n	**148**	**42**	**22**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Figure 5-25: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation and IOU – Indoor Lighting



* **The results presented above have been weighted by site weight.**

<u>Performance Group Distribution by EE 2009-2012 Lighting HIM Participation and Business Size</u>

Table 5-57, Table 5-58, Table 5-59, Table 5-60, and Figure 5-26 display ICLH lamp saturations for each business size by EE participation. In Large businesses, Pin-Based CFL lamps are most likely to be found of any other technology type, with EE Lighting program participants having lower proportions than EE Lighting non-participants and CFL/LED program participants. Pin-Based CFLs make up the majority of lamps found in Medium-sized businesses, with relatively even distributions between EE Lighting participants and non-participants. In Small businesses, EE Lighting participants are more likely to have pin-based Halogen lamps and less likely to have pin-based CFL lamps relative to non-participants. In Very Small businesses, EE Lighting participants are more likely to have medium screw-based CFL and LED lamps, but much less likely to have medium screw-based Incandescent and pin-based Halogen lamps.

Table 5-57: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation for Large-Sized Businesses – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	4.4%	8%	9%
Halogen Pin-Based	2.4%	12% *	0.8%
Halogen MSBL	1.2%	7%	0.9%
CFL Pin-Based	82%	46% ***	80%
CFL MSBL	8%	12%	3.0%
LED Pin-Based	1.0%	1.3%	3.9%
LED MSBL	1.5%	12% *	2.3%
Total	**100%**	**100%**	**100%**
n	**43**	**42**	**11**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-58: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation for Medium-Sized Businesses – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0%	0.3% *	0%
Incandescent MSBL	13%	8%	6%
Halogen Pin-Based	6%	8%	4.9%
Halogen MSBL	6%	3.8%	0.7%
CFL Pin-Based	48%	41%	41%
CFL MSBL	20%	21%	21%
LED Pin-Based	0.7%	1.4%	2.6%
LED MSBL	6%	17%	24%
Total	**100%**	**100%**	**100%**
n	**289**	**89**	**38**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Medium sites have greater than 300,000 kWh and less than or equal to 1,750,000. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-59: ICLH Lamp Distribution by EE 2009-2012 Lighting HIM Participation for Small-Sized Businesses – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0.5%	0%	0%
Incandescent MSBL	18%	23%	23%
Halogen Pin-Based	7%	19% **	20%
Halogen MSBL	4.8%	2.7%	2.9%
CFL Pin-Based	21%	10% *	11%
CFL MSBL	44%	44%	41%
LED Pin-Based	2.0%	0.1%	0.1%
LED MSBL	3.5%	1.4%	1.5%
Total	**100%**	**100%**	**100%**
n	**314**	**93**	**59**

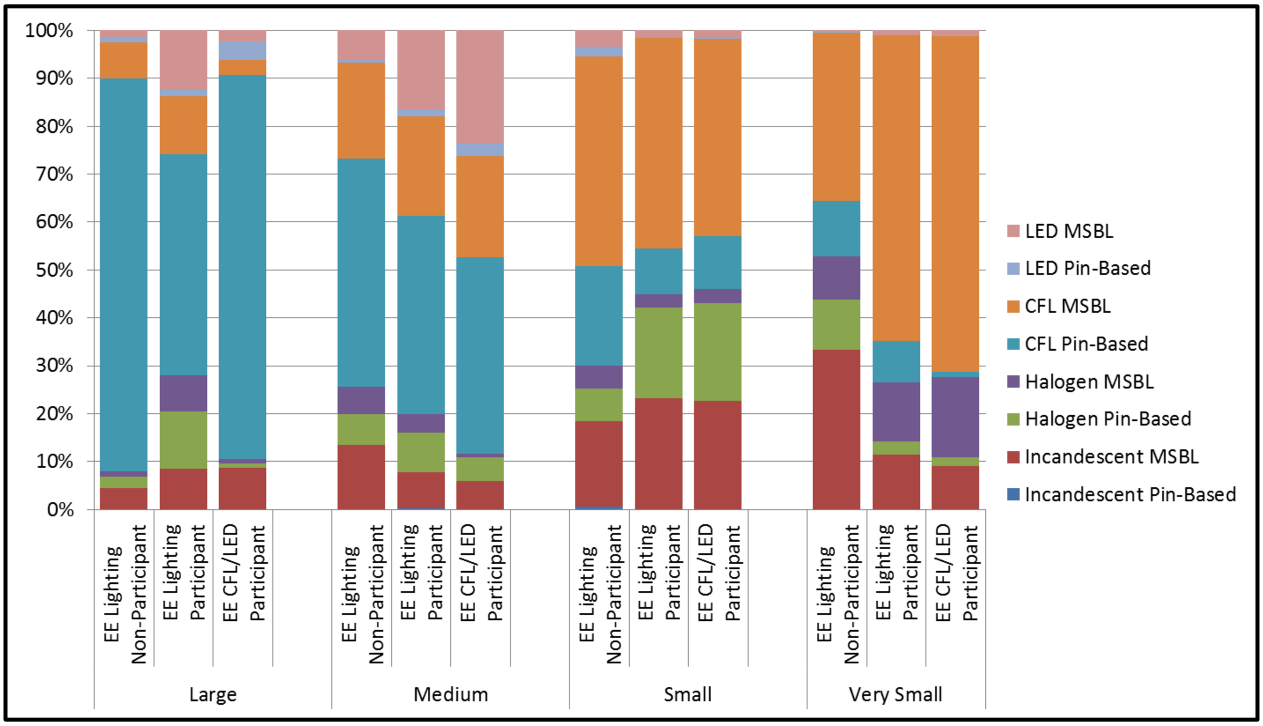
* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Small sites have max annual usage greater than 40,000 kWh and less than or equal to 300,000. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-60: ICLH Lamp Distribution EE 2009-2012 Lighting HIM Participation for Very Small-Sized Businesses – Indoor Lighting

Technology Type	EE Lighting Non-Participant	EE Lighting Participant	EE CFL/LED Participant
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	33%	11% ***	9%
Halogen Pin-Based	11%	2.7% *	1.9%
Halogen MSBL	9%	12%	17%
CFL Pin-Based	12%	9%	1.2%
CFL MSBL	35%	64% ***	70%
LED Pin-Based	0.2%	0%	0%
LED MSBL	0.3%	1.0% *	1.2%
Total	**100%**	**100%**	**100%**
n	**254**	**76**	**51**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Very Small sites have annual usage less than or equal to 40,000 kWh. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Figure 5-26: ICLH Lamp Distribution by Business Size and EE 2009-2012 Lighting HIM Participation – Indoor Lighting



*** The results presented above have been weighted by site weight.**

5.5.3 Comparison with 2006 CEUS Study

Table 5-61 provides the distribution of Incandescent and CFL lamps found in the CSS study and the 2006 CEUS study. The CSS results are presented by the CSS analysis business types while the CEUS results are listed by similar CEUS business types. Prior to discussing the lighting results, it is worth noting that the business type definitions have been modified across these two studies. Specifically, the CSS study does not include Hospitals in the Health/Medical Clinic business type, while the CEUS results include Hospitals. In addition, the CSS study does not disaggregate Offices into Small and Large Offices or Warehouses into Refrigerated and Other Warehouses. For the findings reported in Table 5-61, it was possible to combine CEUS Small and Large Offices and Refrigerated and Other Warehouses into single categories, but it was not possible to take Hospitals out of the CEUS Health/Medical Clinic category.

Comparing the distribution of Incandescent and CFL bulbs in the CSS and the CEUS, businesses in California have clearly reduced their reliance on Incandescent lamps during the period between the 2006 CEUS and the 2014 CSS.[17] All business types show a substantial reduction in the share of Incandescent lamps in the CSS relative to the CEUS. In the CEUS, the highest

[17] The majority of the data collected for the 2014 CSS occurred during 2012 and 2013, while the data collected for the 2006 CEUS occurred during 2002-2005.

shares of Incandescent lamps were in Warehouses (73%), Restaurants (78%), and Food/Liquor stores (71%). In the CSS, Warehouses (11%) and Food/Liquor stores (32%) have substantially switched from Incandescent lamps to CFLs, while Restaurants (47%) still maintain a significant share of Incandescent lamps.

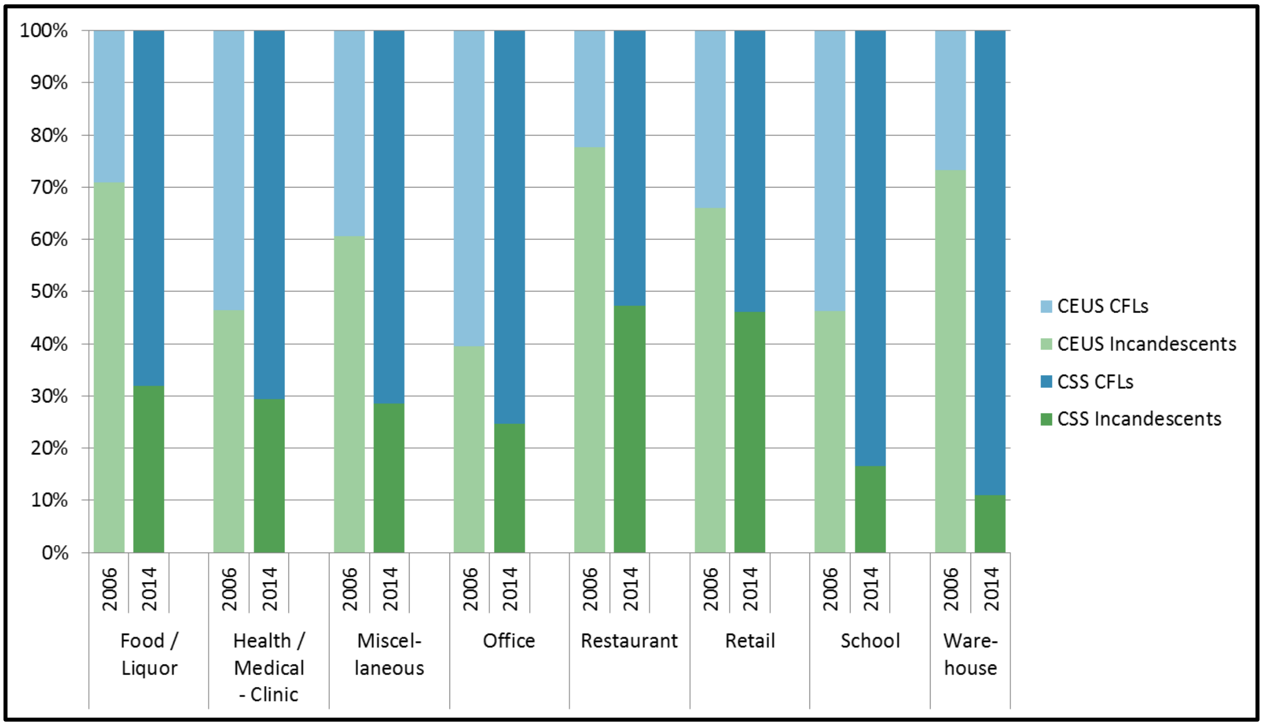
Table 5-61: 2014 CSS and 2006 CEUS Incandescent and CFL Lamp Distribution by Business Type – Indoor Lighting

2014 CSS	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescents	32%	29%	28%	25%	47%	46%	17%	11%
CFLs	68%	71%	72%	75%	53%	54%	83%	89%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
2006 CEUS	**Food/ Liquor**	**Health/ Medical – Includes Hospitals**	**Miscel-laneous**	**Office – Large & Small**	**Restau-rant**	**Retail**	**School**	**Ware-house – Ref & Other**
Incandescents	71%	46%	61%	39%	78%	66%	46%	73%
CFLs	29%	54%	39%	61%	22%	34%	54%	27%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

*** The results presented above have been weighted by site weight.**

Figure 5-27 presents the data above in a bar graph to compare the findings from the 2006 CEUS with the 2014 CSS. Since the 2006 CEUS, the share of CFL lamps has increased for all business types. Accordingly, the share of incandescent lamps has decreased for all business types between the 2006 CEUS and 2014 CSS. Warehouses have experienced the most dramatic shift in CFL/incandescent lamp distribution between the two study periods.

Figure 5-27: 2014 CSS and 2006 CEUS Incandescent and CFL Lamp Distribution by Business Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

5.5.4 Burnt Out ICLH Lamps

This subsection analyzes the distribution by performance group of ICLH lamps that were found on site to be burnt out. The results presented in the tables represent Linear lamps burnt out as a percentage of total ICLH lamps found at businesses within a performance group. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total burnt out ICLH lamps as a percentage of total ILH lamps for each column.

Table 5-62 shows the distribution of burnt out ICLH lamps relative to total ICLH lamps in each performance group by business type. For example, the table shows that 2.7% of medium screw-based Incandescent lamps installed in Food/Liquor stores were burnt out; this is not equivalent to the share of total ICLH lamps across all performance groups that are burnt out. Note that no burnt out pin-based Incandescent lamps or medium screw-based LEDs were found on site. No more than 5% of lamps in any performance group for a given business type were found to be burnt out. Medium screw-based Incandescent lamps and pin-based Halogen lamps in Warehouses have the highest share of burnt out lamps.

Table 5-62: Burnt Out ICLH Lamps as Shares of Total ICLH Lamps by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	2.7%	3.9%	1.8%	3.7%	3.1%	1.3%	3.0%	5%
Halogen Pin-Based	0%	0.6%	1.0%	2.3%	1.0%	2.5%	0%	5%
Halogen MSBL	3.4%	0%	0.3%	0%	0.8%	0.8%	0.8%	0%
CFL Pin-Based	3.6%	0.5%	2.0%	0.4%	1.1%	1.4%	0.4%	1.0%
CFL MSBL	0.6%	1.7%	1.4%	3.9%	2.2%	2.2%	0.1%	0.1%
LED Pin-Based	0%	0%	0%	0%	0%	0%	0%	2.7%
LED MSBL	0%	0%	0%	0%	0%	0%	0%	0%
Total (Burnt Out / All ICLH Lamps)	**1.9%**	**1.8%**	**1.6%**	**2.1%**	**1.9%**	**1.5%**	**0.7%**	**0.7%**
n	**89**	**119**	**217**	**206**	**163**	**195**	**131**	**80**
Sites with Burnt Out ICLH Lamps	**11**	**24**	**30**	**21**	**37**	**30**	**21**	**13**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out ICLH lamps as a percentage of total ICLH lamps for each business type. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-63 shows the distribution of burnt out ICLH lamps relative to total ICLH lamps in each performance group by IOU. The highest share of burnt out lamps in PG&E are medium screw-based Incandescent lamps and medium screw-based CFLs. In SDG&E, pin-based CFLs have the highest share of burnt out lamps. No performance group in any utility was found to have more than 4% of lamps burnt out.

Table 5-63: Burnt Out ICLH Lamps as Shares of Total ICLH Lamps by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	3.9%	1.2%	2.8%
Halogen Pin-Based	2.3%	2.0%	0.4%
Halogen MSBL	1.5%	0%	0.5%
CFL Pin-Based	0.5%	0.9%	3.4%
CFL MSBL	3.4%	0.8%	0.9%
LED Pin-Based	0%	0.2%	0%
LED MSBL	0%	0%	0%
Total (Burnt Out / All ICLH Lamps)	**2.3%**	**0.9%**	**2.2%**
n	**477**	**533**	**190**
Sites with Burnt Out ICLH Lamps	**92**	**73**	**22**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out ICLH lamps as a percentage of total ICLH lamps for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

The distribution of burnt out ICLH lamps relative to total ICLH lamps in each performance group is presented in Table 5-64 by business size. Very Small businesses were found to have higher shares of burnt out lamps than other business sizes for medium screw-based Incandescent lamps, pin-based and medium screw-based CFLs, and pin-based LEDs. Large and Medium businesses have almost 3% of their pin-based Halogen lamps burnt out.

Table 5-64: Burnt Out ICLH Lamps as Shares of Total ICLH Lamps by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0%	0%	0%
Incandescent MSBL	0.6%	0.8%	1.7%	4.0%
Halogen Pin-Based	2.9%	2.7%	1.3%	2.0%
Halogen MSBL	0%	0.8%	1.7%	0%
CFL Pin-Based	0.1%	0.6%	0.8%	5%
CFL MSBL	0.3%	0.8%	0.8%	3.0%
LED Pin-Based	0%	0%	0%	3.6%
LED MSBL	0%	0%	0%	0%
Total (Burnt Out / All ICLH Lamps)	**0.3%**	**0.8%**	**1.0%**	**3.2%**
n	**85**	**378**	**407**	**330**
Sites with Burnt Out ICLH Lamps	**12**	**65**	**69**	**41**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total burnt out ICLH lamps as a percentage of total ICLH lamps for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.5.5 Inoperable ICLH Fixtures

This subsection analyzes the distribution of ICLH fixtures that were found on site to be inoperable. Note that this is an analysis of fixtures rather than lamps, as presented above. The following results represent inoperable ICLH fixtures as a percentage of total ICLH fixtures found at businesses within a performance group. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total inoperable ICLH fixtures as a percentage of total ICLH fixtures for each column.

Table 5-65 presents the distribution of inoperable ICLH fixtures relative to total ICLH fixtures in a performance group by business type. For example, the table shows that 0.6% of medium screw-based Incandescent fixtures installed in Food/Liquor stores were inoperable; this is not equivalent to the share of total ICLH fixtures across all performance groups that are inoperable. As in the above analysis of burnt out lamps, no inoperable pin-based Incandescent or medium screw-based LED fixtures were found on site. Across the business types, most performance groups have fewer than 3% of fixtures inoperable. Offices, however were found to have relatively high shares of inoperable fixtures for medium screw-based Incandescent lamps and pin-based Halogen lamps, at 9% and 11% respectively. In Warehouses, 14% of pin-based LED fixtures are inoperable.

Table 5-65: Inoperable ICLH Fixtures as Shares of Total ICLH Fixtures by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	0.6%	0.1%	1.8%	9%	1.7%	0.4%	0.6%	0%
Halogen Pin-Based	1.6%	0%	0%	11%	0%	1.7%	0%	0%
Halogen MSBL	0%	0%	0%	0%	0%	0.1%	0%	0%
CFL Pin-Based	1.4%	2.4%	1.0%	0.1%	0%	1.3%	1.9%	0%
CFL MSBL	0%	0.5%	0.3%	3.2%	1.5%	2.0%	0%	0%
LED Pin-Based	0%	0%	0%	0%	0%	0%	0%	14%
LED MSBL	0%	0%	0%	0%	8%	0%	0%	0%
Total (Inoperable Fixtures / All ICLH Fixtures)	**0.8%**	**1.0%**	**0.8%**	**3.4%**	**1.2%**	**1.0%**	**1.1%**	**<0.1%**
n	**89**	**119**	**217**	**206**	**163**	**195**	**131**	**80**
Sites with Inoperable ICLH Fixtures	**3**	**8**	**17**	**7**	**10**	**9**	**7**	**1**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable ICLH fixtures as a percentage of total ICLH fixtures for each business type. *n*'s represent the number of surveyed sites included in the analysis.

The distribution of inoperable ICLH fixtures relative to total ICLH fixtures in a performance group by IOU is shown in Table 5-66. While no performance group exceeded 5% of inoperable fixtures, PG&E had relatively higher shares of inoperable fixtures for medium screw-based Incandescent lamps, pin-based Halogen lamps, and medium screw-based CFLs. SCE also had a relatively higher share of inoperable pin-based Halogen fixtures. In SDG&E, very few inoperable fixtures were found.

Table 5-66: Inoperable ICLH Fixtures as Shares of Total ICLH Fixtures by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	4.4%	0.7%	0.3%
Halogen Pin-Based	2.7%	2.5%	0%
Halogen MSBL	0.1%	0%	0%
CFL Pin-Based	1.1%	1.0%	0.1%
CFL MSBL	2.7%	0.2%	0.4%
LED Pin-Based	0%	0.3%	0%
LED MSBL	0%	1.1%	0%
Total (Inoperable Fixtures / All ICLH Fixtures)	**2.4%**	**0.6%**	**0.2%**
n	**477**	**533**	**190**
Sites with Inoperable ICLH Fixtures	**41**	**16**	**5**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable ICLH fixtures as a percentage of total ICLH fixtures for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-67 shows the distribution of inoperable ICLH fixtures relative to total ICLH fixtures in a performance group by business size. Very Small businesses have 3.6% of medium screw-based Incandescent fixtures inoperable, compared to 0.9% for Small businesses, 2.7% for Medium businesses, and 0.1% for Large businesses. A full 25% of pin-based LEDs at Very Small businesses were in inoperable fixtures. However, this share may be inflated because the total number of pin-based LEDs found on site at Very Small businesses is substantially lower than other performance groups for any business size.

Table 5-67: Inoperable ICLH Fixtures as Shares of Total ICLH Fixtures by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0%	0%	0%
Incandescent MSBL	0.1%	2.7%	0.9%	3.6%
Halogen Pin-Based	1.9%	0%	0%	6%
Halogen MSBL	0%	0%	0.2%	0%
CFL Pin-Based	0.1%	0.9%	1.8%	0%
CFL MSBL	0%	0.4%	0.4%	2.1%
LED Pin-Based	0%	0%	0%	25%
LED MSBL	0%	1.7%	0%	0%
Total (Inoperable Fixtures / All ICLH Fixtures)	**0.2%**	**1.0%**	**0.7%**	**2.5%**
n	**85**	**378**	**407**	**330**
Sites with Inoperable ICLH Fixtures	**6**	**22**	**24**	**10**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total inoperable ICLH fixtures as a percentage of total ICLH fixtures for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.5.6 ICLH Lamps in Storage

This subsection analyzes the distribution by performance group of ICLH lamps that were found in storage on site. The results presented in the tables represent ICLH lamps in storage as a percentage of total ICLH lamps found at businesses within a performance group. Total ICLH lamp counts include burnt out lamps and lamps installed in inoperable fixtures, but exclude lamps in storage. Instead, the shares presented below can be interpreted as the proportion of installed lamps that have replacement lamps in storage. Since shares are relative to a performance group, columns should not be summed to represent the share across performance groups. Rather, total percentages have been calculated as total ICLH lamps in storage as a percentage of total ICLH lamps for each column.

Table 5-68 shows the share of ICLH lamps in storage relative to total ICLH lamps in a performance group by business type. For example, the table shows that 19% of medium screw-based Incandescent lamps installed in Food/Liquor stores have replacements in storage; this is not equivalent to the share of total ICLH lamps across all performance groups that have replacements in storage. A considerable 19% of medium screw-based Incandescent lamps in Food/Liquor stores have replacements in storage. Twenty-eight percent of pin-based Halogen lamps in Restaurants have replacements in storage. At Schools, 12% of medium screw-based Incandescent lamps and 18% of medium screw-based CFLs have replacements in storage. For

Offices, 14% of medium screw-based Halogen lamps and 10% of pin-based CFLs have replacements in storage.

Table 5-68: ICLH Lamps in Storage as Shares of Total ICLH Lamps by Business Type – Indoor Lighting

Performance Group	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Incandescent Pin-Based	0%	0%	0%	0%	0%	0%	0%	0%
Incandescent MSBL	19%	2.6%	3.0%	0.5%	4.8%	3.2%	12%	3.3%
Halogen Pin-Based	2.6%	2.7%	0.7%	3.4%	28%	3.2%	0%	0%
Halogen MSBL	0%	2.0%	0.4%	14%	6%	1.4%	9%	0%
CFL Pin-Based	7%	7%	4.1%	10%	2.2%	6%	9%	2.9%
CFL MSBL	4.2%	7%	3.3%	7%	4.5%	3.2%	18%	0.4%
LED Pin-Based	0%	0%	0%	4.7%	0%	0%	0%	0%
LED MSBL	0%	0%	0.4%	1.6%	1.2%	0.9%	0%	0%
Total (Lamps in Storage / All ICLH Lamps)	**8%**	**6%**	**3.1%**	**7%**	**6%**	**3.2%**	**11%**	**0.8%**
n	**89**	**119**	**217**	**206**	**163**	**195**	**131**	**80**
Sites with ICLH Lamps in Storage	**8**	**23**	**46**	**51**	**28**	**34**	**36**	**6**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total ICLH lamps in storage as a percentage of total ICLH lamps for each business type. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-69 shows the share of ICLH lamps in storage relative to total ICLH lamps in a performance group by IOU. At 11%, SCE has a significantly higher share of pin-based Halogen lamps with replacements in storage than the other IOUs. Excluding pin-based Halogen lamps, PG&E generally has higher shares of replacement lamps in storage for the remaining performance groups than SCE and SDG&E. Across the IOUs, pin-based and medium screw-based CFLs have relatively high shares of replacement lamps in storage.

Table 5-69: ICLH Lamps in Storage as Shares of Total ICLH Lamps by IOU – Indoor Lighting

Performance Group	PG&E	SCE	SDG&E
Incandescent Pin-Based	0%	0%	0%
Incandescent MSBL	4.4%	2.7%	0.9%
Halogen Pin-Based	3.6%	11%	3.2%
Halogen MSBL	3.2%	1.9%	1.6%
CFL Pin-Based	8%	5%	4.2%
CFL MSBL	7%	1.9%	6%
LED Pin-Based	0%	0.6%	0%
LED MSBL	1.8%	0.5%	0%
Total (Lamps in Storage / All ICLH Lamps)	**6%**	**3.2%**	**3.3%**
n	**477**	**533**	**190**
Sites with ICLH Lamps in Storage	**126**	**67**	**39**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total ICLH lamps in storage as a percentage of total ICLH lamps for each IOU. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-71 presents the share of ICLH lamps in storage relative to total ICLH lamps in a performance group by business size. Large businesses have a high share of medium screw-based Incandescent replacement lamps in storage at 14%, compared to less than 5% in other sized businesses. At Small businesses, 11% of pin-based Halogen lamps have replacements in storage. Across all business sizes, pin-based Halogen lamps and pin-based CFLs have replacements in storage at relatively high proportions, around 6% of lamps on site for each respective performance group.

Table 5-70: ICLH Lamps in Storage as Shares of Total ICLH Lamps by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
Incandescent Pin-Based	0%	0%	0%	0%
Incandescent MSBL	14%	3.8%	4.5%	1.5%
Halogen Pin-Based	0.5%	4.7%	11%	3.3%
Halogen MSBL	7%	4.7%	2.9%	0.4%
CFL Pin-Based	5%	7%	7%	6%
CFL MSBL	0.4%	4.9%	4.1%	3.2%
LED Pin-Based	0%	3.4%	0%	0%
LED MSBL	0%	1.8%	0.4%	0%
Total (Lamps in Storage / All ICLH Lamps)	**4.7%**	**5%**	**5%**	**2.7%**
n	**85**	**378**	**407**	**330**
Sites with ICLH Lamps in Storage	**29**	**110**	**71**	**22**

* **The results presented above have been weighted by site weight.** Totals have been calculated as total ICLH lamps in storage as a percentage of total ICLH lamps for each business size. *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.6 High Bay Lighting

The High Bay lighting section presents information on lighting technologies currently installed in High Bay fixtures at commercial businesses in California. For the purposes of this analysis, High Bay lighting is defined as lamps in fixtures installed at a height of 15 feet or above. Therefore, this section includes lamps that are also discussed in the Linear and ICLH sections that have a special application as High Bay lighting. Table 5-71 shows the share of High Bay lamps for each technology type as a percentage of all indoor lamps of that technology type. Shares are given by technology type, and therefore should not be summed. For example, the table shows that 13% of indoor Linear lamps are installed in High Bay applications; this is not equivalent to the share of all indoor lamps that are High Bay Linear lamps.

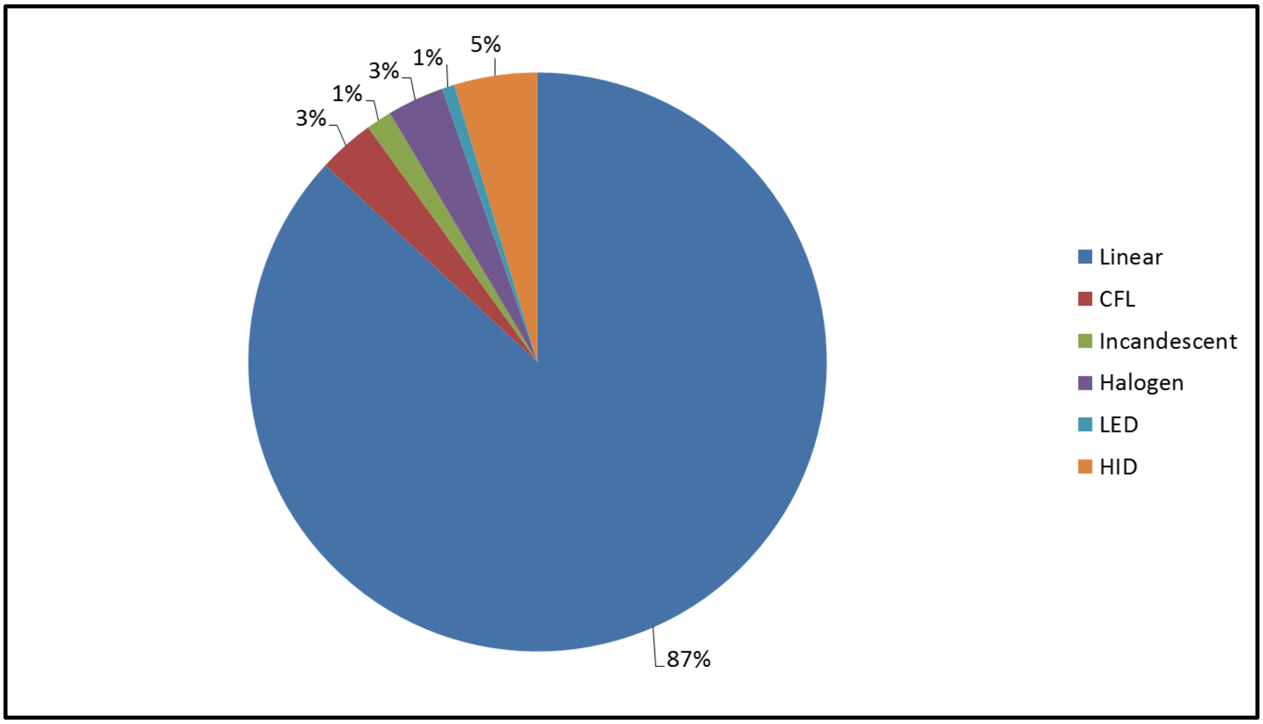
Table 5-71: Share of Each Technology Type's Lamps that are High Bay – Indoor Lighting

Technology Type	Share of Each Technology Type's Indoor Lamps that are High Bay
Linear	13%
CFL	4.5%
Incandescent	4.7%
Halogen	17%
LED	9%
HID	60%
n	**1,436**

* **The results presented above have been weighted by site weight.** Shares represent High Bay lamps of a given technology type as a percentage of all indoor lamps of the same technology type. Therefore, shares do not represent percentages of total indoor lamps and should not be summed. *n* represents the number of surveyed sites included in the analysis.

Figure 5-28 presents the distribution of High Bay lamps by technology type. In contrast to Table 5-71 above which gives shares of total indoor lamps by technology type, this figure shows the share of High Bay lamps represented by each technology type. As shown, Linear lamps constitute the majority of High Bay lamps at 87%. Interestingly, Table 5-71 shows that 60% of all indoor HID lamps are installed in High Bay applications, yet these lamps represent only 5% of High Bay lamps installed across all technology types.

Figure 5-28: Distribution of High Bay Lamps by Technology Type – Indoor Lighting



*** The results presented above have been weighted by site weight.**

The analysis will look at some basic characteristics of High Bay lighting, including the average number of lamps per square foot and efficiency distributions by business type, IOU, business size, and EE program participation. The analysis includes data for the following business types: Food/Liquor, Health/Medical Clinics, Miscellaneous, Office, Restaurant, Retail, School, and Warehouse. While High Bay lighting was found in some Health/Medical Clinics and Restaurants, the total sampled sites were so few that these two business types have been excluded from the presentation of data within this section. The data collected for these business types is, however, included in all results other than those presented by business type.

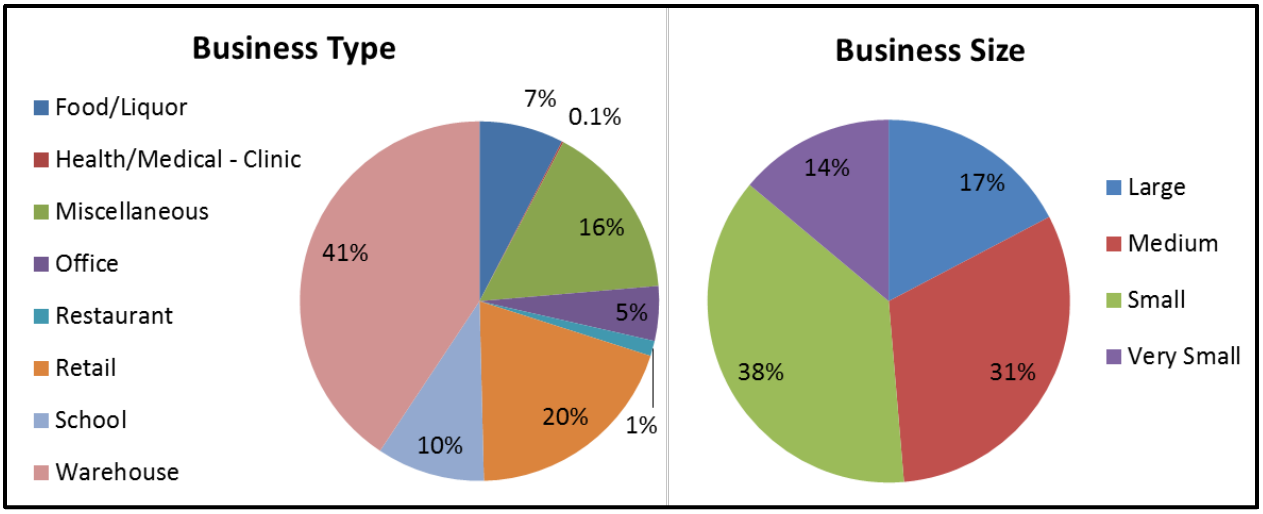
5.6.1 General Saturation and Density

Figure 5-29 illustrates the distribution of High Bay lamps across business types and business sizes. This provides perspective on the relative magnitude of the distributions that follow. As shown below, Warehouses comprise the greatest share of High Bay lamps of any business type. The relatively large quantity of High Bay lamps in the Warehouse segment is because 55% of Warehouses have High Bay lamps and Warehouses have the largest share (29%) of CSS commercial floor stock.[18] Given the very small share of Health/Medical Clinics and Restaurants

[18] See Section 4 of this report for information on the distribution of CSS commercial floor stock across business types.

with High Bay lamps, these business types will not be included in the presentation of future tables and figures in this sub-section. Within business size, Small and Medium businesses represent the greatest share of High Bay lamps.

Figure 5-29: Distribution of High Bay Lamps by Business Type and Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

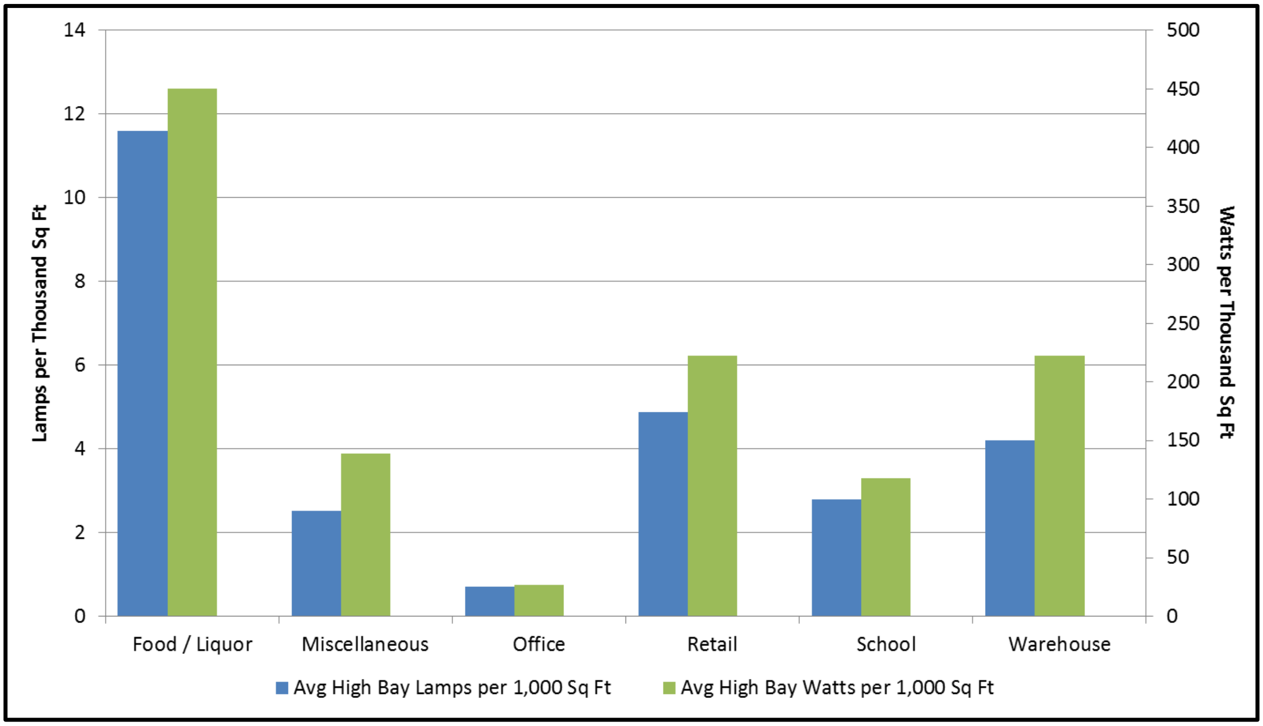
Table 5-72 shows the average density of High Bay lighting technologies within commercial businesses in California in terms of the share of businesses with High Bay lamps, average lamps per 1,000 square feet, average watts per square foot, and average lumens per square foot by business type. High bay lamps were found in over 35% of businesses across all business types. Relative to other business types, Schools have the highest share of businesses with High Bay lamps at 64% of Schools, followed by Warehouses at 55%. Food/Liquor stores, Miscellaneous businesses, Offices, and Retail stores have 13-24% of businesses with High Bay lamps, while Restaurants and Health/Medical Clinics have considerably fewer businesses with High Bay lamps. When looking only at businesses with High Bay lighting, Food/Liquor stores exhibit the highest density of High Bay lighting across all three measures of density: average number of lamps per 1,000 square feet, average watts per square foot, and average lumens per square foot. These numbers indicate that while only 19% of all businesses grouped as Food/Liquor have High Bay lamps, the 19% with High Bay lamps have a substantial quantity of these lamps. In contrast, while 64% of Schools have High Bay lamps, the quantity of High Bay lamps, their watts, and lumens per square foot are only a quarter of the density seen in Food/Liquor stores with High Bay lamps. The relationship between lamp and wattage densities by business type is also depicted in Figure 5-30.

Table 5-72: Average Density of High Bay Lamps by Business Type – Indoor Lighting

Business Type	*n*	Share of Businesses with High Bay Lamps	Average High Bay Lamps per 1,000 Sq Ft	Average High Bay Watts per Sq Ft	Average High Bay Lumens per Sq Ft
Food/Liquor	126	19%	11.6	0.45	36
Miscellaneous	245	24%	2.5	0.14	9
Office	246	13%	0.7	0.03	2
Retail	233	19%	4.9	0.22	16
School	161	64%	2.8	0.12	8
Warehouse	127	55%	4.2	0.22	17
Total	**1,436**	**21%**	**3.0**	**0.15**	**11**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Total Share of Businesses with High Bay Lamps is the share across all business types, including Health/Medical Clinics and Restaurants. Totals for Average High Bay Lamps per 1,000 Sq Ft, Average High Bay Watts per Sq Ft, and Average High Bay Lumens per Sq Ft represent weighted averages across all business types, including Health/Medical Clinics and Restaurants.

Figure 5-30: Average High Bay Lamps and Watts per Thousand Square Feet by Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

5.6.2 Saturations by Performance Group

Performance Group Distribution by Business Type

Table 5-73 and Figure 5-31 present the share of High Bay lamps in each performance group by business type. As depicted, Linear lamps represents the greatest proportion of High Bay lamps for all business types. For High Bay applications, Linear lighting is disaggregated into four efficiency groups.

- Linear – T12: The lowest efficiency Linear lamp
- Linear – Unknown: Given that the on-site surveyors could largely visually classify Linear lamps as T12 or T5, the Linear – Unknown group is mostly a mix of base and high efficiency T8s
- Linear – Base Efficiency: 700- and 800-series T8s
- Linear – High Efficiency: Reduced Wattage and High Performance T8s and T5s

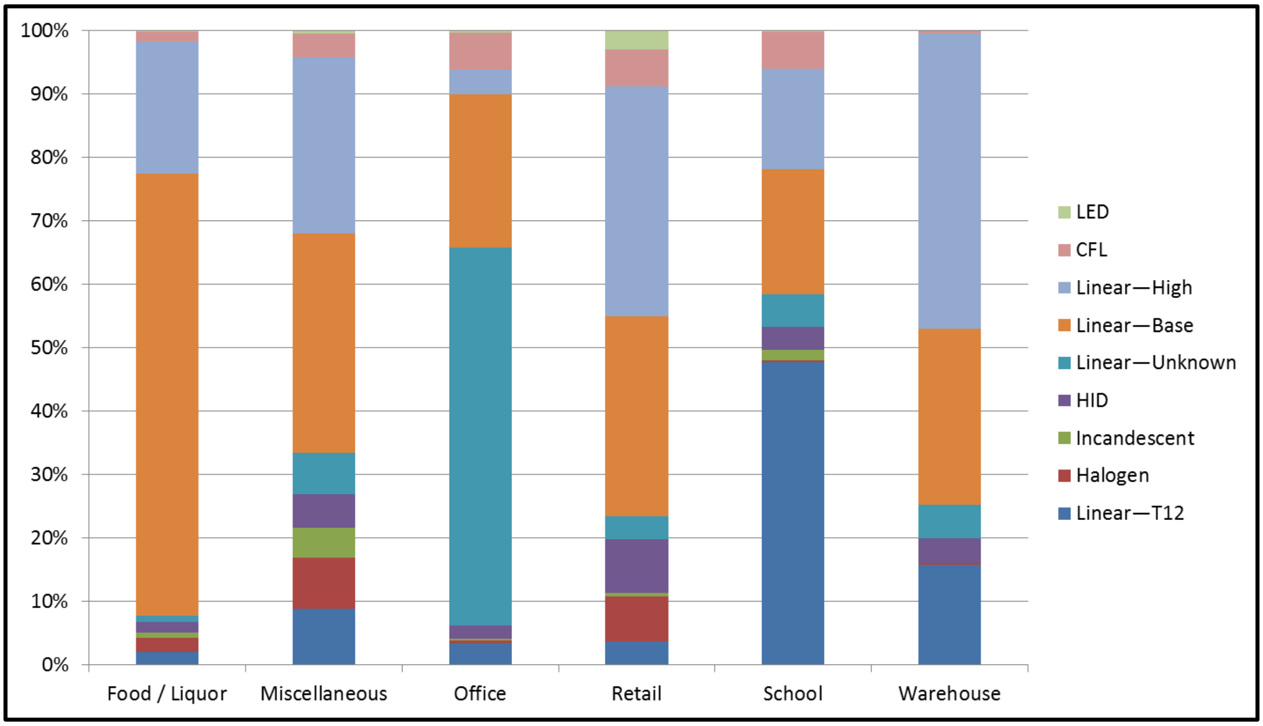
Food/Liquor stores have a large share of Base Efficiency Linear lamps, while Offices have a majority share of Unknown Linear lamps. Warehouses have the greatest share of High Efficiency Linear High Bay lamps. Halogen, Incandescent, HID, CFL, and LED lamps each constitute less than 10% of High Bay lamps across all business types. Miscellaneous businesses have relatively higher shares of Halogens and Incandescents. Retail stores have higher shares of HIDs and LEDs. Offices, Retail stores, and Schools each have about a 6% share of CFLs.

Table 5-73: High Bay Lamp Efficiency Distribution by Business Type – Indoor Lighting

Performance Group	**Food/ Liquor**	**Miscel-laneous**	**Office**	**Retail**	**School**	**Ware-house**
Linear—T12	2.0%	9%	3.4%	3.8%	48%	16%
Halogen	2.2%	8%	0.4%	7%	0.2%	0.2%
Incandescent	0.9%	4.7%	0.3%	0.6%	1.7%	<0.1%
HID	1.7%	5%	2.2%	8%	3.5%	3.9%
Linear—Unknown	1.0%	7%	60%	3.6%	5%	5%
Linear— T8 Base Efficiency	70%	35%	24%	32%	20%	28%
Linear— T8 High Efficiency	21%	28%	3.9%	36%	16%	46%
CFL	1.6%	3.8%	6%	6%	6%	0.5%
LED	0.1%	0.4%	0.3%	3.0%	0.1%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**48**	**101**	**54**	**76**	**118**	**90**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-31: High Bay Lamp Efficiency Distribution by Business Type – Indoor Lighting

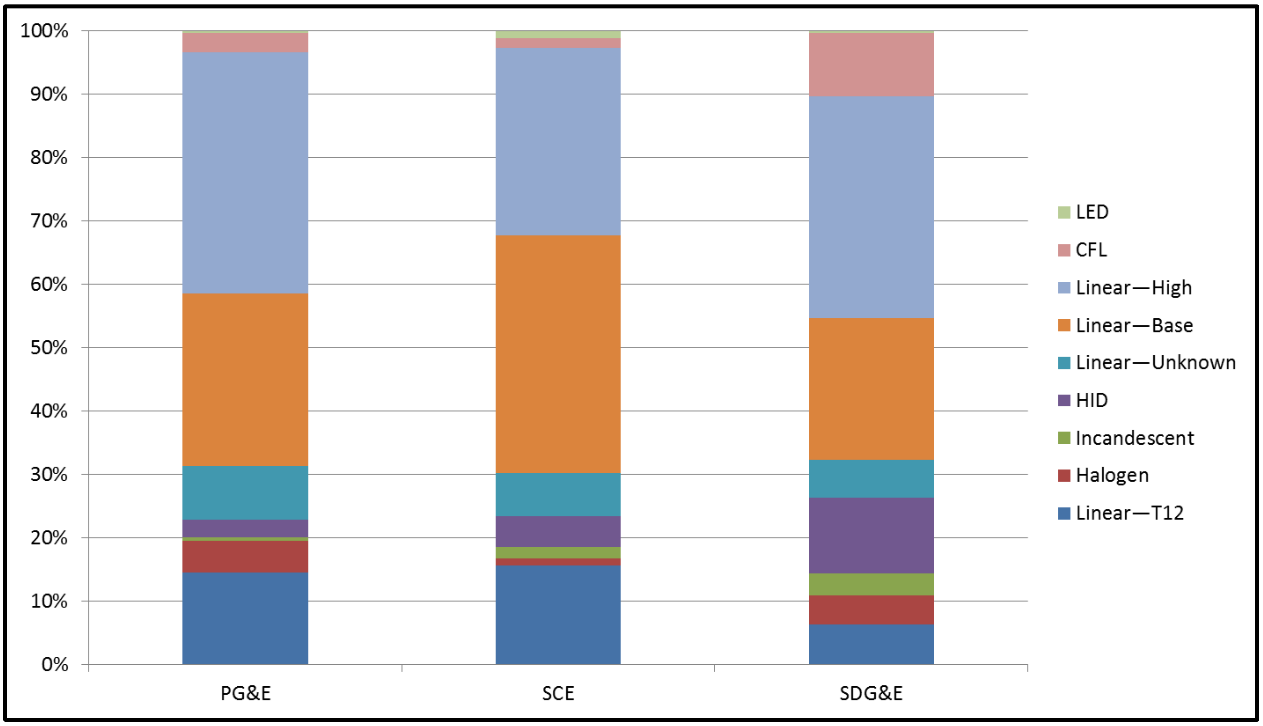


*** The results presented above have been weighted by site weight.**

Performance Group Distribution by IOU

Figure 5-32 illustrates the saturation of High Bay technologies by performance group for each IOU. High Efficiency Linear lamps make up over 30% of High Bay lamps across all three IOUs. SCE has a higher proportion of Base Efficiency Linear lamps than High Efficiency Linear lamps and has a higher share of Base Efficiency Linears than PG&E and SDG&E. If the share of T12 lamps is added to the share of Base Efficiency Linear lamps, SCE's share of low and base efficiency Linear lamps is higher than the other two IOUs. SCE also has lower shares of CFLs, but has over three times the share of LEDs as the other IOUs.

Figure 5-32: High Bay Lamp Efficiency Distribution by IOU – Indoor Lighting



*** The results presented above have been weighted by site weight.**

Performance Group Distribution by Business Size

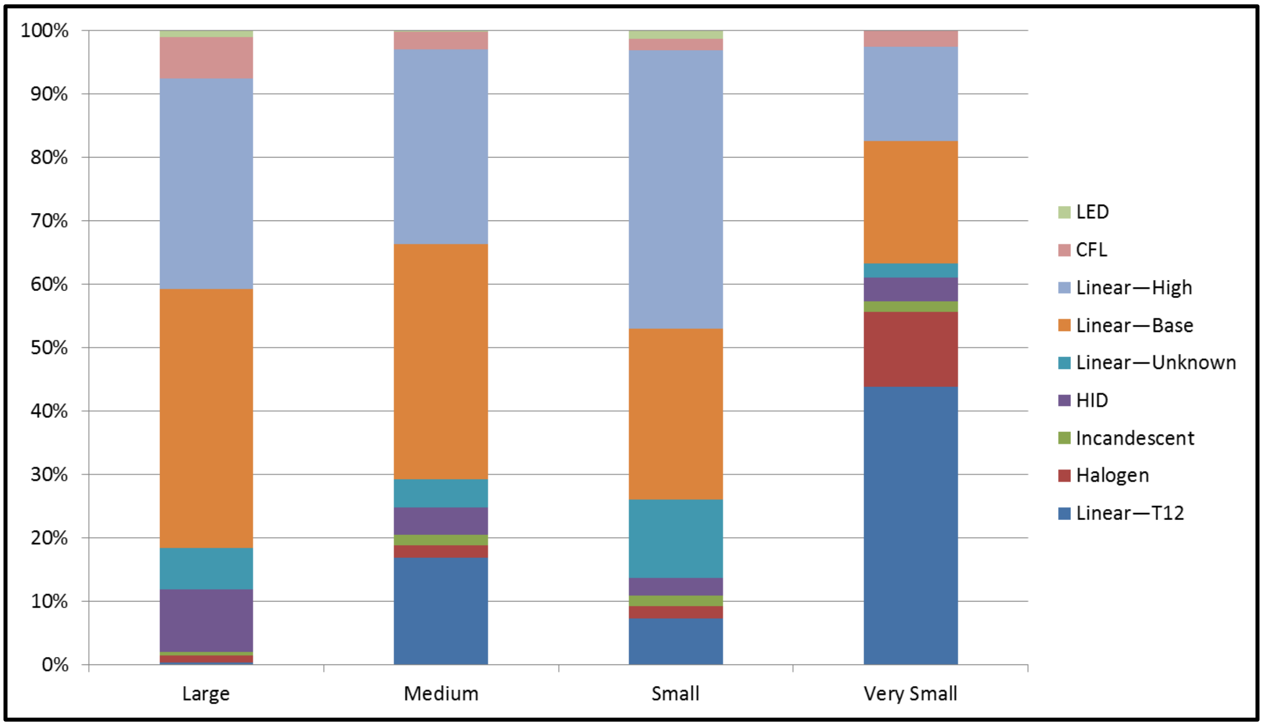
Table 5-19Table 5-74 and Figure 5-33 present the efficiency distribution of High Bay lamps by business size, based on kWh consumption. Large businesses tend to have a greater proportion of Base Efficiency Linear High Bay lamps, while Small businesses have relatively higher proportions of High Efficiency Linear lamps. Large businesses also have higher shares of HID and CFL High Bay lamps. Very Small businesses were found to have particularly high shares of T12 and Halogen lamps relative to other business sizes, at 44% and 12%, respectively. Incandescents and LEDs each represent less than 2% of High Bay lamps across all business sizes.

Table 5-74: High Bay Lamp Efficiency Distribution by Business Size – Indoor Lighting

Performance Group	Large	Medium	Small	Very Small
Linear—T12	0.4%	17%	7%	44%
Halogen	1.0%	2.0%	2.0%	12%
Incandescent	0.6%	1.6%	1.6%	1.6%
HID	10%	4.3%	2.9%	3.7%
Linear—Unknown	7%	4.5%	12%	2.3%
Linear—Base Efficiency	41%	37%	27%	19%
Linear—High Efficiency	33%	31%	44%	15%
CFL	7%	2.8%	1.8%	2.6%
LED	1.0%	0.2%	1.3%	0%
Total	**100%**	**100%**	**100%**	**100%**
n	**70**	**227**	**160**	**52**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-33: High Bay Lamp Efficiency Distribution by Business Size – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Performance Group Distribution by EE 2009-2012 Lighting HIM Participation

For the purposes of this analysis, Energy Efficiency (EE) program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[19] The EE program participation analysis characterizes EE Lighting program participants as businesses who identified the installation of high efficiency lighting on any EE program application, including custom applications.[20]

Displayed in Table 5-75 is the efficiency distribution of High Bay lamps by participation in 2009-2012 Energy Efficiency programs for High-Impact Lighting measures (EE Lighting). As shown, EE Lighting non-participants have a statistically significant higher share of T12 lamps as compared to program participants. EE Lighting participants have significantly lower shares of Halogen, Incandescent, and HID High Bay lamps than non-participants.

[19] Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

[20] EE LF HIM program participants are included as EE Lighting program participants.

Table 5-75: High Bay Lamp Efficiency Distribution by EE 2009-2012 Lighting HIM Participation – Indoor Lighting

Performance Group	EE Lighting Non-Participant	EE Lighting Participant
Linear—T12	18%	2.0% **
Halogen	4.0%	0.4% **
Incandescent	1.8%	0.3% *
HID	6%	0.6% **
Linear—Unknown	6%	13%
Linear—Base Efficiency	32%	29%
Linear—High Efficiency	29%	51%
CFL	3.3%	2.2%
LED	0.7%	0.6%
Total	**100%**	**100%**
n	**363**	**146**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Performance Group Distribution by EE 2009-2012 Lighting HIM Participation and IOU

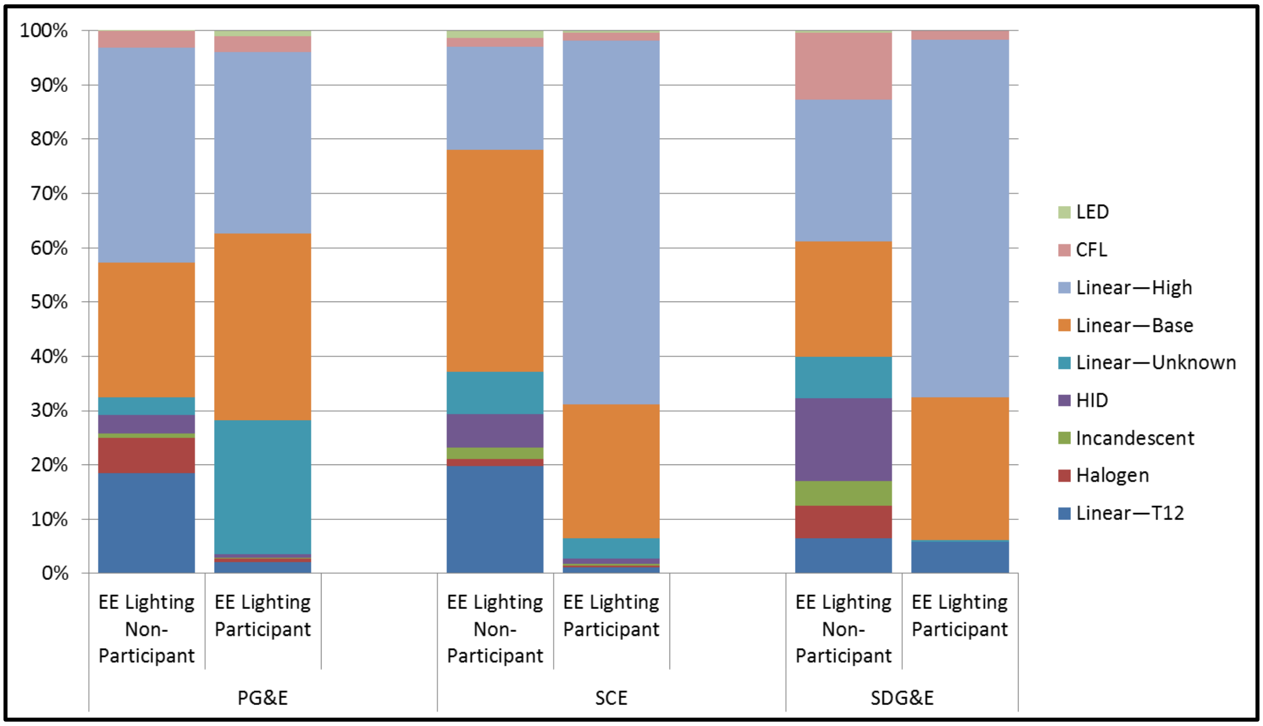
Table 5-76 and Figure 5-34 display the efficiency distribution of High Bay lamps by participation in 2009-2012 Energy Efficiency programs for High-Impact Lighting measures (EE Lighting) and by IOU. SCE and SDG&E's EE Lighting program participants have significantly higher share of High Efficiency Linear lamps than non-participants. EE Lighting participants in SCE have a statistically significant lower share of T12 than non-participants, while PG&E and SDG&E's participant shares of T12s are not statistically significantly different than non-participant shares for each respective utility. In PG&E, while EE Lighting non-participants have a higher share of High Efficiency Linear lamps than non-participants, this difference is not statistically significant at the 10% level. One factor that may contribute to the low share of High Efficiency Linear High Bay lamps among PG&E's EE Lighting participants is their disproportionately high share of Unknown Linear High Bay lamps. Given that the Unknown Linear lamps are likely to be either Base or High Efficiency T8 lamps, it is possible that some, or even many, of these Unknown Linear lamps are in fact High Efficiency. LEDs make up a statistically significant higher share of High Bay lamps for PG&E's EE Lighting participants than its non-participants. For all three utilities, HIDs represent a higher share of lamps among EE Lighting non-participants than participants, perhaps due to the emphasis within recent EE Lighting programs to replace high wattage HIDs with High Efficiency Linear technologies.

Table 5-76: High Bay Lamp Efficiency Distribution by EE 2009-2012 Lighting HIM Participation and IOU – Indoor Lighting

Performance Group	PG&E		SCE		SDG&E	
	EE Lighting Non-Participant	EE Lighting Participant	EE Lighting Non-Participant	EE Lighting Participant	EE Lighting Non-Participant	EE Lighting Participant
Linear—T12	19%	2.1%	20%	1.2% **	7%	6%
Halogen	6%	0.7%	1.4%	0.2%	6%	<0.1%
Incandescent	0.8%	0.2%	2.2%	0.4%	4.5%	<0.1%
HID	3.5%	0.5%	6%	0.9% *	15%	<0.1%
Linear—Unknown	3.2%	25% **	8%	3.7%	8%	0.2%
Linear—Base Efficiency	25%	34%	41%	25% *	21%	26%
Linear—High Efficiency	40%	33%	19%	67% ***	26%	66% **
CFL	3.1%	2.9%	1.6%	1.6%	12%	1.7%
LED	0.1%	1.1% *	1.4%	0.3%	0.4%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**153**	**63**	**158**	**67**	**53**	**16**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Figure 5-34: High Bay Lamp Efficiency Distribution by EE 2009-2012 Lighting HIM Participation and IOU – Indoor Lighting



* **The results presented above have been weighted by site weight.**

5.7 Commercial Indoor Lighting Schedules and Usage

5.7.1 Introduction

An important component of the on-site data collection effort was gathering self-reported lighting schedules for different activity areas within the building. For each activity area, the site contact provided the surveyor with daily percent "ON" estimates for lighting throughout a typical 24 hour period for each day of the week.[21] Along with these typical schedules, if a site had seasonal schedules, the contact was asked to provide an estimate of lighting schedules throughout those time periods as well. These self-reported estimates by activity area and typical/seasonal operations more accurately capture lighting hours at the site level than business hours.

Lighting self-reports were also adjusted based on actual lighting logger data that was collected and analyzed by the 2006 – 2008 California Small Commercial Contract Group (SCCG).[22] The

[21] Self-reported lighting schedules were developed for activity areas with installed lighting controls in the same manner in which schedules were developed for manual controls. The self-reported schedules represent a percent time "ON" per hour for each hour of the day throughout the week. Therefore, these schedules account for any lighting controls that may be installed in an activity area.

[22] The 2006-2008 SCCG included nearly 7,000 logger installations at over 1,200 non-residential buildings in California. Loggers recorded actual lighting hours for each activity area. As part of the on-site visit, not only

adjusted self-reports (by business type and day type) were used as a proxy for lighting hours of usage (HOU) for each site. Equipped with the number of lamps installed and operational within each activity area from the on-site survey, a make and model lookup that attached lamp wattages to installed lighting technologies and the adjusted self-reported hours of usage, load shapes were developed and lighting kWh estimates were calculated for each business type and installed lighting technology.

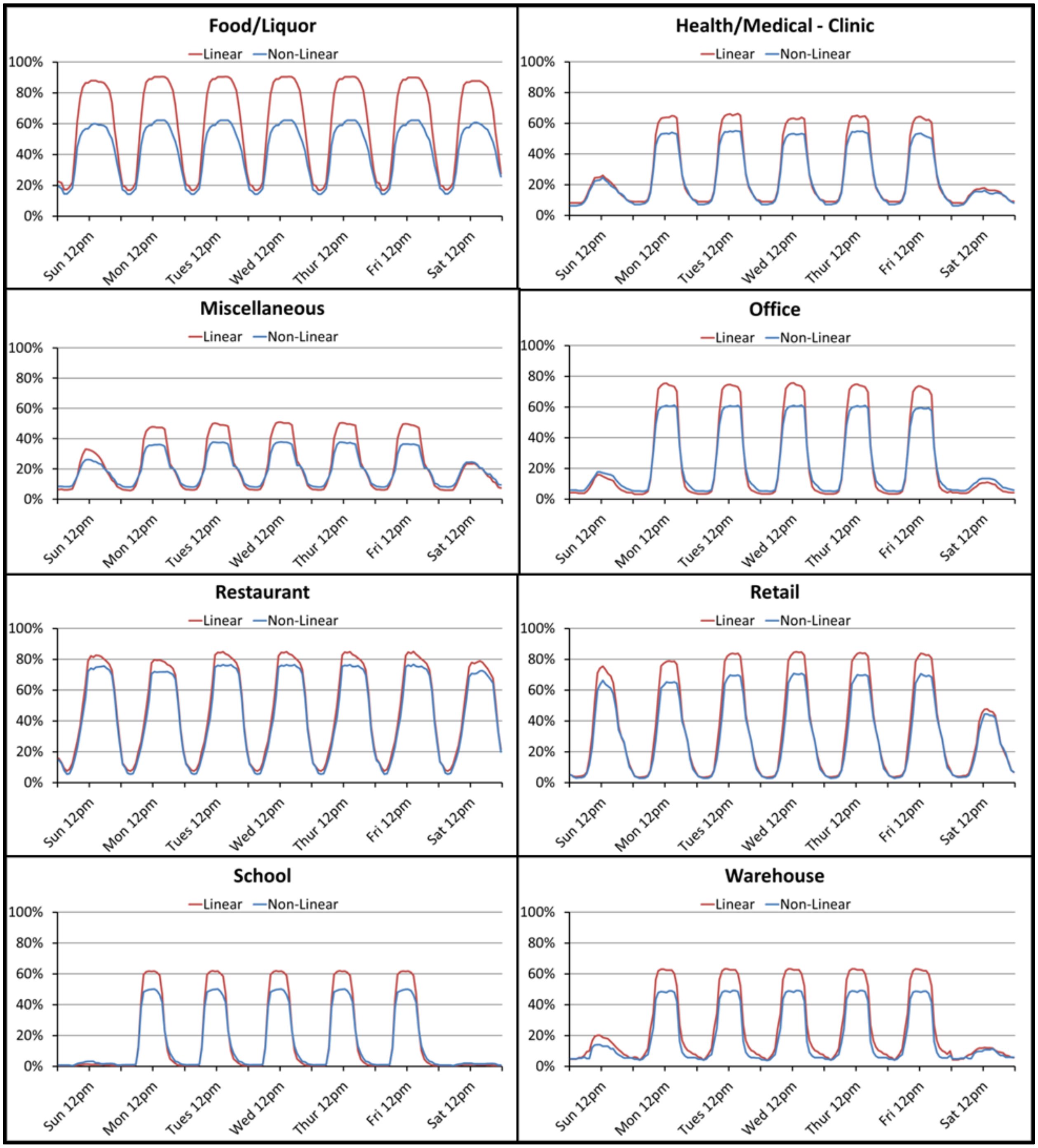
5.7.2 Weekly Load Shapes by Lighting Technology

Weekly load shapes for each analysis business type were developed by averaging the daily schedules (both typical and seasonal) for each site, activity area and lighting technology combination throughout the calendar year. For sites without a seasonal schedule, their weekly load shape represented their typical schedule and for sites with seasonal schedules (e.g. Schools), their load shape was adjusted to take into account seasonal operations. The activity area schedules were also collapsed across business type and lighting technology.

Figure 5-35 illustrates weekly load shapes for Linear and Non-Linear lighting and the eight analysis business types that were visited as part of the CSS on-site data collection effort. While the patterns of usage throughout the week tend to be similar, the average percent "ON" for Linear lighting is higher throughout the peak hours of the work week for all business types. The nuances in the data tend to occur throughout the closing shoulder periods and weekend hours. Linear lighting in Warehouses transitions off more slowly throughout the evening hours of the work week and weekend periods. The opposite is true for Offices. This could reflect the fact that general Office lighting (which is often Linear) is turned off at the end of the day or remains off throughout the weekend while private Offices and other activity areas that use non-Linear technologies transition off more slowly throughout the work week and weekend periods.

were loggers installed, but self-reported operating hours were collected. These self reports were collected as a percent time "ON" per hour for each hour of the day throughout the week. Surveyors collected these self-reports for each lighting schedule within the facility. Equipped with the self-reported schedule as well as actual usage from logger data, adjustment factors (or multipliers) were developed which represent actual logged lighting hours divided by self-reported lighting hours. These adjustment factors were applied at several different levels of aggregation: the business type level, activity area level, and by the installed technology. Self-reported schedules were also collected as part of the CSS on-site effort. The adjustment factors developed from the SCCG data were applied to the CSS self-reported hours to develop a proxy for actual lighting usage since loggers had not been installed at CSS sites. Given constraints in both time and scope, the CSS self-reports were only adjusted at the business type and day type (weekday and weekend) level. However, future studies that incorporate this level of disaggregation would provide even more accurate and meaningful estimates of actual lighting hours of operation. See also: Blake Rector, John Cavalli and Rachel Harcharik, "Is the Customer Always Right? A Cost-Effective Method for Estimating Light Usage in Commercial Buildings," *International Energy Program Evaluation Conference*, Boston, 2011.

Figure 5-35: Weekly Lighting Load Shapes by Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.**

5.7.3 Lighting kWh

The weekly profiles were ultimately used to develop annual lighting hour estimates and combined with data collected throughout the on-site survey effort to estimate annual lighting kWh, lumens, and lumens per square foot. Table 5-77 provides estimates of average lumens and average lumens per square foot for each business type. The higher relative precisions for average total lumens (especially in the case of Offices and Warehouses) suggest that there is variability within each business type. The lower relative precision for average lumens per square foot suggests that some of that variability can be explained by variations in business square footage.

Table 5-77: Annual Lighting Statistics by Business Type – Indoor Lighting

Business Type	*n*	Average Total Lumens	Relative Precision	Average Lumens Per Sq Ft	Relative Precision
Food/Liquor	**126**	507,952	22%	83	9%
Health/Medical - Clinic	**128**	376,388	21%	78	11%
Miscellaneous	**244**	378,203	16%	63	9%
Office	**246**	746,578	50%	75	17%
Restaurant	**170**	144,505	10%	55	8%
Retail	**233**	540,427	17%	79	7%
School	**161**	3,946,612	23%	83	7%
Warehouse	**127**	863,685	27%	29	19%

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

The HOU estimates and wattage data were collected and analyzed to not only estimate annual lighting kWh by business type, but also to estimate the share of lighting kWh to total annual kWh. The CSS effort not only included an extensive on-site data collection effort, but included the collection of annual total consumption data from meter lookups for each of the sites where an on-site survey was completed.[23] While it is often difficult to discern what percentage of kWh is attributable to lighting versus office equipment and/or other plug loads, these data allow for that level of disaggregation.

Table 5-78 and Figure 5-36 provide estimates of the total kWh (by business type) attributable to indoor lighting over the course of a typical year. Retail establishments, Schools and Warehouses have the highest share of lighting consumption to total consumption at 34%, 24% and 23%, respectively. Retail stores generally have large showrooms that demand much greater lighting loads compared to HVAC or plug loads. The same is typically true for Schools that have several different activity areas that require a consistent lighting load throughout the day. Restaurants and Food/Liquor have the lowest shares (11% and 13%) of all business types. The lower lighting share for these two business types reflects the fact that they typically have much greater

[23] Customer Information System (CIS) data was used to determine meter numbers for each site. The on-site survey verified most of these meter numbers, which were then used to determine a site's annual total consumption based on IOU billing data. If the meter number was not verified, this was usually because the site was not included in the CIS data.

cooling demands than other business types. Restaurants and Food/Liquor stores also have large refrigeration loads that reduce the share of their loads attributable to lighting.

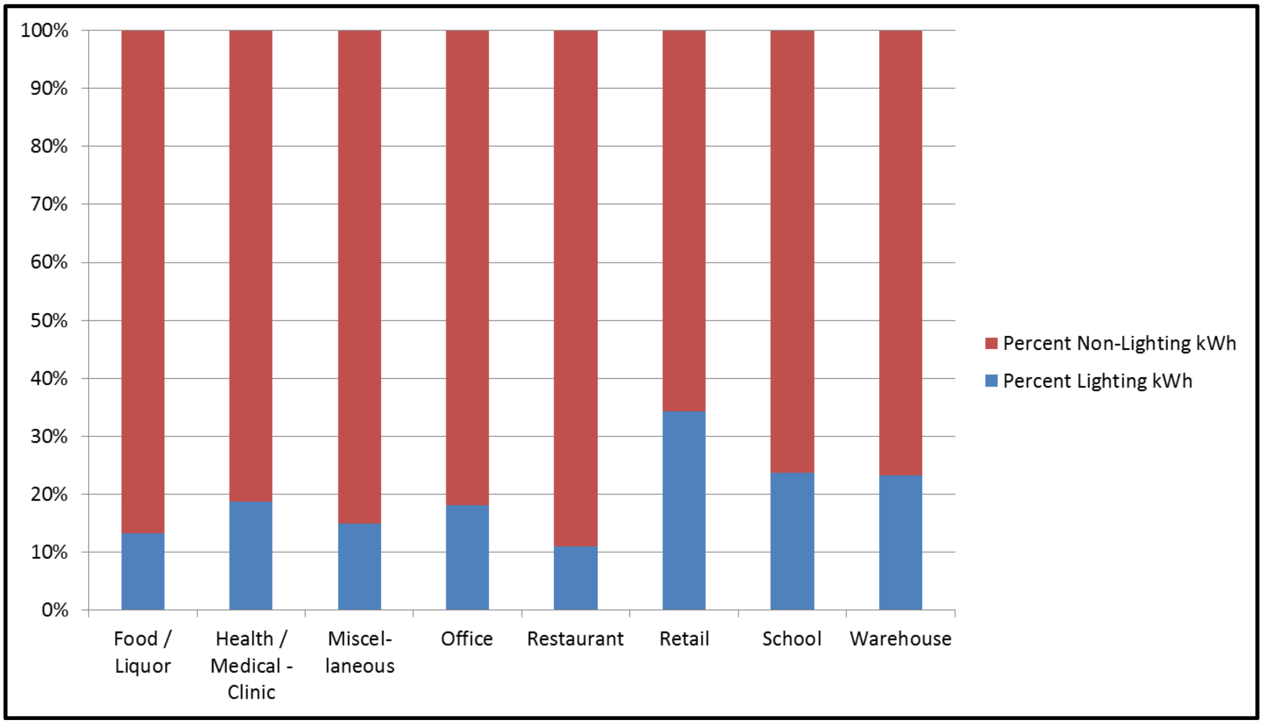
Thirty sites were removed from this analysis because their annual lighting kWh exceeded their total annual kWh. Incomplete information from the meter lookups explains some of the discrepancies in the data, especially in cases where lighting kWh was two times that of overall kWh. For 10 of the 30 sites, lighting kWh exceeded annual kWh by less than 15% indicating that, perhaps, self-reports over-estimated actual lighting usage. A more in depth analysis that utilizes adjustment factors garnered from actual lighting usage, not only at the business type level, but at the activity area level as well may provide more accurate estimates of annual lighting hours.

Table 5-78: Share of Annual Lighting kWh to Total kWh – Indoor Lighting

Business Type	*n*	Percent Lighting kWh	Relative Precision
Food/Liquor	**126**	13%	9%
Health/Medical - Clinic	**127**	19%	15%
Miscellaneous	**241**	15%	27%
Office	**238**	18%	17%
Restaurant	**170**	11%	8%
Retail	**223**	34%	9%
School	**157**	24%	9%
Warehouse	**122**	23%	23%

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-36: Share of Annual Lighting kWh to Total kWh – Indoor Lighting



*** The results presented above have been weighted by site weight.**

The data in Table 5-78 and Figure 5-36 represent weighted averages across each of the four analysis business sizes. The share of lighting kWh is also predicated on the level of total kWh consumption at each site or facility. For analysis purposes, each of the business types were classified as Large, Medium, Small or Very Small based on their total consumption. Table 5-79 provides the share of lighting kWh for each of these classifications across all business types. Generally, lighting kWh is a smaller percentage of total kWh for businesses that consume significant amounts of electricity (13% for Large businesses) and the share of lighting increases as overall consumption decreases (31% for Very Small businesses).

Table 5-79: Lighting kWh by Size – Indoor Lighting

Business Size	*n*	Percent Lighting kWh	Relative Precision
Large	**97**	13%	25%
Medium	**460**	20%	8%
Small	**478**	20%	10%
Very Small	**369**	31%	8%

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

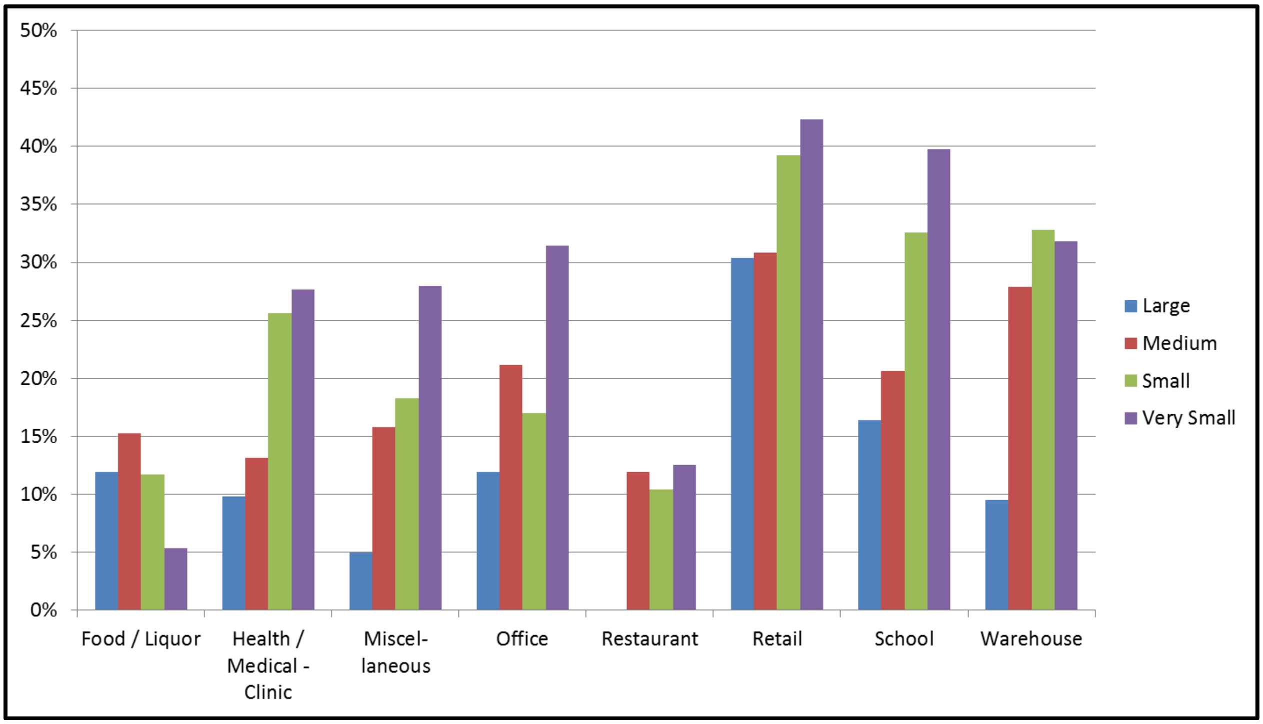
Table 5-80 and Figure 5-37 provide more disaggregated results by extending the lighting kWh to both size and business type. For several size/business type combinations, there were not enough sample points to develop statistically significant estimates, but the trends observed in Table 5-79 are evident here as well. With the exception of Food/Liquor stores and Restaurants, lighting represents a greater share of overall demand for smaller businesses than businesses with greater overall consumption. The similarities evident in Restaurants and Food/Liquor stores again suggest that cooling loads represent a consistent and majority share of overall kWh, regardless of size.

Table 5-80: Lighting kWh by Business Size and Business Type – Indoor Lighting

Business Type	Business Size	*n*	Percent Lighting kWh
Food/Liquor	Large	**12**	12%
	Medium	**54**	15%
	Small	**55**	12%
	Very Small	**5**	5%
Health/Medical - Clinic	Large	**2**	10%
	Medium	**43**	13%
	Small	**31**	26%
	Very Small	**51**	28%
Miscellaneous	Large	**12**	5%
	Medium	**63**	16%
	Small	**84**	18%
	Very Small	**82**	28%
Office	Large	**25**	12%
	Medium	**84**	21%
	Small	**59**	17%
	Very Small	**69**	31%
Restaurant	Medium	**36**	12%
	Small	**108**	10%
	Very Small	**26**	12%
Retail	Large	**20**	30%
	Medium	**51**	31%
	Small	**60**	39%
	Very Small	**92**	42%
School	Large	**18**	16%
	Medium	**95**	21%
	Small	**40**	33%
	Very Small	**5**	40%
Warehouse	Large	**8**	10%
	Medium	**35**	28%
	Small	**41**	33%
	Very Small	**39**	32%

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-37: Lighting kWh as Share of Total kWh by Size and Business Type – Indoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.7.4 Conclusions and Recommendations

Based on the data collected throughout the CSS on-site data collection effort, there are several conclusions that can be drawn regarding lighting usage in the commercial sector of California:

- Linear lighting technologies not only represent the greatest share of installed technologies, but their annual hours of usage are greater than Non-Linear technologies for all business types.
- Food/Liquor, Retail and Restaurants have the highest annual operating hours for lighting, while Schools and Warehouses have the lowest.
- On average, the share of annual lighting kWh to overall kWh varies significantly by business type. Retail, Schools and Warehouses have the highest lighting kWh shares (34%, 24% and 23%) while Food/Liquor stores and Restaurants have the lowest shares (13% and 11%).
- On average, the share of annual lighting kWh to overall kWh tends to decrease as overall consumption increases.

- This relationship is also evident when examined by business type, except for Food/Liquor and Restaurants where there is little to no change.

This analysis provides a way in which the percent of overall kWh attributable to lighting can be disaggregated from other loads within the commercial sector. One limitation to this approach is the reliance on self-reported lighting schedules that may under- or over-estimate actual lighting usage. As stated earlier, these self-reported estimates were adjusted at the business type and day type level for this analysis based on data from the *Small Commercial Contract Group Direct Impact Evaluation Report*[24]. Lighting usage, however, varies significantly at the activity area level as well as by technology installed. This level of disaggregation was performed on data from that report, but given constraints in both time and scope was not included here. The application of these more granular adjustments to the CSS self-reported hours would create more accurate lighting usage profiles and more reliable lighting share estimates within commercial businesses.

5.8 Other Indoor Lighting

This section details the distribution of indoor lighting by control type, the distribution of exit signs, and the distribution of advertising displays.

5.8.1 Indoor Lighting Controls

The CSS study gathered data on lighting controls installed and in use in indoor spaces. For the purposes of this report, lighting controls have been classified into eight categories:

- Manual: These may be manual switches, bi-level or multi-level switches, dimmers, or twist timers. These are manual switches without occupancy sensors.
- Manual w/ Occ. Sensor: These may be manual switches, bi-level or multi-level switches, dimmers, or twist timers. These are manual switches with occupancy sensors.
- EMS: Energy Management Systems are designed to control all lighting (along with other end-uses) at a facility from a single source and can potentially have features such as control of lighting schedules.
- Photocell & Motion Sensor: This category includes wall mounted, ceiling mounted or fixture integrated controls that are photocells and motion sensors.
- Motion Sensor: These may be wall mounted, ceiling mounted or fixture integrated motion sensors that include passive infrared, ultrasonic, or a combination of both technologies to sense when a space is occupied.

[24] California Public Utility Commission, *Small Commercial Contract Group Direct Impact Evaluation Report*, prepared by Itron, Inc. February 9, 2010

- Continuous On: This category of lighting is on 24 hours per day, 7 days per week.
- Photocell and/or Timeclock: This category includes photocells, timeclocks, and controls that are photocells and timeclocks.
- Daylighting & Other: Daylighting refers to controls that can be used to adjust lighting in response to levels of natural light. The Other category includes Electrical Panels, Breakers, and Lighting Contactors.[25]

Table 5-81 shows the distribution of lamps by their control type for each technology classification. As seen, Manual controls dominate the distribution and were found to be used for the majority of fixtures surveyed. Incandescent lamps are at the top of the list with 95% of all their indoor fixtures being manually controlled. EMS controls were used for 50% of HID lamps and 20% of all LED lamps.

Table 5-81: Distribution of Lamps by Control Type and Lighting Technology – Indoor Lighting

Control Type	Linears	CFLs	Incan-descents	Halogens	LEDs	HIDs	Other
Manual	79%	78%	95%	90%	63%	47%	65%
Manual w/ Occ. Sensor	0.9%	0.4%	0.1%	0.6%	0%	0%	0%
EMS	7%	9%	2.0%	5%	20%	50%	35%
Photocell & Motion Sensor	2.0%	0.2%	0.2%	0%	0%	0%	0%
Motion Sensor	9%	5%	1.4%	0.7%	7%	1.4%	0%
Continuous On	0.3%	2.9%	0.1%	0.8%	0.8%	<0.1%	0%
Photocell and/or Timeclock	1.4%	3.5%	1.5%	2.4%	9%	1.7%	0%
Daylighting & Other	0.3%	0.1%	0.1%	0.4%	0.6%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**1,404**	**990**	**626**	**311**	**125**	**189**	**13**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-82 shows the distribution of lamps by control type as shares of the EE Lighting program non-participants and the EE Lighting, Control, and Demand Response (DR) program participants. For the purposes of this analysis, Energy Efficiency (EE) program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[26] The EE program participation analysis characterizes EE Lighting

[25] Only a small number of businesses were found to have Daylighting controls, Electrical Panels, Breakers, or Lighting Contactors, so these control types were grouped for the purposes of this analysis.

[26] Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

program participants as businesses who identified the installation of high efficiency lighting on any EE program application, including custom applications.[27] The indoor lighting controls analyses also present distributions for participants of Lighting Control and Demand Response (DR) programs.[28]

As seen, participants of EE Lighting, Control, and DR programs were found to have installed a larger share of Motion Sensors compared to EE Lighting non-participants.[29] Also, the share of EMS for EE Lighting and Control participants is about twice that seen for the non-participants; EMS for DR participants is three and a half times what is seen in EE Lighting non-participants. All groups show that Manual controls predominate, although EE Lighting, Control, and DR participants have a substantially lower share of lamps manually controlled compared to non-participants.

Table 5-82: Distribution of Lamps by Control Type and 2009-2012 EE Lighting, Control, and DR Participation – Indoor Lighting

Control Type	EE Lighting Non-Participant	EE Lighting Participant	Control Participant	DR Participant
Manual	82%	69% ***	65%	53%
Manual w/ Occ. Sensor	0.7%	1.4% *	1.1%	2.3%
EMS	6%	13% ***	11%	20%
Photocell & Motion Sensor	1.9%	0.8%	1.4%	1.5%
Motion Sensor	8%	11% **	14%	15%
Continuous On	0.4%	1.0% ***	1.7%	0.9%
Photocell and/or Timeclock	1.4%	3.0% ***	3.0%	4.7%
Daylighting & Other	0.1%	1.4% **	2.9%	2.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**1,076**	**360**	**139**	**155**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column. Significance testing was only implemented to compare EE Lighting participants and non-participants.

27 EE LF HIM program participants are included as EE Lighting program participants.

28 Businesses who are EE control participants are included in the EE lighting participant column, therefore, EE control participants are not in the EE lighting non-participants. Of the 155 businesses that are DR participants, 63 are EE lighting non-participants. These 63 businesses are included in both the DR participant and the EE lighting non-participant columns.

29 Table 5-82 includes difference in means statistical t-test results comparing the EE lighting non-participant and EE lighting participant columns. These tests were not undertaken for the other potential groups.

Table 5-83 shows the distribution of businesses by control type as shares of the EE Lighting program non-participants and the EE Lighting, Control, and Demand Response (DR) program participants. Nearly all businesses have manual controls regardless of participation in EE programs. Seventy-one percent of Control program participant businesses have Motion Sensors, compared to 34% of EE Lighting participant businesses and 11% of non-participant businesses.

Table 5-83: Distribution of Businesses by Control Type and EE/DR Participation – Indoor Lighting

Control Type	EE Lighting Non-Participant	EE Lighting Participant	Control Participant	DR Participant
Manual	98%	99%	99%	96%
Manual w/ Occ. Sensor	1.8%	6%	9%	10%
EMS	1.2%	1.7%	0.6%	8%
Photocell & Motion Sensor	1.5%	1.2%	3.1%	6%
Motion Sensor	11%	34%	71%	42%
Continuous On	1.3%	2.6%	4.1%	8%
Photocell and/or Timeclock	3.1%	4.1%	4.2%	12%
Daylighting & Other	0.3%	2.2%	0.3%	4.8%
n	**1,076**	**360**	**139**	**155**

* **The results presented above have been weighted by site weight.** Percentages sum to more than 100% because, for any given participant group, a business may have installed more than one type of lighting control. *n*'s represent the number of surveyed sites included in the analysis.

Table 5-84 details the share of indoor lamps by control type for the business size groupings. As expected, Large businesses have the highest shares of lamps controlled by Motion Sensors and EMS compared to other business sizes, but a relatively low 39% percent share for Manual controls. Very Small businesses, on the other hand, have 96% of indoor lamps regulated by Manual controls.

Table 5-84: Distribution of Lamps by Control Type and Business Size – Indoor Lighting

Control Type	Large	Medium	Small	Very Small
Manual	39%	76%	86%	96%
Manual w/ Occ. Sensor	0.7%	1.4%	0.5%	0.3%
EMS	29%	9%	3.6%	0%
Photocell & Motion Sensor	2.9%	0.4%	3.7%	0.1%
Motion Sensor	20%	11%	5%	2.7%
Continuous On	1.7%	0.5%	0.4%	0.2%
Photocell and/or Timeclock	4.0%	2.7%	0.9%	0.1%
Daylighting & Other	1.8%	0.2%	<0.1%	0.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**97**	**463**	**484**	**392**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.8.2 Exit Signs

The on-site effort gathered information on the quantity, lamp type, make and model of Exit Signs found within commercial spaces. Table 5-85 provides a distribution of Exit Signs by business type. Offices dominate this distribution with 31% of all Exit Signs followed by the Miscellaneous sector at 26%.

Table 5-85: Distribution of Exit Signs by Business Type – Indoor Lighting

Business Type	*n*	Percent of Total Exit Signs
Food/Liquor	**77**	1.1%
Health/Medical - Clinic	**101**	7%
Miscellaneous	**156**	26%
Office	**169**	31%
Restaurant	**135**	6%
Retail	**150**	10%
School	**157**	12%
Warehouse	**82**	7%
Total	**1,027**	**100%**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites with Exit Signs included in the analysis. Total percent has been summed in the direction in which individual percentages were calculated.

Table 5-86 details the average number of Exit Signs found per thousand square feet of commercial property by business size. The Very Small businesses are seen here to have the largest average of 0.67 Exit Signs per thousand square feet, while the Small business group has the lowest average.

Table 5-86: Average Number of Exit Signs per Thousand Square Feet by Business Size – Indoor Lighting

Business Size	*n*	Average Number of Exit Signs per 1,000 Sq Ft
Large	**97**	0.54
Medium	**436**	0.52
Small	**356**	0.44
Very Small	**138**	0.67
Total	**1,027**	**0.51**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Total Average Number of Exit Signs per 1,000 Sq Ft represents the average across all business sizes. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.9 Aggregate Outdoor Lighting Analysis

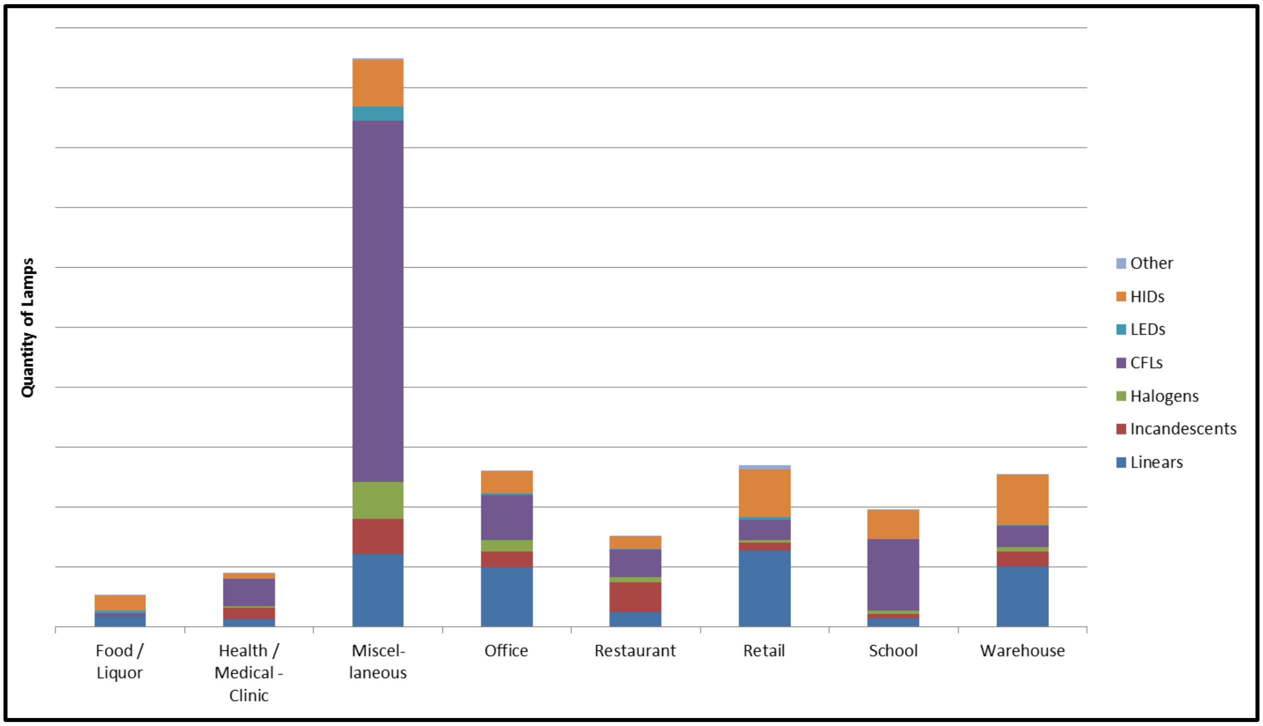
The 2006 CA CEUS[30] estimated that exterior lighting accounted for approximately 6% of the electricity usage in the commercial sector. This section of the CSS Lighting study focuses on a segment that is often considered to be highly inefficient. The outdoor lighting segment can also be very challenging from a data collection perspective. The height, proportion, and placement of outdoor fixtures cause them to be difficult to access and to determine their technical specifications. The on-site survey effort during this study captured a significant amount of information regarding light fixtures installed in outdoor spaces. This section presents the results of the analysis of outdoor lighting data recorded on site, combined with customer information and technology lookups.

The broader lighting categories remain the same as defined previously for the indoor section of this chapter. Besides lighting in parking lots and outside spaces at the site of a business, an outdoor space for this analysis also includes patios and covered parking garages. Outdoor lighting excludes all advertising displays, as these are analyzed separately. The results are presented by business type, size, and IOU for Linears, CFLs, Incandescents, Halogens, LEDs, HIDs, and Other Lighting. A sub-section presents findings for lighting controls for outdoor fixtures.

[30] California Commercial End-Use Survey; Prepared for California Energy Commission by Itron Inc.; March 2006

Figure 5-38 illustrates the distribution of the quantity of lamps for outdoor lighting technologies across business types. This depiction is intended only to show the relative volume of lamps within each business type, as the site-weighted lamp counts do not reflect the actual quantity of lamps installed in commercial businesses. The Miscellaneous business type has nearly four times the quantity of lamps as Retail stores, the business type with the next largest quantity. Miscellaneous incorporates many different sub-business types that have substantial outdoor lighting including the common areas of apartment complexes and places of assembly like religious assembly facilities.

Figure 5-38: Distribution of Lamps by Technology Type and Business Type – Outdoor Lighting

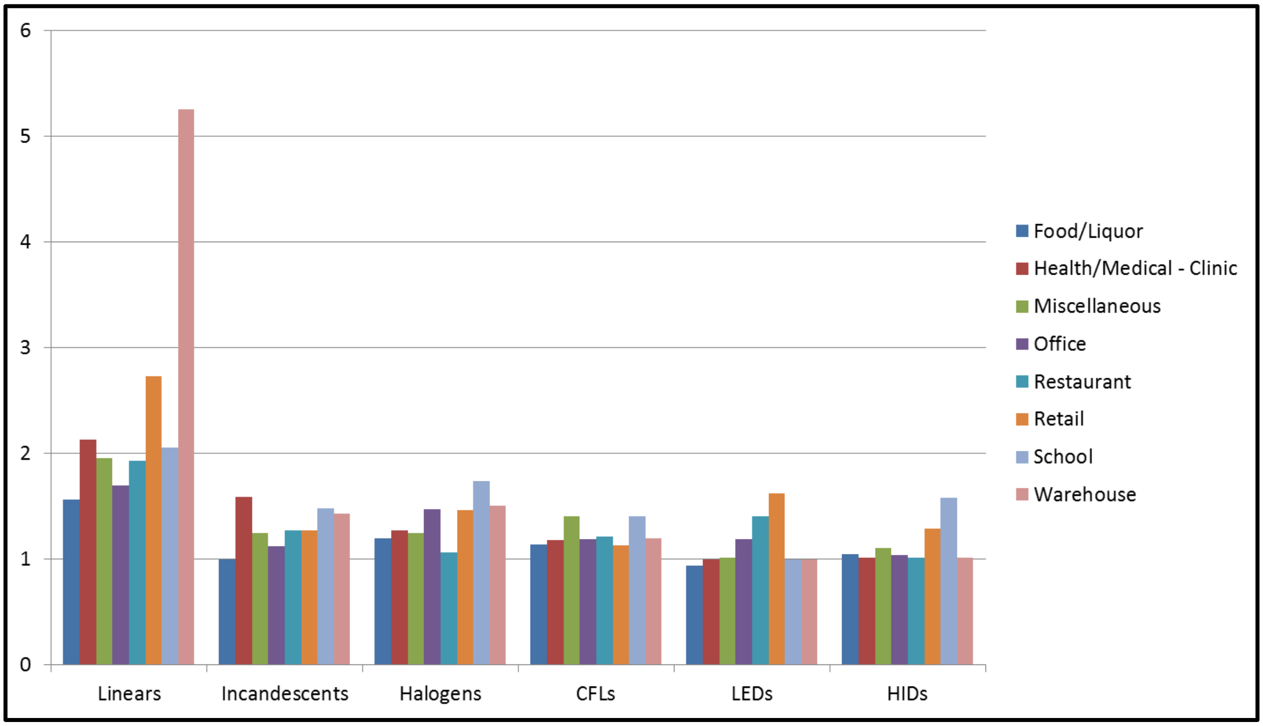


* **The results presented above have been weighted by site weight.** This depiction is intended only to show the relative volume of lamps within each business type, as the site-weighted lamp counts do not reflect the actual quantity of lamps installed in commercial businesses.

5.9.1 Saturations by Technology

Figure 5-39 shows the average number of lamps per fixture found in outdoor spaces by lighting technology. This graph illustrates that across all business types, Linear lighting has the highest average number of lamps per fixture, with a maximum of 5.25 lamps per fixture for Warehouses.

Figure 5-39: Average Number of Lamps per Fixture – Outdoor Lighting



*** The results presented above have been weighted by site weight.**

Saturation by Business Type

This section presents information on the saturation of the different outdoor lighting technologies by business types. The findings reported in the outdoor lighting segment differ from those reported in the indoor segment. Chief among these differences is a high incidence of HID lamps across all business types.

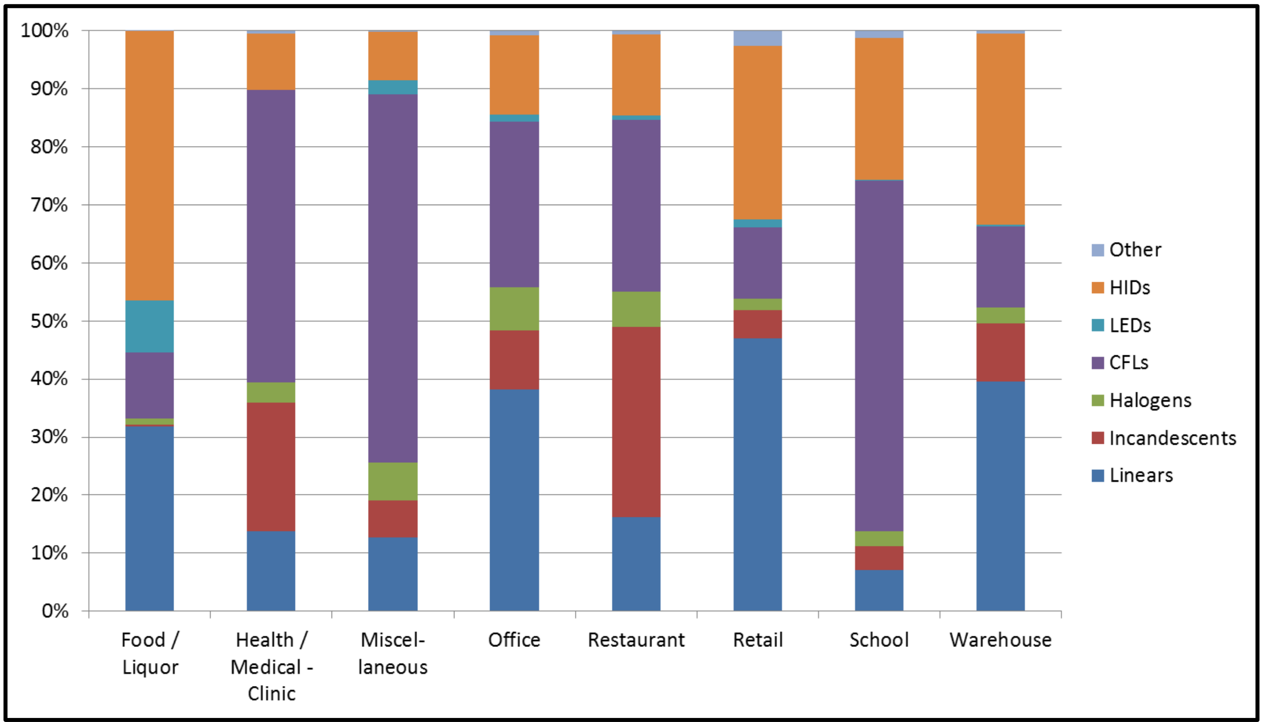
Table 5-87 and Figure 5-40 show the distribution of lighting technologies for the lamps found outdoors among the various business types. CFLs have a 693% share of outdoor lamps in the Miscellaneous segment and 60% in Schools. HIDs capture a 46% share in Food/Liquor stores, 24% in Schools and 33% in Warehouses across all outdoor lighting technologies. Outdoor Linear lamps have a 32% share in Food/Liquor stores and 40% in Warehouses.

Table 5-87: Distribution of Lamps by Lighting Technology and Business Type – Outdoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Linears	32%	14%	13%	38%	16%	47%	7%	40%
Incandescents	0.3%	22%	6%	10%	33%	4.9%	4.2%	10%
Halogens	1.0%	3.5%	7%	7%	6%	1.9%	2.5%	2.8%
CFLs	11%	50%	63%	29%	30%	12%	60%	14%
LEDs	9%	<0.1%	2.5%	1.2%	0.7%	1.5%	0.2%	0.2%
HIDs	46%	10%	8%	14%	14%	30%	24%	33%
Other	0.1%	0.6%	0.3%	0.8%	0.6%	2.7%	1.3%	0.5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**86**	**83**	**171**	**156**	**104**	**136**	**153**	**91**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-40: Distribution of Lamps by Lighting Technology for Business Types – Outdoor Lighting



* **The results presented above have been weighted by site weight.**

Table 5-88 shows the distribution of wattages and Table 5-89 details the distribution of lumens across business types for lighting technologies found outdoors. HIDs have a dominant share of the wattage and lumen distribution across outdoor lighting technologies for almost all business types. Looking at Table 5-87, HIDs account for only 8-46% of the outdoor lamps across the different business types, while Table 5-88 and

Table 5-89 shows that HIDs account for 33-82% of the watts and 48-79% of the outdoor lumens. For Miscellaneous, the business type with the largest number of outdoor lamps, HIDs have an 8% share of outdoor lamps, a 40% share of watts, and a 48% share of lumens. CFLs have a 63% share of the outdoor lamps in Miscellaneous but only 28% of the watts and 29% of the lumens. Outdoor lamps with high lamp shares (Linears and CFLs) represent lower wattage and lumen shares due to the high wattage and lumen output of HID lamps. Figure 5-41 illustrates the distribution of wattages and lumens by business type for outdoor lighting technologies.

Table 5-88: Distribution of Watts by Lighting Technology and Business Type – Outdoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Linears	10%	8%	11%	16%	14%	16%	6%	18%
Incandescents	0.2%	31%	9%	13%	22%	3.4%	3.1%	10%
Halogens	0.5%	5%	10%	28%	7%	1.2%	4.3%	3.9%
CFLs	1.9%	18%	28%	9%	10%	7%	17%	4.0%
LEDs	6%	0%	1.8%	0.8%	0.3%	0.2%	0.1%	<0.1%
HIDs	82%	37%	40%	33%	47%	70%	70%	63%
Other	0%	0%	0%	0.2%	0%	1.9%	0%	0.7%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**86**	**83**	**171**	**156**	**104**	**136**	**153**	**91**

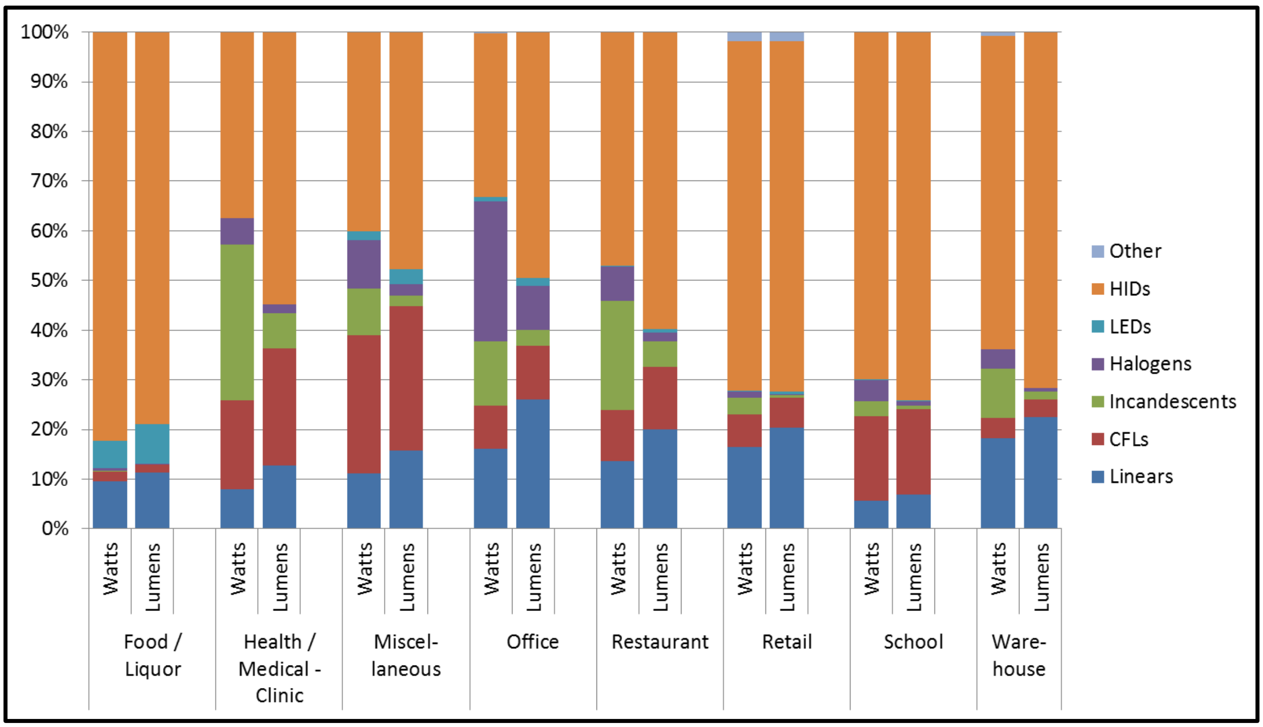
* **The results presented above have been weighted by site weight.** *n*’s represent the number of surveyed sites included in the analysis.

Table 5-89: Distribution of Lumens by Lighting Technology and Business Type – Outdoor Lighting

Technology Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Linears	11%	13%	16%	26%	20%	20%	7%	23%
Incandescents	<0.1%	7%	2.2%	3.1%	5%	0.6%	0.6%	1.5%
Halogens	0.1%	1.7%	2.2%	9%	1.8%	0.2%	0.9%	0.8%
CFLs	1.6%	23%	29%	11%	12%	6%	17%	3.5%
LEDs	8%	0%	3.0%	1.6%	0.6%	0.4%	0.2%	0.1%
HIDs	79%	55%	48%	49%	60%	71%	74%	72%
Other	0%	0%	0%	0%	0%	1.8%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**86**	**83**	**171**	**156**	**104**	**136**	**153**	**91**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-41: Distribution of Lighting Wattage and Lumens by Business Type – Outdoor Lighting



* **The results presented above have been weighted by site weight.**

Saturation by Business Size

This section discusses findings of the lighting analysis for outdoor spaces by size of the business. Approximately 1% of all site-weighted businesses in the outdoor lighting segment are categorized as Large in the population, 8% as Medium, 33% as Small, and 58% as Very Small.

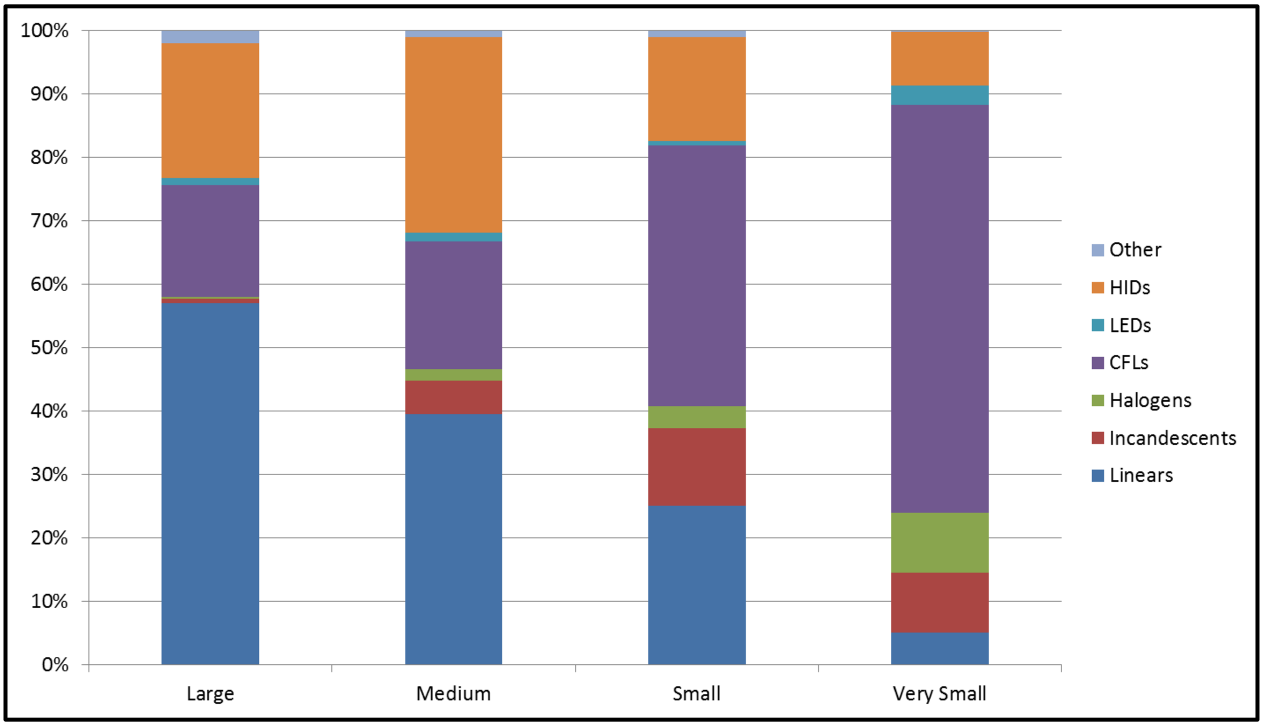
Table 5-90 provides the distribution of lamps by lighting technology across the four size groups. Figure 5-42 illustrates the lamp distribution for outdoor lighting technologies by business size. Linear lighting has the largest share of lamp installations for Large and Medium businesses, followed for both size groups by HIDs and then CFLs. For Small businesses, CFLs have the largest share of outdoor lamp installations, followed by Linears. In the Very Small category, 64% of outdoor lamps are CFLs.

Table 5-90: Distribution of Lamps by Lighting Technology and Business Size – Outdoor Lighting

Technology Type	Large	Medium	Small	Very Small
Linears	57%	40%	25%	5%
CFLs	18%	20%	41%	64%
Incandescents	0.7%	5%	12%	10%
Halogens	0.3%	1.8%	3.5%	9%
LEDs	1.2%	1.4%	0.8%	3.0%
HIDs	21%	31%	16%	9%
Other	2.0%	1.0%	1.0%	0.2%
Total	**100%**	**100%**	**100%**	**100%**
n	**84**	**393**	**339**	**164**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Figure 5-42: Distribution of Lamps by Lighting Technology Business Size – Outdoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Saturation by IOU

The distribution of outdoor lighting technologies is discussed at the IOU level in the next section. The site-weighted counts of businesses with outdoor lighting installed have a distribution of 43% for PG&E, 46% for SCE, and 11% for SDG&E.

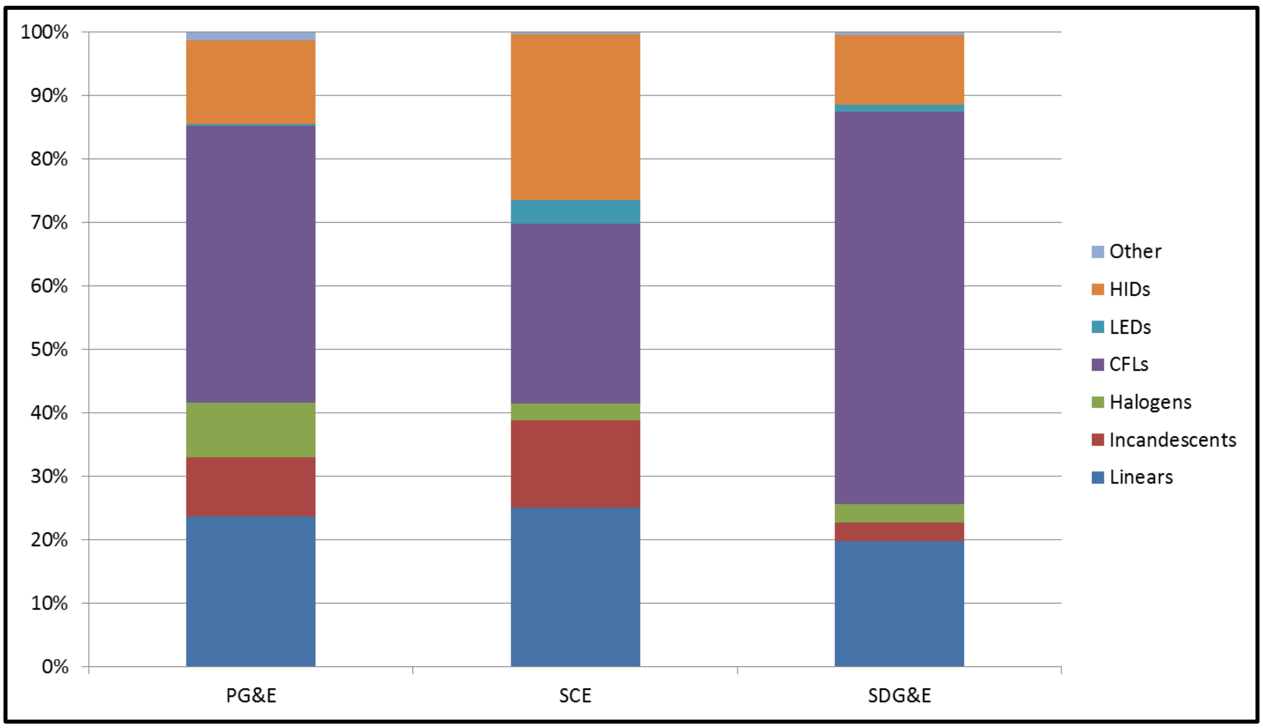
Table 5-91 and Figure 5-43 present the distribution of outdoor lamps for the technology groups included in the analysis for the three IOUs. CFLs have a 62% share of outdoor lamp installations for SDG&E and a 44% share for PG&E. SCE has a lamp share of 28% for CFLs and 26% for HIDs. Linear lamps have a 24% share of outdoor lamps for PG&E, a 25% share for SCE, and a 20% share for SDG&E.

Table 5-91: Distribution of Lamps by Lighting Technology and IOU – Outdoor Lighting

Technology Type	PG&E	SCE	SDG&E
Linears	24%	25%	20%
Incandescents	9%	14%	3.0%
Halogens	9%	2.6%	2.8%
CFLs	44%	28%	62%
LEDs	0.2%	3.7%	1.1%
HIDs	13%	26%	11%
Other	1.3%	0.4%	0.5%
Total	**100%**	**100%**	**100%**
n	**389**	**452**	**139**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Figure 5-43: Distribution of Lamps by Lighting Technology and IOU – Outdoor Lighting



* **The results presented above have been weighted by site weight.**

Saturation by EE 2009-2012 Lighting HIM Participation

For the purposes of this analysis, Energy Efficiency (EE) program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[31] The EE program participation analysis characterizes EE Lighting program participants as businesses who identified the installation of high efficiency lighting on any EE program application, including custom applications.[32]

Table 5-92 provides the distribution of outdoor lamps by EE 2009-2012 Lighting HIM participation. EE Lighting non-participants have a share of 46% for CFL installations across all technology groupings compared to 28% for EE Lighting participants. T-test undertaken on these data indicate that EE Lighting non-participants have a statistically significant higher share of their outdoor lighting in CFLs than lighting participants. EE Lighting participants have a statistically significant higher share of their outdoor lighting in Linear technologies than non-participants. EE Lighting non-participants have a 6% share of outdoor lamps for Halogens, compared to just 1.3% for participants.

Table 5-92: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation – Outdoor Lighting

Lighting Technology	EE Lighting Non-Participant	EE Lighting Participant
Linears	20%	42% **
Incandescents	10%	6%
Halogens	6%	1.3% **
CFLs	46%	28% *
LEDs	1.7%	1.5%
HIDs	17%	20%
Other Lighting	0.7%	1.0%
Total	**100%**	**100%**
n	**727**	**253**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Saturation by EE 2009-2012 Lighting HIM Participation and IOU

Table 5-93, Table 5-94, and Table 5-95 provide the distribution of lamps installed in outdoor spaces across lighting technologies for businesses participating in IOU Energy Efficiency programs for Lighting for PG&E, SCE and SDG&E respectively. The share of CFLs for EE Lighting participants and non-participants does not differ significantly for PG&E or SCE. However, SDG&E EE Lighting participants have a CFL share of 18% and non-participants have a share of 66%, and this difference is statistically significant at the 1% level. For all three IOUs,

[31] Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

[32] EE LF HIM program participants are included as EE Lighting program participants.

Linear lamps have a higher share for EE Lighting participants than non-participants, while Incandescents show the opposite.

Table 5-93: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for PG&E – Outdoor Lighting

Lighting Technology	EE Lighting Non-Participant	EE Lighting Participant
Linears	22%	41%
Incandescents	10%	5%
Halogens	9%	2.5%
CFLs	45%	32%
LEDs	0.2%	1.0% **
HIDs	12%	18%
Other Lighting	1.4%	0.7%
Total	**100%**	**100%**
n	**302**	**87**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Table 5-94: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for SCE – Outdoor Lighting

Lighting Technology	EE Lighting Non-Participant	EE Lighting Participant
Linears	22%	37% *
Incandescents	15%	8%
Halogens	3.1%	0.8% ***
CFLs	28%	29%
LEDs	4.5%	0.8%
HIDs	27%	24%
Other Lighting	0.4%	0.1%
Total	**100%**	**100%**
n	**319**	**133**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

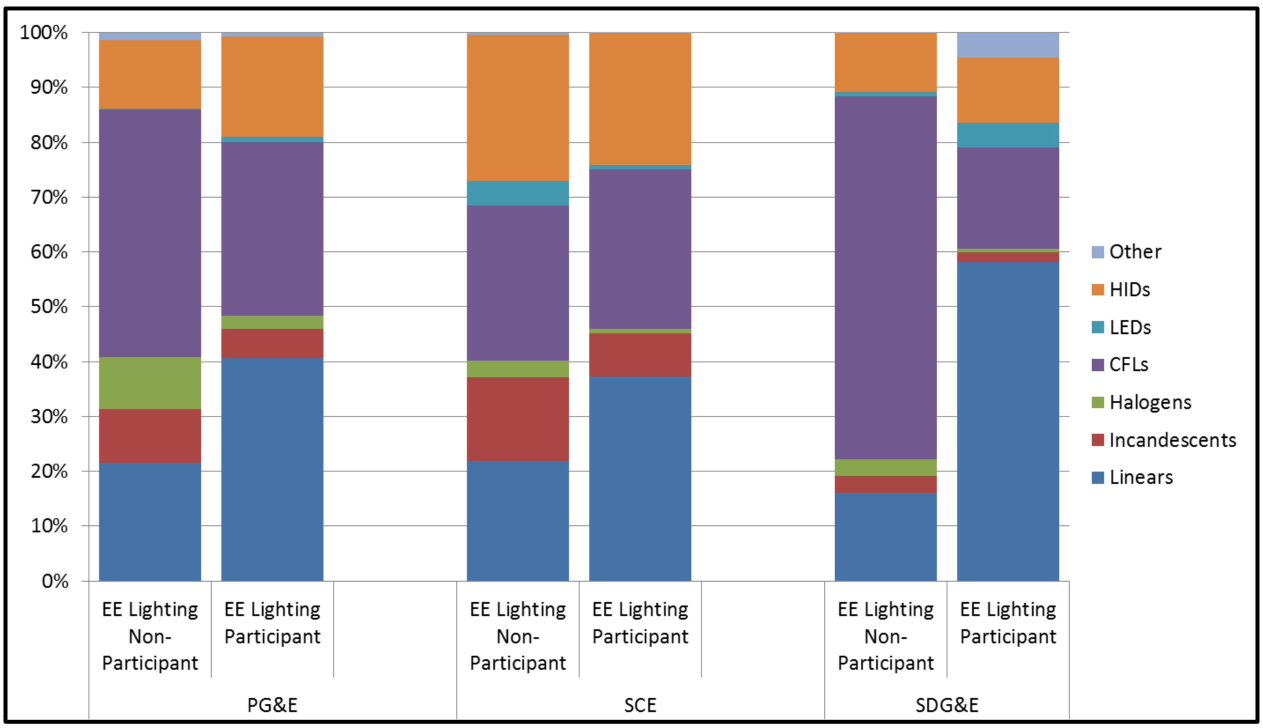
Table 5-95: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for SDG&E – Outdoor Lighting

Lighting Technology	EE Lighting Non-Participant	EE Lighting Participant
Linears	16%	58% ***
Incandescents	3.1%	1.7%
Halogens	3.0%	0.6%
CFLs	66%	18% ***
LEDs	0.8%	4.5% **
HIDs	11%	12%
Other Lighting	0.1%	4.6% **
Total	**100%**	**100%**
n	**106**	**33**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Figure 5-44 illustrates the distribution of lamps installed in outdoor spaces by EE participation in IOU Lighting programs and IOU.

Figure 5-44: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation and IOU – Outdoor Lighting



* **The results presented above have been weighted by site weight.**

Saturation by EE 2009-2012 Lighting HIM Participation and Business Size

This subsection reports the distribution of lamps installed in outdoor spaces by lighting technology and EE participation in Lighting programs for the four kWh usage size groupings. Table 5-96, Table 5-97, Table 5-98 and Table 5-99 show the share of outdoor lamps installed by EE Lighting participants and non-participants for Large, Medium, Small and Very Small businesses respectively. T-tests were undertaken by business size to determine if observed differences for Lighting non-participants and participants differed statistically. Very few statistically significant differences were found.

Large and Medium EE Lighting participant businesses have higher shares of Linear lamps compared to their non-participant counterparts. HIDs have a smaller share among EE Lighting participants than non-participants for Large and Medium businesses, while Small and Very Small businesses have higher HID shares for participants. Very Small businesses also have a higher share of Incandescents for EE Lighting participants compared to non-participants. Distributions for both the Large and Medium EE Lighting participant groups are dominated by Linear lamps, with a 64% share among Large participant businesses and a 55% share among Medium participant businesses.

Table 5-96: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for Large Businesses – Outdoor Lighting

Lighting Technology	Lighting Non-Participant	Lighting Participant
Linears	47%	64%
Incandescents	1.1%	0.4%
Halogens	0.8%	0%
CFLs	23%	14%
LEDs	1.9%	0.7%
HIDs	26%	18%
Other Lighting	0.5%	3.1%
Total	**100%**	**100%**
n	**43**	**41**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Table 5-97: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for Medium Businesses – Outdoor Lighting

Lighting Technology	Lighting Non-Participant	Lighting Participant
Linears	35%	55%
Incandescents	6%	3.2%
Halogens	2.3%	0.3%
CFLs	20%	20%
LEDs	1.4%	1.2%
HIDs	34%	20%
Other Lighting	1.2%	0.4%
Total	**100%**	**100%**
n	**292**	**101**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Medium sites have greater than 300,000 kWh and less than or equal to 1,750,000. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Table 5-98: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for Small Businesses – Outdoor Lighting

Lighting Technology	Lighting Non-Participant	Lighting Participant
Linears	25%	22%
Incandescents	12%	11%
Halogens	3.8%	1.5%
CFLs	41%	42%
LEDs	0.5%	2.6% **
HIDs	16%	21%
Other Lighting	1.0%	0.5%
Total	**100%**	**100%**
n	**259**	**80**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Small sites have max annual usage greater than 40,000 kWh and less than or equal to 300,000. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

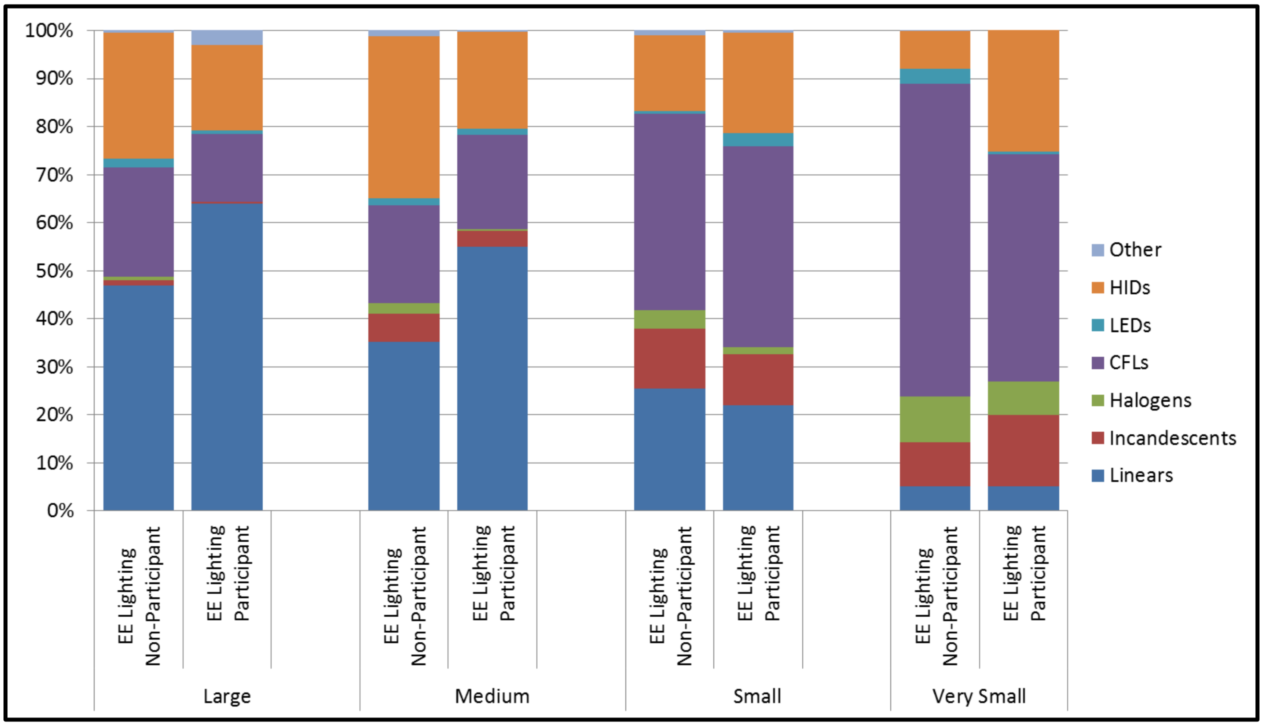
Table 5-99: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation for Very Small Businesses – Outdoor Lighting

Lighting Technology	Lighting Non-Participant	Lighting Participant
Linears	5%	5%
Incandescents	9%	15%
Halogens	9%	7%
CFLs	65%	47%
LEDs	3.1%	0.6%
HIDs	8%	25% ***
Other Lighting	0.2%	0%
Total	**100%**	**100%**
n	**133**	**31**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Very Small sites have annual usage less than or equal to 40,000 kWh. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The participant and non-participant percentages do not differ significantly if there is no asterisk in the participant column.

Figure 5-45 illustrates the lamp installations in outdoor spaces by Energy Efficiency Lighting program participant and non-participant businesses by their kWh usage size category.

Figure 5-45: Distribution of Lamps by EE 2009-2012 Lighting HIM Participation and Business Size – Outdoor Lighting



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.9.2 Outdoor Lighting – HIDs

This sub-section focuses on the HID lighting element of outdoor lighting technologies. HID technologies are ranked in order of highest to lowest efficiency:

- Mercury Vapor
- Metal Halide
- Ceramic Metal Halide, Pulse Start Metal Halide
- High Pressure Sodium
- Low Pressure Sodium

Table 5-100 presents the distribution of lamps by HID technologies for the analysis business types. Mercury Vapor lamps, the highest efficiency HID, represent 30% of the HID lamps in Restaurants, but have a low share for all other business types. Metal Halides are the most prevalent HID lamp for all business types. High pressure sodium lamps are 49% of all HID lamps in Warehouses. Low Pressure Sodium lamps are uncommon for all business types.

Table 5-100: Distribution of HID Lighting by Business Type – Outdoor Lighting

Lighting Technology	Food/ Liquor	Health/ Medical – Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
Mercury Vapor	0.4%	11%	6%	7%	30%	4.5%	1.3%	0.7%
Metal Halide	76%	49%	60%	51%	49%	71%	78%	50%
Ceramic Metal Halide, Pulse Start	10%	4.5%	6%	7%	4.4%	11%	7%	0.4%
High Pressure Sodium	13%	36%	29%	33%	17%	11%	13%	49%
Low Pressure Sodium	0.3%	0%	0%	2.6%	0%	3.1%	0.2%	0.3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**58**	**40**	**91**	**84**	**36**	**87**	**96**	**68**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-101 provides the same distribution of HID lamps by business size. Business size does not appear to impact the likelihood that the highest efficiency HID lamp, Mercury Vapor, is used for outdoor lighting. Metal Halides are found to have a dominant share of HID technologies across all usage size groups. Looking at less efficient HIDs, Large businesses have a 35% share of High Pressure Sodium lamps and a 10% share of Low Pressure Sodium lamps. Very Small business had a majority share of 54% of their HID lamps in the High Pressure Sodium category.

Table 5-101: Distribution of HID Lighting by Business Size – Outdoor Lighting

Lighting Technology	Large	Medium	Small	Very Small
Mercury Vapor	4.0%	6%	4.4%	3.9%
Metal Halide	51%	68%	69%	36%
Ceramic Metal Halide, Pulse Start	0.2%	10%	3.9%	5%
High Pressure Sodium	35%	15%	23%	54%
Low Pressure Sodium	10%	0.3%	0.3%	0.4%
Total	**100%**	**100%**	**100%**	**100%**
n	**69**	**279**	**160**	**52**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.9.3 Outdoor Lighting Controls

In this section, we discuss the lighting controls that were used to regulate lighting usage in outdoor spaces. Outdoor lighting controls have been classified into seven categories:

- Manual: These include manual switches, bi-level or multi-level switches, dimmers, and twist timers.
- EMS: Energy Management Systems are designed to control all lighting (along with other end-uses) at a facility from a single source and can potentially have features such as control of lighting schedules
- Photocell & Motion Sensor: This category includes wall mounted, ceiling mounted, or fixture integrated controls that are photocells and motion sensors.
- Motion Sensor: These may be wall mounted, ceiling mounted, or fixture integrated motion sensors that include passive infrared, ultrasonic, or a combination of both technologies to sense when a space is occupied.
- Continuous On: This category of lighting is on 24 hours per day, 7 days per week.
- Photocell and/or Timeclock: This category includes photocells, timeclocks, and controls that are photocells and timeclocks.
- Daylighting & Other: Daylighting refers to controls that can be used to adjust lighting in response to levels of natural light. The Other category includes Electrical Panels, Breakers, and Lighting Contactors.

Table 5-102 shows the distribution of lamps by their control type and lighting technology classification. As expected, Photocell and/or Timeclock controls were used to control the majority of outdoor fixtures for all lighting technologies. Manual switches control 9-29% of lamps for the different types of outdoor lighting.

Table 5-102: Distribution of Lamps by Control Type and Lighting Technology – Outdoor Lighting

Control Type	Linears	CFLs	Incan-descents	Halogens	LEDs	HIDs
Manual	29%	9%	23%	22%	10%	10%
EMS	2.8%	1.4%	0.4%	0.2%	1.4%	9%
Photocell & Motion Sensor	1.0%	0.4%	2.6%	21%	2.0%	0.1%
Motion Sensor	4.4%	0.7%	8%	3.0%	0%	0.5%
Continuous On	10%	0.1%	<0.1%	0.8%	0%	0.2%
Photocell and/or Timeclock	52%	88%	65%	53%	87%	79%
Daylighting & Other	0.5%	<0.1%	1.2%	0%	0%	0.4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**205**	**498**	**176**	**101**	**33**	**559**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-103 provides the distribution of outdoor lamps by control type across all businesses as shares of the Energy Efficiency program participants and non-participants. For the purposes of this analysis, Energy Efficiency (EE) program participation is constrained to 2009-2012 programs in order to isolate the distribution of lighting for recent program participation.[33] The EE program participation analysis characterizes EE Lighting program participants as businesses who identified the installation of high efficiency lighting on any EE program application, including custom applications.[34] The outdoor lighting controls analyses also present distributions for participants of Lighting Control and Demand Response (DR) programs.[35]

As seen, EE Lighting non-participants were found to have installed a larger share of Photocell and/or Timeclock controls for outdoor lamps compared to EE Lighting, Control, and DR participants. EE Lighting non-participants have a significantly lower share of lamps controlled by EMS than participants.

[33] Businesses who participated in an EE program prior to 2009 are categorized as non-participants in this analysis.

[34] EE LF HIM program participants are included as EE Lighting program participants.

[35] Businesses who are EE control participants are included in the EE lighting participant column, therefore, EE control participants are not in the EE lighting non-participants. Businesses that are in the DR participation column may be in either the EE participant or non-participant column.

Table 5-103: Distribution of Lamps by Control Type and EE 2009-2012 Lighting Participation – Outdoor Lighting

Control Type	Lighting Non-Participants	EE Lighting Participants	Control Participants	DR Participants
Manual	15%	22%	19%	15%
EMS	2.1%	8% ***	11%	13%
Photocell & Motion Sensor	1.8%	1.8%	6%	0.5%
Motion Sensor	2.0%	4.2%	0.7%	11%
Continuous On	2.5%	2.2%	1.9%	6%
Photocell and /or Timeclock	77%	61% ***	61%	54%
Daylighting & Other	0.2%	0.9%	0.6%	0.4%
Total	**100%**	**100%**	**100%**	**100%**
n	**727**	**253**	**105**	**129**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that EE Lighting participant and EE Lighting non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes a 10% significance level. The EE Lighting participant and EE Lighting non-participant percentages do not differ significantly if there is no asterisk in the EE Lighting Participant column.

Table 5-104 details the share of outdoor lamps by control type for the business size groupings. As seen, Large businesses have the highest share of lamps controlled by EMS, as well as a 19% share for Manual controls and a 51% share of Photocell and/or Timeclock controls. Very Small businesses, on the other hand, have 82% of their outdoor lamps regulated by Photocell and/or Timeclock controls, Small businesses have 78%, and Medium businesses have 63%.

Table 5-104: Distribution of Lamps by Control Type and Business Size – Outdoor Lighting

Control Type	Large	Medium	Small	Very Small
Manual	19%	16%	18%	13%
EMS	16%	8%	0.4%	0%
Photocell & Motion Sensor	0.6%	1.4%	0.8%	3.3%
Motion Sensor	9%	0.5%	2.7%	1.8%
Continuous On	3.8%	9%	0.4%	0.2%
Photocell and/or Timeclock	51%	63%	78%	82%
Daylighting & Other	0.4%	1.2%	<0.1%	<0.1%
Total	**100%**	**100%**	**100%**	**100%**
n	**84**	**393**	**339**	**164**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

5.10 Advertising Displays

In this section we look at Advertising Lighting Displays which were analyzed independently of the indoor and outdoor lighting segments. Data collected for displays spanned both indoor and outdoor locations. The research team found that most advertising signs were hardwired (56%) or plug-in (44%), with a very low incidence of battery or solar powered displays.

Advertising fixtures in this study are classified as:

- Cabinet (CA): Cabinet signs are found in both indoor and outdoor areas. These signs usually have lighting to illuminate a translucent plastic sign.
- Channel Letter (CL): Channel Letter signs consist of individual illuminated letters.
- Externally Illuminated (EI): Externally Illuminated Signs are signs that are not electrically powered, but are lit through external lights which are pointed up at the sign. A common example of these includes billboards or road signs.
- Electronic Message Center (EMC): Electronic Message Center boards are customizable signs which display messages or numbers of some kind. These can include scoreboards at event centers, or can also be seen as signs to display weather or time.
- Unenclosed or Bare Lights (UE): These signs have bare lamps. These can either be neon tubes or can have individual lamps arranged in the shape of letters or designs.
- Other (OT): Signs that cannot be classified as any of the above.

The break-up of the different types of advertising displays found indoors and outdoors is provided in Table 5-105 below. Sites with both indoor and outdoor advertising displays are represented in both the Indoor Signs section and the Outdoor Signs summaries of the table. As seen, for the majority of businesses in the analysis, advertising displays were found in outdoor spaces. Outdoor advertising displays tended to be Cabinet or Channel Letter signs, while indoor spaces predominantly used Unenclosed/Bare Lights for advertising displays.

Table 5-105: Distribution of Advertising Display Quantities and Area by Fixture Type and Location

Fixture Type	Indoor Signs			Outdoor Signs		
	n	Sign Quantity	Display Area	*n*	Sign Quantity	Display Area
CA	**66**	19%	16%	**193**	53%	38%
CL	**9**	2.1%	3.1%	**154**	33%	37%
EMC	**15**	1.6%	0.3%	**12**	1.2%	1.5%
OT	**5**	1.7%	0.5%	**10**	2.4%	3.3%
UE	**202**	75%	79%	**25**	4.5%	10%
EI	**8**	1.2%	1.1%	**33**	6%	10%
Total	**261**	**100%**	**100%**	**359**	**100%**	**100%**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *n*'s sum to more than the Total because a business may have installed more than one type of advertising display type. Sites with both indoor and outdoor advertising displays are presented in both the Indoor Signs section and the Outdoor Signs section of the table.

5.10.1 Distributions by Business Type

Table 5-106 provides the distribution of the advertising fixtures, while Table 5-107 provides a distribution of the display areas by Business Type. As seen, 65% of all advertising displays and 54% of advertising display areas in Schools are found to be Cabinet signs. The distribution of Advertising Signs in Offices shows a 41% share for Cabinet signs and a 30% share for Unenclosed or Bare Lights. Channel Lettering has a 27% share of all Advertising Displays in the Health/Medical Clinic segment and a 55% share of all display area for the same business type.

Table 5-106: Distribution of Advertising Displays by Fixture Type and Business Type

Fixture Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
CA	27%	24%	27%	41%	30%	43%	65%	54%
CL	8%	27%	18%	13%	11%	22%	0%	19%
EMC	1.4%	0%	0.3%	12%	0.1%	0.1%	31%	21%
OT	0%	29%	3.4%	2.5%	1.3%	0.4%	0%	0%
UE	62%	10%	50%	30%	53%	30%	0%	3.2%
EI	1.5%	10%	1.6%	0.2%	3.7%	4.8%	3.3%	3.0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**97**	**22**	**59**	**30**	**129**	**137**	**24**	**10**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Totals sum to more than 100% because, for any given business type, a business may have installed more than one type of advertising fixture type.

Table 5-107: Distribution of Advertising Display Area by Fixture Type and Business Type

Fixture Type	Food/ Liquor	Health/ Medical - Clinic	Miscel-laneous	Office	Restau-rant	Retail	School	Ware-house
CA	17%	18%	28%	55%	24%	28%	54%	39%
CL	20%	52%	30%	5%	12%	36%	0%	27%
EMC	0.1%	0%	0.5%	1.3%	<0.1%	<0.1%	41%	31%
OT	0%	15%	8%	0.8%	1.8%	<0.1%	0%	0%
UE	63%	13%	31%	37%	50%	30%	0%	0.5%
EI	0.3%	2.2%	2.5%	0.2%	13%	5%	5%	3.5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
n	**97**	**22**	**59**	**30**	**129**	**137**	**24**	**10**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

5.10.2 Distributions by Business Size

Table 5-108 provides the distribution of advertising displays and Table 5-109 provides the distribution of display areas by business size, while Table 5-110 provides a distribution of lamp types by business size. The Large and Medium categories have a 22% and 37% share respectively of the distribution of signs with Channel Letter, while Cabinet displays find a 38% share among Medium-sized business, 39% among Small businesses, and 25% among Very Small businesses.

Table 5-108: Distribution of Advertising Displays by Fixture Type and Business Size

Fixture Type	Large	Medium	Small	Very Small
CA	13%	38%	39%	25%
CL	22%	37%	10%	17%
EMC	10%	1.2%	0.5%	2.4%
OT	0%	0.8%	0.8%	3.7%
UE	50%	21%	46%	48%
EI	5%	1.8%	3.1%	3.6%
Total	**100%**	**100%**	**100%**	**100%**
n	**28**	**156**	**212**	**112**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

As seen in Table 5-109, Channel Letter displays have the largest share of the distribution of display area by fixture type for the Large and Medium size categories with a 48% and 40% share respectively. Cabinet displays have a 31% share of display area across all fixture types for both Medium and Small businesses, an 11% share for Large businesses, and a 24% share for Very Small businesses.

Table 5-109: Distribution of Advertising Display Area by Fixture Type and Business Size

Fixture Type	Large	Medium	Small	Very Small
CA	11%	31%	31%	24%
CL	48%	40%	16%	20%
EMC	3.6%	1.1%	0.1%	1.8%
OT	0%	1.0%	0.2%	4.4%
UE	35%	26%	48%	42%
EI	3.0%	0.9%	5%	9%
Total	**100%**	**100%**	**100%**	**100%**
n	**28**	**156**	**212**	**112**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

Table 5-110 shows the distribution of advertising displays by lighting technology used and size of the business installing. Displays with neon lighting are found to be used 82% of the time for Large businesses and 56% for Small businesses. Displays with Linear Fluorescents are found to have a share of 35% across lighting technologies for Medium and Small businesses, and 28% for Very Small businesses.

Table 5-110: Distribution of Advertising Displays by Lamp Type and Business Size

Fixture Type	Large	Medium	Small	Very Small
Linears	13%	35%	35%	28%
Incandescents	4.2%	2.0%	0.9%	1.6%
Halogens	0%	2.0%	1.9%	1.3%
CFLs	0%	2.5%	2.2%	2.3%
LEDs	1.3%	6%	4.2%	12%
HIDs	0%	0.3%	0.3%	0.4%
Neons	82%	52%	56%	55%
Total	**100%**	**100%**	**100%**	**100%**
n	**15**	**99**	**179**	**91**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, and Very Small have annual usage less than or equal to 40,000 kWh.

5.10.3 Distributions by IOU

Table 5-111 and Table 5-112 provide the distribution of advertising displays and display areas respectively by IOU. Unenclosed/Bare Lights represent the largest share of displays for PG&E and SCE, while Cabinet signs are found to have the highest incidence among businesses with advertising displays for all SDG&E. Unenclosed/Bare Lights dominate the distribution of display area for all three IOUs. Cabinet signs have a 34% share of quantity of signs and a 25% share of display area for PG&E, a 28% share of signs and a 30% share of display area for SCE, and a 51% share of signs and a 26% share of display area for SDG&E.

Table 5-111: Distribution of Advertising Displays by Fixture Type and IOU

Fixture Type	PG&E	SCE	SDG&E
CA	34%	28%	51%
CL	13%	20%	6%
EMC	0.7%	2.2%	0.3%
OT	0.9%	3.0%	0.7%
UE	48%	45%	37%
EI	3.8%	2.3%	5%
Total	**100%**	**100%**	**100%**
n	**177**	**255**	**76**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-112: Distribution of Advertising Display Area by Fixture Type and IOU

Fixture Type	PG&E	SCE	SDG&E
CA	25%	30%	26%
CL	27%	23%	8%
EMC	0.4%	1.6%	<0.1%
OT	0.7%	3.4%	<0.1%
UE	44%	35%	58%
EI	2.9%	7%	9%
Total	**100%**	**100%**	**100%**
n	**177**	**255**	**76**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

Table 5-113 provides the distribution of advertising displays by lamp type and IOU. As shown, displays with Linear Fluorescent lighting have a 45% share across all lamp types for SDG&E, a 30% share for SCE, and a 26% share for PG&E. Displays with neon lighting have a share of 61% of advertising displays for PG&E and 57% for SCE.

Table 5-113: Distribution of Advertising Displays by Lamp Type and IOU

Fixture Type	**PG&E**	**SCE**	**SDG&E**
Linears	26%	30%	45%
Incandescents	1.4%	0.8%	3.1%
Halogens	1.1%	2.0%	1.6%
CFLs	4.6%	0.8%	2.5%
LEDs	6%	9%	7%
HIDs	0.4%	0%	1.3%
Neons	61%	57%	39%
Total	**100%**	**100%**	**100%**
n	**127**	**194**	**63**

* **The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis.

6

Commercial Televisions

The prevalence of TVs within the commercial sector is highly uncertain. Until recently, TVs were seldom analyzed within the commercial sector; TVs were primarily viewed as an energy-consuming end use within the residential sector. Anecdotal evidence, however, indicates that the number of TVs within the business sector is rising. The CMST analysis of recently purchased TVs found that 60% of the TVs purchased by businesses from 2009 to 2012 represented new or additional TVs not replacement TVs.

Recent advances in TV technology have created a push toward increased energy efficiency. The ENERGY STAR rating for TVs has been updated three times during the 2009-2012 time period. Modern LCD and LED TVs use less energy than older CRT TVs even though they tend to be substantially larger. This study provides a better understanding of the saturation of TVs within the commercial sector and a characterization of the types of TVs by their technology type, size, and efficiency using ENERGY STAR rating information. The scope of this study is inclusive of all TVs found in California businesses, regardless of whether or not they were specifically designed for commercial use.

The CSS TV data is derived from data collected on site and make and model lookups to determine the TV efficiency levels. Unlike some other end uses analyzed for this report, there are no site-specific energy efficiency programs geared towards TVs.

6.1 Sources of Data

Information on TVs within CSS businesses was collected during the telephone and on-site surveys. During the telephone survey, sites were asked if they have TVs at their facility. Sites within CSS business types were recruited to participate in on-site surveys to collect detailed on-site information. During the on-site survey, data was collected on the age of the televisions, the number of TVs at the facility, the technology type, the TV's size, and the make and model number of the TVs.

Using the make and model number information collected during the on-sites, the research team verified the type and efficiency level of the televisions. As part of the make and model number lookup, the CSS/CMST research team requested and received make and model number tables from ENERGY STAR. These tables identify TVs that qualify for all ENERGY STAR efficiency levels since 2009. These data, combined with web-based make and model look ups were used to identify if the new TV was an ENERGY STAR TV and if so, the corresponding ENERGY STAR efficiency version.

Performance groups for TVs were established by matching the on-site data with quarterly ENERGY STAR Qualifying Products Lists from 2009-2013, corresponding with ENERGY STAR ratings of 3.0, 4.1, and 5.3.[1] Table 6-1 lists the ENERGY STAR version numbers and their start and end dates. The information on the age of the TV, collected as part of the on-site survey, indicates the year the TV was installed or manufactured. Given the data collected on-site, all ENERGY STAR-qualified TVs were classified into one of the three versions regardless of install or manufacture date. This represents a change from the CMST study, where newly purchased TVs were classified based on their purchase date falling within the eligible dates for each respective version. Given that the CSS study is a baseline study of existing equipment and not a market study of recent purchases, the Research Team chose to report all TVs found on-site by the known efficiency ratings.

TVs not found on the ENERGY STAR list were put into groups based on ENERGY STAR standards comparing the relationship between TV screen area and on-mode power consumption. Because TV sizes are generally expressed in diagonal screen length, screen areas were calculated for the on-site TV inventory using Pythagorean relationships between diagonal screen size and aspect ratio (width:height). In videography, there are two nearly-universal standard aspect ratios, 4:3 and 16:9. The 4:3 aspect ratio is characteristic of all TV media prior to the onset of high definition (HD) media, which is when the 16:9 aspect ratio came to prominence. Therefore, by imagining the length and width of the TV as forming a right triangle, with the diagonal screen length as the hypotenuse, and knowing the technology type of the TV (HD or non-HD), we can derive a formula for screen area:

$$A = \frac{d^2}{r + \frac{1}{r}} \tag{1}$$

where *d* is the diagonal screen length and *r* is the aspect ratio.

Table 6-1: Energy Star Version Number and Eligibility Dates

ENERGY STAR	Start Date	End Date
Version 3.0	October 2008	April 2010
Version 4.1	April 2010	September 2011
Version 5.3	September 2011	June 2013

1 The official ENERGY STAR Product List was provided to Itron by ICF International with the permission of ENERGY STAR. The list included qualified products for 2009, 2010, 2011, 2012, and the first quarter of 2013.

For the TV make and model look ups, if the TV was not in the ENERGY STAR efficiency lists, it was often difficult to collect efficiency data from the web-based lookups. Given that the research team has the ENERGY STAR make and model catalog for all measures with an ENERGY STAR rating for 2009-2012, it is likely that most of the TVs whose efficiency level is officially not classified are, in fact, non-ENERGY STAR units during this time period.[2] Given the ENERGY STAR specifications for ratings version 3.0, 4.1 and 5.3, all CRT TVs are classified as non-ENERGY STAR or base efficiency TVs.

A total of 6,907 telephone surveys with CSS businesses were completed from November 17th, 2011 to May 9th, 2013. The study completed 1,439 on-site surveys with CSS businesses.[3] The on-site surveys found TVs at 888 of the 1,439 on-sites. See Table 6-2 for a distribution by business type of the on-site surveys.

Table 6-2: CSS TV Site Counts by Business Type

Business Type	Phone Survey Completes	CSS On-Sites Completed	Sites with TVs On Site
Food/Liquor	486	132	79
Health/Medical Clinic	633	126	90
Miscellaneous	1,637	263	172
Office	1,314	233	131
Restaurant	595	166	107
Retail	1,019	234	123
School	479	160	131
Warehouse	745	125	55
Total	**6,907**	**1,439**	**888**

6.2 Saturation of TVs in CSS Businesses

Table 6-3 shows the weighted proportion of businesses that have TVs by CSS business types. The table also presents the average number of TVs per business for each business that has at least one TV. Seventy-seven percent of Schools and almost two-thirds of Restaurants have TVs on-site, while less than a third of Warehouses have TVs. Schools have the highest average quantity of TVs, with approximately 26 TVs per business, followed by Health/Medical Clinics,

2 CRT TVs do not qualify for the Version 3.0-5.3 ENERGY STAR Product Lists. Therefore, all CRTs are classified as base efficiency measures.

3 The CSS survey completed 1,461 CSS surveys. After review of the on-site data, it was found that some of these surveys were completed with businesses not eligible for the CSS study. In addition, two surveys were completed at sites found to be customers of electric municipal utilities and one of the gas IOUs. The study scope was limited to the electric IOUs.

with approximately 4-5 TVs per business. Overall, using site-based weights, 47% of CSS businesses have TVs, with an average of 3.5 TVs per business.

Table 6-3: CSS Businesses with TVs by Business Type

Business Type	Share of Businesses With TVs	Relative Precision	Average TVs Per Business With TVs	Relative Precision
Food/Liquor	**55%**	18%	**1.9**	18%
Health/Medical – Clinic	**60%**	17%	**4.4**	31%
Miscellaneous	**50%**	16%	**2.4**	18%
Office	**38%**	22%	**3.1**	28%
Restaurant	**65%**	11%	**3.0**	23%
Retail	**39%**	20%	**2.0**	18%
School	**77%**	16%	**26.0**	31%
Warehouse	**31%**	37%	**1.9**	24%
Total	**47%**	8%	**3.5**	12%

* **The results presented above have been weighted by site weight.**

Table 6-4 presents the distribution of TVs by business size, which is determined by annual kWh usage. These data indicate that Large and Medium businesses are more likely to have TVs than Small and Very Small businesses. Eighty-two percent of Large CSS businesses have TVs, while 40% of Very Small businesses have TVs. A similar trend exists for the average number of TVs per business, with Large and Medium businesses having about 18 and 11 units per business, respectively, while Very Small businesses average 1-2 TVs per business.

Table 6-4: CSS Businesses with TVs by Business Size

Business Size	Share of Businesses With TVs	Relative Precision	Average TVs Per Business for Businesses with TVs	Relative Precision
Large	**82%**	11%	**18.3**	30%
Medium	**73%**	8%	**10.9**	16%
Small	**60%**	8%	**4.3**	21%
Very Small	**40%**	13%	**1.6**	13%
Total	**47%**	8%	**3.5**	12%

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

6.3 TV Characteristics

While on-site, surveyors collected various data about the televisions including technology type, age, and screen size. Table 6-5 presents the distribution, average age, and average screen size of these TVs by the TV type. Within the commercial sector, 94% of TVs are CRT, LCD, or LED. The remaining TVs are grouped into the “other” category, which includes projection, plasma, and other TV types. CRTs and LCDs are the predominant TV types, together evenly making up 85% of TVs in California businesses. The average age of CRTs is 12 years, while the average age of LCDs and LEDs is 3 years, implying a decade in age difference between these types of TVs. The average screen size of TVs varies significantly by technology- 25 inches for CRTs, 35 inches for LCDs, 41 inches for LEDs, and 46 inches for other types of TVs.

Table 6-5: TV Type Distribution, Average Age, and Screen Size

TV Type	Share of TVs	Relative Precision	Average TV Age (Years)	Relative Precision	Average Screen Size (Inches)	Relative Precision
CRT	**42%**	13%	**12**	7%	**25**	3%
LCD	**43%**	12%	**3**	7%	**35**	3%
LED	**8%**	51%	**3**	21%	**41**	4%
Other	**6%**	24%	**4**	15%	**46**	3%
n	**10,322**		**7,119**		**9,910**	

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Table 6-6 lists the distribution of year of TV installation by technology, including the share whose year of installation was unidentifiable or unknown. For CRTs, 37% have an unknown year of installation while 25% were installed between 2000 and 2003. For LCD TVs, 20% have an unknown year of installation while 65% were installed between 2009 and 2012. Only 1% of LCDs found on site were installed prior to 2004. Similarly, 39% of LED TVs were installed between 2009 and 2012, while only 2% were installed before 2004. The age distributions for TVs in CSS businesses indicate a recent shift in technology from smaller sized CRT TVs to larger-sized LCD and LED TVs.

Table 6-6: TV Type Distribution by Year of Purchase

TV Type	Year Missing	Pre 2000	2000-2003	2004-2008	2009-2012
CRT	37%	21%	25%	15%	2%
LCD	20%	1%	0%	14%	65%
LED	54%	0%	2%	6%	39%
Other	27%	0%	0%	21%	52%
n	**3,203**	**2,459**	**1,249**	**930**	**2,481**

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

6.3.1 Television Type Characteristics by Business Type

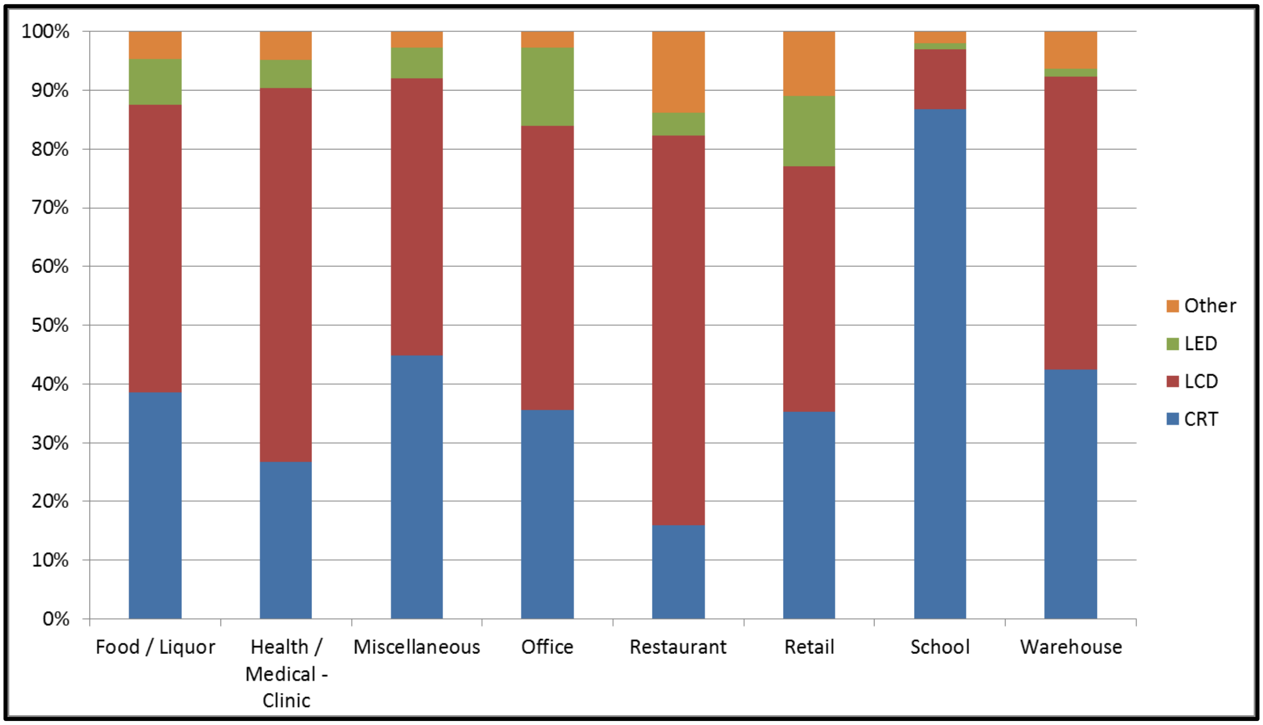
Table 6-7 and Figure 6-1 show the distributions of each TV technology type within each business type for businesses with TVs. For every business type except Schools, LCD TVs are the most prevalent technology type. Two-thirds of Restaurants have LCD TVs, as do 64% of Clinics. In Schools, CRTs comprise an overwhelming 87% of TVs, while other business types have more modest CRT proportions. Offices and Retail stores have the highest percentage of LED TVs, with 13% and 12%, respectively.

Table 6-7: CSS Businesses with TVs by TV Type

Business Type	CRT	LCD	LED	Other
Food/Liquor	39%	49%	8%	5%
Health/Medical – Clinic	27%	64%	5%	5%
Miscellaneous	45%	47%	5%	3%
Office	36%	48%	13%	3%
Restaurant	16%	66%	4%	14%
Retail	35%	41%	12%	11%
School	87%	10%	1%	2%
Warehouse	42%	50%	1%	6%
n	**366**	**550**	**104**	**129**

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed sites included in the analysis.

Figure 6-1: CSS Businesses with TVs by TV Type



*** The results presented above have been weighted by site weight.**

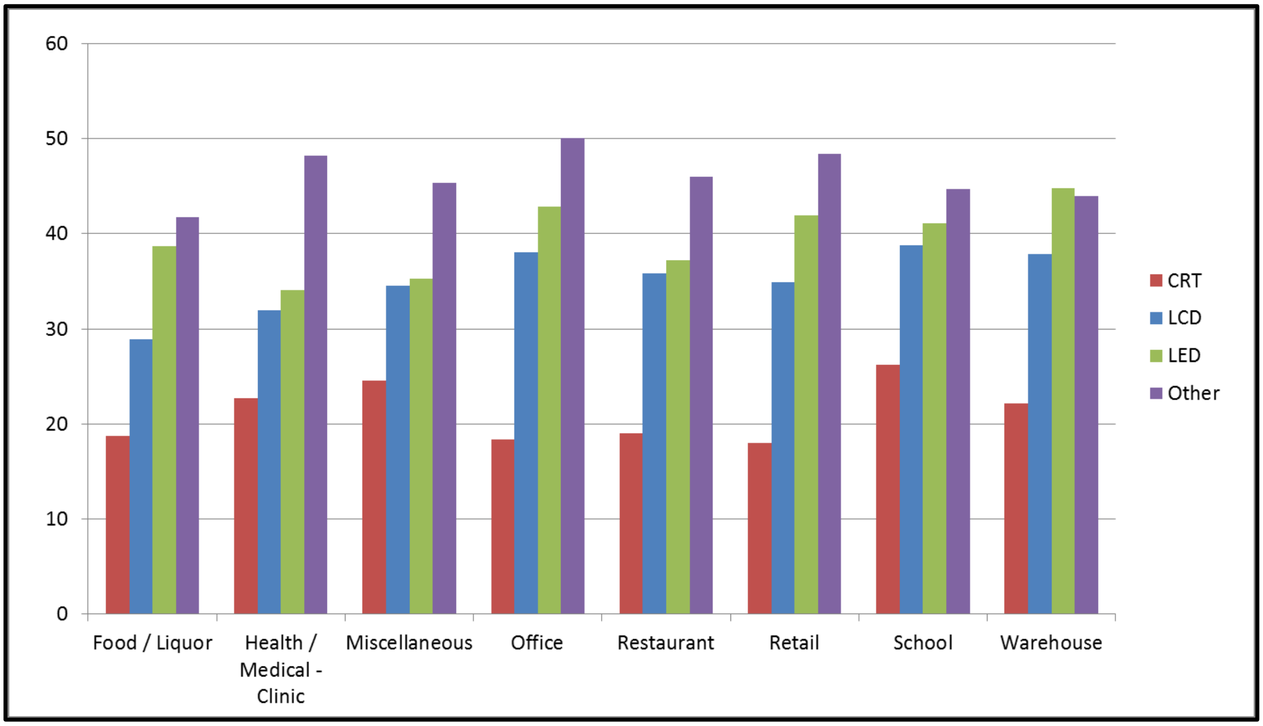
Table 6-8 and Figure 6-2 present the average screen size of the different TV types by business type. Schools have the largest CRTs at an average of 27 inches, while Offices have the largest LCDs (40 inches), along with Warehouses (39 inches). Warehouses and Schools have the largest LEDs (44 inches). "Other" TVs are the largest type, ranging from an average of 39 inches in Schools to 51 inches in Offices.

Table 6-8: Average Screen Size of TV Types by Business Type (Inches)

Business Type	CRT	LCD	LED	Other
Food/Liquor	19	29	41	42
Health/Medical – Clinic	23	30	34	47
Miscellaneous	24	35	36	45
Office	19	40	42	51
Restaurant	19	36	39	45
Retail	18	35	42	50
School	27	34	44	39
Warehouse	22	39	44	49
n	**5,339**	**3,383**	**771**	**417**

*** The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Figure 6-2: Average Screen Size of TV Types by Business Type (Inches)



*** The results presented above have been weighted by site weight.**

6.3.2 Television Usage Characterization

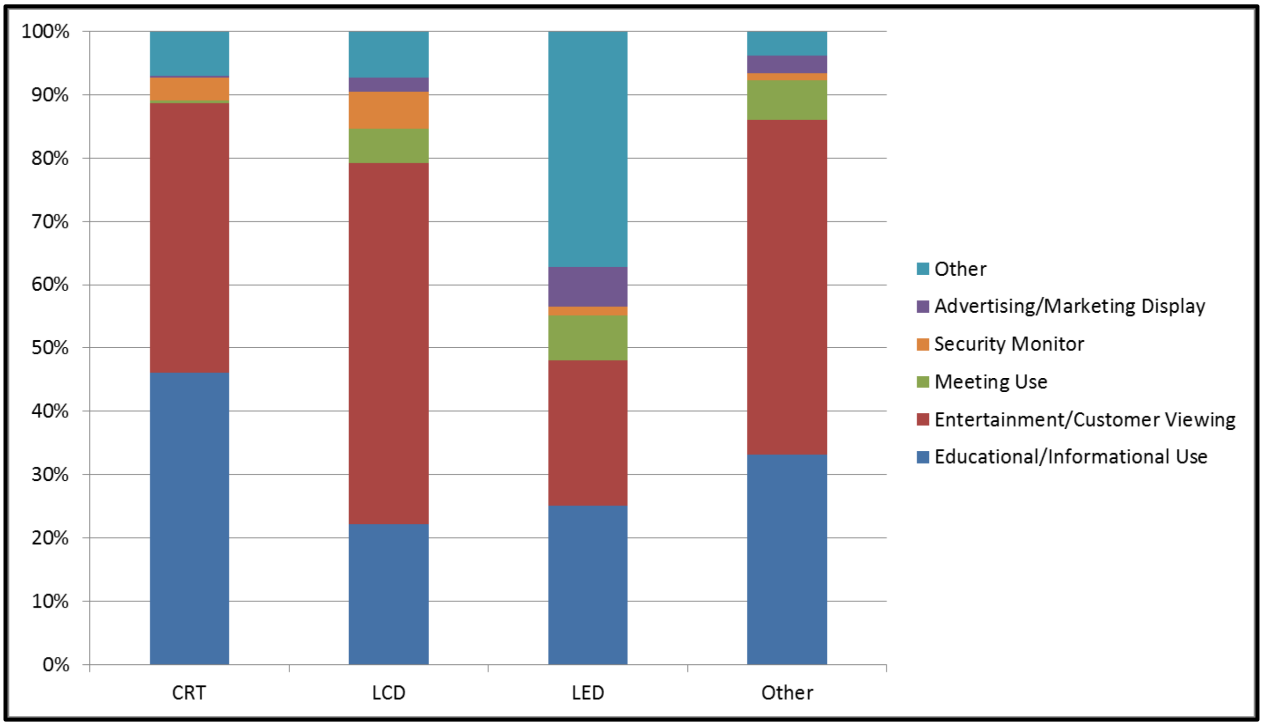
Throughout the state, the on-site survey found televisions in a wide variety of applications, from entertainment to security. Surveyors recorded the self-reported usage of each of the TVs they found at each business, and these descriptions were categorized into several groups. Table 6-9 and Figure 6-3 show the distribution of these groups, presented by TV type. Almost all of the TVs are used for either educational/informational or entertainment purposes. Forty-six percent of CRT TVs are used for education or informational display. Fifty-eight percent of LCD TVs are used for entertainment or customer viewing. Meetings, security, advertising/marketing, and other uses only constitute about 10% of all TV units.

Table 6-9: TV Usage by TV Type

TV Type	Educational / Informational Use	Entertainment / Customer Viewing	Meeting Use	Security Monitor	Advertising / Marketing Display	Other
CRT	46%	43%	0%	4%	0%	7%
LCD	22%	57%	5%	6%	2%	7%
LED	25%	23%	7%	1%	6%	37%
Other	33%	53%	6%	1%	3%	4%
n	**6,173**	**3,018**	**276**	**192**	**154**	**509**

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Figure 6-3: TV Usage by TV Type



* **The results presented above have been weighted by site weight.**

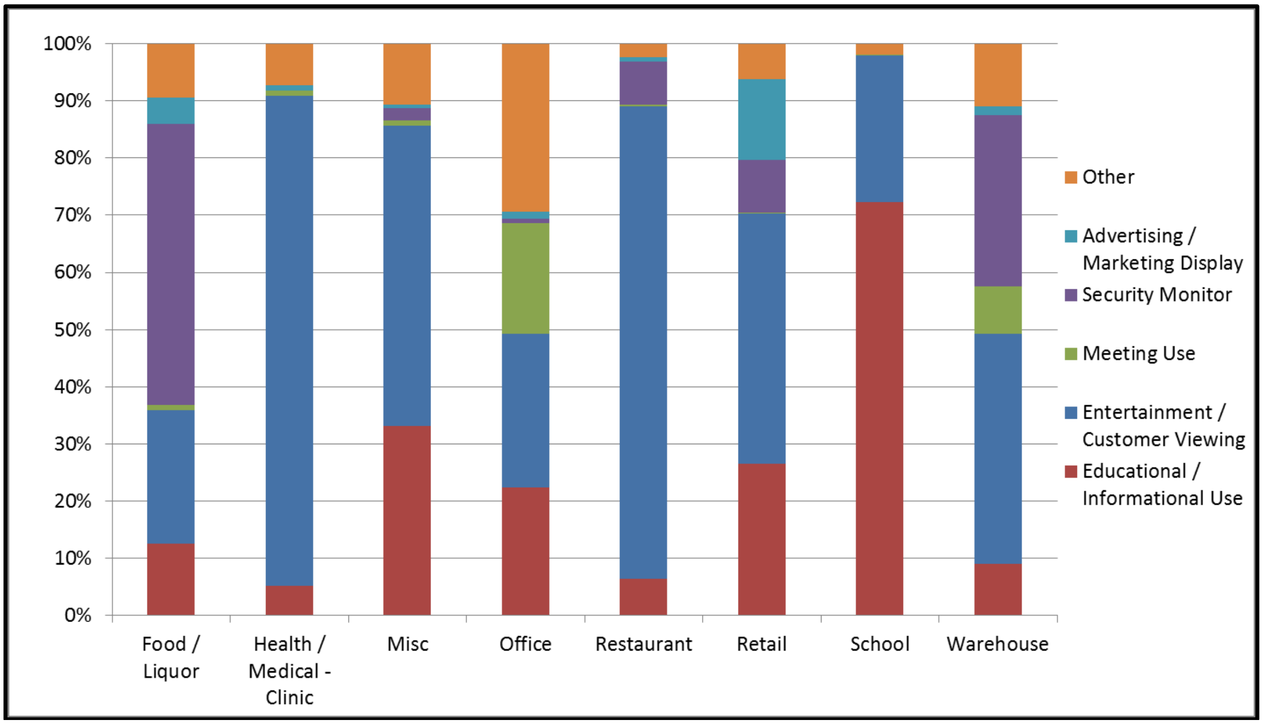
Table 6-10 and Figure 6-4 present the distribution of TV usage by business type. These data show that the majority of televisions in Schools (72%) are for educational or informational purposes. In Restaurants and Health Clinics, the TVs are overwhelmingly used for patrons' entertainment (83% and 86%, respectively). The only business type that has significant usage for meeting is Offices, with 22% of their TVs used for this purpose. Another finding of interest is that almost half of TVs in Food/Liquor stores and 30% of those in Warehouses are used for security monitoring, while 13% of Retail stores' TVs are used for advertising, significantly higher proportions than any other business type.

Table 6-10: TV Usage by Business Type

Business Type	Educational / Informational Use	Entertainment / Customer Viewing	Meeting Use	Security Monitor	Advertising / Marketing Display	Other
Food/Liquor	13%	23%	1%	49%	5%	9%
Health/Medical - Clinic	5%	86%	1%	0%	1%	7%
Miscellaneous	33%	52%	1%	2%	0%	11%
Office	22%	27%	19%	1%	1%	29%
Restaurant	6%	83%	0%	8%	1%	2%
Retail	27%	44%	0%	9%	14%	6%
School	72%	26%	0%	0%	0%	2%
Warehouse	9%	40%	8%	30%	1%	11%
n	**6,173**	**3,018**	**276**	**192**	**154**	**509**

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Figure 6-4: TV Usage by Business Type



* **The results presented above have been weighted by site weight.**

6.4 Efficiency Analysis

The CSS-TV study collected make and model number information during the on-site survey. For 13% of the TVs found on site it was not possible to collect these data.[4] The make and model number information that was collected was looked up as part of the analysis effort to classify the TVs as not ENERGY STAR eligible or ENERGY STAR Version 3.0, 4.1, or 5.3. For the ENERGY STAR eligible units, higher version numbers represent more efficient units. Table 6-1 presents the eligibility time frame for the ENERGY STAR versions.

Occasionally the make and model number collected during the on-site data collection effort could not be found during the look up effort. For 9% of the TVs found on site it was not possible to determine the ENERGY STAR classification from the make and model number collected on site.[5] Given that the make and model number look up effort used the official ENERGY STAR classification lists, it is likely that nearly all of the 9% of unclassified TVs found on site are not ENERGY STAR qualified.[6] For 78% or 7,864 out of 10,067 TVs found on site, the TV efficiency analysis was able to classify the ENERGY STAR efficiency level.

6.4.1 Efficiency Distribution

Table 6-11 lists the efficiency distribution of businesses and distribution of TV units using site weights while Figure 6-5 illustrates the distribution. The distribution of businesses includes CSS businesses where no TVs were found. These data indicate that 53% of businesses do not have a TV on site, but when businesses have TVs, 22% have base efficiency units, and 13% have high efficiency units. [7] These data also imply that about half of the TVs in CSS businesses are non-ENERGY STAR base efficiency units (51%), while over a quarter are high efficiency units. Comparing the TV units and businesses, TV information implies that businesses with a higher number of TVs were more likely to have base efficiency TVs than businesses with fewer TVs.

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4 For most of the sites where it was not possible to collect make and model number information the televisions were mounted on the wall. For televisions mounted on the wall, the surveyors asked the site contact for the User's Guide but these were not always available. For some televisions, it is possible to determine the make and model number using the TV menus, for others this feature is not available. The 13% of TVs were the model number was not collected represents the unweighted actual count of TVs. The tables below will present statistics on the weighted TV counts.

5 The 9% of TVs were the model number was not found during make and model lookups represents the unweighted actual count of TVs. The tables below will present statistics on the weighted TV counts.

6 The unclassified or "Model not found" group are made up of televisions not on the ENERGY STAR qualified list. These measures were looked up on the Internet but they were either not found or energy usage information was not available. For those measures found, but without energy usage information, it is likely that these measures are not ENERGY STAR qualified as the ENERGY STAR lists are assumed to include all ENERGY STAR qualified units. For those measures not found on the internet, it is likely that the make and model number were recorded with error.

7 If a site has both an efficient TV and a base efficiency TV it will be counted as both an efficient and a base site.

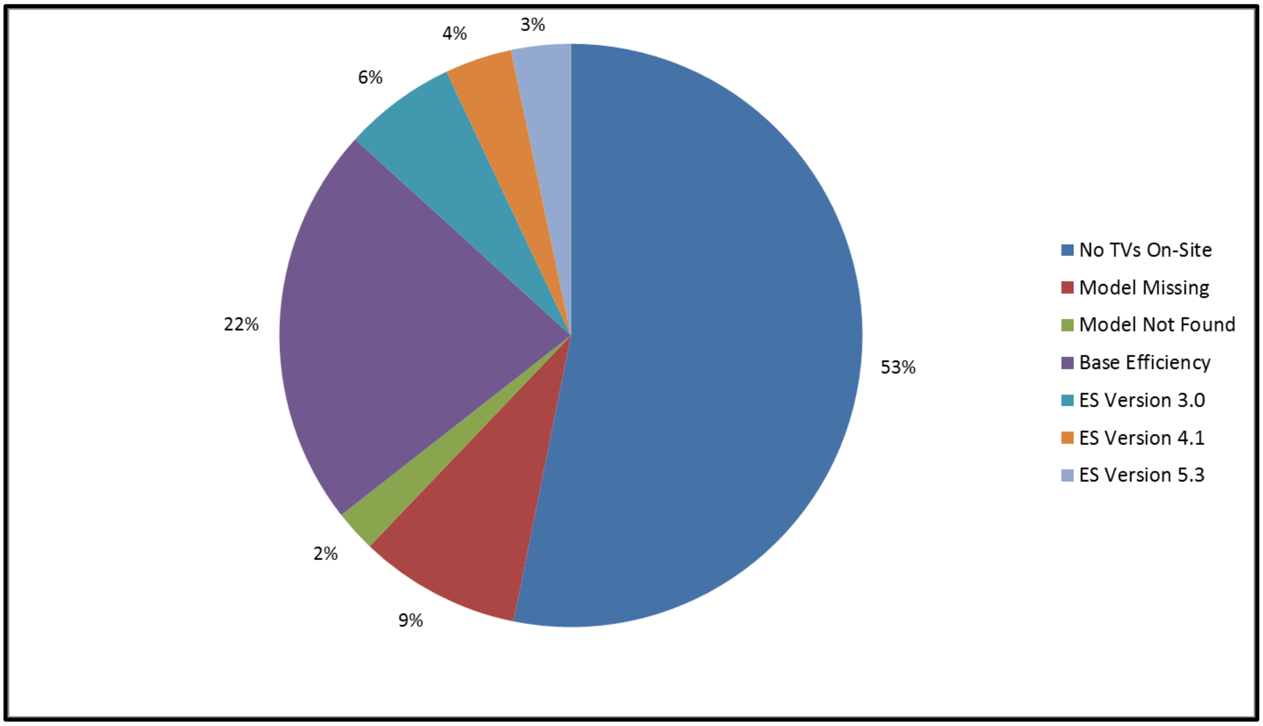
The disaggregated measure level high efficiency data in Table 6-11 indicate that the ENERGY STAR 3.0 TVs are the most common high efficiency TV technology at CSS businesses. Looking at the site-level data, for businesses with high efficiency TVs, they are most likely to have Version 3.0 as well.

Table 6-11: CSS TV Efficiency Distribution

Efficiency Level	Percent of Businesses	Relative Precision	Percent of TVs	Relative Precision
No TVs On Site	**53%**	7%	**–**	–
Model Missing	**9%**	21%	**17%**	25%
Model Not Found	**2%**	34%	**5%**	33%
Base Efficiency	**22%**	13%	**51%**	11%
High Efficiency	**13%**	18%	**26%**	16%
High Efficiency ENERGY STAR Distribution				
ES Version 3.0	**6%**		**12%**	
ES Version 4.1	**4%**		**9%**	
ES Version 5.3	**3%**		**6%**	
n	**1,439**		**10,322**	

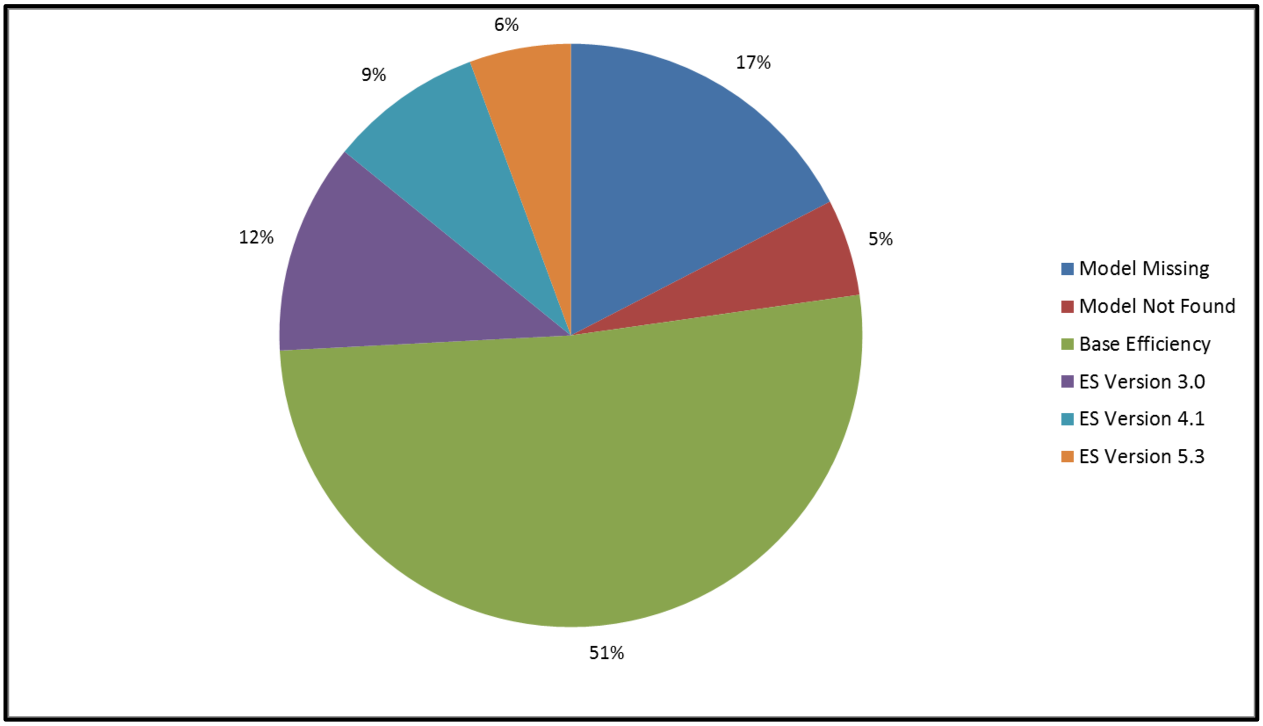
* **The results presented above have been weighted by site weight.** The percent of sites with TVs includes those where no TVs were found on site.

Figure 6-5: CSS TV Efficiency Distribution, Site Count Shares



*** The results presented above have been weighted by site weight.**

Figure 6-6: CSS TV Efficiency Distribution, Unit Count Shares



*** The results presented above have been weighted by site weight.**

6.4.2 Efficiency by Year

As part of the CSS on-site data collection, the on-site surveyor collects self-reported information from the site contact on the year of installation of the TV. When this information is unavailable, the year of manufacture is used to determine the approximate age of the television. Table 6-12 lists the TV distribution by year.

Figure 6-7 is site-weighted and represents the distribution of TV efficiency within each year grouping. When reviewing the data in Table 6-12 and Figure 7-3 it is important to remember that, for the purposes of this study, all ENERGY STAR-qualified TVs were classified into one of the three versions regardless of eligibility date. Our estimates show that the overwhelming majority of televisions installed before 2004 are base efficiency where base efficiency is defined as not ENERGY STAR Version 3.0, 4.1, or 5.3. For TVs purchased from 2004 onwards, the prevalence of ENERGY STAR-qualified televisions steadily increases. For TVs purchased in 2004 to 2008, the share of base efficiency TVs drops from 97% in 2000-2003 to 63%. The share of high efficiency TVs purchased in this year range rises from 0.4% to 21%. From 2009 to 2012, base efficiency TVs only comprise 16% of units, while high efficiency TVs make up 53% of units. It should be noted that the incidence of TVs with missing or unidentifiable model numbers increases as TVs have a more recent purchase or manufacture date. The increase in missing or unidentifiable model numbers is most likely due to the fact that newer televisions have the ability to be mounted to a wall or otherwise placed in locations where older TVs would be impractical. This placement often prevented the surveyors from successfully collecting the model numbers.

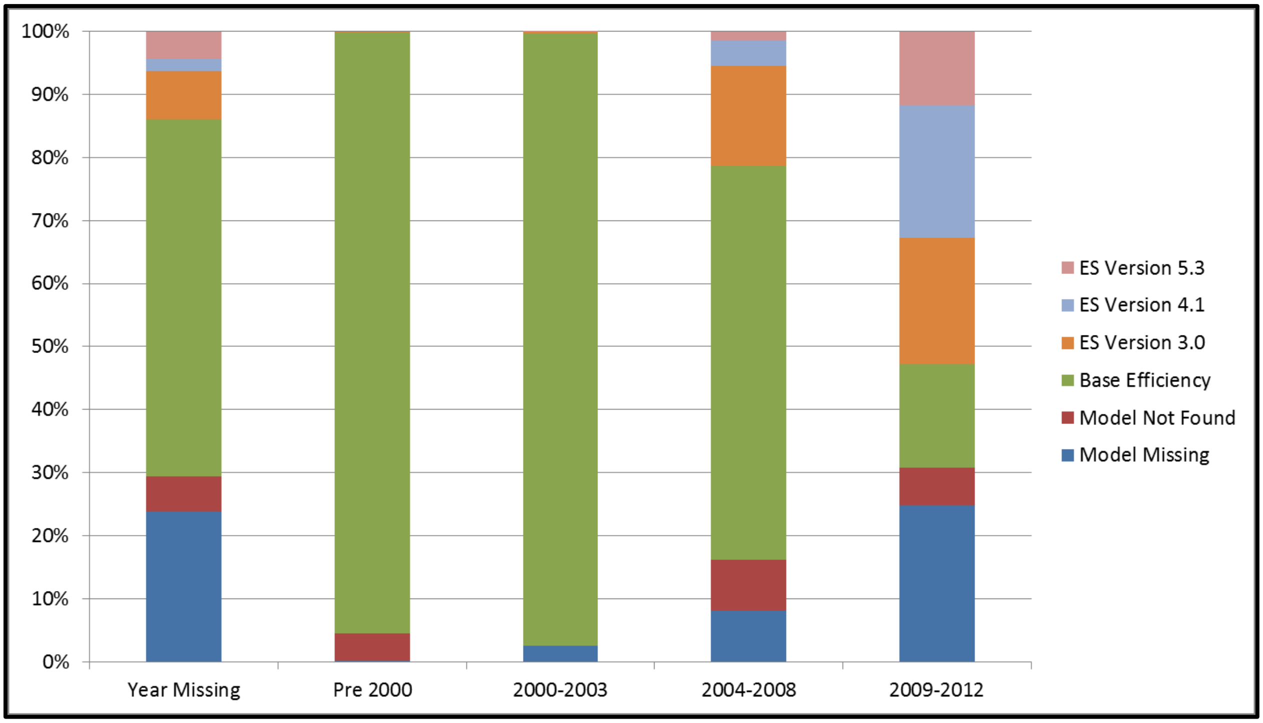
Turning to the disaggregated high efficiency shares, these data indicate that ENERGY STAR Version 3.0 is the most common high efficiency TV in the 2004-2008 range while Version 4.1 is the most common high efficiency TV in the 2009-2012 range. This progression of high efficiency shares is largely a function of the ENERGY STAR classification. Version 3.0 TVs were not ENERGY STAR eligible in 2011 and 2012 and the specifications for Version 5.3 were not announce in 2009 so few TVs would have been built to these higher efficiency specifications.

Table 6-12: CSS TV Efficiency Distribution by Year

Efficiency Level	Year Missing	Relative Precision	Pre 2000	Relative Precision	2000 – 2003	Relative Precision	2004-2008	Relative Precision	2009 - 2012	Relative Precision
Model Missing	**24%**	51%	**0.1%**	119%	**3%**	124%	**8%**	48%	**25%**	20%
Model Not Found	**6%**	68%	**4%**	121%	**0%**	0%	**8%**	61%	**6%**	47%
Base Efficiency	**57%**	21%	**95%**	5%	**97%**	3%	**63%**	18%	**16%**	26%
High Efficiency	**14%**	37%	**0.1%**	167%	**0.4%**	149%	**21%**	46%	**53%**	12%
High Efficiency ENERGY STAR Distribution										
Version 3.0	**8%**		**0.1%**		**0.3%**		**16%**		**20%**	
Version 4.1	**2%**		**0%**		**0%**		**4%**		**21%**	
Version 5.3	**4%**		**0%**		**0%**		**1%**		**12%**	
n	**3,203**		**2,459**		**1,249**		**930**		**2,481**	

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Figure 6-7: CSS TV Efficiency Distribution by Year



* **The results presented above have been weighted by site weight.**

6.4.3 Efficiency by Utility

Table 6-13 and Figure 6-8 present the CSS TV efficiency distribution by utility using site-weighted unit counts. Televisions in CSS businesses in SDG&E's territory have the highest share of high efficiency units (37%), while those in PG&E's territory have the lowest share (20%). This represents a marked change from the CMST study of recent television purchases, where CMST businesses in PG&E's territory had the largest high efficiency share for televisions purchased from 2009 to 2012.[8] ENERGY STAR Version 3.0 is the most commonly installed TV in both PG&E and SCE territory, while Version 4.1 is the most common efficiency level installed in SDG&E.

Table 6-14 and Figure 6-9 present the CSS TV efficiency distribution by utility using site-weighted businesses rather than unit counts. These distributions include those businesses that do not have televisions. When looking at the business level, the proportion of businesses with high efficiency TVs is relatively even across utilities, from 12% of CSS businesses in both SCE and SDG&E to 15% of CSS businesses in PG&E. ENERGY STAR Version 3.0 is again the most common efficiency found at CSS businesses in each utility. It is also interesting to note that slightly over half of the CSS businesses within each utility's territory do not have any televisions and that this distribution is relatively even across utilities.

8 The CSS and CMST analysis differ in several ways. The CMST analysis included business types not surveyed as part of the CSS study, the CMST only looked at TVs purchased from 2009-2012, and the CMST analysis classified high efficiency differently than the CSS. Because the CMST was analyzing recent purchases, the high efficiency purchase designation was very dependent on the date of purchase. The CSS analysis classifies all ENERGY STAR Version 3.0, 4.1, and 5.3 TVs as high efficiency regardless of purchase date.

Table 6-13: CSS TV Efficiency Distribution by Utility, TV Count Shares

Efficiency Level	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
Model Missing	**17%**	53%	**17%**	22%	**22%**	29%
Model Not Found	**6%**	49%	**5%**	51%	**5%**	73%
Base Efficiency	**57%**	17%	**49%**	11%	**35%**	25%
High Efficiency	**20%**	28%	**29%**	19%	**37%**	30%
High Efficiency ENERGY STAR Distribution						
ES Version 3.0	**8%**		**15%**		**14%**	
ES Version 4.1	**7%**		**8%**		**21%**	
ES Version 5.3	**6%**		**6%**		**3%**	
n	**4,479**		**4,973**		**870**	

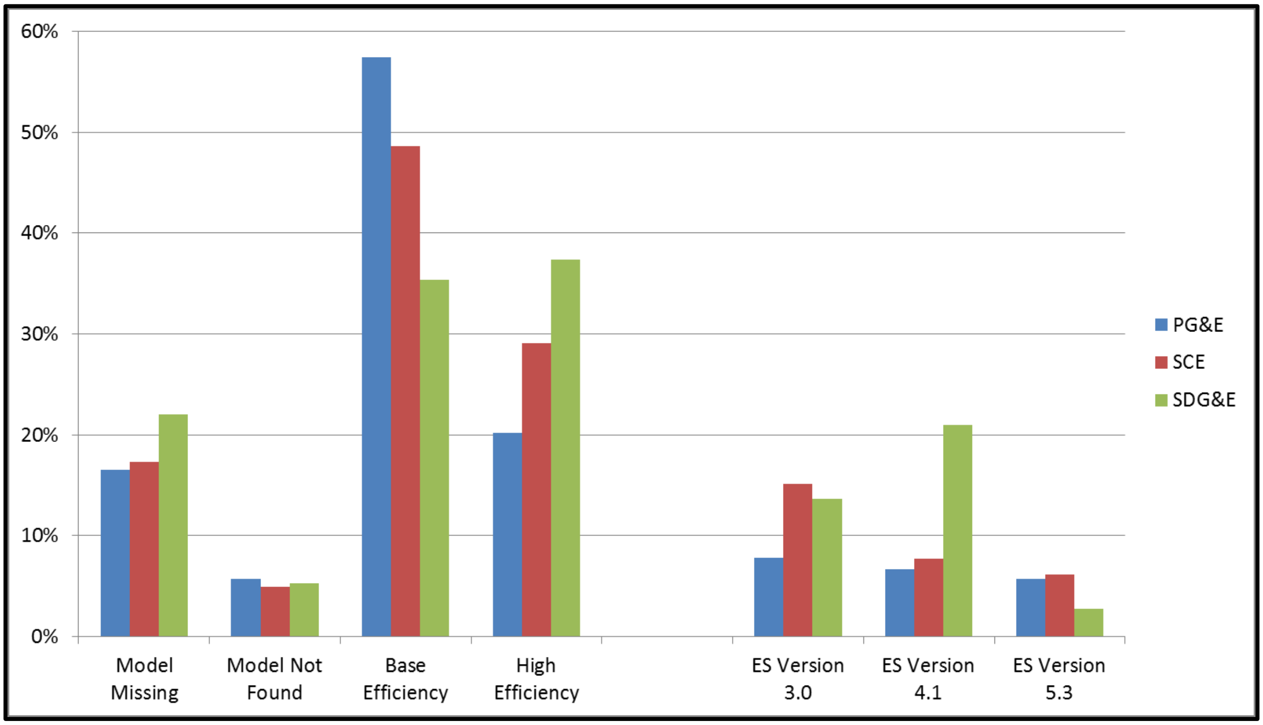
* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Table 6-14: CSS TV Efficiency Distribution by Utility, Site Count Shares

Efficiency Level	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
No TVs On Site	**52%**	12%	**53%**	10%	**57%**	16%
Model Missing	**8%**	40%	**10%**	27%	**7%**	43%
Model Not Found	**2%**	48%	**2%**	42%	**5%**	92%
Base Efficiency	**22%**	22%	**23%**	18%	**19%**	42%
High Efficiency	**15%**	28%	**12%**	26%	**12%**	42%
High Efficiency ENERGY STAR Distribution						
ES Version 3.0	**6%**		**7%**		**7%**	
ES Version 4.1	**5%**		**3%**		**4%**	
ES Version 5.3	**4%**		**3%**		**1%**	
n	**573**		**642**		**224**	

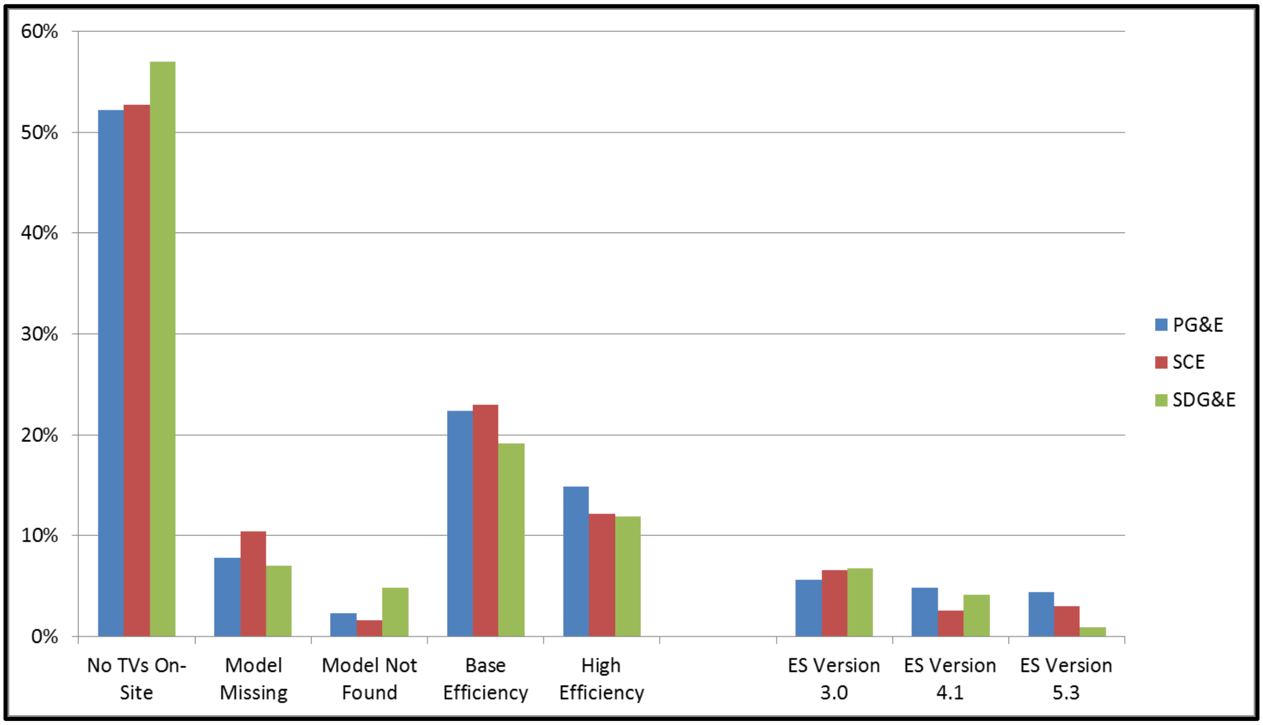
* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed sites included in the analysis, including those where no TVs were found on site.

Figure 6-8: CSS TV Efficiency Distribution by Utility, TV Count Shares



* **The results presented above have been weighted by site weight.**

Figure 6-9: CSS TV Efficiency Distribution by Utility, Site Count Shares



* **The results presented above have been weighted by site weight.**

6.4.4 Efficiency by Business Size

Table 6-15 and Figure 6-10 present the CSS TV efficiency distribution by business size using site weights for TV counts. When looking at the efficiency distribution by TV counts, the distribution of high efficiency units is relatively even across business sizes, ranging from 23% of units in Medium-sized businesses to 29% of units in Very Small businesses. Of the ENERGY STAR-qualified units in these Very Small businesses, most TVs are Version 3.0. In Small and Medium CSS businesses, the distribution of Version 3.0 and Version 4.1 is even, at 10% of all units for both. Most of the high efficiency TVs at Large businesses are Version 5.3, comprising 18% of all units at these businesses.

When looking at the business based efficiency distributions in Table 6-16 and Figure 6-11, larger sized businesses are significantly more likely to have TVs than Small or Very Small businesses. Only 18% of Large businesses don't have TVs while 60% of Very Small businesses and 40% of Small businesses don't have TVs. In addition, larger businesses are more likely it is to have high efficiency televisions than smaller businesses. Only 11% of Very Small businesses have ENERGY STAR-qualified TVs, while 29% of Large businesses have them. The same general distributions exist at the site level for the disaggregated ENERGY STAR versions; Large businesses have more Version 5.3 TVs, Medium and Small businesses have roughly even Version 4.3 and 3.0 TVs, and Very Small businesses with efficient TVs have mostly Version 3.0 TVs.

Table 6-15: CSS TV Efficiency Distribution by Business Size, TV Count Shares

Efficiency Level	Large	Relative Precision	Medium	Relative Precision	Small	Relative Precision	Very Small	Relative Precision
Model Missing	**23%**	42%	**24%**	56%	**14%**	31%	**16%**	30%
Model Not Found	**10%**	87%	**3%**	72%	**7%**	48%	**4%**	73%
Base Efficiency	**42%**	26%	**50%**	21%	**54%**	18%	**51%**	15%
High Efficiency	**26%**	25%	**23%**	34%	**26%**	26%	**29%**	25%
High Efficiency ENERGY STAR Distribution								
Version 3.0	**4%**		**10%**		**10%**		**17%**	
Version 4.1	**4%**		**10%**		**10%**		**6%**	
Version 5.3	**18%**		**3%**		**5%**		**6%**	
n	**2,992**		**5,264**		**1,802**		**264**	

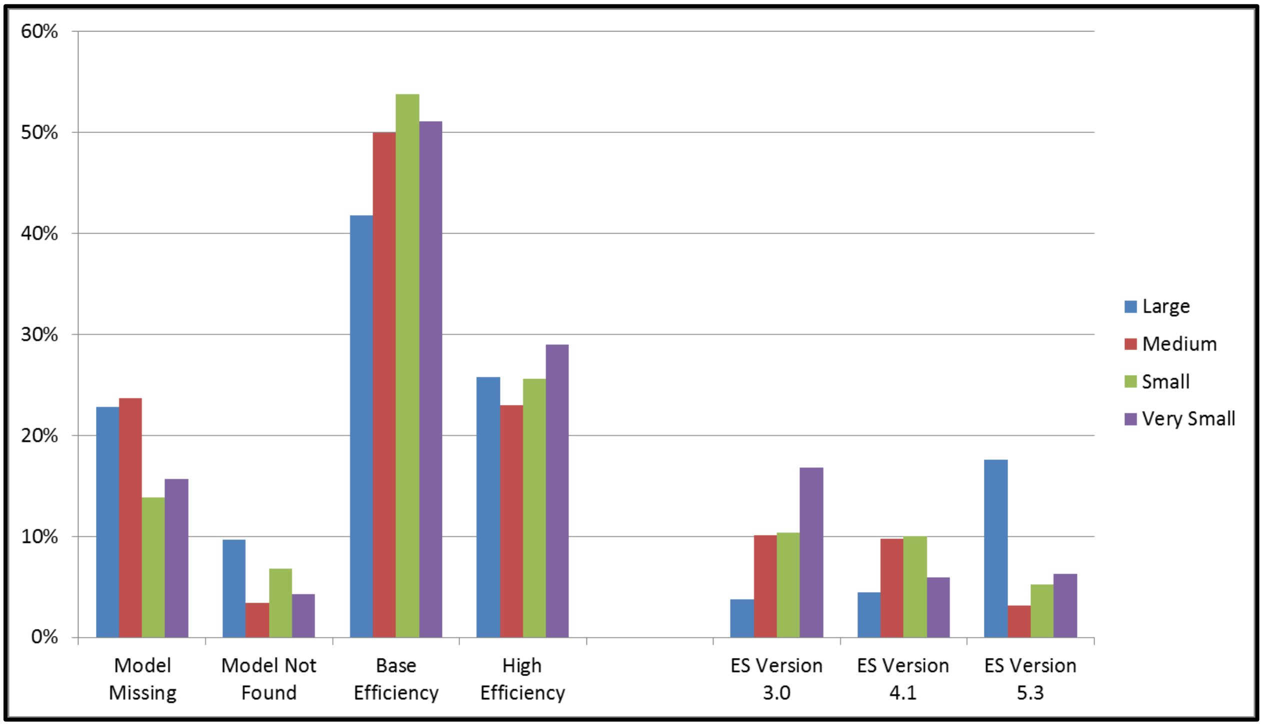
* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Table 6-16: CSS TV Efficiency Distribution by Business Size, Site Count Shares

Efficiency Level	Large	Relative Precision	Medium	Relative Precision	Small	Relative Precision	Very Small	Relative Precision
No TVs On Site	**18%**	50%	**27%**	22%	**40%**	13%	**60%**	8%
Model Missing	**25%**	33%	**21%**	50%	**14%**	26%	**6%**	36%
Model Not Found	**3%**	88%	**4%**	47%	**4%**	37%	**1%**	68%
Base Efficiency	**26%**	28%	**28%**	19%	**25%**	15%	**21%**	20%
High Efficiency	**29%**	28%	**20%**	24%	**18%**	22%	**11%**	28%
High Efficiency ENERGY STAR Distribution								
Version 3.0	**9%**		**8%**		**7%**		**6%**	
Version 4.1	**9%**		**8%**		**7%**		**2%**	
Version 5.3	**12%**		**3%**		**4%**		**3%**	
n	**98**		**463**		**484**		**394**	

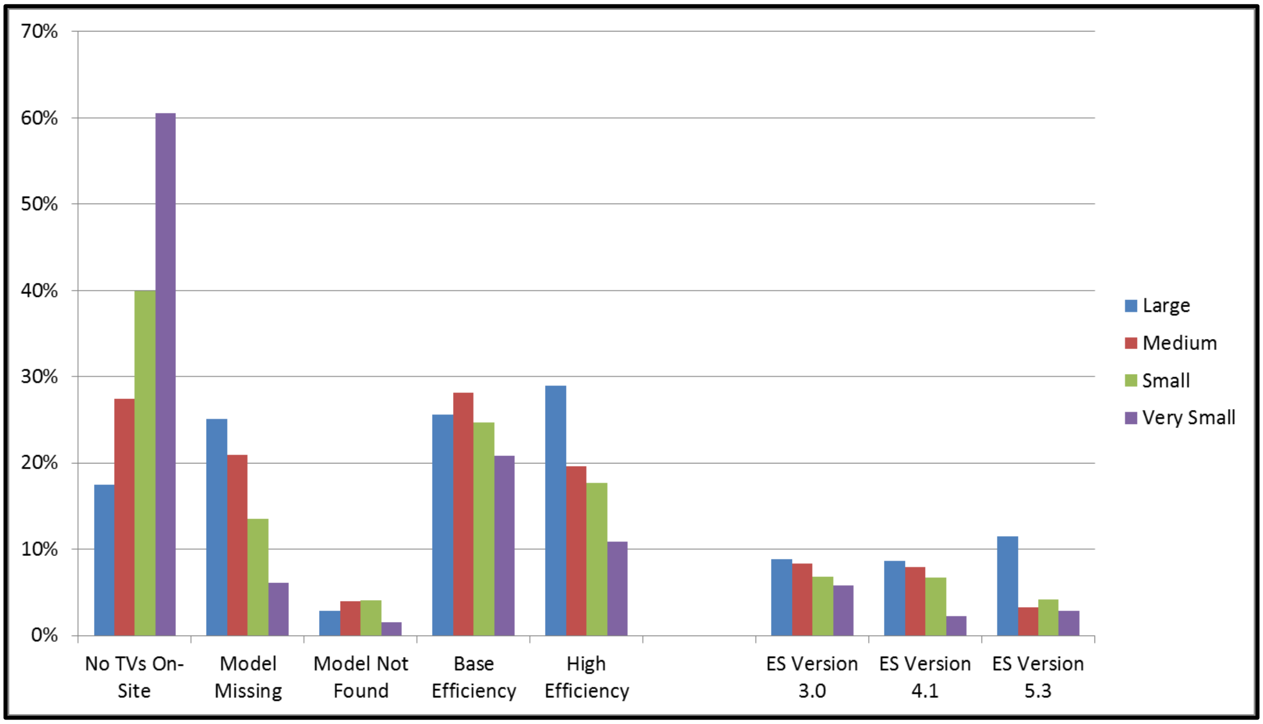
* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed sites included in the analysis, including those where no TVs were found on site. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 6-10: CSS TV Efficiency Distribution by Business Size, TV Count Shares



* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 6-11: CSS TV Efficiency Distribution by Business Size, Site Count Shares



*** The results presented above have been weighted by site weight.**

6.4.5 Efficiency by Business Type

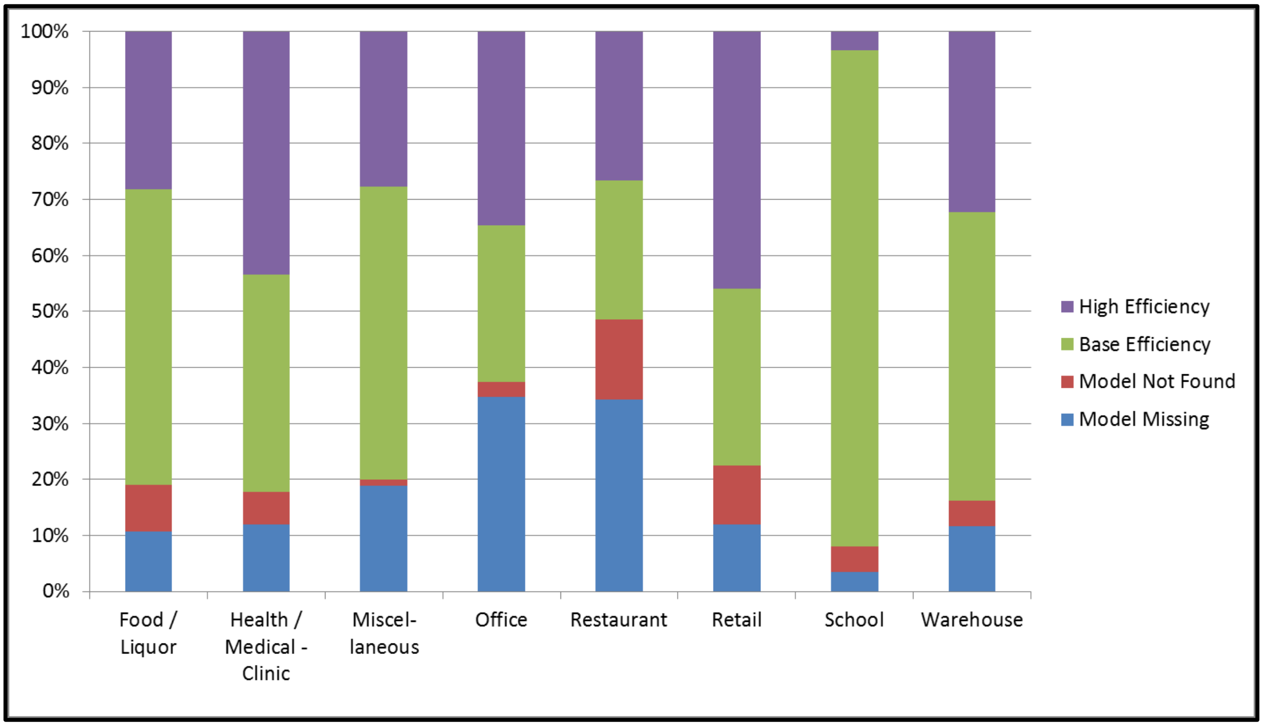
Table 6-17 and shows the distribution of TV efficiency by business type for TV unit counts using site weights. Certain business types that were unique to the CMST study, which include Colleges, Hospitals, Hotels, and Industrial sites, were excluded from the CSS analysis. Overall, the highest proportions of high efficiency TVs can be found in Health/Medical Clinics and Retail stores, with 43% and 46% of TVs, respectively. Schools, on the other hand, have an overwhelming majority of base efficiency measures, comprising 89% of the units found on site. Approximately half of the televisions in Restaurants had model numbers that were either not collected or unable to be found in the make/model lookups. This is likely due to the communal placement of TVs in restaurants for either customer viewing or menu display, often making it difficult to collect model numbers without interfering with diners or business operations.

Table 6-17: CSS TV Efficiency Distribution by Business Type, TV Count Shares

Business Type	Efficiency Level	Percent of Units	Relative Precision	*n*
Food/Liquor	Model Missing	**11%**	54%	**170**
	Model Not Found	**8%**	84%	
	Base Efficiency	**53%**	21%	
	High Efficiency	**28%**	33%	
Health/Medical - Clinic	Model Missing	**12%**	40%	**1,336**
	Model Not Found	**6%**	86%	
	Base Efficiency	**39%**	34%	
	High Efficiency	**43%**	31%	
Miscellaneous	Model Missing	**19%**	29%	**948**
	Model Not Found	**1%**	53%	
	Base Efficiency	**52%**	15%	
	High Efficiency	**28%**	26%	
Office	Model Missing	**35%**	59%	**961**
	Model Not Found	**3%**	99%	
	Base Efficiency	**28%**	39%	
	High Efficiency	**35%**	41%	
Restaurant	Model Missing	**34%**	27%	**364**
	Model Not Found	**14%**	56%	
	Base Efficiency	**25%**	28%	
	High Efficiency	**27%**	33%	
Retail	Model Missing	**12%**	41%	**689**
	Model Not Found	**11%**	81%	
	Base Efficiency	**31%**	26%	
	High Efficiency	**46%**	19%	
School	Model Missing	**3%**	85%	**5,734**
	Model Not Found	**5%**	81%	
	Base Efficiency	**89%**	7%	
	High Efficiency	**3%**	76%	
Warehouse	Model Missing	**12%**	82%	**120**
	Model Not Found	**5%**	96%	
	Base Efficiency	**51%**	39%	
	High Efficiency	**32%**	68%	

* **The results presented above have been weighted by site weight.** *n*'s represent the count of surveyed televisions included in the analysis.

Figure 6-12: CSS TV Efficiency Distribution by Business Type, TV Count Shares



* **The results presented above have been weighted by site weight.**

7

Commercial Office Equipment

The CSS study collected extensive information on the saturation of multiple types of office equipment. Some form of office equipment exists in nearly all businesses. The ubiquitous nature of office equipment helps to clarify the importance of developing a better understanding of the saturation and distribution of these technologies.

Office equipment technologies have been undergoing rapid technological changes. The energy usage and cost of office technologies has generally been falling while the functionality has generally improved. Given the rapid technological change of office equipment, it is likely that these technologies experience a relatively rapid turnover or have a short expect life as business purchase new equipment for the technological improvements. Given the level of rapid technological change and potentially short life, collecting information on these technologies is necessary to update our understanding of the current distribution of office equipment.

7.1 Sources of Data

Information on Office Equipment within CSS businesses was collected during the on-site surveys. During the on-site survey, data was collected on the number of each type of equipment found at the facility. Other information about personal or shared usage, whether the technology was turned off at night, and ENERGY STAR qualification were also collected for the office equipment found on-site.

To assist in the reporting of office equipment the most important office equipment technologies were grouped together for the purposes of this report. Data on the individual components of office equipment are maintained within the project database. The four groups of office equipment that have been analyzed for this report are Copiers, Printers, Computers, and Servers. The technologies included in these groups are as follows:

- Copiers – Copiers and All-in-One Multi-function Copiers (large networked)
- Printers – Ink Jet, Laser, All-in-One Multi-function Desktop, Dot Matrix, Scanners, Fax
- Computers – Desktop, Integrated, Laptops, Netbooks, and Tablets
- Servers – Blade, Tower, and Rack Servers

7.2 Distribution of Office Equipment

The following section describes the distribution of office equipment by sites and quantity of equipment. The site discussion describes the share of sites by business type with office equipment technology for the grouped technology types described above. The quantity distributions clarify the business types where these technology types dominate.

7.2.1 Distribution of Businesses with Office Equipment

The study completed 1,439 on-site surveys with CSS businesses.[1] The on-site surveys found that most of the CSS businesses (1,365) have some type of office equipment. Table 7-1 presents the distribution of sites with office equipment in general and then shows the distribution of sites with the four office equipment groups listed above. The table also presents the relative precision (RP) reported at the 90% confidence level for all statistics presented.

Table 7-1: CSS Office Equipment Distribution by Business Type

Business Type	Total	RP	Copier	RP	Printer	RP	Computer	RP	Server	RP
Food/Liquor	**98%**	2%	**11%**	50%	**64%**	15%	**59%**	17%	**0%**	167%
Health/ Medical - Clinic	**100%**	0%	**52%**	20%	**87%**	9%	**89%**	8%	**7%**	73%
Miscellaneous	**82%**	8%	**21%**	29%	**57%**	14%	**66%**	12%	**3%**	78%
Office	**97%**	3%	**55%**	16%	**91%**	6%	**92%**	5%	**9%**	49%
Restaurant	**93%**	4%	**5%**	54%	**55%**	14%	**67%**	12%	**0%**	126%
Retail	**98%**	2%	**18%**	35%	**82%**	7%	**83%**	6%	**5%**	83%
School	**99%**	2%	**75%**	23%	**90%**	8%	**92%**	8%	**12%**	42%
Warehouse	**80%**	14%	**30%**	36%	**63%**	20%	**70%**	18%	**5%**	51%
n	**1,365**		**640**		**1,138**		**1,215**		**170**	

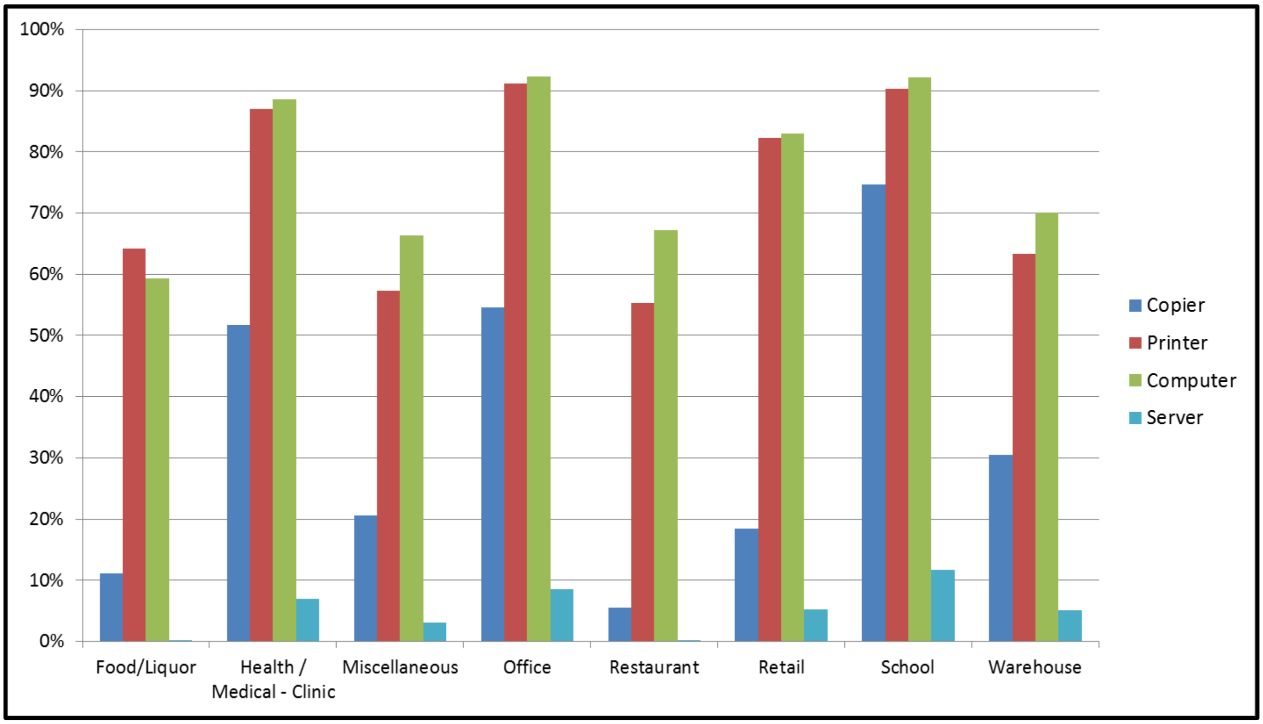
* **The results presented above have been weighted by site weight.** RP is Relative Precision. Totals represent the count of surveyed units included in the analysis.

Figure 7-1 shows graphically the contents of Table 7-1 above. The vast majority of sites have both Computers and Printers. Computers include desktops, laptops, and notebooks while Printers include Networked and Desktop printers. Given these definitions it is not surprising that most businesses have both Printers and Computers. Copiers are less common than Computers or Printers, dominating in Health Care, Offices, and Schools. Servers are the least common type of

[1] The CSS survey completed 1,461 CSS surveys. After review of the on-site data, it was found that some of these surveys were completed with businesses not eligible for the CSS study. In addition, two surveys were completed at sites found to be customers of electric municipal utilities and one of the gas IOUs. The study scope was limited to the electric IOUs.

office equipment analyzed in this report with only 12% of Schools and 9% of Offices having these technologies.

Figure 7-1: Distribution of Office Equipment by Business Type



* **The results presented above have been weighted by site weight.**

Table 7-2 presents the site level distribution of office equipment by utility. Again, most businesses have office equipment. As would be expected the distribution of specific office equipment groups does not vary drastically by utility. The use of office equipment is universal and has little to do with geographic region or weather conditions implied by the various regions served by the three IOUs. The small number of servers that were surveyed contributes to the high relative precision reported for the equipment group.

Table 7-2: CSS Office Equipment Distribution by Utility

Utility	Total	RP	Copier	RP	Printer	RP	Computer	RP	Server	RP
PG&E	**91%**	5%	**30%**	17%	**75%**	7%	**79%**	7%	**7%**	45%
SCE	**90%**	4%	**27%**	17%	**71%**	8%	**74%**	7%	**3%**	37%
SDG&E	**93%**	4%	**38%**	25%	**67%**	13%	**80%**	9%	**4%**	60%
n	**1,365**		**640**		**1,138**		**1,215**		**170**	

* **The results presented above have been weighted by site weight.** RP is Relative Precision. Totals represent the count of surveyed sites included in the analysis.

Table 7-3 presents the site level distribution of office equipment by business size groups. These groups are created using Annual kWh developed from the billing records for each business. Here too we see an even distribution of all office equipment in the Total column. As expected sites with the other equipment types follow the size distribution in a regular way. Large energy users generally have larger shares of equipment than smaller energy users. Also, Offices dominate the Medium size category and we see a larger share of Computers in this size category with a small relative precision.

Table 7-3: CSS Office Equipment Site Distribution by Annual kWh Groups

Business Size	Total	RP	Copier	RP	Printer	RP	Computer	RP	Server	RP
Large	**90%**	9%	**57%**	18%	**80%**	12%	**84%**	10%	**16%**	46%
Medium	**98%**	1%	**56%**	14%	**88%**	4%	**91%**	3%	**16%**	23%
Small	**96%**	2%	**36%**	14%	**79%**	5%	**82%**	5%	**9%**	39%
Very Small	**88%**	4%	**25%**	17%	**68%**	7%	**74%**	6%	**2%**	69%
n	**1,365**		**640**		**1,138**		**1,215**		**170**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, medium have greater than 300,000 kWh and less than or equal to 1,750,000, small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, very small have annual usage less than or equal to 40,000 kWh. RP is Relative Precision.

7.2.2 Distribution of Office Equipment Quantity

The following tables show the distribution of the quantity of office equipment groups by various classifications. Relative Precision is presented in these tables in the columns labeled RP.

Table 7-4 presents the four groups of office equipment and their weighted distribution of quantity by business type. As expected, the Office sector dominates the share of office equipment for all types of equipment. With the exception of Computers, within Offices all equipment shares are greater than 50% with Servers as high as 76% of all servers. Weighted estimates of the CSS data indicate that 52% of Copiers within the CSS businesses are in Offices, 51% of the Printers, and 47% of the Computers. Schools also have a large share of Computers at 21% of all Computers within CSS businesses. On the low end of the distribution, Food and Liquor stores have 1% or less of all Copiers, Printers, Computers, and Servers within CSS businesses and Restaurants have only 0-2% of all of these technologies.

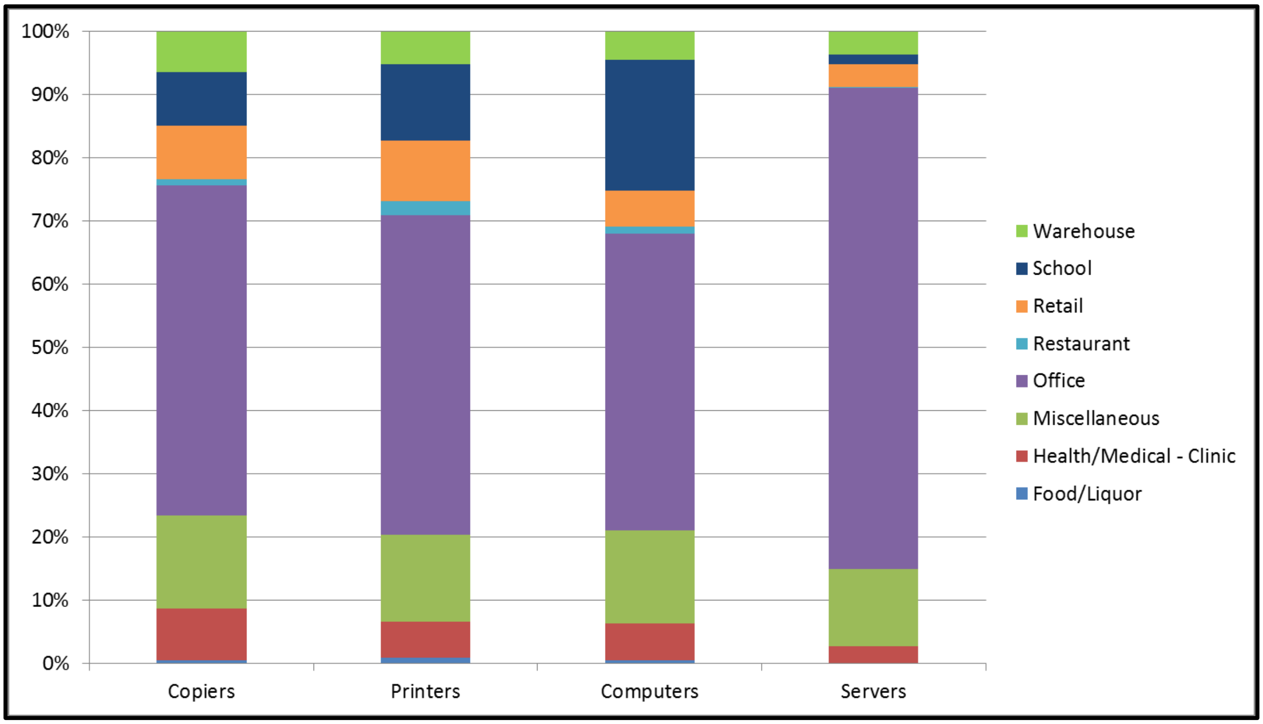
Table 7-4: CSS Office Equipment Quantity Distribution by Business Type

Business Type	Copier	RP	Printer	RP	Computer	RP	Server	RP
Food/Liquor	**1%**	54%	**1%**	44%	**0%**	34%	**0%**	182%
Health/Medical – Clinic	**8%**	34%	**6%**	43%	**6%**	32%	**3%**	92%
Miscellaneous	**15%**	34%	**14%**	44%	**15%**	36%	**12%**	99%
Office	**52%**	23%	**51%**	36%	**47%**	27%	**76%**	25%
Restaurant	**1%**	59%	**2%**	44%	**1%**	31%	**0%**	141%
Retail	**8%**	52%	**10%**	42%	**6%**	33%	**4%**	93%
School	**9%**	55%	**12%**	48%	**21%**	34%	**2%**	84%
Warehouse	**6%**	42%	**5%**	45%	**5%**	35%	**4%**	92%
n	**3,451**		**17,615**		**71,071**		**2,801**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed units included in the analysis. RP is Relative Precision.

As expected, Offices dominate the distribution of office equipment (Figure 7-2). Schools have a larger concentration of Computers in support of computer labs for the students. The Miscellaneous business sector has a consistent percentage of all office equipment presented in this analysis.

Figure 7-2: Distribution of Office Equipment by Business Type



* **The results presented above have been weighted by site weight.**

The distribution of office equipment by utility shows the relative sizes of the utilities. PG&E shows the largest share of Computers and has the largest number of customers. PG&E also has the largest estimated floor stock in Offices of the three IOUs. Given the predominance of Offices in the quantity of office equipment technologies (see Table 7-4), the higher share of Office floor stock also helps to explain the higher share of office equipment for PG&E. SCE has the second highest share of office equipment while SDG&E has the smallest share of the three IOUs. SDG&E's service territory and associated commercial floor stock is significantly smaller than PG&E's and SCE's. All four equipment groups show the same relationship across the Utilities.

Table 7-5: CSS Office Equipment Quantity Distribution by Utility

Utility	Copier	RP	Printer	RP	Computer	RP	Server	RP
PG&E	**53%**	22%	**57%**	29%	**58%**	18%	**60%**	53%
SCE	**36%**	27%	**35%**	38%	**31%**	26%	**35%**	85%
SDG&E	**11%**	36%	**9%**	45%	**11%**	41%	**5%**	97%
n	**3,451**		**17,615**		**71,071**		**2,801**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed units included in the analysis. RP is Relative Precision.

7.2.3 Distribution of Office Equipment Quantity in Office Activity Areas

The tables above show that Office businesses have more office equipment than other types of businesses. The data collected during the CSS study allow for the disaggregation of a business into its activity areas. For the analysis of office equipment the CSS analyzed the equipment in activity areas described as "Offices" and "Computer Rooms".

Table 7-6 shows the distribution of equipment for the Office activity areas that were surveyed for the project. The two Office activity areas are Open Plan Office which may be thought of as cubicles and Private Offices which may be thought of as an office with one or more persons and a door that may be closed. The data in Table 7-6 shows that the distribution of Copiers in Office spaces is approximately equal between Open Plan Office spaces and Private Offices. Copiers are often found in open areas so that they can be shared by multiple staff. The majority of all other office equipment found in Office spaces is found in the Private Office group.

Table 7-6: CSS Office Equipment Activity Area Quantity Distributions for Offices

Activity Area	Copier	RP	Printer	RP	Computer	RP	Server	RP
Open Plan Office	**51%**	35%	**27%**	55%	**37%**	33%	**39%**	70%
Private Office	**49%**	37%	**73%**	20%	**63%**	20%	**61%**	45%
n	**2,000**		**10,227**		**38,851**		**77**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed units included in the analysis. RP is Relative Precision.

7.2.4 Distribution of Office Equipment Quantity in Computer Room Activity Areas

Information on the distribution of office equipment was also analyzed for Computer Areas. Computer Areas could be described as either Computer Rooms or Network Rooms/Data Centers. Computer Rooms are rooms with a number of desktop-style Computers in a class room setting or a laboratory. Network Rooms/Data Centers include both Network Server Rooms in offices and large data centers where Servers are mounted in racks serving a multitude of users.

Table 7-7 show the distribution of all the office equipment being analyzed using these definitions of Computer Rooms. As expected the majority of Servers are in Network Rooms. All other office equipment types are found in greater quantities in Computer Rooms than in Network Rooms. The quantity of equipment in some categories surveyed is quiet small for Computer Areas (n in the table below). These rooms are designed for a single purpose, and it shows in the statistics presented in the table below. The number of Servers in Network Rooms, however, represents over 90% of all Servers surveyed during the CSS study.

Table 7-7: CSS Office Equipment Activity Area Quantity Distributions for Computer Areas

Room Type	Copier	RP	Printer	RP	Computer	RP	Server	RP
Computer Room	**75%**	33%	**94%**	5%	**87%**	11%	**2%**	168%
Network/Server/ Data Center	**25%**	145%	**6%**	73%	**13%**	77%	**98%**	2%
n	**18**		**346**		**5,818**		**2,621**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed units included in the analysis. RP is Relative Precision.

8

Commercial Refrigeration Equipment

Refrigeration systems represent a significant source of energy usage within the commercial sector. The 2006 CEUS[1] estimated that refrigeration systems account for approximately 13% of the electricity usage in the commercial sector. Within select commercial segments, however, refrigeration usage accounts for a significantly higher share of usage than for the average commercial business. Refrigeration systems account for approximately 54% of electricity usage within Food and Liquor Stores, 67% of the usage within Refrigerated Warehouses and 25% of electricity usage for Restaurants.[2] Collecting information on the saturation, distribution, and quantity of refrigeration systems, technologies, and measures will help the CPUC, CEC, IOUs, and DSM evaluators better understand how refrigeration energy usage is linked to existing equipment and how programs can be improved to help reduce refrigeration energy usage.

8.1 Refrigeration Data Sources

Data for the refrigeration analysis was collected from several sources: The CSS/CMST phone surveys, CSS on-site surveys, IOU customer information systems, 2009-2012 energy efficiency program tracking data, and billing data. The telephone surveys were used to collect self-reported information on the presence of refrigeration equipment and to recruit for the on-site data collection effort. The on-site survey collected information on refrigeration systems, technologies, and measures. Data collected on-site included the type of refrigeration system (remote, self-contained, or ice maker), refrigeration equipment type (such as ice makers, display cases, and walk-ins), and refrigeration measures (such as strip curtains, and anti-sweat heater controls. Data collected on-site also included the age of the equipment, the condition, and for some technologies and measures the make and model numbers.[3] The CIS data combined with phone survey and on-site information were used to develop business classifications, the billing data was used to develop annual consumption business size information, and the program tracking information allowed for the analysis to determine if energy efficiency program participants have different technologies and measures than non-participants.

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1 The CA CEUS Project Final Report was completed on behalf of the California Energy Commission. Report # CEC-400-2006-005. CA CEUS is also available at: http://capabilities.itron.com/CA CEUSWeb/Default.aspx

2 Ibid.

3 The CSS effort included the collection of make and model numbers for some refrigeration equipment types. These data were not used for the CSS current analysis, but could be used for future baseline efficiency efforts.

Data was collected on commercial refrigeration systems, technologies, and measures as part of the CSS telephone and on-site data collection effort. Table 8-1 presents information on the distribution of telephone surveys, on-site surveys, and on-site surveys with refrigeration equipment by CSS business types.

Table 8-1: Phone Survey, On-Site, and Refrigeration Sites

Business Type	Phone Survey Completes	Total Number of On-Sites	On-Site Surveys with Refrigeration Equipment
Food/Liquor	486	127	127
Health/Medical - Clinic	633	128	30
Miscellaneous	1,637	246	78
Office	1,313	246	32
Restaurant	595	170	166
Retail	1,019	233	50
School	479	161	142
Warehouse	745	128	24
n	**6,907**	**1,439**	**649**

For the CSS study, refrigeration systems were broken down into three different types of refrigeration: Ice Makers, Remote Refrigeration, and Self-Contained Refrigeration. Table 8-2 presents information on the share of CSS businesses with different types of refrigeration systems by business type. Note that remote refrigeration systems are concentrated in the Food/Liquor segment, as these are the predominant system type used in supermarkets. Thirteen percent of Food/Liquor stores have remote refrigeration, and for Food/Liquor businesses with remote refrigeration, 81% of these businesses were either supermarkets or small general grocery stores. Self-contained refrigeration systems are more common and are found in all business segments, but the highest percentages are in Food/Liquor stores (100%), Restaurants (96%), and Schools (84%).

Table 8-2: Distribution of Businesses with Different Types of Refrigeration

Business Type	Businesses with Refrigeration Equipment	Remote Refrigeration	Self-Contained Refrigeration	Ice Makers
Food/Liquor	100%	13%	100%	46%
Health/Medical - Clinic	4%	0%	4%	3%
Miscellaneous	13%	0%	13%	3%
Office	3%	0%	3%	1%
Restaurant	97%	0%	96%	84%
Retail	13%	0%	13%	1%
School	84%	0%	84%	12%
Warehouse	3%	1%	2%	<1%
n	**649**	**65**	**637**	**350**

*** The results presented above have been weighted by site weight.**

The next sub-section provides an overview of the distributions of refrigeration system types. Information on technologies and measures within these system types follows the brief discussion on refrigeration systems.

8.1.1 Overview of Ice Makers

The on-site data collected for Ice Makers was straight-forward and limited. ENERGY STAR® classifies commercial Ice Makers into two general types; batch (cube) and continuous-type (which produce flakes and nuggets). The ice shape type was collected for each system, along with the make and model number.[4] The on-site survey also collected information on whether the Ice Maker was only an ice-making head, a remote condensing unit, or a self-contained unit.

Table 8-3 and Figure 8-1 present the distribution of Ice Makers by business type and IOU. These data indicate that almost all Restaurants, regardless of utility, have Ice Makers and that just over half of Food/Liquor stores have Ice Makers. Warehouses and Offices are the business types least likely to have Ice Makers.

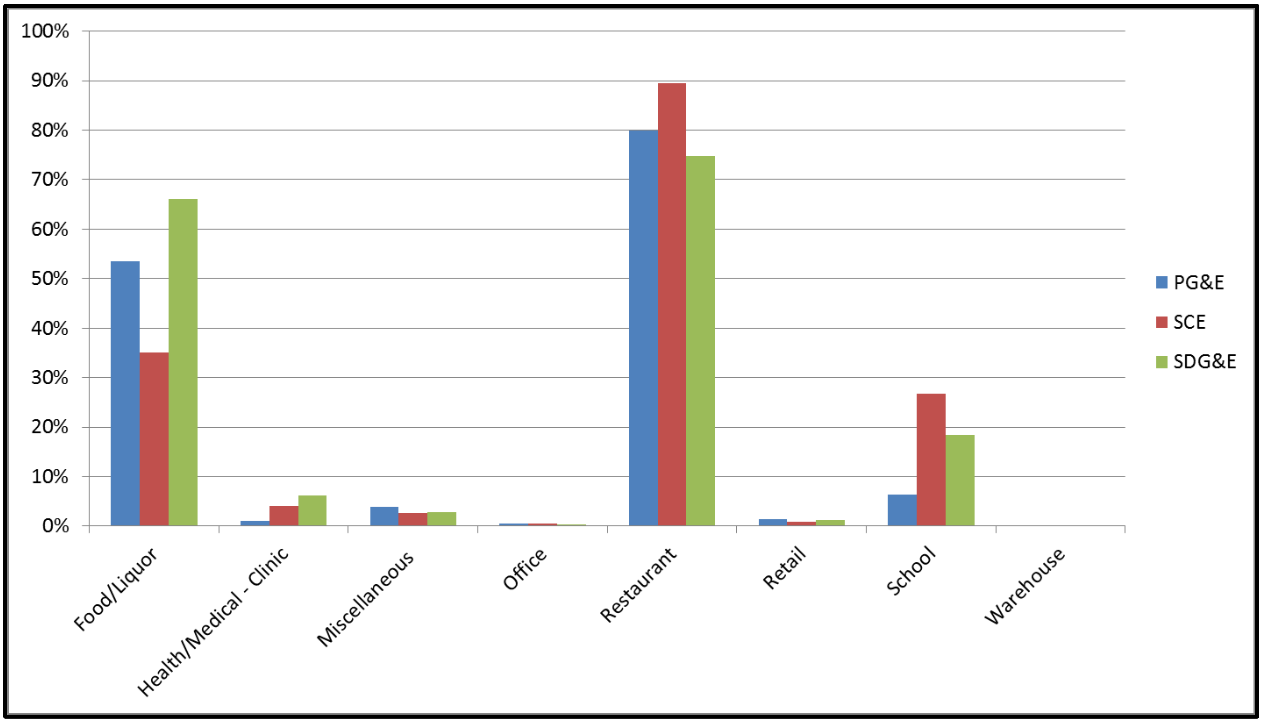
[4] Due to budget limitations, the make and model numbers were not looked up for an efficiency analysis.

Table 8-3: Incidence of Ice Makers found On-Site by Business Type and Utility

Business Type	PG&E	SCE	SDG&E
Food/Liquor	54%	35%	66%
Health/Medical - Clinic	1%	4%	6%
Miscellaneous	4%	3%	3%
Office	1%	1%	0%
Restaurant	80%	89%	75%
Retail	1%	1%	1%
School	6%	27%	18%
Warehouse	0%	0%	0%
On-Site Completed	**573**	**642**	**224**
On-Sites with Ice Makers	**139**	**153**	**58**

*** The results presented above have been weighted by site weight.**

Figure 8-1: Businesses with Ice Makers by Business Type by Utility



*** The results presented above have been weighted by site weight.**

8.1.2 Overview of Self-Contained Refrigeration Equipment

Self-contained refrigeration normally refers to refrigerated units where all refrigeration components (compressor, condenser, evaporator, etc.) are contained within the same package, eliminating the need to run insulated refrigerant lines throughout the building. However, for this study, refrigeration systems with remote condensing units (RCUs) were included as self-contained refrigeration units.[5] Refrigeration technologies and measures analyzed as self-contained systems include the following:

- Walk-ins,
- Solid and glass door upright or worktop table refrigerator or freezer cases,
- Glass door reach-ins associated with self-contained/unitary walk-in coolers and freezers,
- Glass door beverage merchandisers (with and without vending miser controllers),
- Open island cases and coffins,
- Service cases, and
- Ice merchandisers.

The information collected on these technologies and measures included make and model information, temperature range, length, volume, and number of doors, lighting types, year manufactured, and a visual inspection of the overall condition.

The distribution of businesses with self-contained refrigeration by business type and utility are shown in Table 8-4 and Figure 8-2. These data indicate that all Food/Liquor stores and majority of Restaurants (96-97%) have some self-contained refrigeration equipment. Over 80% of Schools in all three utility service territories have self-contained refrigeration. As with Ice Makers, the least likely business types to have self-contained refrigeration are Warehouses (2-4%) and Offices (1-4%).

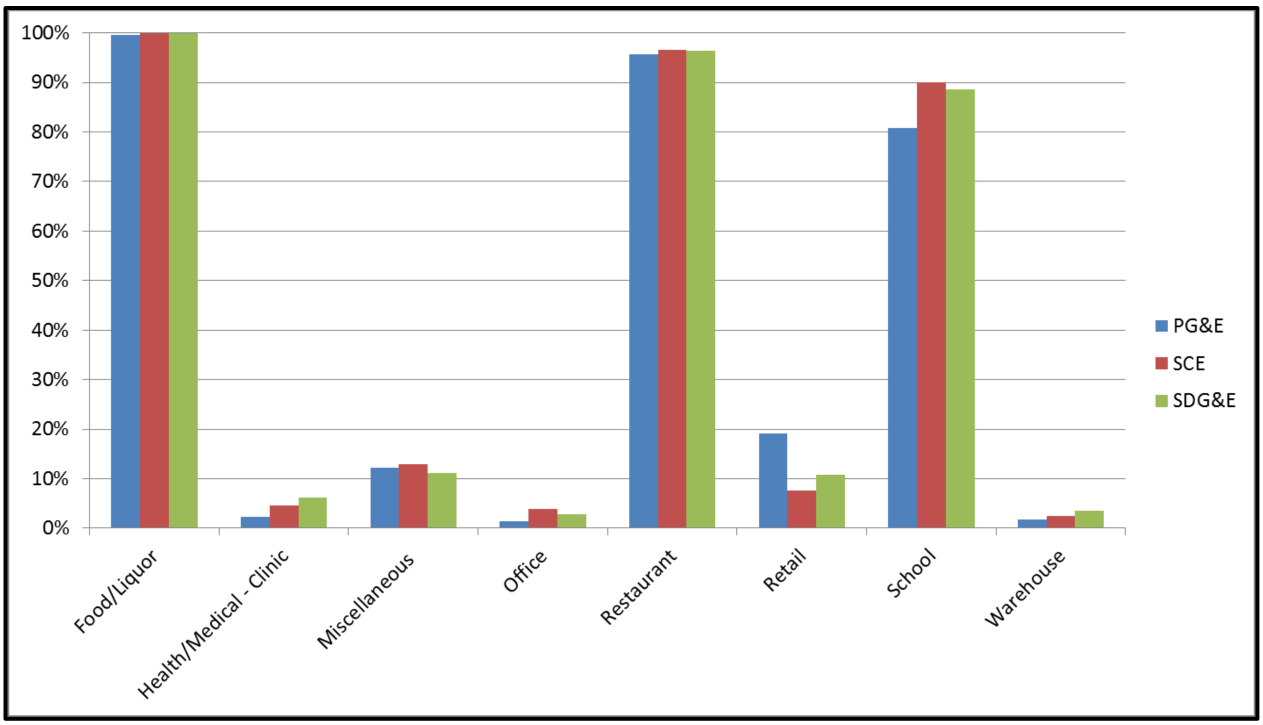
[5] For RCU refrigeration systems, a specific compressor-condenser unit is located as a single unit elsewhere, typically on the roof.

Table 8-4: Incidence of Self Contained Refrigeration Systems by Business Type and Utility

Business Type	PG&E	SCE	SDG&E
Food/Liquor	100%	100%	100%
Health/Medical – Clinic	2%	5%	6%
Miscellaneous	12%	13%	11%
Office	1%	4%	3%
Restaurant	96%	97%	96%
Retail	19%	8%	11%
School	81%	90%	89%
Warehouse	2%	3%	4%
On-Site Completed	**573**	**642**	**224**
On-Sites with Self Contained Refrigeration	**268**	**266**	**103**

*** The results presented above have been weighted by site weight.**

Figure 8-2: Businesses with Self-Contained Refrigeration by Business Type by Utility



*** The results presented above have been weighted by site weight.**

8.1.3 Overview of Remote Refrigeration Systems

Remote refrigeration systems are individual pieces that are purchased separately and then installed together in a system. The compressors are typically installed on a “rack” in a back room or on the roof, and the refrigerant lines are pumped throughout the store. The refrigeration technologies included here include walk-in coolers and freezers, glass door display cases, or open cases or islands. Additionally, for remote refrigeration system information was collected for the compressors, condensers, and any refrigeration controls.

The information for remote refrigeration cases and walk-ins are linked to the compressor, condenser, and controls to create the entire remote refrigeration system. In addition, specific information on the refrigeration cases and walk-ins were collected, including temperature ranges, evaporator fan information, size and dimensions, and details on efficiency measures or options.

The breakdown of these businesses by business type and utility are shown in Table 8-5. Only three business types (Food/Liquor, Retail, and Warehouses) were found to have remote refrigeration systems. For Food/Liquor stores, 81% of the remote refrigeration systems were at Food/Liquor stores classified as Supermarkets and Small General Grocery Stores. The Retail stores with remote refrigeration systems were large department or variety stores, and the Warehouses were warehouse retail stores and refrigerated storage facilities.

Table 8-5: Incidence of Remote Refrigeration Systems by Business Type and IOU

Business Type	PG&E	SCE	SDG&E
Food/Liquor	16%	12%	11%
Retail	<1%	<1%	0%
Restaurant	0%	0%	0%
Warehouse	1%	1%	<1%
On-Site Completed	**573**	**642**	**224**
On-Sites with Remote Refrigeration	**33**	**26**	**6**

*** The results presented above have been weighted by site weight.**

8.2 Ice Makers

The Food Service Technology Center (FSTC) has designed standards for efficient commercial ice-makers. They have been separated into three different classifications, per ENERGY STAR, as icemaker heads, remote condensing systems, or self-contained ice-makers. Each type of system has separate requirements to be ENERGY STAR eligible, including ice harvesting rates, energy consumption rates, and potable water usage. Other details on their eligibility criteria are provided on the FSTC website and ENERGY STAR website.

Approximately half of Ice Makers in CSS businesses are self-contained systems (51%) which include both ice making and storage abilities. The second most common Ice Maker type is Ice-Making Heads (37%). Table 8-6 shows the distribution of Ice Maker technologies, across business types. Offices and Warehouses were the only two business types more likely to have Ice-Making Heads than Self-Contained Systems, although, as seen from Table 8-3, only 1% of Office and 0% of Warehouses have Ice Makers. As seen in Table 8-3, 84% of Restaurants and 46% of Food/Liquor stores have Ice Makers. For these businesses types that commonly have Ice Makers, the distribution of Ice Makers is 48-50% Self-Contained, 35-38% Ice Making Head and 12-17% Remote Condensing Unit. The distribution of Ice Makers in Food/Liquor Stores and Restaurants clearly dominates the total distribution of Ice Makers within CSS businesses.

Table 8-6: Distribution of Ice Maker Equipment by Business Type

Business Type	Ice Making Head Only	Remote Condensing Unit	Self-Contained (ice + storage)	Total
Food/Liquor	35%	17%	48%	**100%**
Health/Medical - Clinic	29%	0%	71%	**100%**
Miscellaneous	29%	8%	64%	**100%**
Office	72%	1%	28%	**100%**
Restaurant	38%	12%	50%	**100%**
Retail	49%	0%	51%	**100%**
School	31%	7%	62%	**100%**
Warehouse	100%	0%	0%	**100%**
Total Percent by Type	**37%**	**11%**	**51%**	**100%**
Total Quantity of Ice Makers Found On-Site	**188**	**34**	**215**	

*** The results presented above have been weighted by site weight.**

Complete make and model information was collected for almost 90% of the ice makers found on site. This information can be matched against lists of High Efficiency ENERGY STAR® equipment, such as that available from the Food Service Technology Center (FSTC)[6], to establish the baseline penetration of High Efficiency ice makers. A lookup effort for ice makers was outside the scope of the CSS study.

8.2.1 Average Number of Ice Makers per Business

Table 8-7 displays the average number of Ice Makers per business for businesses with Ice Makers. The average number of Ice Makers per business ranges from 1 for Warehouses to 1.66 in Offices[7]. The data in Table 8-3 show that only 1% of Offices have Ice Makers, while the data

[6] The FSTC list of qualified energy-efficient ice machines is: http://www.fishnick.com/saveenergy/rebates/icemakers.pdf

[7] This number is driven up by a corporate office site with a large food service area with kitchen and dining.

in Table 8-7 show that the few Offices with Ice Makers average more Ice Makers than other business types.

Table 8-7: Average Number of Ice Makers at a Business by Business Types

Business Type	Percent of Businesses with Ice Makers	Average Quantity per Business that had Ice Makers
Food/Liquor	46%	1.20
Health/Medical - Clinic	3%	1.16
Miscellaneous	3%	1.14
Office	1%	1.66
Restaurant	84%	1.16
Retail	1%	1.26
School	12%	1.30
Warehouse	<1%	1.00

*** The results presented above have been weighted by site weight.**

8.2.2 Physical Condition

The surveyor self-reported the visual condition of ice maker equipment is presented in Table 8-8. A large majority of Ice Makers in CSS businesses are in Good condition with no physical or visual flaws. Just over 16% of Ice Makers are in Fair condition, while very few are in Poor or New condition.

Table 8-8: Distribution of Ice Maker Condition Business Types

Business Type	New	Good	Fair	Poor	Total
Food/Liquor	3%	85%	9%	2%	**100%**
Health/Medical - Clinic	7%	88%	5%	0%	**100%**
Miscellaneous	0%	70%	30%	0%	**100%**
Office	0%	99%	1%	0%	**100%**
Restaurant	2%	77%	16%	5%	**100%**
Retail	0%	100%	0%	0%	**100%**
School	0%	78%	12%	10%	**100%**
Warehouse	0%	100%	0%	0%	**100%**
Total Share by Condition	**2%**	**78%**	**16%**	**4%**	**100%**

*** The results presented above have been weighted by site weight.**

The ENERGY STAR certification and year of installation were also collected for ice makers. Of the ice makers found on-site, only 7% were observed to be ENERGY STAR labeled[8], and 13% of the units were found to have a year manufactured stamped on the label.

8.3 Refrigerated Display Cases

Refrigerated display cases can be stand-alone Self-Contained units or served by a Remote Refrigeration/Rack system, and these two categories are used for the analysis throughout this section. The seven display case configurations used for this analysis are described in Table 8-9.

Table 8-9: Display Case Equipment Type Description

<table>
<tr><th>Display Case Equipment Type</th><th>Self-Contained Refrigeration</th><th>Remote Refrigeration</th></tr>
<tr><td>Glass Door Case</td><td colspan="2">Upright, Glass Door Cases. May be associated with Walk-ins. (May hold frozen foods, juices, ice cream).</td></tr>
<tr><td>Solid Door Storage Case</td><td>Solid Door Upright, or Worktop Table. May be found in restaurants.</td><td>None</td></tr>
<tr><td>Open Display Case</td><td colspan="2">Open upright display case, single or multi-deck. (May hold milk, eggs, fresh meat, and cheese).</td></tr>
<tr><td>Island/Coffin Case</td><td colspan="2">Open Island or Glass-Top Coffin Cases. (May hold ice cream, or deli meat, cheeses, or produce).</td></tr>
<tr><td>Service Case</td><td colspan="2">Closed Service Cases, found in delis or meat counters.</td></tr>
<tr><td>Beverage Merchandiser</td><td>Glass-Door Beverage Merchandisers. May include Vending Miser-type control. May be found in many different business types.</td><td>None</td></tr>
<tr><td>Other/Unlisted Case</td><td>Other self-contained cases. Includes Ice Merchandisers.</td><td>None</td></tr>
</table>

Display case length in linear feet is the standard metric used for the display case analysis. However for glass door cases, the size of the units was recorded on-site as the number of doors. To convert the number-of-glass-door case sizes to linear feet, an estimate of 2.5 ft. per door was used for Self-Contained cases, and 3 ft. per door was used for Remote Refrigeration cases[9].

8.3.1 All Refrigerated Display Cases: Self-Contained and Remote

Table 8-10 provides the average linear feet of Display Cases per business and the share of total linear feet of Display Cases per business, by equipment type. The display case type with the highest share of linear feet is Glass Door cases, followed closely by Solid Door Cases at 33% and 30% respectively. Open Display Cases have the highest average linear feet at just over 25 feet per business, followed by Service Cases at approximately 14 feet. As expected, Beverage Merchandisers have the smallest average size.

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8 Only 7% of units were observed to have the ENERGY STAR label onsite. However, the make and model information collected on-site could be used to develop a true assessment of baseline efficiency.

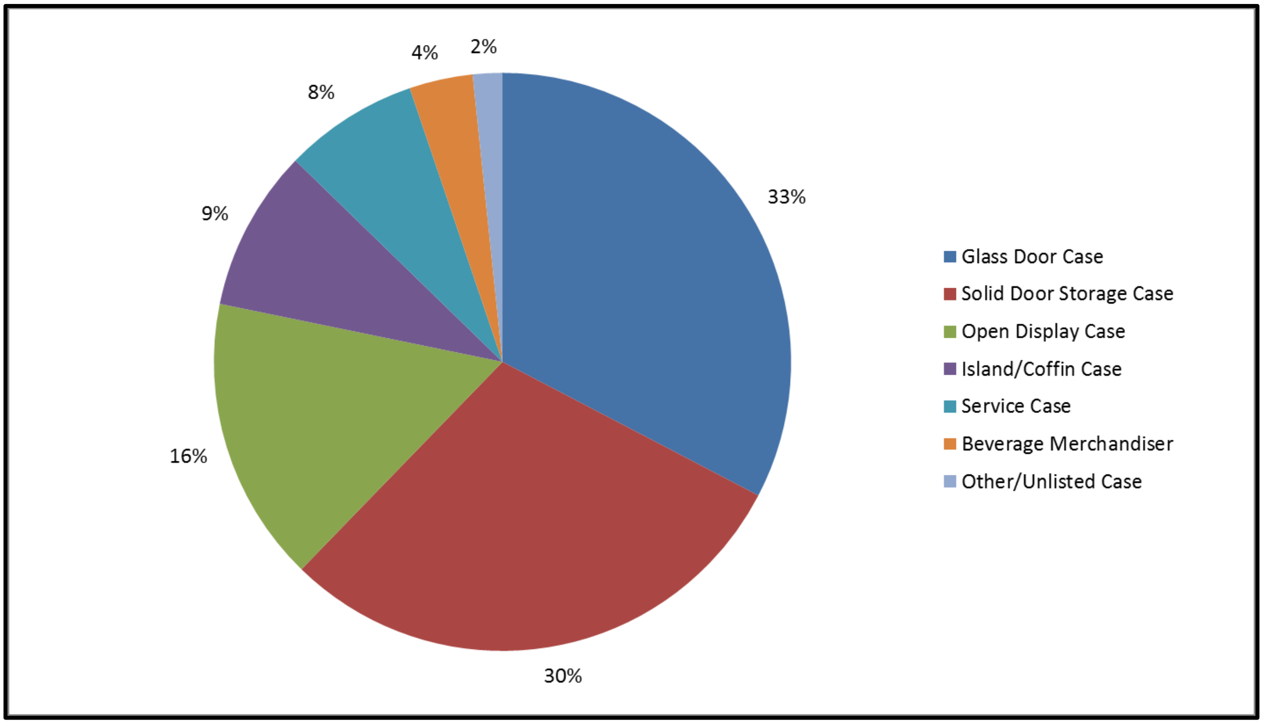
9 The values of 2.5 ft. and 3 ft. were average values developed from the on-site survey data.

Table 8-10: Linear Feet of Display Cases by Case Type, per Business

Equipment Type	Average Linear Feet of Case per Business for Businesses with the Case Type	Share of Total Linear Feet
Glass Door Case	10.7	33%
Solid Door Storage Case	5.8	30%
Open Display Case	25.3	16%
Island/Coffin Case	9.7	9%
Service Case	14.1	8%
Beverage Merchandiser	4.7	4%
Other/Unlisted Case	6.0	2%

*** The results presented above have been weighted by site weight.**

Figure 8-3: Share of Total Linear Feet of Display Cases by Equipment Type



*** The results presented above have been weighted by site weight.**

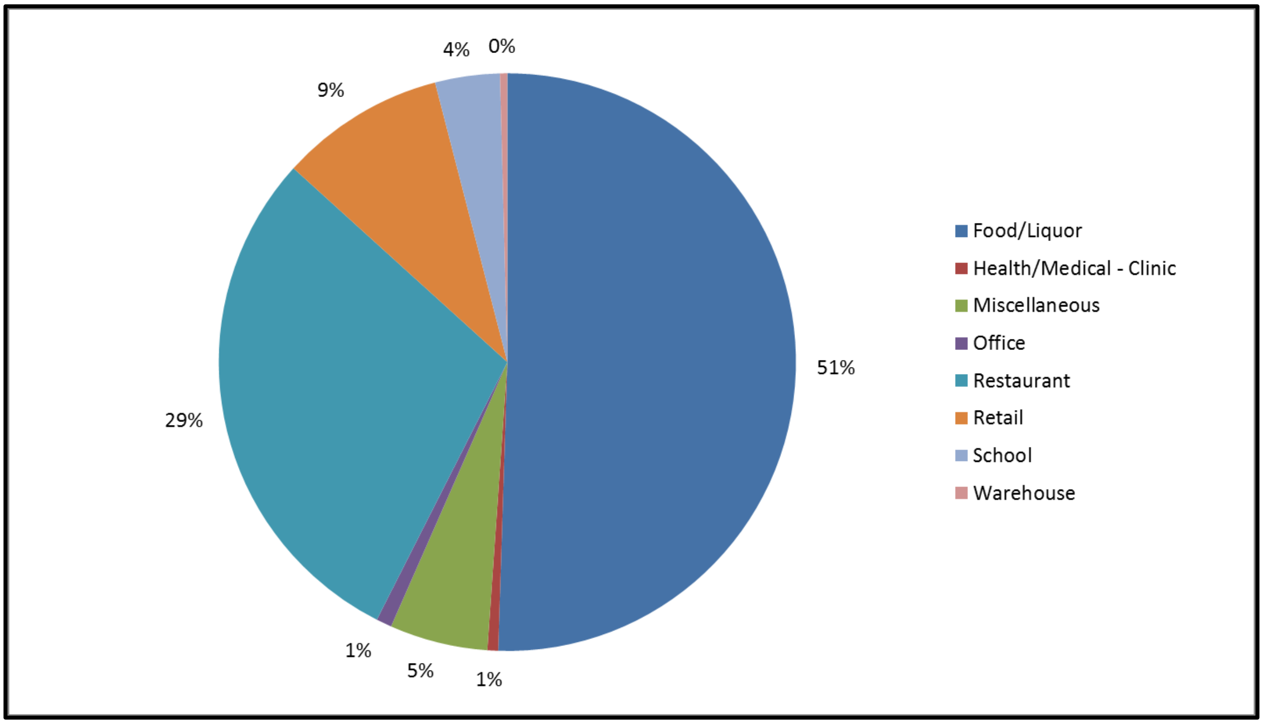
The average length and share of all Display Cases were examined by business type in Table 8-11. Restaurants and Food/Liquor stores have the majority of display cases, with 29% and 51% of the total linear feet of cases, respectively. The business type with the largest average units are Food/Liquor stores where you see aisles upon aisles of refrigerated cases.

Table 8-11: Linear Feet of Display Cases by Business Type

Business Type	Average Linear Feet Per Business	Percent of Total Linear Feet
Food/Liquor	117.1	51%
Health/Medical - Clinic	18.1	1%
Miscellaneous	11.4	5%
Office	12.0	1%
Restaurant	20.8	29%
Retail	30.1	9%
School	16.5	4%
Warehouse	16.1	0%

*** The results presented above have been weighted by site weight.**

Figure 8-4: Share of Total Linear Feet of Display Cases by Business Type



*** The results presented above have been weighted by site weight.**

Information on the service temperature of Display Cases was collected as part of the CSS Study. Display Cases can be disaggregated into Medium and Low Temperature cases. Medium Temperature cases contain products like fresh meat/deli, dairy, produce, and beverages. Low Temperature cases contain products like ice cream, frozen juices, and frozen food/meat. Table 8-12 displays the data on temperature type disaggregated by equipment type. The majority of Island/Coffin Cases are Low Temperature while the majority of all other case types are Medium Temperature.

Table 8-12: Distributions of Temperature of Case Types by Equipment Type

Equipment Type	Medium Temperature	Low Temperature	Total
Glass Door Case	68%	32%	**100%**
Solid Door Storage Case	76%	24%	**100%**
Open Display Case	98%	2%	**100%**
Island/Coffin Case	39%	61%	**100%**
Service Case	73%	27%	**100%**
Beverage Merchandiser	100%	N/A	**100%**
Other/Unlisted Case	57%	43%	**100%**
Distribution of Cases	**75%**	**25%**	**100%**

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

As presented in Table 8-13, the majority of refrigeration systems in commercial businesses are Self-Contained Refrigeration systems, which make up approximately 67% of the linear feet of refrigeration cases. All case types other than Open Display Cases have a higher share of equipment in Self-Contained Refrigeration Cases than Remoter Refrigeration Cases. Solid Door Storage Cases, Beverage Merchandisers, and Other/Unlisted Cases are only Self-Contained Refrigerated Cases and are not found as Remote Refrigeration Systems.

Table 8-13: Distribution of Refrigeration Display Case Equipment by System Type

Equipment Type	Self-Contained	Remote Refrigeration	Total
Glass Door Case	65%	35%	**100%**
Solid Door Storage Case	100%	N/A	**100%**
Open Display Case	11%	89%	**100%**
Island/Coffin Case	53%	47%	**100%**
Service Case	60%	40%	**100%**
Beverage Merchandiser	100%	N/A	**100%**
Other/Unlisted Case	100%	N/A	**100%**
Distribution of Cases	**67%**	**33%**	**100%**

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

As shown in Table 8-14, Solid Door Storage Cases make up 44% of Self-Contained Display cases, followed by Glass Door Cases making up 32%. The Remote Refrigerated cases are made up mostly of Open Display Cases (43%), followed also by Glass Door Cases (35%). These data show that even though 100% of Beverage Merchandisers are Self-Contained, these technologies make up only 5% of Self-Contained cases. Beverage Merchandisers make up only a small share of refrigeration cases.

Table 8-14: Distribution of Display Case Types by System Type

Equipment Type	Self-Contained	Remote Refrigeration
Glass Door Case	32%	35%
Solid Door Storage Case	44%	N/A
Open Display Case	3%	43%
Island/Coffin Case	7%	13%
Service Case	7%	9%
Beverage Merchandiser	5%	N/A
Other/Unlisted Case	2%	N/A
Total	**100%**	**100%**

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

All Display Cases by Business Type

As presented previously in Table 8-10, the majority of refrigeration cases are either Glass Door Cases or Solid Door Storage Cases, representing 33% and 30% respectively, of the total linear feet of cases found in CSS businesses. Food/Liquor stores contain 51% of the linear feet of refrigeration cases (Table 8-11) and the most common case in Food/Liquor stores are Glass Door Cases (42%), followed by Open Display Cases (29%) (Table 8-15 and Figure 8-5). The refrigeration display cases in Restaurants, the business type with 29% of the linear feet of cases, are dominated by Solid Door Storage Cases (70%) and Glass Door Cases (14%). Given that Food/Liquor and Restaurant businesses have the two highest shares of linear feet of refrigerated cases, it is not surprising that the case that the predominant case type in each business type are also the two most common types of cases. In Retail, the business type with the third highest share of cases (9%), Glass Door Cases dominate with 68% of Retails' refrigerated cases.

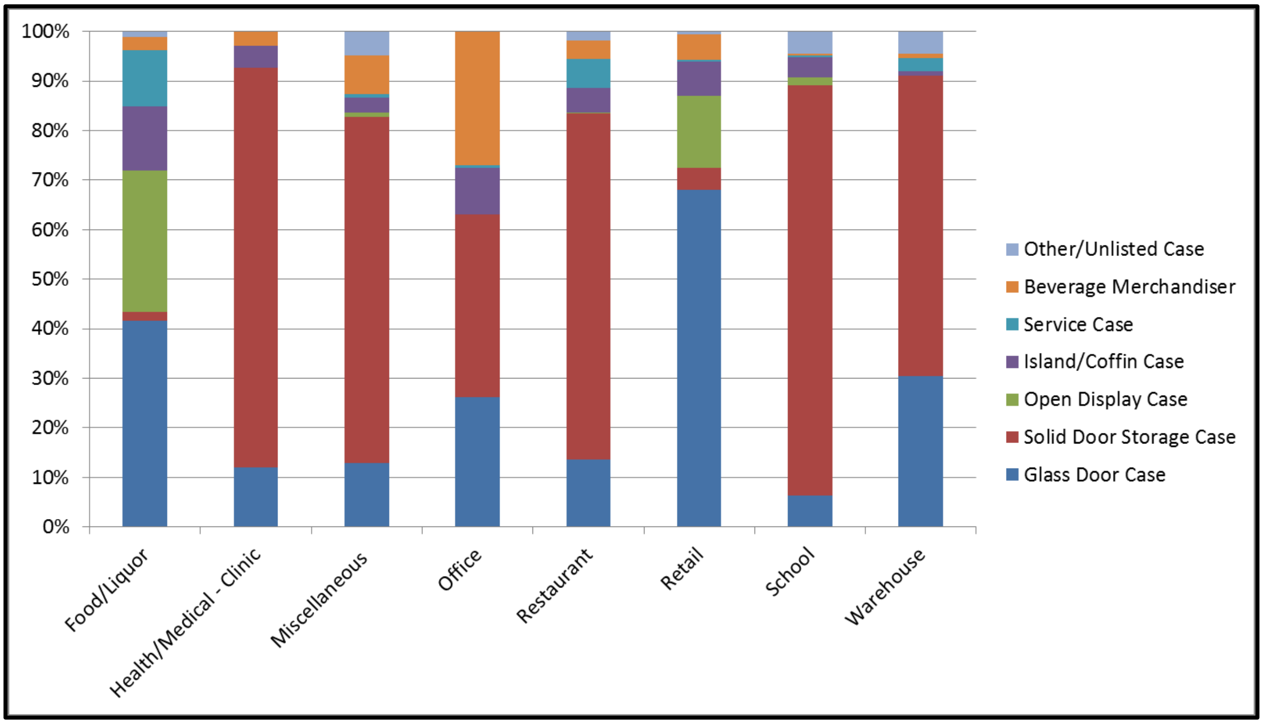
The distribution of display cases by Self Contained and Remote Refrigeration, presented in Table 8-14, combined with the distribution of case types by business type (Table 8-15) will be discussed in more detail in later sections that describe cases disaggregated by system type.

Table 8-15: Distribution of Display Case Types by Business Type

Business Type	Glass Door Case	Solid Door Storage Case	Open Display Case	Island/ Coffin Case	Service Case	Beverage Merchan-diser	Other/ Unlisted Case	Total
Food/Liquor	42%	2%	29%	13%	11%	3%	1%	**100%**
Health/Medical - Clinic	12%	81%	0%	4%	0%	3%	0%	**100%**
Miscellaneous	13%	70%	0.85%	3%	<1%	8%	5%	**100%**
Office	26%	37%	0%	9%	<1%	27%	<1%	**100%**
Restaurant	14%	70%	<1%	5%	6%	4%	2%	**100%**
Retail	68%	4%	15%	7%	<1%	5%	<1%	**100%**
School	6%	83%	2%	4%	<1%	<1%	4%	**100%**
Warehouse	30%	61%	0%	<1%	3%	<1%	4%	**100%**

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

Figure 8-5: Distribution of Display Case Types by Business Type



*** The results presented above have been weighted by site weight and display case length (in linear feet).**

All Display Cases by Business Size

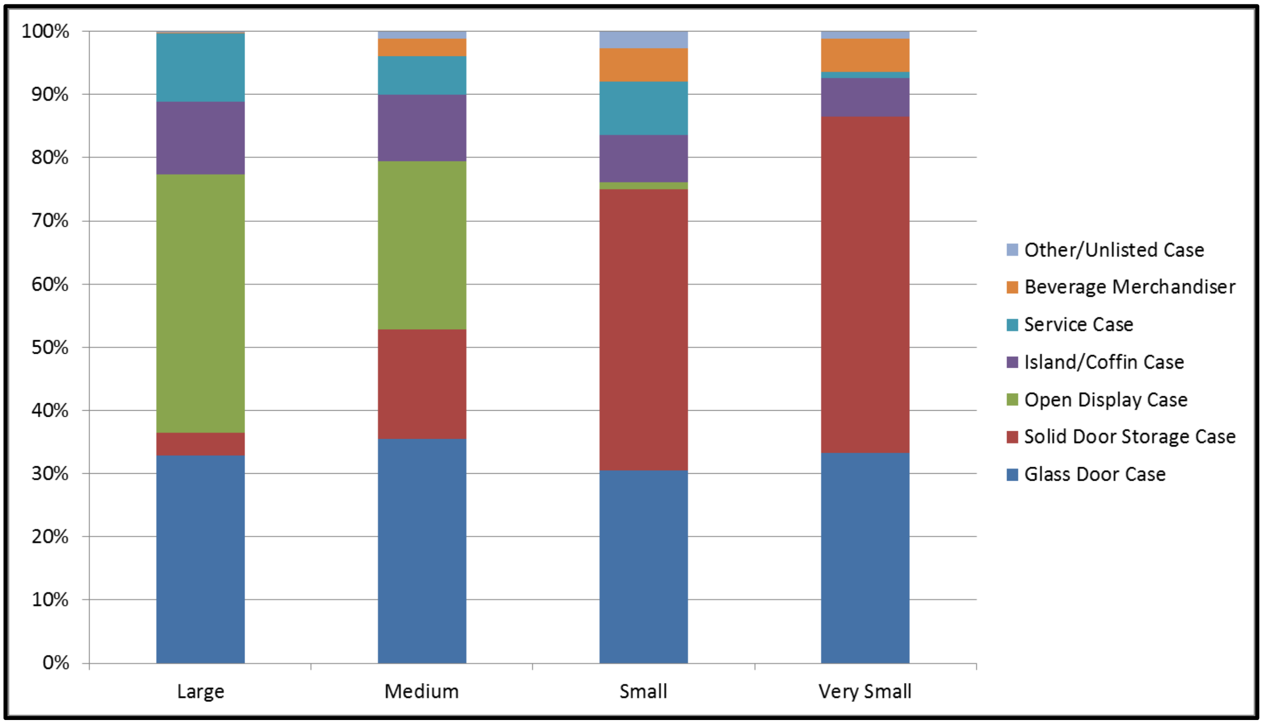
The distribution of the refrigeration systems by business size is shown in Table 8-16 and Figure 8-6. In Large-sized businesses, 41% of cases are Open Display Cases and 33% of the cases are Glass Door Cases. The cases in Food/Liquor stores dominate the Large business linear foot distribution. In Medium-sized businesses, 35% of cases are Glass Door Display Cases and 27% of cases are Open Display Cases. The significant difference in the share of Solid Door Cases between Large and Medium-sized businesses is largely due to the heavy use of Solid Door Cases within Restaurants. Many Restaurants are Medium-sized businesses but no Restaurants are Large-sized businesses. The prevalence of Solid Door Cases in Restaurants explains the dominance of these technologies in Small and Very Small-sized businesses.

Table 8-16: Distribution of Display Case Types by Business Size

Equipment Type	Large	Relative Precision	Medium	Relative Precision	Small	Relative Precision	Very Small	Relative Precision
Glass Door Case	33%	19%	35%	12%	30%	13%	33%	34%
Solid Door Storage Case	4%	22%	17%	14%	45%	9%	53%	22%
Open Display Case	41%	14%	27%	15%	1%	68%	0%	N/A
Island/Coffin Case	12%	31%	10%	30%	8%	21%	6%	64%
Service Case	11%	44%	6%	37%	8%	29%	<1%	150%
Beverage Merchandiser	<1%	71%	3%	39%	5%	26%	5%	94%
Other/Unlisted Case	<1%	99%	1%	49%	3%	41%	1%	127%
Total	**100%**		**100%**		**100%**		**100%**	

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 8-6: Distribution of Display Case Types by Business Size



* **The results presented above have been weighted by site weight and display case length (in linear feet).** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

The following subsections describe the breakdown of Self-Contained Systems and Remote Refrigeration Systems separately.

8.3.2 Self-Contained Refrigeration Systems

The CSS business types are high level groupings of detailed business types, and analyzing refrigeration equipment at the detailed business type is needed to provide additional insight. The detailed business types are shown in Table 8-17 and the Percent of Linear Feet of Self-Contained Cases is presented by detailed business type. The majority of Self-Contained Display Cases are found in Restaurants, making up 44% of all systems found, followed by Food/Liquor Stores, with 32% of these systems. Table Service Restaurants account for 17% of all Self Contained Cases or approximately 39% of the cases in Restaurants. Convenience Stores also account for 17% of the Self-Contained cases but these cases represent slightly more than 50% of the Self-Contained Refrigeration cases in Food/Liquor stores. Many of the Display Cases in Supermarkets are Remote Refrigeration Cases. Warehouses made up a very small percentage of Self-Contained Display Cases.

Table 8-17: Self-Contained Display Case Systems by Detailed Business Type

Business Type	Detailed Business Type	Percent of Linear Feet of Cases
Food/Liquor	Convenience Store	17%
	Small Grocery	10%
	Supermarket	5%
Health/Medical - Clinic	Medical/Dental	<1%
	Rehab	<1%
Miscellaneous	Assembly	5%
	Lab	1%
	Multi-Family	<1%
	Miscellaneous	<1%
	Services	<1%
Office	Office	1%
Restaurant	Fast Food Restaurant	12%
	Other Food	15%
	Table Service Restaurant	17%
Retail	Auto	<1%
	Retail	4%
	Department/Warehouse Retail	4%
School	School	5%
Warehouse	Conditioned Warehouse	<1%
	Unconditioned Warehouse	<1%
	Refrigerated Warehouse	<1%
	Storage	0%

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

Self-Contained Refrigerated Display Cases by Temperature Range

Table 8-18 shows the distribution of Medium Temperature versus Low Temperature cases that are found in CSS businesses by the case type. For Self-Contained cases, Medium Temperature cases represent 79% of cases while Low Temperature cases are 21% of cases. Self-Contained Open Display Cases and Beverage Merchandisers are only found as medium temperature systems.[10] The only case type that was found to have a majority of low temperature systems were Island/Coffin Cases, with 81% of them being low temperature cases. Self-Contained Island/Coffin cases were found mostly in Convenience Stores, which explains why they are more likely low temperature than high temperature cases.

[10] Table 8-12 shows that 17% of Open Display Cases are low temperature. All of these low temperature Open Display Cases are associated with remote refrigeration systems.

Table 8-18: Distribution of Self-Contained Refrigeration Equipment Temperature Range by Equipment Type

Equipment Type	Medium Temperature	Relative Precision	Low Temperature	Relative Precision	Total
Glass Door Case	**90%**	3%	**10%**	24%	**100%**
Solid Door Storage Case	**76%**	5%	**24%**	16%	**100%**
Open Display Case	**100%**	0%	**0%**	–	**100%**
Island/Coffin Case	**19%**	31%	**81%**	7%	**100%**
Service Case	**90%**	10%	**10%**	85%	**100%**
Beverage Merchandiser	**100%**	0%	**0%**	–	**100%**
Other/Unlisted Case	**57%**	26%	**43%**	36%	**100%**
Total	**79%**		**21%**		**100%**

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

Data was also collected on the age of display cases, but this data was very limited, and the study was only able to confirm a year of installation for 15% of the cases. As such, the data was not summarized in a table, but some useful observations were made. Self-Contained Refrigerated Display Cases have an effective useful life of 12 years, according to DEER.[11] The majority of the Self-Contained Display Cases systems where age was collected were younger than the EUL. In Retail, Fast Food Restaurants, Unconditioned Warehouses, and Convenience Stores, however, these self-contained display cases were generally older than the EUL.

Although the Study was only able to confirm the year of installation or manufacture for a low percentage of self-contained cases, the Study was able to obtain complete make and model information for 85% of the cases. This information can be used to collect details on year manufactured, as well as details on ENERGY STAR® certification.

8.3.3 Remote Refrigeration Display Case Systems

Remote Refrigeration Display Case Systems, make up 33% of the total linear feet of display case systems. Only four of the original seven Display Case types are found in Remote Refrigerated Systems. The four Remote Refrigeration Display Case types are Glass Door, Open Display, Service Case, and Island/Coffin cases (see Table 8-13). Because remote refrigeration systems are engineered, custom designed systems, these cases are only found in the few detailed business types shown in Table 8-19. Supermarkets make up 77% of the total Remote Refrigeration Display Cases and a total of 88% of all Remote Refrigeration Cases are in the Food/Liquor

[11] Database for Energy Efficiency Resources (DEER). October 10th, 2008. http://deeresources.com/files/deer0911planning/downloads/EUL_Summary_10-1-08.xls

business type. Department/Warehouse Retail stores make up the remaining 12% of Remote Refrigeration Cases.

Table 8-19: Remote Refrigeration Display Case Systems by Detailed Business Type

Business Type	Detailed Business Type	Percent
Retail	Dept./Warehouse Retail	12%
Food/Liquor	Small Grocery	11%
	Supermarket	77%

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

<u>Remote Refrigerated Display Cases by Temperature Range</u>

Remote Refrigeration Display Cases classified by their four different case types are broken down by temperature ranges in Table 8-20. Remote Refrigeration Glass Door Cases are approximately 26% Medium temperature/74% Low temperature while Open Display Cases are 97% Medium and 3% Low temperature. Service Cases were almost split down the middle between temperature types, and Island/Coffin Cases, although more likely to be found as Medium temperature, have about 40% Low temperature cases. The descriptions of the different case types are found in Table 8-9 which will help visualize the case types.

Table 8-20: Distribution of Remote Refrigeration Equipment Temperature Range by Equipment Type

Equipment Type	Medium Temp	Relative Precision	Low Temp	Relative Precision	Total
Glass Door Case	**26%**	24%	**74%**	9%	**100%**
Open Display Case	**97%**	1%	**3%**	41%	**100%**
Service Case	**49%**	35%	**51%**	34%	**100%**
Island/Coffin Case	**61%**	24%	**39%**	38%	**100%**
Total	**64%**		**36%**		

*** The results presented above have been weighted by site weight and display case length (in linear feet).**

As seen in Table 8-17 and Table 8-19, Self-Contained Refrigeration Systems and Remote Refrigeration Systems are found in different building types. Among Food/Liquor stores, Self-Contained Refrigeration is generally found in Convenience stores and Small Grocery stores, while Remote Refrigeration is largely found in Supermarkets. Similarly, Self-Contained Refrigeration is not often found in Retail stores, whereas, Remote Refrigeration Systems are more often found in Large Dept./Warehouse Retail stores. The different business types and their refrigeration needs helps to explain the differences in Remote Refrigeration and Self-Contained

Refrigeration Glass Door Cases, as seen in Table 8-18 and Table 8-20. Remote Refrigeration Glass Door Cases, found in the larger supermarkets and big-box variety stores are more likely to consist of low-temperature cases than the Self-Contained Glass Door cases common in smaller convenience stores. Service Cases, although only making up 8% of the total linear feet of cases found onsite, were more likely to be found as medium temperature Self-Contained Refrigeration cases, in Small Grocery and Convenience Stores. The low temperature Remote Refrigeration Service Cases were generally found in Supermarkets.

Remote Refrigerated Display Cases by Energy Efficiency Measures

Energy efficiency feature information for Remote Refrigeration Display Cases was collected during the CSS survey. Some of these parameters are displayed in Table 8-22. Anti-sweat heaters (ASH) are electric resistance heaters, installed on Glass Door Cases to prevent condensation on the glass and to ensure the refrigeration doors do not freeze shut. Without controllers, these heaters run continuously, resulting in continuous, additional load on the refrigeration system, increasing refrigeration run-times and refrigeration demand. ASH controls will sense the dew point temperature in the store (the temperature at which condensation will form, which depends on the amount of moisture in the air, surrounding the refrigeration equipment), modulate the heater accordingly. These ASH controls are found on 36% of Glass Door Cases. Anti-sweat heater controls are only applicable to Glass Door and Service Cases (which are also glass).

The other measure reported here is Insulated Suction Lines. These lines contain refrigerant flowing into the compressor. The insulation on the line, from an efficiency perspective, ensures that no additional heat is being added into the system. Additional heat that may be added to the system may, not only cause the compressor to run poorly, but will also need to be ultimately removed by the system, increasing the energy usage. Insulated suction lines are found on approximately a quarter of all systems.

The CSS study also attempted to gather information on High Efficiency evaporator fan motors, and some limited data is available, but the data was not analyzed for this report.

Table 8-21: Remote Refrigeration Display Case Efficiency Measures by Case Type

Equipment Type	Anti-Sweat Heater Controls	Relative Precision	Insulated Suction Lines	Relative Precision
Glass Door Case	**36%**	23%	**26%**	31%
Open Display Case	**0%**	–	**21%**	23%
Service Case	**9%**	104%	**24%**	53%
Open Island Case	**0%**	–	**28%**	51%

* **The results presented above have been weighted by site weight and display case length (in linear feet).** These numbers represent the percent of all systems where these measures were identified. Out of these, it is possible that some cases were not able to determine whether or not the case had the measure installed. If this was the case, it was assumed the measure was not installed.

8.4 Walk-in Cooler/Freezers

As with display cases, walk-ins can be either Self-Contained units, or served by a Remote Refrigeration system. Table 8-22 provides the distribution of walk-ins by business type. To standardize the units of walk-ins, the floor area, in square feet, of the walk-ins was used in all analyses.[12] When looking at the average size of Walk-ins and the share of Walk-in square footage, 84% of walk-ins square footage is found in Warehouses, with an average square footage, per business, of approximately 85,000 ft^2. However, when looking at the quantity of walk-ins, only 5% of the walk-ins are very large, Warehouse Walk-ins. Restaurants have 46% of all walk-ins, but only 4% of the floor area, with an average floor area of 129 ft^2.

Table 8-22: Statistics on Floor Area of Walk-ins by Business Type

Business Type	Share of Walk-ins	Average Walk-ins per Business	Percent of Floor Area of Walk-ins	Average Floor Area per Business
Food/Liquor	28%	2.5	8%	557
Health/Medical – Clinic	1%	1.7	<1%	137
Miscellaneous	7%	1.5	1%	174
Office	1%	2.4	<1%	346
Restaurant	46%	1.6	4%	129
Retail	5%	1.5	2%	428
School	6%	1.6	<1%	141
Warehouse	5%	5.6	84%	84,311

* **The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

[12] The same statistics, based on quantity of walk-ins are also available.

8.4.1 All Walk-in System Types by Business Type

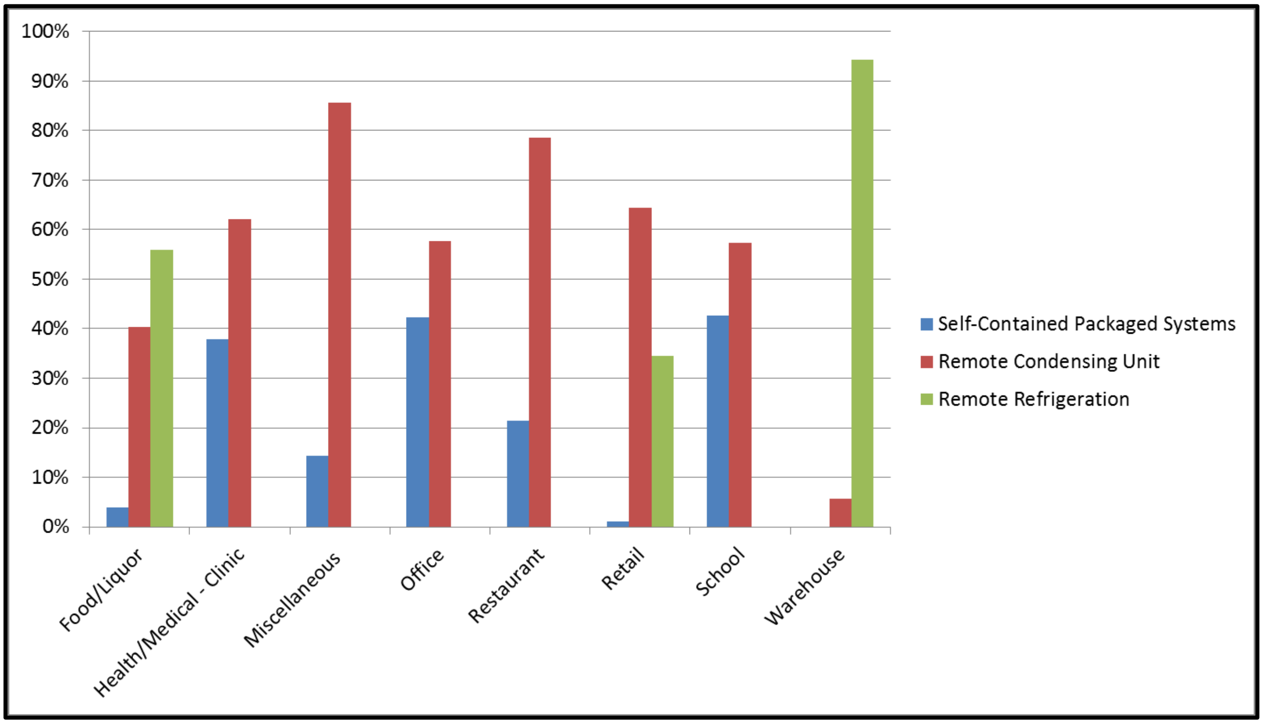
When looking at all types of Walk-ins, the Self-Contained Packaged systems are broken down into true Self-Contained Walk-ins, and Walk-ins with Remote Condensing Units. Table 8-23 and Figure 8-7 shows the breakdown of each type of walk-in by business type. The most common type of Walk-in in Warehouse and Food/Liquor stores are Remote Refrigeration Systems (94% and 56% of the Walk-in space, respectively). Retail is the only other business type to have Remote Refrigeration Walk-ins. Walk-ins with Remote Condensing units are more common than Self-Contained Packaged systems.

Table 8-23: Distribution of Walk-in System Types by Business Type

Business Type	Self-Contained Packaged Systems	Relative Precision	Remote Condensing Unit	Relative Precision	Remote Refrig-eration	Relative Precision	Total
Food/Liquor	**4%**	59%	**40%**	14%	**56%**	10%	**100%**
Health/Medical - Clinic	**38%**	48%	**62%**	29%	**0%**	–	**100%**
Miscellaneous	**14%**	66%	**86%**	11%	**0%**	–	**100%**
Office	**42%**	43%	**58%**	31%	**0%**	–	**100%**
Restaurant	**21%**	39%	**79%**	11%	**0%**	–	**100%**
Retail	**1%**	70%	**64%**	21%	**35%**	38%	**100%**
School	**43%**	30%	**57%**	22%	**0%**	–	**100%**
Warehouse	**0%**	–	**6%**	64%	**94%**	4%	**100%**

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

Figure 8-7: Distribution of Walk-in System Types by Business Type



*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.4.2 All Walk-in System Types by Business Size

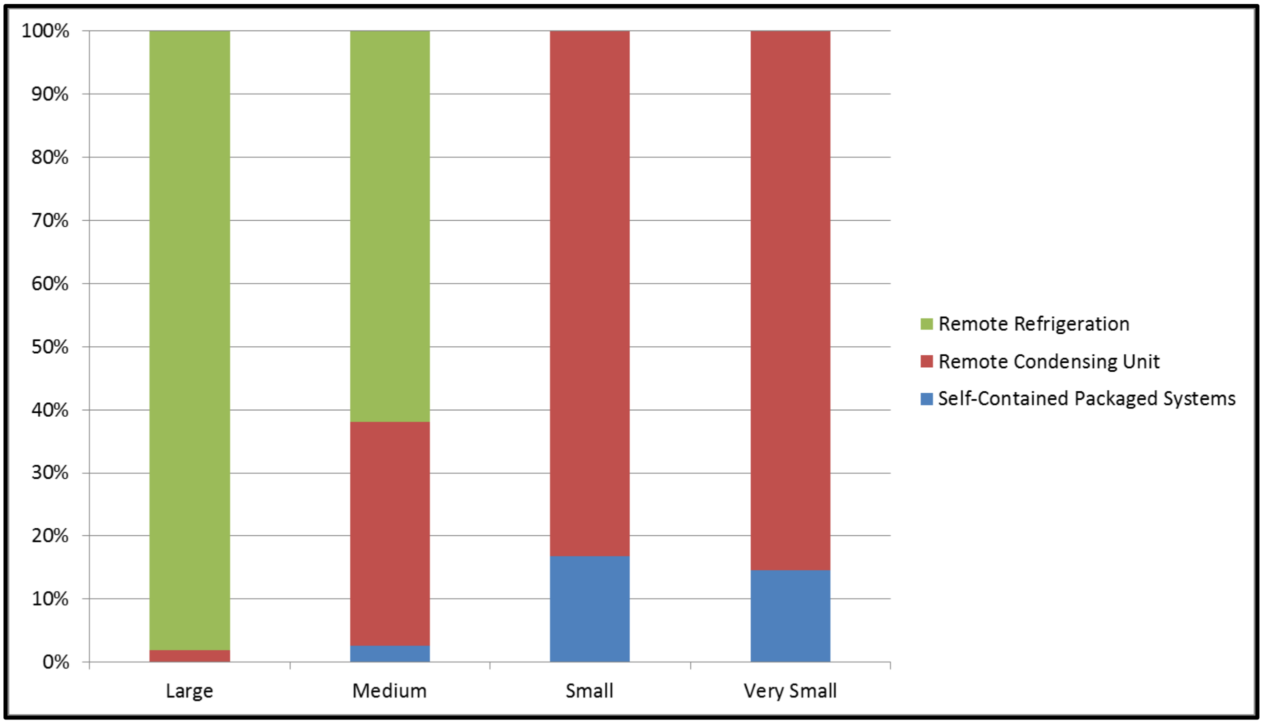
Data in Table 8-24 describes the distribution of walk-in system types by business size. Large and Medium sized businesses with Walk-ins had a majority of Remote Refrigeration walk-ins, which were generally made up of Warehouses, Supermarkets, and Department/Retail stores, where remote refrigerated systems are more common. The Self-Contained Packaged systems account for 17% and 15% square footage of walk-ins at Small and Very Small businesses, respectively. These systems are less popular than those with Remote Condensing Units, which typically require a minimum level of design effort. Self-contained refrigerated cases are more bulky, due to the compressor and condenser components being housed in the unit, and will reject heat into the conditioned space. Systems with remote condensing units account for between 83-85% of the square footage at Small and Very Small businesses and 36% at Medium businesses. Remote Condensing units are the most common type of refrigeration, and easily implemented at most businesses that require smaller-sized walk-ins.

Table 8-24: Distribution of Walk-in System Types by Business Size

Business Size	Self-Contained Packaged Systems	Relative Precision	Remote Condensing Unit	Relative Precision	Remote Refrigeration	Relative Precision
Large	**<1%**	74%	**2%**	74%	**98%**	1%
Medium	**3%**	45%	**36%**	36%	**62%**	22%
Small	**17%**	37%	**83%**	8%	**0%**	-
Very Small	**15%**	96%	**85%**	16%	**0%**	–

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 8-8: Distribution of Walk-in System Types by Business Size



* **The results presented above have been weighted by site weight and walk-in floor area (ft^2).** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

8.4.3 All Walk-In System Types by Walk-in Fabrication Type

Large-Built up Walk-ins are constructed on-site for a specific site purpose, while small pre-fabricated systems can be bought and delivered for installation at a facility. These fabrication types are broken down by walk-in system type in Table 8-25. Large built-up Walk-ins are generally Remote Refrigeration Systems. The small pre-fabricated Walk-ins are most likely to be RCU units (78%), followed by Self-Contained Packaged Units (18%).

Table 8-25: Distribution of Walk-in System Types by Walk-In Construction Type

Walk-In Fabrication Type	Self-Contained Packaged Systems	Relative Precision	Remote Condensing Unit	Relative Precision	Remote Refrigeration	Relative Precision
Large Built-Up	**0%**	84%	**5%**	63%	**95%**	3%
Small Pre-Fabricated	**18%**	26%	**78%**	7%	**4%**	61%

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.4.4 All Walk-In System Temperatures

Walk-ins were classified into three temperature ranges: Low, Medium, and High Temperature. Low temperature systems are freezers, medium temperatures – coolers, and high temperatures – preparation areas. Medium temperature Walk-ins, or coolers, make up the majority of Walk-in floor area in all business types. The highest percentage of high-temperature Walk-ins are in Food/Liquor (9%), followed by Retail (8%). Health/Medical Clinics, Offices, Miscellaneous, and Schools do not have any high temperature Walk-ins. The highest percentage of low-temperature Walk-ins are found in Warehouses (62%), Offices (48%), and Health/Medical Clinics (45%).

Table 8-26: Distribution of Walk-in Temperature Types Business Type

Business Type	Low Temperature	Medium Temperature	High Temperature	Total
Food/Liquor	18%	73%	9%	**100%**
Health/Medical - Clinic	45%	55%	0%	**100%**
Miscellaneous	11%	89%	<1%	**100%**
Office	48%	52%	0%	**100%**
Restaurant	36%	63%	1%	**100%**
Retail	18%	74%	8%	**100%**
School	40%	60%	0%	**100%**
Warehouse	62%	31%	6%	**100%**

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.4.5 All Walk-In System Temperatures by Efficiency Measures

The on-site survey collected information on efficiency measures in walk-ins. These data included information on Defrost Control Type, Auto-Closers and Strip Curtains, Insulation thickness, and Evaporator Fans. Some of these measures are displayed in Table 8-27 and Table 8-28. Approximately 72% of all Walk-Ins have Strip Curtains, and 75% have Auto Door Closers. As expected, it is more common for low temperature Walk-Ins to have Auto Door Closers or Strip Curtains, than it is for high temperature Walk-Ins.

Table 8-27: Efficiency Measures of Walk-in by Temperature Range

Temperature Type	Door Auto-Closer	Relative Precision	Strip Curtains	Relative Precision
Low Temp	**90%**	10%	**96%**	4%
Medium Temp	**50%**	39%	**50%**	39%
High Temp	**4%**	97%	**29%**	90%

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

Table 8-28 presents the incidence of the efficiency measures by business type. The Energy Independence and Security Act (EISA) 2007[13] states that walk-ins that have a total chilled storage area of 3,000 ft^2 and are manufactured after January 1st, 2009, shall have automatic door closers for doors smaller than 7 ft. tall or 3’ 9” wide. It also states that walk-ins should have strip doors, spring hinged doors, or other methods of minimizing infiltration when the doors are open. Ninety three percent of Warehouse low temperature Walk-Ins have Automatic Door Closers and 99% have Strip Curtains while 57% of medium temperature Walk-Ins in Warehouses have Automatic Door Closers and 51% have Strip Curtains. Warehouses are more likely to have a larger opening for doors, as they generally require space for equipment and machines moving in and out, unlike walk-ins which just have foot traffic. The larger sized doors in Warehouse Walk-Ins likely help to explain why they have a larger share of Automatic Door Closers and Strip Curtains than other business types. The business types grouped into “All Other” include Health/Medical-Clinics, Miscellaneous, Office, and Retail. These businesses have a high likelihood of having strip curtains, but were generally less likely to have automatic door closers.

[13] Energy Independence and Security Act of 2007. (EISA 2007). Section 312: Walk-In Coolers and Walk-In Freezers.

Table 8-28: Efficiency Measures of Walk-in by Temperature Range – Shown by Business Types

Temperature Type	Door Auto-Closer	Relative Precision	Strip Curtains	Relative Precision
Food/Liquor				
Low Temp	**35%**	32%	**63%**	17%
Medium Temp	**29%**	20%	**59%**	11%
High Temp	**24%**	74%	**39%**	47%
Restaurants				
Low Temp	**59%**	22%	**31%**	40%
Medium Temp	**49%**	22%	**40%**	27%
High Temp	**100%**	–	**0%**	–
Schools				
Low Temp	**61%**	22%	**29%**	36%
Medium Temp	**55%**	32%	**42%**	47%
High Temp	**0%**	–	**0%**	–
Warehouse				
Low Temp	**93%**	7%	**99%**	1%
Medium Temp	**57%**	44%	**51%**	56%
High Temp	**<1%**	195%	**26%**	115%
All Other				
Low Temp	**32%**	38%	**53%**	27%
Medium Temp	**22%**	47%	**24%**	40%
High Temp	**14%**	136%	**77%**	31%

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.4.6 Self-Contained Refrigeration Walk-Ins

Information on the distribution of Walk-ins is presented in Table 8-29 using the same disaggregated, detailed business types that are used for the presentation of refrigerated display cases. The self-contained category of walk-ins includes both Self-Contained Packaged walk-ins and Remote Condensing units. As seen in Table 8-29, the majority of the Self-Contained Walk-in floor area is found in Warehouses (32%), which is broken down into Conditioned, Unconditioned, and Refrigerated Warehouses. Warehouses also included Storage, although there are no walk-ins in Storage. The average floor area of Walk-in per Warehouse business for each of these types of Warehouses is 1,420, 580, and 4,864 ft2 respectively. For other detailed business types, the average floor area ranged from under 100 ft2 to under 300 ft2. The average size of Self-Contained Walk-ins in the Warehouse business type is substantially smaller than Remote Refrigeration Walk-ins in Warehouses but substantially larger than Self-Contained Walk-ins in other business types.

Table 8-29: Self-Contained Walk-In Systems by Detailed Business Type

Business Type	Detailed Business Type	Percent of Total Walk-in Floor Area	Average Floor Area Per Walk-in of SC/RCU Walk-ins (ft^2)
Food/Liquor	Convenience Store	11%	158
	Small Grocery	6%	139
	Supermarket	3%	215
Health/Medical - Clinic	Medical/Dental	<1%	60
	Rehab	1%	82
Miscellaneous	Assembly	2%	76
	Lab	2%	253
	Multifamily	<1%	107
	Miscellaneous	<1%	83
	Services	1%	96
Office	Office	2%	143
Restaurant	Fast Food Restaurant	12%	80
	Other Food	5%	68
	Table Service Restaurant	11%	88
Retail	Auto	0%	-
	Retail	5%	213
	Department/Warehouse Retail	3%	243
School	School	4%	86
Warehouse	Conditioned Warehouse	7%	1,420
	Unconditioned Warehouse	10%	580
	Refrigerated Warehouse	15%	4,864
	Storage	0%	-

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.4.7 Remote Refrigeration Walk-in Systems

Statistics for Remote Refrigeration Walk-in systems are shown in Table 8-30, broken down by disaggregated business type. The average floor area of the Remote Refrigeration systems is much larger across all business types than for Self-Contained units. Remote Refrigeration systems tend to be larger, site-built units, not pre-fabricated smaller units more common in Self-Contained units. Refrigerated Warehouses have 94% of the remote refrigeration walk-in floor area. The average floor area per Refrigerated Warehouse is 44,887 ft^2.

Table 8-30: Remote Refrigeration Walk-In Systems by Detailed Business Type

Business Type	Detailed Business Type	Percent	Average Floor Area per Business (ft^2)
Retail	Department/Warehouse Retail	1%	720
Food/Liquor	Small Grocery	1%	293
	Supermarket	4%	353
Warehouse	Conditioned Warehouse	<1%	15,970
	Refrigerated Warehouse	94%	44,887

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.5 Remote/Rack Refrigeration Systems

This section presents information on Remote/Rack refrigeration systems, both display cases and walk-ins. Equipment characteristics for compressors, condensers, and refrigeration controls were collected on site and are presented for CSS detailed business types. The information displayed in the tables that follow is only a sample of the data that was collected for remote refrigeration systems. A complete list of the characteristics collected is available from the on-site survey form.

8.5.1 Remote/Rack Systems – Compressors

A compressor is the primary component of a refrigeration cycle. It compresses refrigerant vapor drawn from the evaporator and passes it to the condenser. There are four main types of compressors, as shown in Table 8-31. The CSS on-site survey included 65 remote/rack refrigeration sites where 240 compressors were analyzed. These compressors were analyzed by compressor type, and service temperature. On average, there are 2.8 compressors per system serving low temperature lines, and 2 compressors per system serving high temperature lines. Semi-hermetic reciprocating compressors are the majority of the compressors regardless of the system's temperature, followed by open reciprocating compressors. Screw and scroll compressor types are the highest-efficiency units.

Table 8-31: Remote/Rack Compressor Types by Service Temperature

Compressor Type	High Temp.	Medium Temp.	Low Temp.
Open Reciprocating	25%	12%	10%
Semi-Hermetic Reciprocating	43%	70%	70%
Scroll (hermetic)	1%	6%	6%
Screw	13%	7%	6%
Other[14]	17%	4%	8%
Average Number of Compressors	**2.0**	**2.5**	**2.8**
Total Share of Compressors	**5%**	**53%**	**43%**
Total Compressors Surveyed	**17**	**131**	**92**

*** The results presented above have been weighted by site weight.**

The distribution of remote/rack compressors by business type is shown in Table 8-32. These are weighted by compressor quantity and site weights. As expected, Food/Liquor businesses account for the majority of compressors used in Remote/Rack refrigeration systems.

Table 8-32: Distribution of Compressors by Detailed Business Type

Business Type	Detailed Business Type	Percent
Food/Liquor	Small Grocery	11%
	Supermarket	65%
Retail	Dept./Warehouse Retail	11%
Warehouse	Conditioned Warehouse	<1%
	Refrigerated Warehouse	12%

*** The results presented above have been weighted by site weight.**

Remote/Rack Compressors by Business Type and Year Installed

Compressor year of installation was collected for about 45% of the compressors found on site. Table 8-33 displays average year of installation of these components. Refrigerated Warehouses and Small Grocery stores have the oldest systems (1986 and 1998 respectively), while Supermarkets and Department/Warehouse Retail stores have the newest systems (2002 and 2003 respectively).

[14] Other was used in cases where there were multiple compressor types serving a single rack.

Table 8-33: Distribution of Age Range of Remote/Rack Compressors by Detailed Business Type

Detailed Business Type	Average Year of Compressor Installation
Small Grocery	1988
Supermarket	2002
Dept./Warehouse Retail	2003
Conditioned Warehouse	1994
Refrigerated Warehouse	1986
Total Compressors Surveyed	**107**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed systems included in the analysis.

8.5.2 Remote/Rack Systems - Condensers

A condenser is a heat rejection; the hot, high pressure refrigerant from the compressor is passed through a heat exchanger that is cooled either with ambient air (air-cooled) or water (evaporative cooled). Air-cooled condensers serving multiple compressors will typically have multiple, even numbers, smaller hp fans. Evaporative condensers will typically have one or two larger hp fans, as well as a water pump. There were a total of 118 condensers analyzed as part of the CSS study. Both air-cooled and evaporative-cooled condensers were found on site. As shown in Table 8-34, in Food/Liquor and Retail stores air-cooled condensers are more common than evaporative-cooled, while in Warehouses evaporative-cooled condensers are more common.

Table 8-34: Distribution of Remote/Rack Condensers by Detailed Business Type

Detailed Business Type	Air-Cooled	Evaporative-Cooled	Share of Condensers
Small Grocery	84%	16%	8%
Supermarket	78%	22%	67%
Dept./Warehouse Retail	88%	12%	9%
Conditioned Warehouse	0%	100%	0%
Refrigerated Warehouse	23%	77%	16%
n	**72**	**46**	**118**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed condensers included in the analysis.

Condenser fan characteristics are presented in Table 8-35. Condenser fans typically run as determined by the cooling load, and without speed control will run at a constant speed and toggle on/off as needed. Adding fan control can allow finer matching to the system cooling load, which reduces fan run times and energy use. On average, air-cooled condensers have more fans than evaporator-cooled systems. Air-cooled condensers have an average of 4.4 fans per condenser, while evaporator-cooled condensers have an average of 1.4 fans. Evaporated-cooled condensers are more likely to have a fan control type, with 82% either having variable speed, or two-speed controls. Thirty percent of air-cooled condensers were verified as either Modulated Speed or Staged Pairs control types, while the remaining were either single-speed, or the control type could not be determined.

Table 8-35: Remote/Rack Condenser Fan Controller Type and Average Fans

Fan Type	Fan Control Type	Percent	Average Number of Fans
Air Cooled	Modulated Speed	10%	4.4
	Staged Pairs	20%	
	Single-speed	47%	
	Unknown	23%	
Evaporative Cooled	Two-Speed	12%	1.4
	Variable Speed	70%	
	Single-speed	1%	
	Unknown	17%	

*** The results presented above have been weighted by site weight.**

<u>Remote/Rack Condensers by Business Type and Year Installed</u>

The average year of installation by disaggregated business type is shown in Table 8-36. Year of installation for the remote/rack condensers found on site was populated for 40% of the systems. Both Refrigerated Warehouses and Small Grocery stores had the oldest average year of installation (1987 for both). Supermarkets and Department/Warehouse Retail stores had the newest equipment (2004 for both).

Table 8-36: Average Age of Remote/Rack Condensers by Business Type

Detailed Business Type	Average Year of Condenser Installation
Small Grocery	1987
Supermarket	2004
Dept./Warehouse Retail	2004
Conditioned Warehouse	1997
Refrigerated Warehouse	1987
n	**47**

*** The results presented above have been weighted by site weight.** Totals represent the count of surveyed systems included in the analysis.

8.5.3 Remote/Rack Systems – Controllers

A controller is a central electronic device that is used to control the operation of the remote/rack refrigeration system; it is basically an EMS for the remote refrigeration system. For the on-site survey, whenever possible, field staff accessed the controllers to obtain key operating parameters. The information collected from remote/rack system controllers included condensing temperature parameters, floating suction pressure parameters, sub-cooling parameters, anti-sweat heater parameters, and display case lighting control.

Out of the 65 remote refrigeration sites surveyed, 55 of them were found to have a rack controller. Of these 55 sites, all of them had local accessibility to the controls from an interface. One hundred percent of the Department/Warehouse Retail stores and Conditioned Warehouse facilities have controls. Only 62% of Small Grocery systems have controllers, and 80% of Supermarkets (see Table 8-37).

Table 8-37: Share of Remote/Rack Businesses with Controls

Business Type	Detailed Business Type	Share of Remote Refrigeration Businesses with Controls
Retail	Department/Warehouse Retail	100%
Food/Liquor	Small Grocery	62%
	Supermarket	80%
Warehouse	Conditioned Warehouse	100%
	Refrigerated Warehouse	93%

*** The results presented above have been weighted by site weight.**

<u>Remote/Rack Controllers by Business Type and Year Installed.</u>

Data was also collected on the age of controllers, but this data was very limited. Year of installation information was found for just over 40% of the controllers, and no data was recorded for Conditioned Warehouses. As such, the data was not summarized in a table, but some useful observations were made for detailed business types: The oldest controllers, like condensers and compressors, were found in Refrigerated Warehouses. Almost 40% of Supermarkets installed their controllers between 2009 and 2012, while the majority of Department/Warehouse Retail and Small Grocery stores installed their systems in the 1990s.

<u>Remote/Rack Controllers – Control Options</u>

Table 8-38 lists some of the controller options that were surveyed in Remote/Rack systems. The controller functions presented are defrost control type, floating head pressure (FHP) control, and scheduled control of display case lighting. Results are presented by detailed business type. Defrost controllers are necessary for a refrigeration system to prevent the evaporator from freezing up. Defrost control type was available for most controllers, and the control options included electric, hot gas, or a timer to cycle the compressor on and off to allow time to defrost.

Floating Head Pressure control allows the typically fixed head pressure setting to “float” based on the outside ambient temperature. FHP saves energy by reducing the compressor run times when outdoor temperatures are cooler; It essentially uses “free cooling” to reduce the amount of work that the compressor needs to do. FHP controls were found on 53% of Small Grocery stores, but for less than 50% of Supermarkets and Refrigerated Warehouses. Finally, display case lighting control schedules were only found on the rack controller interface, for a very small percentage of Supermarkets.

Table 8-38: Distribution of Remote/Rack Control Features by Business Type

Detailed Business Type	Defrost Control	Float Pressure Control	Lighting Schedules
Department/Warehouse Retail	46%	0%	0%
Small Grocery	100%	53%	0%
Supermarket	88%	37%	9%
Conditioned Warehouse	100%	0%	0%
Refrigerated Warehouse	100%	35%	0%
n	**46**	**43**	**2**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed control types included in the analysis.

8.6 Refrigeration Lighting

High-level lighting information was collected for refrigerated walk-ins and display cases. This data included information like lighting type, wattage, and number of bulbs. The lighting was also classified as either High or Base Efficiency, using the following allocation (Table 8-39).

Table 8-39: Refrigeration Lighting Efficiency Grouping

High Efficiency	Base Efficiency
High Pressure Sodium	T12
T8	Incandescent
T5	Metal Halides
CFL	
LED	

Walk-In Area Lighting

For the CSS study, any refrigerated area that a person could walk in to was considered a walk-in area. However, for the lighting analysis, two subcategories will be used: Walk-in Units and

Refrigerated Spaces.[15] Walk-in units are generally smaller and typically pre-fabricated units (although some are site-assembled or site-built). Refrigerated Spaces are constructed, integral sections of a building that are specifically designed for refrigerated storage. Walk-in Units may be found in any business type, whereas Refrigerated Space will only be found in the Warehouse/Storage and Refrigerated Warehouse business types.

As shown in Table 8-40, the average height of Refrigerated Space is about 27 feet, while the average height of Walk-in Units is only about 9 feet. This significant difference in ceiling heights is only one of several reasons for presenting walk-in lighting using these two subcategories. The floor area of Refrigerated Space accounted for 84% of the CSS total walk-in floor area. The larger floor area of Refrigerated Space implies that they represent a larger share of total CSS walk-in area lighting. However, as shown in Table 8-22, Walk-in Units represent 95% of the total CSS walk-in area while Refrigerated Space is only 5% of the businesses with refrigerated walk-in space.

Refrigerated Spaces have a higher share of High Pressure Sodium lights and Metal Halide lighting, lighting than Walk-in Units. High Pressure Sodium and Metal Halide lighting is more applicable to high-bay applications. LED lighting represents a higher share of lighting in Walk-in Units than in Refrigerated Spaces. LED technologies in Walk-in Units included Linear Fluorescent replacements and LED screw-in bulbs, while the LEDs in Refrigerated Space were Metal Halide replacements. CFLs and Incandescent bulbs are used more commonly in Walk-in Units than in Refrigerated Spaces.

When analyzed by High Efficiency versus Base Efficiency lighting, both Walk-in Units and Refrigerated Space tended to have a pretty high dominance of High Efficiency lighting installed.

[15] This naming convention follows the convention used for Title 24 Standards for Refrigerated Warehouses http://www.energy.ca.gov/2008publications/CEC-400-2008-017/rev1_chapters/NRCM_Chapter_8_Refrigerated_Warehouse.pdf

Table 8-40: Lighting Type Distribution for Walk-in Areas

Lamp Efficiency Group or Type	Walk-in Units	Refrigerated Space
Base Efficiency	23%	15%
High Efficiency	68%	79%
Unknown/None	9%	6%
Total	**100%**	**100%**
Base Efficiency Tiers Distribution		
T12	4%	<1%
Incandescent	18%	<1%
Metal Halides	<1%	14%
High Efficiency Tiers Distribution		
High Pressure Sodium	0%	64%
T8	26%	11%
T5	2%	3%
CFL	36%	<1%
LED	4%	<1%
Total % of Walk-in Area	**16%**	**84%**
Average Ceiling Height	**8.6**	**26.7**

*** The results presented above have been weighted by site weight and walk-in floor area (ft^2).**

8.6.1 Display Case Lighting

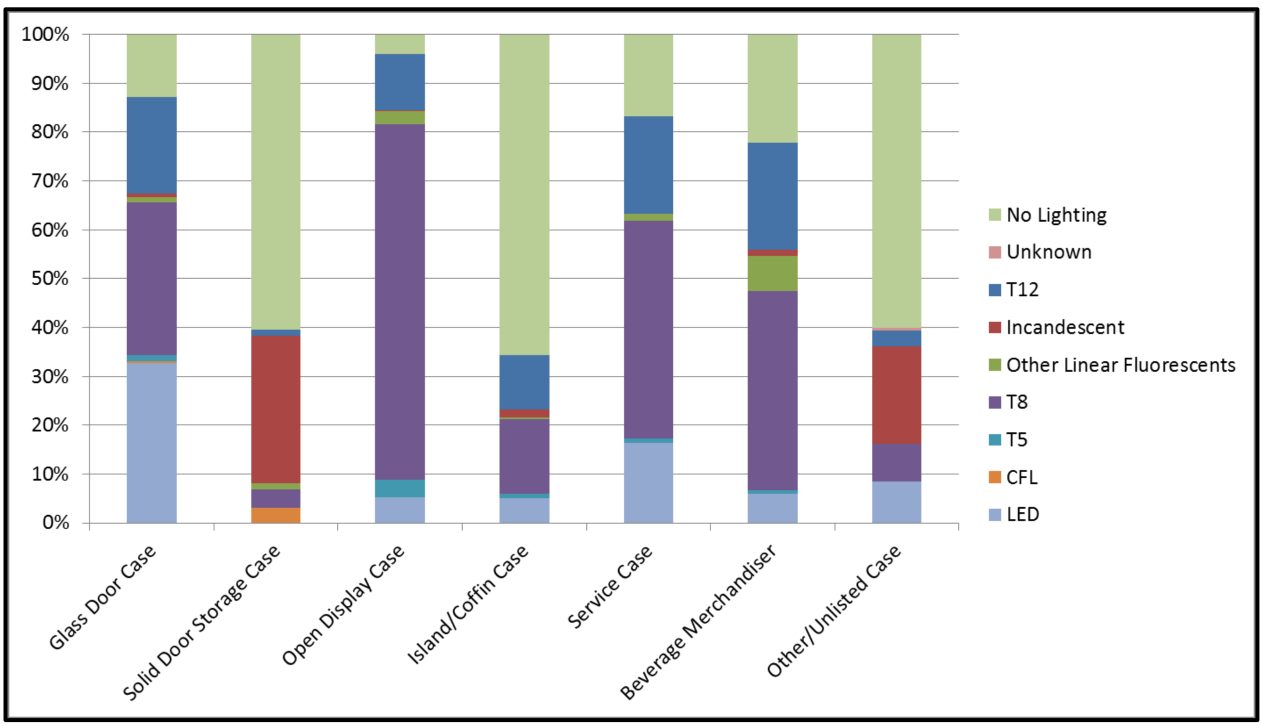
Display case lighting information is presented by display case type in Table 8-41 and Figure 8-9. As shown in Table 8-10, Glass Door Cases and Solid Door Storage Cases make up the largest percent of refrigerated display cases. The data indicates that Open Display Cases have 82% High Efficiency lighting, while 66% of Glass Door Case lighting is High Efficiency. Sixty one percent of Solid Door Cases have no lighting. Seventy-three percent of the lighting in Open Display Cases is T8s. In Glass Door Cases, 33% of the cases have LED lighting and 31% have T8s. Solid Door Cases have the highest percentage of Base Efficiency lighting at 31%, followed by 23% for Beverage Merchandisers and Other/Unlisted Cases. The majority of Island/Coffin Cases, Solid Door Storage, and Other/Unlisted Cases did not have any lighting.

Table 8-41: Distribution of Lamp Types by Display Case Type

Lamp Type	Glass Door Case	Solid Door Storage Case	Open Display Case	Island/ Coffin Case	Service Case	Beverage Merchan -diser	Other/ Unlisted Case
Base Efficiency	21%	31%	12%	13%	20%	23%	23%
High Efficiency	66%	7%	82%	21%	62%	48%	16%
No Lighting	13%	61%	4%	66%	17%	22%	61%
Unknown	1%	1%	3%	0%	1%	7%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Base Efficiency Tiers Distribution							
T12	20%	1%	11%	11%	20%	22%	3%
Incandescent	<1%	30%	<1%	2%	0%	1%	20%
High Efficiency Tiers Distribution							
T8	31%	4%	73%	15%	45%	41%	8%
T5	1%	0%	4%	1%	<1%	<1%	0%
CFL	<1%	3%	0%	0%	0%	0%	0%
LED	33%	0%	5%	5%	16%	6%	8%

*** The results presented above have been weighted by site weight and display case length (linear feet).**

Figure 8-9: Graph of Distribution of Lamp Types by Display Case Type



*** The results presented above have been weighted by site weight and display case length (linear feet).**

Table 8-42 presents display case lighting by temperature range. Medium temperature systems include fresh meat/deli cases, dairy/produce cases, and beverage cases, while low temperature cases include ice cream/frozen juices and frozen food/meat cases. Thirty four percent of Low temperature cases have no lighting while 30% have LED lighting and 14% have T8 lighting. T8s are the most common form of lighting in medium temperature cases (35%), followed by Cases having no lighting (31%). Fluorescent lighting, both linear and compact, do not function as well below room temperature, which explains the lower levels of fluorescent lighting (other than T8s). Although T8 efficiency does suffer in refrigerated temperatures, they do not show the same decrease in lighting efficiency and output that T5s do. LED lighting works very well in both medium temperature and low temperature environments, and in addition, produce little heat which will create an additional load on the refrigeration unit.

Table 8-42: Distribution of Display Case Lamp Types by Service Temperature

Lighting Type	Medium Temp	Low Temp
T12	13%	9%
Incandescent	9%	11%
Other Linear Fluorescents	1%	2%
T8	35%	14%
T5	2%	0%
CFL	1%	<1%
LED	8%	30%
Unknown	<1%	<1%
No Lighting	31%	34%
Total	**100%**	**100%**

*** The results presented above have been weighted by site weight and display case length (linear feet).**

9

Commercial HVAC

Heating, ventilation, and air conditioning (HVAC) systems represent a significant fraction of energy use and peak demand within the commercial sector. The 2006 California Commercial End Use Survey (CA CEUS)[1] estimated that HVAC end uses account for approximately 29% of the electricity use in the commercial sector. The California Long-Term Energy Efficiency Strategic Plan[2] emphasizes the importance of achieving dramatic improvements in the efficiency of HVAC systems. The CSS on-site survey collected extensive information on HVAC systems, with a focus on air conditioning systems, specifically direct expansion (DX) space cooling systems. The data collected during these surveys provides a baseline from which it will be possible to measure progress toward achieving the goal of improved HVAC efficiency in the commercial sector. This section provides detailed information on HVAC distribution system types, cooling and heating types, and age and efficiency of the units by IOU and business type. This section also provides detailed information about HVAC system maintenance programs, as self-reported by customers during the on-site survey.

9.1 Sources of Data

Data for the HVAC analysis was collected from several sources. The CSS/CMST telephone survey collected self-reported information on the cooling equipment in non-residential sites in California. Businesses eligible for the CSS on-site survey were recruited for the CSS on-site data collection effort. Telephone surveys were completed with 6,907 businesses eligible to be recruited for the CSS on-site survey (see Table 9-1). During the telephone survey, 5,140 of these sites self-reported that their business had an air conditioning system. The CSS on-site survey collected information from 1,439 commercial businesses out of which 1,256 of these businesses had a heating and/or cooling system.[3]

As part of the on-site survey, data was collected on the site's HVAC system, including information on the type of distribution system, the cooling and heating equipment type, the

1 California Commercial End-Use Survey; Prepared for California Energy Commission by Itron Inc.; March 2006

2 The California Long-Term Energy Efficiency Strategic Plan: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/

3 During the on-site data collection effort, 119 sites either refused to allow the survey to collect information on their HVAC systems or their systems were not accessible.

number of heating and cooling units, the heating fuel type, and the make and model of the heating and cooling equipment where available. In coordination with the CMST HVAC analysis, make and model lookups where undertaken for package single zone, split-single zone, and ground source heat pump system types. These systems could have direct expansion or evaporative cooling as well as gas or electric heating types. Looking up the make and model number information, the research team was able to determine the efficiency level of the technology.

The CSS on-site data has been combined with information from the utility Customer Information System (CIS), billing, and energy-efficiency (EE) program tracking data. With these data, the analysis incorporates information on the annual energy consumption of the site, enabling the development of HVAC distributions by business size. Incorporating information on energy efficiency program participation during the period 2009-2012 allows the research team to determine if the efficiency level of HVAC technology differs for EE program participant and non-participant sites.

Table 9-1: CSS Telephone and On-Site Counts

Business Type	Phone Survey Completes	Phone Survey Sites Self Reporting Air Conditioning	CSS On-Site Completes	On-Site HVAC Accessible	HVAC Not Accessible	No HVAC On-site
Food/Liquor	486	270	127	104	13	10
Health/Medical – Clinic	633	541	128	111	17	0
Miscellaneous	1,637	1,096	246	206	14	26
Office	1,313	1,075	246	229	17	0
Restaurant	595	497	170	143	23	4
Retail	1,019	722	233	196	27	10
School	479	439	161	161	0	0
Warehouse	745	500	128	106	8	14
n	**6,907**	**5,140**	**1,439**	**1,256**	**119**	**64**

HVAC systems were not accessible to the on-site surveyors for 119 sites (8%) for the following reasons:

- Site contact did not provide permission or does not have access to the HVAC units
- Unsafe conditions
- Needed extra equipment to access the roof

HVAC systems were not present at 64 sites and the majority of the sites without HVAC equipment include:

- Multi-family common areas,[4]
- Warehouses, and
- Small sites where HVAC is not present.

The Miscellaneous business type represents a large percentage of on-site surveys where HVAC systems were not present. This business classification is further disaggregated into various sub-categories and can be seen in Table 9-2.

Table 9-2: CSS On-Site Counts for Miscellaneous Sites

Miscellaneous Business Type Disaggregated	CSS On-Site Completes	On-Site HVAC Accessible	HVAC Not Accessible	No HVAC On-site
Public Assembly	89	85	3	1
Laboratory	24	23	1	0
Multi Family	32	19	2	11
Miscellaneous	36	31	3	2
Services	65	48	5	12
n	**246**	**206**	**14**	**26**

9.2 HVAC Distribution System Type Overview

The HVAC on-site survey collected information on numerous characteristics of the HVAC system. Information such as distribution system type, cooling type, heating type, capacity, efficiency, and many other pieces of information were collected. The HVAC distribution system type characterizes the technology, distribution method (air, water, radiant, etc.), and thermal zone service type that is used to transport and deliver conditioned air to the occupied space. For analysis, the detailed CSS distribution system types are classified as either a Single Zone (SZ) or a Multi Zone (Zone) analysis group. A SZ system serves one thermal zone, so with a SZ system there will be one unit for every thermal zone of the building. A MZ system serves multiple thermal zones simultaneously. Table 9-3 shows how the detailed HVAC distribution system types observed during the on-site data collection were mapped to the SZ and MZ analysis groups. Brief descriptions of the detailed HVAC distribution system types that were used for the CSS on-site survey are also provided for each analysis group.

[4] Examples of multi-family common areas include stairs, hallways, laundry rooms, and gyms. Many of these areas are typically not conditioned in California.

Table 9-3: Single and Multi Zone Distribution System Analysis Groups

CSS Single Zone Distribution System Group	CSS Multi Zone Distribution System Group
Package Single Zone	Water Loop Heat Pump
Split-System Single Zone	Package Multi Zone
Package Terminal Units	Package VAV
Ductless, Mini-Split Unit	2 Pipe Fan Coil
Unit Ventilator	4 Pipe Fan Coil
Built-Up Single Zone	Built-Up Multi Zone
Baseboard Heater	Built-Up VAV
Portable Space Heater	
Spot Cooler	
Ground Source Heat Pump	
High Efficiency Wood Furnace	

9.2.1 Single Zone Distribution Systems

The eleven detailed HVAC distribution systems types in the Single Zone analysis group are:

Package Single Zone (PSZ)

A package single zone system is a unitary piece of equipment; all of the components are contained in a single box including the compressor, condenser, expansion valve and evaporator. PSZs are outdoor units typically mounted on the roof, with ductwork that provides conditioned air to the occupied space. These units typically have gas heating, but can also be heat pumps or, very rarely, electric resistance heating.

Split-System Single Zone (SSZ)

A split-system single zone system consists of an outdoor unit and an indoor unit. The outdoor unit contains the condenser and compressor elements of the system while the indoor unit will contain the fan, filter, heating section, cooling coil and expansion valve. The indoor unit distributes conditioned air to the space via ductwork. Split systems can provide both heating and cooling. Many of these smaller systems are very similar to residential systems. For other larger systems, the outdoor units will be mounted on the roof or ground, and the indoor units will be located in the ceiling.

Package Terminal Units (PTU)

A package terminal unit is a unitary, window or through-the-wall type air conditioning unit, and they are non-ducted. These units are typically either cooling-only or heat pumps. They are commonly found in small and/or portable offices, and apartment buildings or motels where they only need to condition a relatively small, single space.

Ductless Mini Split System (MINI)

A ductless mini split system is similar to a SSZ in that it will have an indoor and outdoor unit, but unlike the SSZ a MINI is a non-ducted system. The indoor unit is located directly in the space it is conditioning. They are often used in server rooms to provide dedicated cooling, or other spaces that are isolated from the primary HVAC system. They are also being used more often in place of a PTU. Also like the SSZ, minimum equipment efficiencies for this equipment are specified on a SEER basis.

Unit Ventilator / Unit Heater (UV)

A unit ventilator is a unit that only provides heating or ventilation. Unit heaters are typically located directly in the space and therefore have no duct work. These units can rest on the ground or be suspended from the ceiling. While the majority of UVs use a gas or hot water heating source, they can also use steam or electricity.

Built-Up Single Zone (BSZ)

A built-up single zone system is a custom, ducted system comprised of individual components including, but not limited to, compressors, chillers, boilers, fan coils, air handlers, and cooling towers. The hot or cold air will be distributed to the space via an air handler or fan coil unit, and each one serves a single thermal zone.

Baseboard / Radiant Heater (BR)

Baseboard-radiant heaters use electrical resistance, hot water or gas as the heat source, and as the name implies, they heat the space radiantly. Radiant systems can be configured as baseboards, radiators, or embedded in or attached to floors, walls, or ceilings. These units are often called “zonal” heating systems because they are located directly in the space being heated, and they do not use ducts or fans.

Portable Space Heater (PH)

Portable space heaters are electric resistance heaters that are plugged in and typically used in the corner of an office or a workstation in a warehouse. These units can be easily moved around from one area to another. Although these could be considered miscellaneous plug loads, they have been grouped into HVAC for the purposes of the CSS study.

Portable Spot Cooler (SC)

Portable spot coolers are compact, air-conditioners designed for spot-cooling, emergency-cooling, and after hour cooling. These units are typically like a PTU to which flexible ducts are attached on both the cooled air and heat rejection ends of the units, which allow the cooled air to be focused on a specific *spot* (such as an overheating server) or interior space that is isolated from the primary HVAC system. The heat rejection duct can be similarly directed to the outdoors or to another adjacent space. Although these units are intended primarily for use as temporary cooling solutions, SCs are sometimes observed in a more permanent installation.

Ground Source Heat Pump (GSHP)

A ground source heat pump uses the earth as a heat source in the winter and a heat sink in the summer. The ground stays a constant temperature and therefore can be relied upon to keep the space a constant temperature.

Wood/ Pellet Stove (WF)

These wood furnaces are small wood or pellet burning space heaters. They are used to heat a single room and typically have an exhaust fan leading out of the space.

9.2.2 Multi Zone Distribution Systems

The seven detailed HVAC distribution systems types in the MZ analysis group are:

Water Loop Heat Pump (WLHP)

A water loop heat pump system consists of multiple packaged, water-cooled heat pumps that are tied to a water-loop that runs throughout the building. The water loop is maintained at a temperature between 60°F and 90°F. A cooling tower is used when the water loop temperature is above 90°F where as a backup boiler is used when the water loop temperature falls below 60°F. Heat pumps in cooling mode reject their heat to the water loop, while heat pumps in heating mode can use the water loop as a heat source. The primary advantage of WLHP systems is that during the winter, the rejected heat from spaces that are being cooled can be used to heat colder parts of the building. For this reason, they are quite common in offices in southern California.

Package Multi Zone (PMZ) and Package VAV (PVAV)

Package multi zone and package variable air volume units are similar to a PSZ with the exception that they can condition multiple spaces. These systems will have multiple thermostats to control each zone. These units will typically be much larger than PSZ units. A PMZ is a constant-volume, single speed fan system, whereas a PVAV uses a variable-air flow fan system which includes VAV terminal boxes in the ceiling to control the volume of air entering the space.

2-Pipe and 4-Pipe Fan Coil Systems (2PFC, 4PFC)

Two-pipe and four-pipe fan coil systems provide heating and cooling to a space via a chilled/hot water loop circulated through fan coil units, each of which serves a single thermal zone. A 2PFC has only one supply and one return line (2 pipes) and as such can only provide either heating or cooling, but not both at the same time. A four pipe fan coil (4PFC) has four lines – two dedicated for chilled water, and two for hot water – so a 4PFC system can provide simultaneous heating and cooling.

Built-Up Multi Zone (BMZ) and Built-Up VAV Systems (BVAV)

A built up multi zone system is a custom designed system comprised of individual components such as chillers, boilers, fan coils, air handlers, and cooling towers that serves multiple thermal zones. A built-up multi zone system that also incorporates variable air volume air delivery instead of constant-volume is a built-up VAV system.

9.2.3 Prevalence of HVAC Distribution Systems

The following section presents information on the HVAC distribution systems at commercial facilities in IOU service areas. From Table 9-4 and Figure 9-1, it is clear that SZ systems are the most common type of HVAC distribution systems, constituting around 98% of the sites and 94% of the HVAC units. Table 9-4 also presents the distribution of SZ and MZ systems, and the distribution of the typical SZ and MZ systems observed in the CSS study. Multi-zone systems represent only around 6% of the total HVAC units. Given the prevalence of SZ systems, the analysis focused on developing a better understanding of SZ systems.

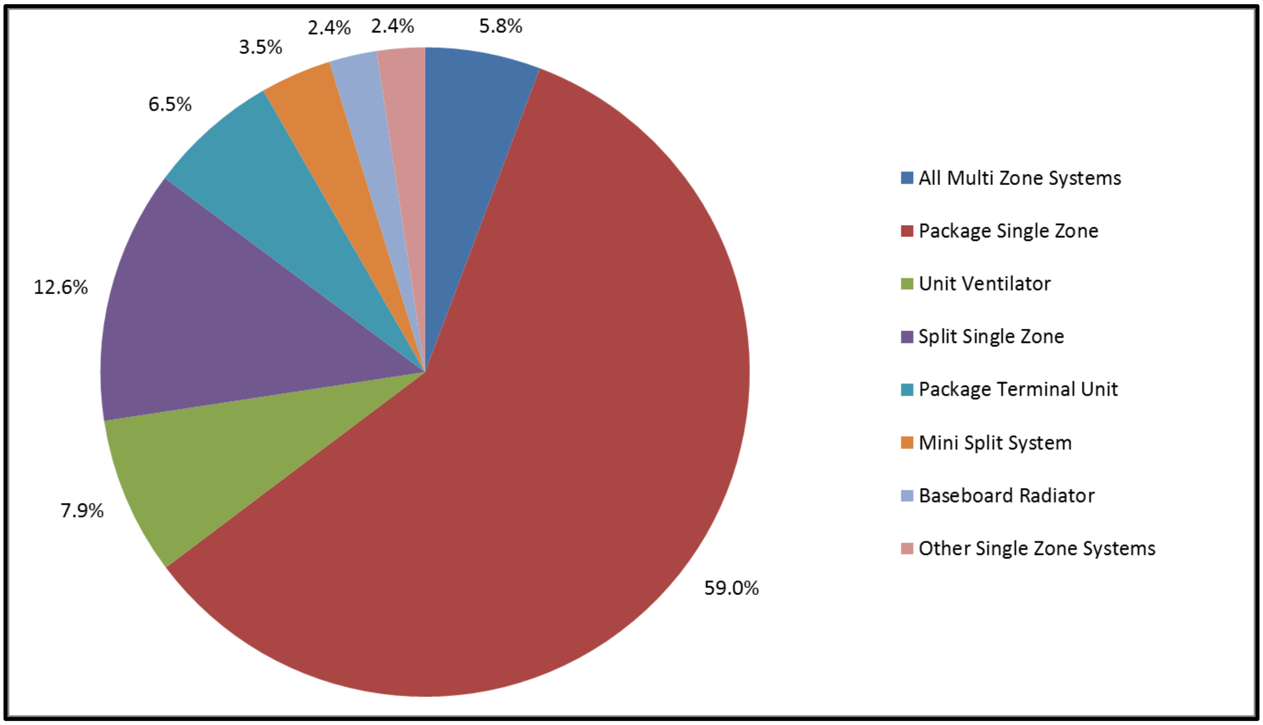
Table 9-4: Distribution of HVAC Units by System Type

System Type	Percent of Sites[5]	Relative Precision	Percent of HVAC Units	Relative Precision
Single Zone	**98.2%**	1%	**94.2%**	4%
Multi Zone	**4.2%**	27%	**5.8%**	59%
Single Zone Systems				
Package Single Zone	**54.3%**	8%	**59.0%**	5%
Unit Ventilator	**12.0%**	24%	**7.9%**	20%
Split Single Zone	**10.2%**	23%	**12.6%**	12%
Package Terminal Unit	**9.1%**	30%	**6.5%**	23%
Mini Split System	**5.1%**	31%	**3.5%**	24%
Baseboard Radiant Heater	**3.5%**	50%	**2.4%**	38%
Other Single Zone Systems	**3.9%**	51%	**2.4%**	37%
Multi Zone Systems				
Package Multi Zone	**1.4%**	40%	**1.1%**	26%
Built-up Multi Zone	**1.0%**	28%	**<1%**	25%
Water Loop Heat Pump	**<1%**	52%	**1.5%**	37%
2 Pipe Fan Coil	**<1%**	120%	**2.4%**	144%
Other Multi Zone Systems	**<1%**	37%	**<1%**	68%
n	**1,256**		**14,302**	

* **The results presented above have been weighted by site weight.** The percent of sites includes all sites with HVAC present and accessible.

5 The percent of sites sums to more than 100% because a site can have both SZ and MZ systems.

Figure 9-1: Distribution of HVAC Units by System Type



*** The results presented above have been weighted by site weight.**

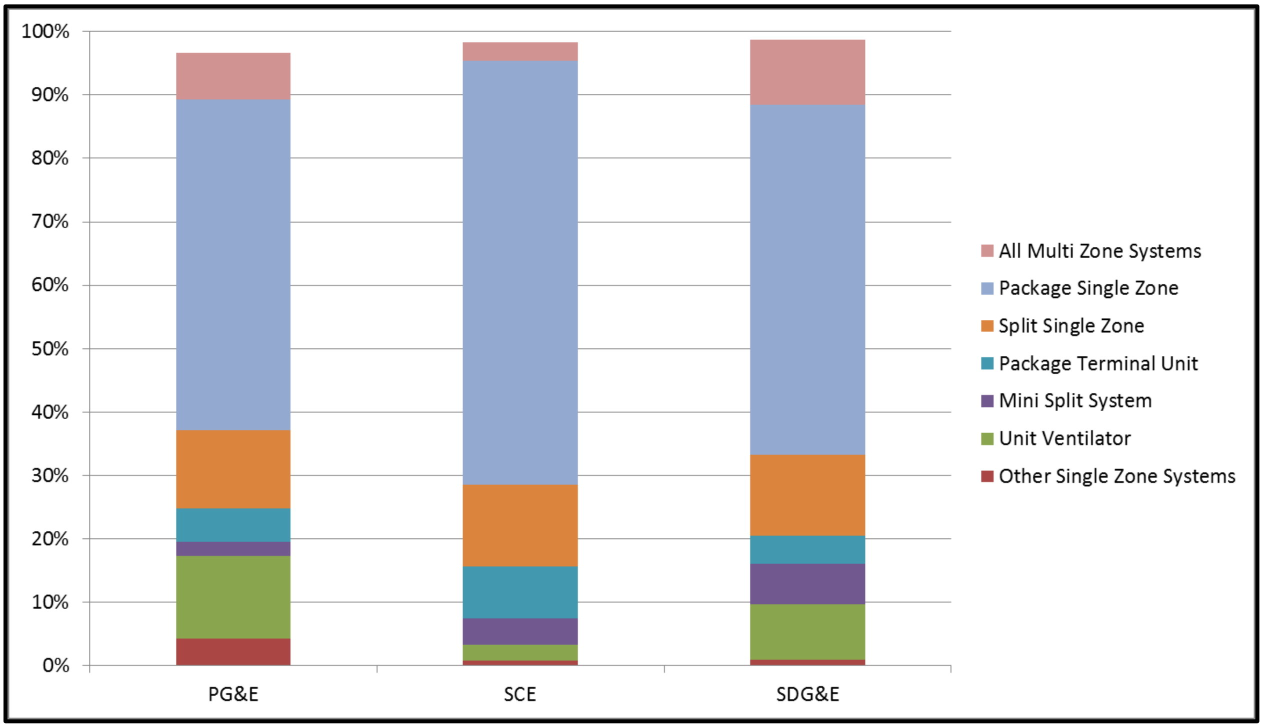
Table 9-5 and Figure 9-2 show the distribution of the HVAC units by system type and IOU. From the data in the table it is clear that the Single Zone systems especially the PSZ and SSZ systems are the predominant system types for all the three IOU's. The Other category for the MZ systems in Table 9-4 and Table 9-5 includes PVAV, 4PFC, and BVAV systems, whereas the other (OT) category in the SZ system includes BSZ, BR, SC and GSHP systems.

Table 9-5: Distribution of HVAC Units by System Type and IOU

Efficiency Level	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
Single Zone	**92.6%**	8%	**97.1%**	1%	**89.7%**	4%
Multi Zone	**7.4%**	99%	**2.9%**	34%	**10.3%**	35%
Single Zone Unit Distribution						
Package Single Zone	**52.1%**	11%	**66.9%**	5%	**55.2%**	12%
Unit Ventilator	**12.9%**	25%	**2.5%**	38%	**8.8%**	49%
Split Single Zone	**12.4%**	19%	**12.8%**	18%	**12.7%**	37%
Package Terminal Unit	**5.3%**	31%	**8.2%**	35%	**4.5%**	50%
Mini Split System	**2.2%**	34%	**4.2%**	34%	**6.3%**	67%
Baseboard Radiant Heater	**3.3%**	52%	**1.6%**	62%	**1.3%**	104%
Other Single Zone Systems	**4.3%**	43%	**0.8%**	71%	**0.9%**	103%
n	**5,755**		**6,965**		**1,582**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-2: Distribution of HVAC Units by System Type and IOU



* **The results presented above have been weighted by site weight.**

In Table 9-6 the system type is broken down in terms of building size where the building size refers to the usage of the facility. It is evident that the Small and Very Small categories have a much higher percentage of Single Zone units with 98% and 100% respectively. These building sizes also tend to have a lower percentage of PSZ systems than the larger sites.

Table 9-6: Distribution of HVAC Units by System Type and Building Size

Efficiency Level	Large	Medium	Small	Very Small
Single Zone	79.5%	82.4%	97.9%	99.9%
Multi Zone	20.5%	17.6%	2.1%	0.1%
Single Zone Unit Distribution				
Package Single Zone	62.1%	60.1%	67.5%	47.8%
Unit Ventilator	2.6%	2.3%	5.9%	14.8%
Split Single Zone	5.0%	10.9%	15.2%	11.5%
Package Terminal Unit	2.4%	2.4%	3.7%	13.1%
Mini Split System	5.6%	4.5%	2.3%	4.1%
Baseboard Radiant Heater	0.2%	1.7%	1.7%	3.9%
Other Single Zone Systems	1.5%	0.6%	1.6%	4.7%
n	**2,517**	**8,341**	**2,861**	**583**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis. Large Sites have an annual usage over 1,750,00 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000 kWh, Small have a max annual usage greater than 40,000 kWh and less than or equal to 300,000 kWh and Very Small have annual usage less than or equal to 40,000 kWh.

9.3 Cooling Equipment

9.3.1 Cooling Equipment Type

This section presents brief description about the different cooling equipment types and their distribution throughout the CSS businesses in California by IOU and the size of the facility.

Direct Expansion (DX)

A Direct Expansion system (DX) is composed of a compressor, condenser, expansion valve and an evaporator. The evaporator comes directly in contact with the air resulting in an improved efficiency. Window air-conditioners, through the wall air-conditioners, rooftop package units and split systems are typically DX systems.

Evaporative Cooling (E)

An Evaporative Cooler (E), also known as a swamp cooler, is a device that cools the air through the simple evaporation of water. Evaporative cooling is especially well suited for climates where the air is hot and the humidity is low. In dry, arid climates the installation and operating cost of an evaporative cooler can be much lower than a refrigeration air conditioning system by about 80%.

Chiller (C)

A Chiller is a refrigeration unit designed to produce chilled water for space cooking purposes. The chilled water is circulated to one or more coils located in air handling units, fan coils, or induction units. Chiller systems will also have a cooling tower.

Dedicated Compressor (DC)

A Dedicated Compressor works the same way as a direct expansion system with the components, but the system will have a stand-alone compressor that compresses the refrigerant and sends it to a condenser that is typically outside. These systems are primary found in places such as grocery stores where remote refrigeration is found.

Purchased Chilled Water (P)

Purchased chilled water will be used in the same way that a chiller is, except that chilled water is not chilled onsite. There will not be cooling equipment onsite; the chilled water will flow directly through the cooling coil. After the chilled water has absorbed the heat from the air it will be sent back to the supplier via return lines.

As seen in Table 9-7, Direct Expansion (DX) is the most common type of cooling equipment across all the three utilities. Since the DX units represent the majority of the population, this section provides an in depth look into the efficiency, size, age and distribution of units with DX cooling by IOU and business type. In a DX system, the air used for cooling space is directly chilled by the refrigerant in the cooling coil of the air handling unit. Since the air is cooled directly by the refrigerant, the efficiency of these DX systems is higher compared to other technologies.

Table 9-7: Distribution of Cooling Equipment Type by IOU

Cooling Equipment Type	Total	PG&E	SCE	SDG&E
Direct Expansion (DX)	79%	68%	88%	87%
Evaporative (E)	4%	4%	5%	1%
Chiller (C)	3%	6%	1%	1%
Dedicated Compressor (DC)	<1%	<1%	<1%	<1%
Purchased Chilled Water (P)	0%	0%	<1%	<1%
None (N)	14%	22%	6%	11%
All Types	**100%**	**100%**	**100%**	**100%**
n	**14,302**	**5,755**	**6,965**	**1,582**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

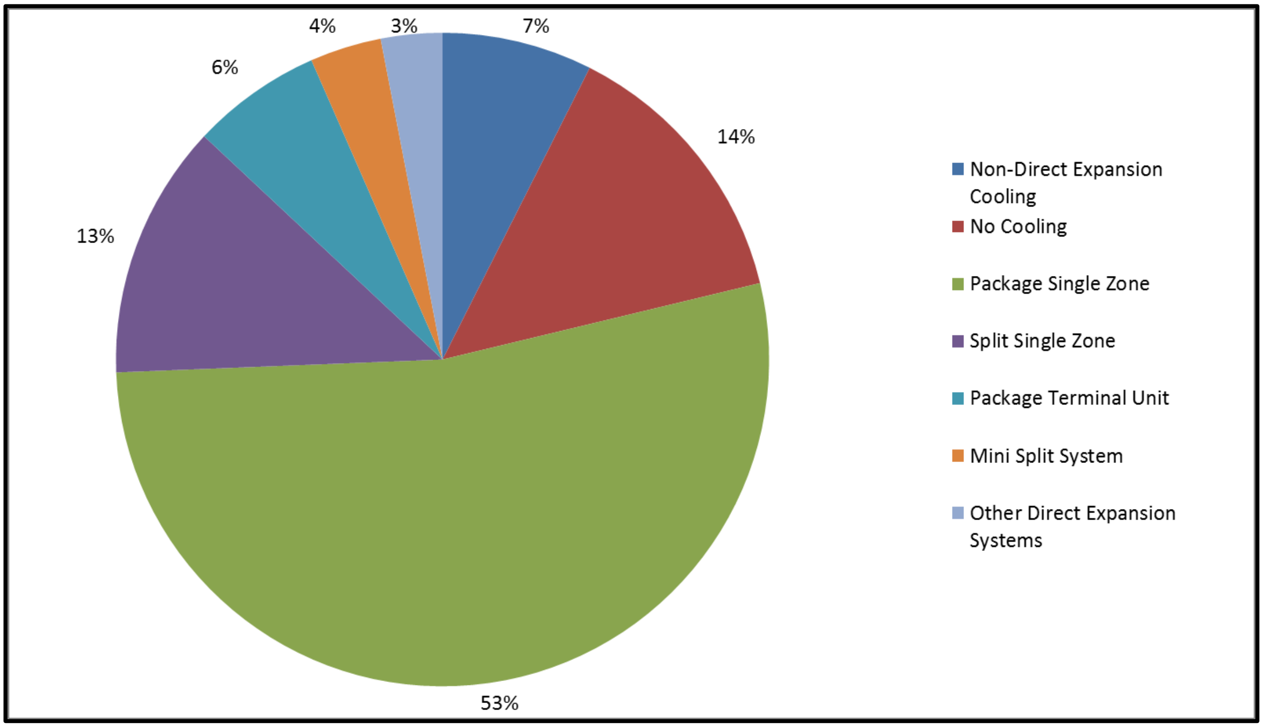
Table 9-8 and Figure 9-3 show the distribution of cooling type across all the utilities. Seventy-nine percent of all the HVAC units have DX cooling whereas only 7% of the units are cooled by other cooling types like chiller, evaporative cooler or compressor.

Table 9-8: Distribution of Cooling Equipment Type

System Type	Percent of Sites	Relative Precision	Percent of HVAC Units	Relative Precision
Direct Expansion Cooling (DX)	**84%**	4%	**79%**	4%
Non-Direct Expansion Cooling	**11%**	21%	**7%**	46%
No Cooling	**23%**	16%	**14%**	15%
SZ DX Cooling Distribution				
Package Single Zone	**52%**	8%	**53%**	6%
Split Single Zone	**12%**	20%	**13%**	12%
Package Terminal Unit	**11%**	25%	**6%**	23%
Mini Split System	**6%**	33%	**4%**	24%
Other Direct Expansion Systems	**2%**	45%	**3%**	23%
n	**1,256**		**14,302**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed sites, with HVAC, included in the analysis. Percentages sum to more than 100% because a business might have installed more than one type of HVAC system.

Figure 9-3: Distribution of Cooling Equipment Type



*** The results presented above have been weighted by site weight.**

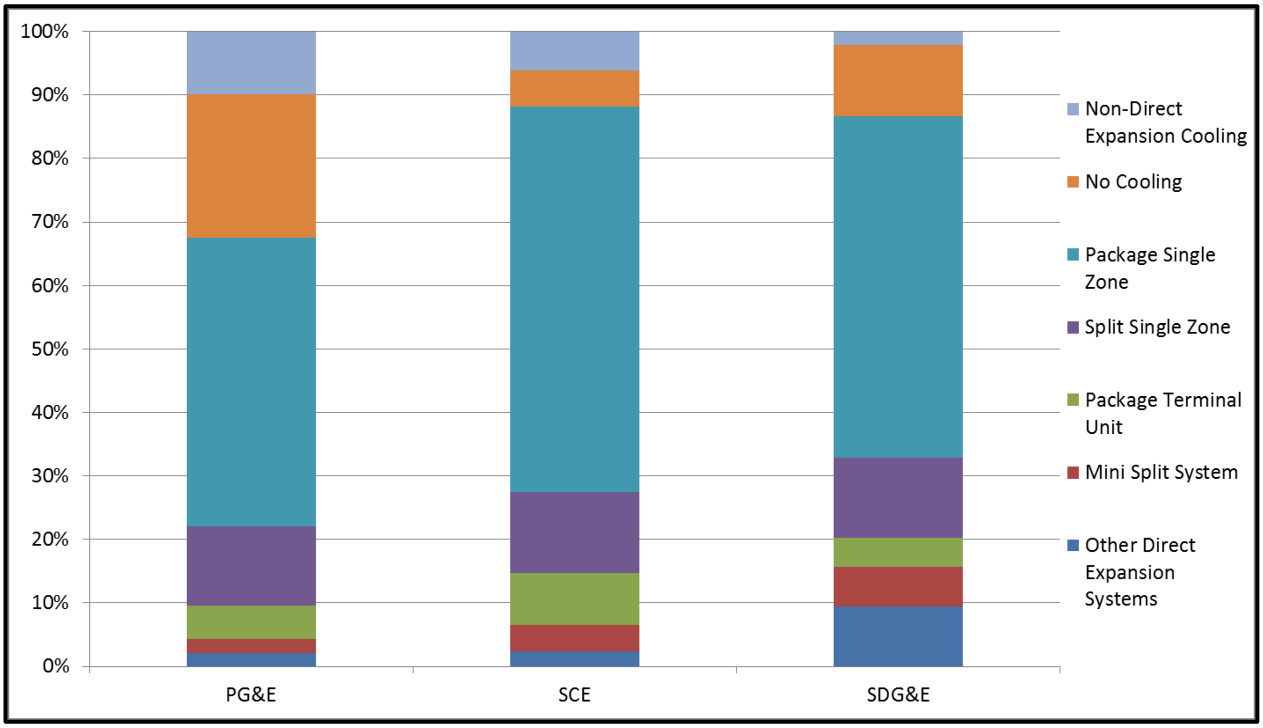
Around 14% of the HVAC units are heating only units that do not provide any cooling. Table 9-9 and Figure 9-4 show that HVAC units providing only heating and no cooling are more common in the PG&E territory where they represent around 22% of the units. The high percentage of heating only units is justified by the cold weather in the PG&E territory compared to the other utilities. The table also provides the predominant distribution types for the DX units. Across all the utilities, PSZ and SSZ units are the most common distribution system types that have DX cooling.

Table 9-9: Distribution of Cooling Equipment Type by IOU

Cooling Equipment Type	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
Direct Expansion Cooling (DX)	**68%**	10%	**88%**	2%	**87%**	5%
Non-Direct Expansion Cooling	**10%**	73%	**6%**	26%	**2%**	40%
No Cooling	**22%**	18%	**6%**	28%	**11%**	41%
SZ DX Cooling Distribution						
Package Single Zone	**46%**	12%	**61%**	6%	**54%**	12%
Split Single Zone	**12%**	19%	**13%**	18%	**13%**	37%
Package Terminal Unit	**5%**	31%	**8%**	36%	**5%**	50%
Mini Split System	**2%**	34%	**4%**	34%	**6%**	67%
Other Direct Expansion Systems	**2%**	41%	**2%**	38%	**9%**	38%
n	**5,755**		**6,965**		**1,582**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-4: Distribution of Cooling Equipment Type by IOU



* **The results presented above have been weighted by site weight.**

Table 9-10 provides a breakdown of Cooling Equipment by the Building Size. HVAC units with Direct Expansion (DX) constitute more than 80% of all the units for the Large, Medium and

Small Building sizes. This percentage is lower than 70% for the Very Small buildings as there are lot of HVAC units that do not provide any cooling. It can also be noted the Package Terminal Units (PTU) are much more common in the Very Small buildings than other building types.

Table 9-10: Distribution of Cooling Equipment Type by Building Size

Cooling Equipment Type	Large	Medium	Small	Very Small
Direct Expansion Cooling (DX)	85.7%	82.0%	84.6%	68.9%
Non-Direct Expansion Cooling	10.9%	12.6%	6.0%	5.0%
No Cooling	3.4%	5.4%	9.4%	26.1%
SZ DX Cooling Distribution				
Package Single Zone	60.3%	57.3%	61.2%	40.0%
Split Single Zone	5.0%	10.9%	15.2%	11.5%
Package Terminal Unit	2.4%	2.4%	3.6%	13.1%
Mini Split System	5.6%	4.5%	2.3%	4.1%
Other Direct Expansion Systems	12.4%	6.9%	2.4%	0.1%
n	**2,517**	**8,341**	**2,861**	**583**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis. Large Sites have an annual usage over 1,750,00 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000 kWh, Small have a max annual usage greater than 40,000 kWh and less than or equal to 300,000 kWh and Very Small have annual usage less than or equal to 40,000 kWh.

9.3.2 Make/Model Lookups

To fill in any missing information on capacity and efficiency from the data collected on-site, as well as to verify what was found on-site, make and model number lookups were performed. For this process, the model numbers reported by surveyors were compared to a database of compiled performance specifications make and model numbers. Due to resource constraints not all types of units were looked up. The PSZ and the SSZ units with direct expansion or evaporative cooling were looked up since they represent the majority of the single zone units. While the focus of the make, model lookups were to find cooling capacity and cooling efficiency ratings, other information was also collected such as the heating type and heating fuel type. These characteristics were not the focus of the lookup and were only used to verify the basic heating equipment type that was reported from the on-site. Approximately 3,200 unique model numbers were found on-site for the PSZ and SSZ units with DX or evaporative cooling. The team was able to collect or verify data for 88% of the model numbers and no information could be found for 10% of the units. Approximately 2% of all model numbers were from units older than 1995 and they were not included in the make model lookup.

9.3.3 DX Cooling System Efficiency

Energy efficiency for an air conditioner is very crucial since it is one of the most energy consuming end uses in a commercial facility. The efficiency of an air conditioner is rated as a Seasonal Energy Efficiency Ratio (SEER) for smaller units (typically less than 65,000 btuh) and as an Energy Efficiency Ratio (EER) for larger units (greater than 65,000 btuh). EER is a single point efficiency measurement, whereas the SEER accounts for variations across a cooling season.

The minimum efficiencies for these HVAC units are governed by Federal appliance standards, but are also covered in California's Title 20 appliance efficiency regulations. Figure 9-5 shows the minimum efficiency requirements for air conditioners over the last two decades, listed by the cooling capacity range and system type.

Figure 9-5: Minimum Efficiency Standards for Air Conditioners and Heat Pumps[6]

Appliance	Cooling Capacity (Btu/hr)	System Type	Minimum Efficiency			
			Effective January 1, 1994[1] or January 1, 1995[2]	Effective June 15, 2008	Effective January 1, 2010	
					Air Conditioners	Heat Pumps
Air-cooled unitary air conditioners and heat pumps (cooling mode)	< 65,000 *	Split system	10.0 SEER[1]	13.0 SEER		
	< 65,000 *	Single package	9.7 SEER[1]	13.0 SEER		
	≥ 65,000 and < 135,000	All	8.9 EER[1]		11.2 EER[3] 11.0 EER[4]	11.0 EER[3] 10.8 EER[4]
	≥ 135,000 and < 240,000	All	8.5 EER[2]		11.0 EER[3] 10.8 EER[4]	10.6 EER[3] 10.4 EER[4]
	≥ 240,000 and < 760,000	All			10.0 EER[3] 9.8 EER[4]	9.5 EER[3] 9.3 EER[4]

* Three phase models only.
[3] Applies to equipment that has electric resistance heat or no heating.
[4] Applies to equipment with all other heating-system types that are integrated into the unitary equipment.

For the cooling efficiency analysis, the team looked into all the PSZ and SSZ HVAC units that have a DX cooling type, and grouped them into three categories based on the size of the HVAC system as listed below:

- Small (< 65,000 Btuh)
- Medium (>= 65,000 Btuh and < 240,000 Btuh). Note that this group combines the two middle minimum-efficiency size categories shown in Figure 9-5.
- Large (>= 240,000 Btuh)

6 2012 Appliance Efficiency Regulations by California Energy Commission – October 2012. http://www.energy.ca.gov/2012publications/CEC-400-2012-019/CEC-400-2012-019-CMF.pdf

A Small unit is defined for this analysis as the unit that is less than or equal to 65,000 Btuh and has a SEER efficiency rating. Table 9-11 and Figure 9-6 clearly show that the efficiency distribution for the small PSZ and SSZ units line up with the 1995 and 2008 minimum efficiency standards. The majority of the Small PSZ and SSZ units are either in the SEER 10-10.9 category (35%) which coincides with the minimum efficiency standard for 1995 or the SEER 13-13.9 (22%) which is the 2008 minimum efficiency standards.

For approximately 25% of the units SEER ratings are not available. These are likely older units where the surveyor was either unable to get the name plate information or the make model lookups did not yield a SEER rating. The majority of these units are older than 1995 and will likely have a SEER rating of 10 or less.

The data presented in Table 9-11 show that for 48% of the Small PSZ and SSZ units the analysis found that their SEER rating is less than 13.0, the current minimum efficiency standard or HVAC production. If a large share of the 25% of unclassified units are also less than 13 SEER, the share of units under 13 SEER is closer to 73% of installed units. Twenty-seven percent of the PSZ and SSZ units meet or exceed the 2008 minimum efficiency standard of 13.0 SEER. Given the large share of units with less than 13 SEER efficiency ratings, small PSZ and SSZ units represent a large potential for energy savings for the businesses and IOUs if these systems were replaced with higher efficiency units.

Table 9-11: Efficiency Distribution for CSS Small PSZ and SSZ Units

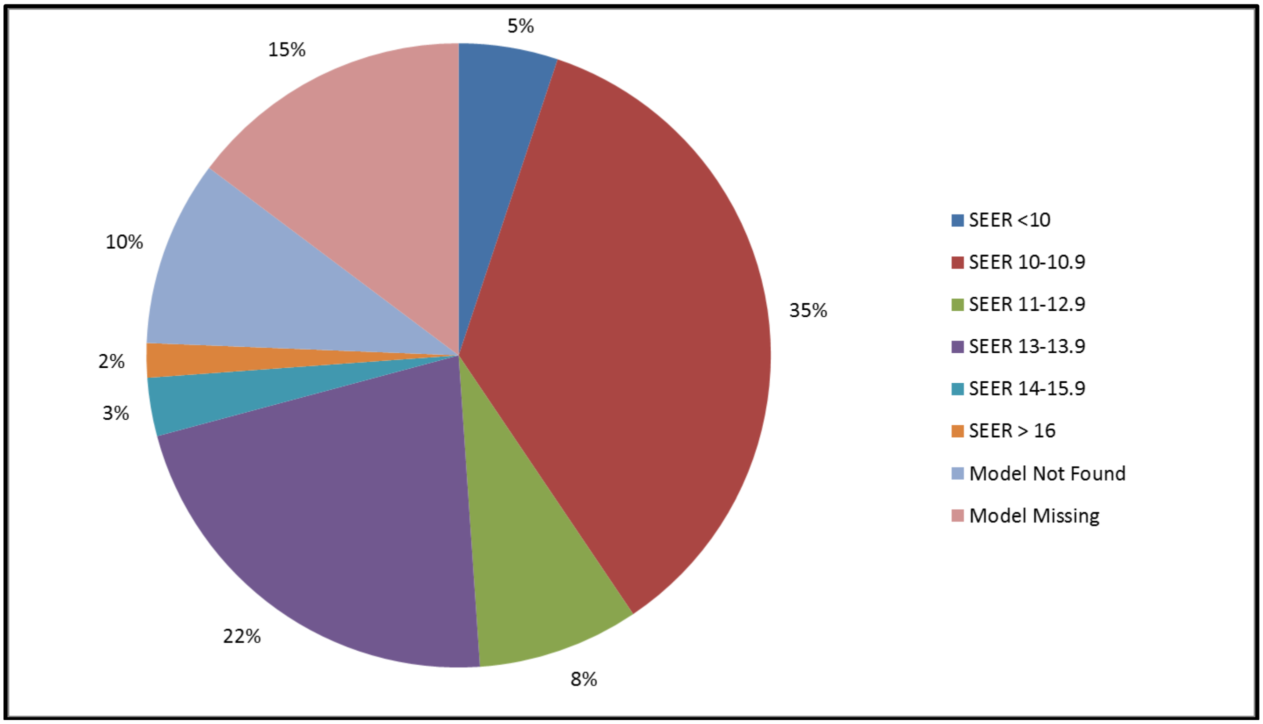
Efficiency	HVAC Distribution by Site	HVAC Distribution by Unit
SEER < 10	9%	5%
SEER 10-10.9	42%	35%
SEER 11-12.9	11%	8%
SEER 13-13.9	28%	22%
SEER 14-15.9	3%	3%
SEER > 16	3%	2%
Efficiency Not Found[7]	11%	10%
Model Missing [8]	27%	15%
n	**938**	**8,637**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed Small HVAC units included in the analysis. Small units are units with a cooling capacity less than 65,000 Btuh. Percentages sum to more than 100% because a business might have installed more than one type of HVAC system.

7 For these units, the model number did not yield efficiency information.

8 Nameplate was not accessible or available for these units.

Figure 9-6: Efficiency Distribution for CSS Small PSZ and SSZ Units



*** The results presented above have been weighted by site weight.**

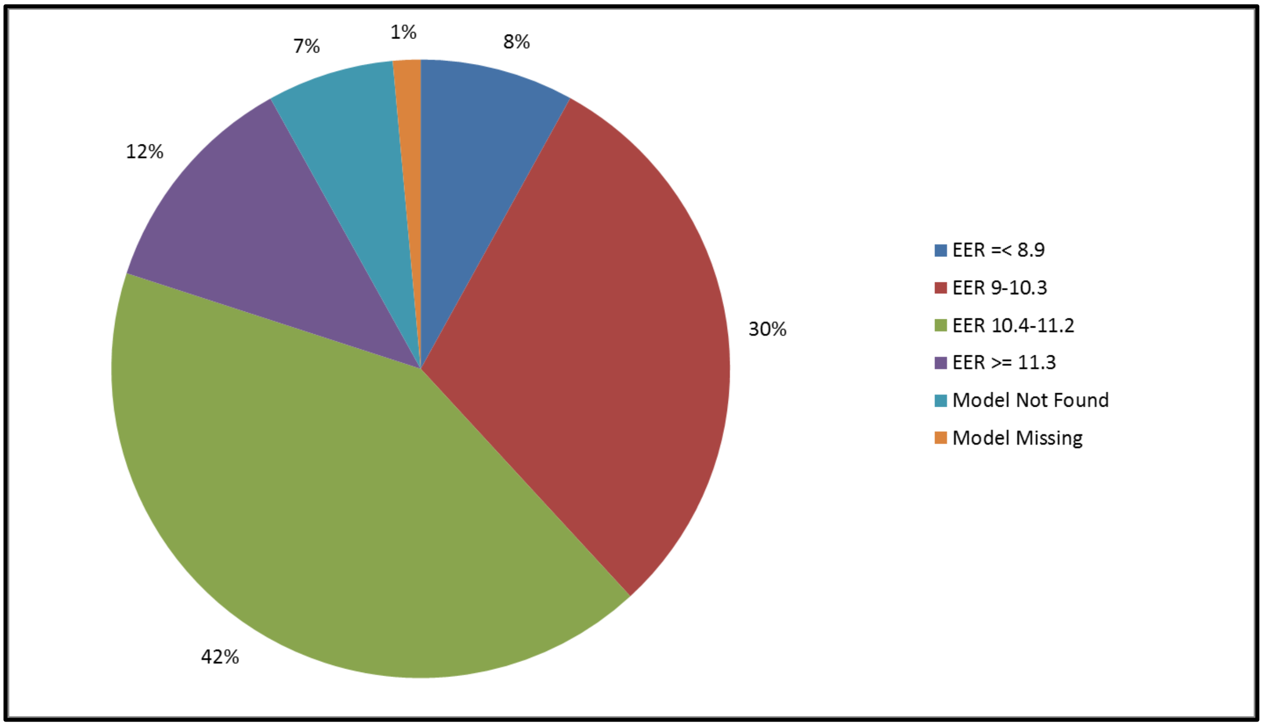
A Medium unit is defined for this analysis as the unit that is greater than or equal to 65,000 Btuh and less than 240,000 Btuh. The medium size units typically have an EER rating instead of a SEER rating. From Table 9-12 and Figure 9-7, it can be seen that only 8% of the HVAC units are less than or equal to EER of 8.9. An EER of 8.5 and 8.9 were the minimum efficiency standards through 1995. Thirty percent of units have an efficiency level between the 1995 and 2010 efficiency standards. These units likely represent units installed prior to 2010 whose efficiency exceeded the minimum standards at the time of installation. Forty-two percent of units are in an efficiency range that likely meets the 2010 minimum efficiency standards (10-4-11.2 EER) and there is at least one unit at 46% of the sites where these standards are met. Table 9-12 also shows that 11% of medium units are installed above base efficiency. It can be noted that for the Medium size units, higher efficiency units are installed at substantially higher rate than the Small size units. The share of Medium sized units above the 2010 efficiency standards is especially high given that these standards were only established three to four years prior to the data collection for this study. In comparison, only 5% of Small sized units exceed the SEER efficiency standard established in 2008 or five to six years prior to the data collection for this study.

Table 9-12: Efficiency Distribution for Medium PSZ and SSZ Units

Efficiency	HVAC Distribution by Site	HVAC Distribution by Unit
EER < = 8.9	11%	8%
EER 9-10.3	40%	30%
EER 10.4-11.2	46%	42%
EER =>11.3	18%	12%
Model Not Found	11%	7%
Model Missing	2%	1%
n	**370**	**1,797**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed Medium HVAC units included in the analysis. Medium units are units with a cooling capacity greater than or equal to 65,000 Btuh but less than 240,000 Btuh.. Percentages sum to more than 100% because a business might have installed more than one type of HVAC system

Figure 9-7: Efficiency Distribution for Medium PSZ and SSZ Units



* **The results presented above have been weighted by site weight.**

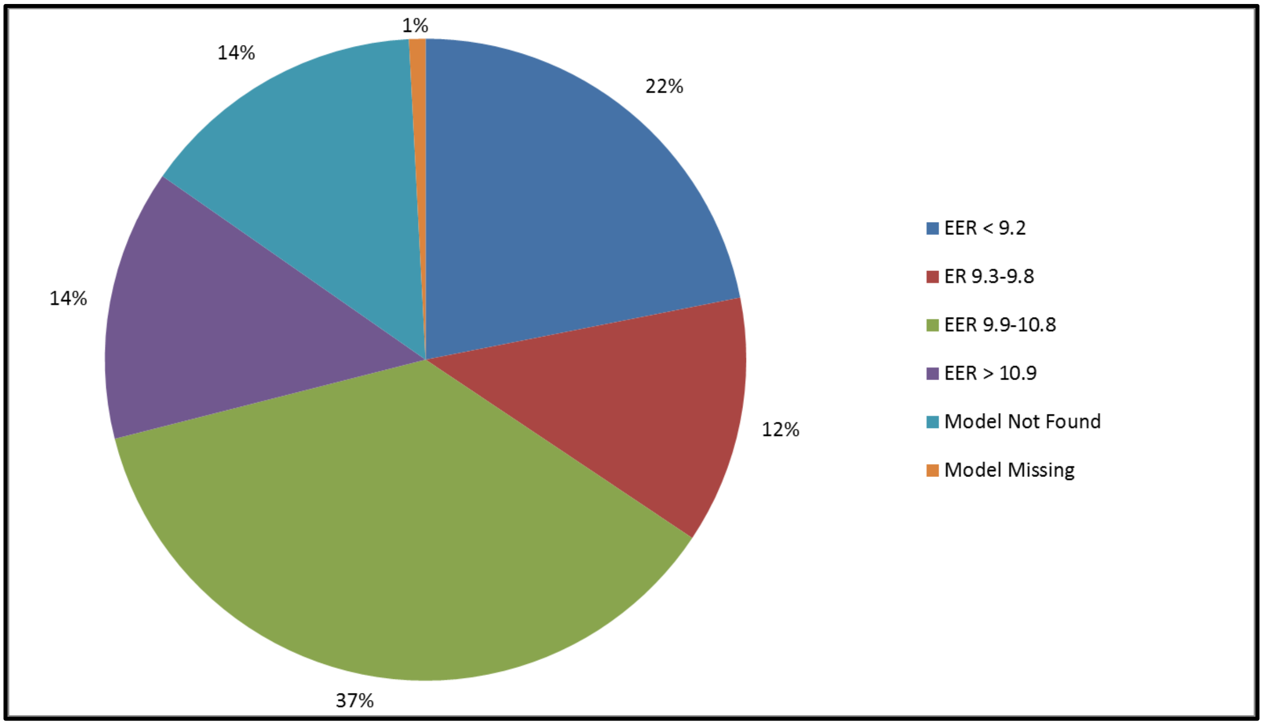
A Large unit is defined for this analysis as the unit that is greater than or equal to 240,000 Btuh and has an EER rating. Table 9-13 and Figure 9-8 shows that at least 51% of the large PSZ and SSZ units exceed the 2010 minimum efficiency requirements of 9.8 EER. Similar to the Medium size grouping, a majority of the Large PSZ and SSZ units are at least as efficient as the 2010 minimum efficiency standards. Approximately 22% of the Large units do not meet the efficiency standards of 9.3 EER.

Table 9-13: Efficiency Distribution for Large PSZ and SSZ Units

Efficiency Levels	HVAC Distribution by Site	HVAC Distribution by Unit
EER < 9.2	45%	22%
EER 9.3-9.8	7%	12%
EER 9.9-10.8	27%	37%
EER > 10.9	8%	14%
Model Not Found	20%	14%
Model Missing	1%	1%
n	**48**	**280**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed Large HVAC units included in the analysis. Large units are units with a cooling capacity greater than or equal to 240,000 Btuh. Percentages sum to more than 100% because a business might have installed more than one type of HVAC system.

Figure 9-8: Efficiency Distribution for Large PSZ and SSZ Units



* **The results presented above have been weighted by site weight.**

9.3.4 Distribution of DX units and Average Size

For all the PSZ and SSZ units with DX cooling where the cooling capacity was available, Table 9-14 provides the distribution and average size of the unit. The units were classified into small, medium and large similar to the categorization in the efficiency section. From the table, it can be seen that small units with less than 65,000 Btuh have an average cooling capacity of 4 tons and they represents 83% of the DX units throughout the CSS businesses in California. It can also be seen that Large DX units that are greater than 20 tons are not common in the CSS businesses, but will provide a large percentage of cooling.

Table 9-14: Distribution and Average Cooling Capacity by Unit Size

Size Category	HVAC Distribution	Average Cooling Capacity (Tons)	Median Cooling Capacity (Tons)
Small (< 65,000 Btuh)	83%	3.6	3.7
Medium (>= 65,000 Btuh and < 240,000 Btuh)	16%	8.9	7.5
Large (>= 240,000 Btuh)	1%	29.4	24.5
n	**10,714**		

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units with DX cooling included in the analysis.

9.3.5 HVAC Square Feet per Ton

For all businesses, where the space is cooled by direct expansion cooling, a cooling load in square feet per ton (ft2/ton) was estimated to better understand the sizing of HVAC systems by business type. There were many sites where the cooling capacity of the HVAC units was not available for all the units at the facility. Out of the 863 sites in the verification sample that used DX cooling, the research team was able to collect cooling capacity for at least 85% of the units for 653 sites. The remaining 210 sites were excluded from this part of the analysis. In cases where the cooling capacity was available for at least 85% of the units at a site, but not 100% of the units, an average cooling capacity was calculated and applied to the remaining percentage of the units that have DX cooling but no known cooling capacity. This estimate was only used to calculate the cooling load. Table 9-15 shows the estimated cooling load in square feet per ton by business type and utility. Only the cooled floor area of the building is used to estimate the cooling load. For most of the business types, the cooling load varies between 300 and 400 square feet per ton. For reference, ASHRAE handbook[9] values range from 80 to 400 square feet per ton for commercial applications. Restaurants have the lowest cooling square feet per ton value (i.e. they require the most cooling) across all the three utilities, as fast food restaurants need substantial cooling to compensate for the internal loads from the kitchen area. Warehouses have the highest cooling square feet per ton value (i.e. they require the least amount of cooling) across all the utilities. As shown in Figure 9-9, for most of the business types, the cooling load follows a similar trend for all utilities.

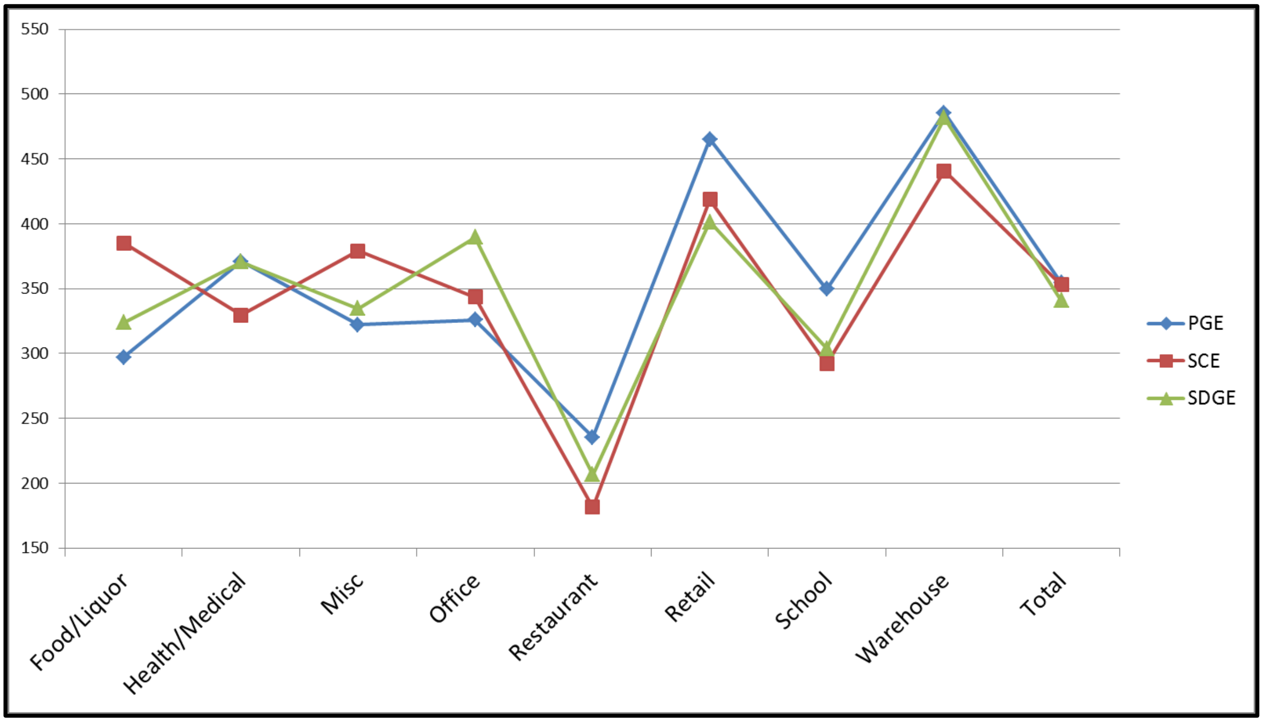
9 ASHRAE Pocket Guide for Air Conditioning Heating Ventilation Refrigeration, Cooling Load Check Figures, 1993, pg. 128-129

Table 9-15: Square feet per Ton of Cooling by Business Type and Utility

Business Type	PG&E	SCE	SDG&E
Food/Liquor	297	385	324
Health/Medical – Clinic	371	330	371
Miscellaneous	322	379	335
Office	326	344	390
Restaurant	236	182	207
Retail	465	419	402
School	350	292	304
Warehouse	485	441	482
Total	354	353	341
n	**238**	**316**	**99**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed sites, with HVAC, included in the analysis.

Figure 9-9: Square Feet per Ton of Cooling by Business Type and Utility



***The results presented above have been weighted by site weight.**

As shown in in Figure 9-10, the 16 California climate zones are grouped into five New Construction Climate Zones.[10] The average square feet per ton of cooling is compared across all

[10] Using the five new construction climate zones limits the number of climate zones the data is disaggregated into while still providing useful information.

the five new construction climate zones and are presented in Table 9-16. The average cooling square feet per ton for the climate zone 5 serving the inland and desert area is much lower than the cooling square feet per ton for the other climate zones.

Figure 9-10: California New Construction Climate Zones

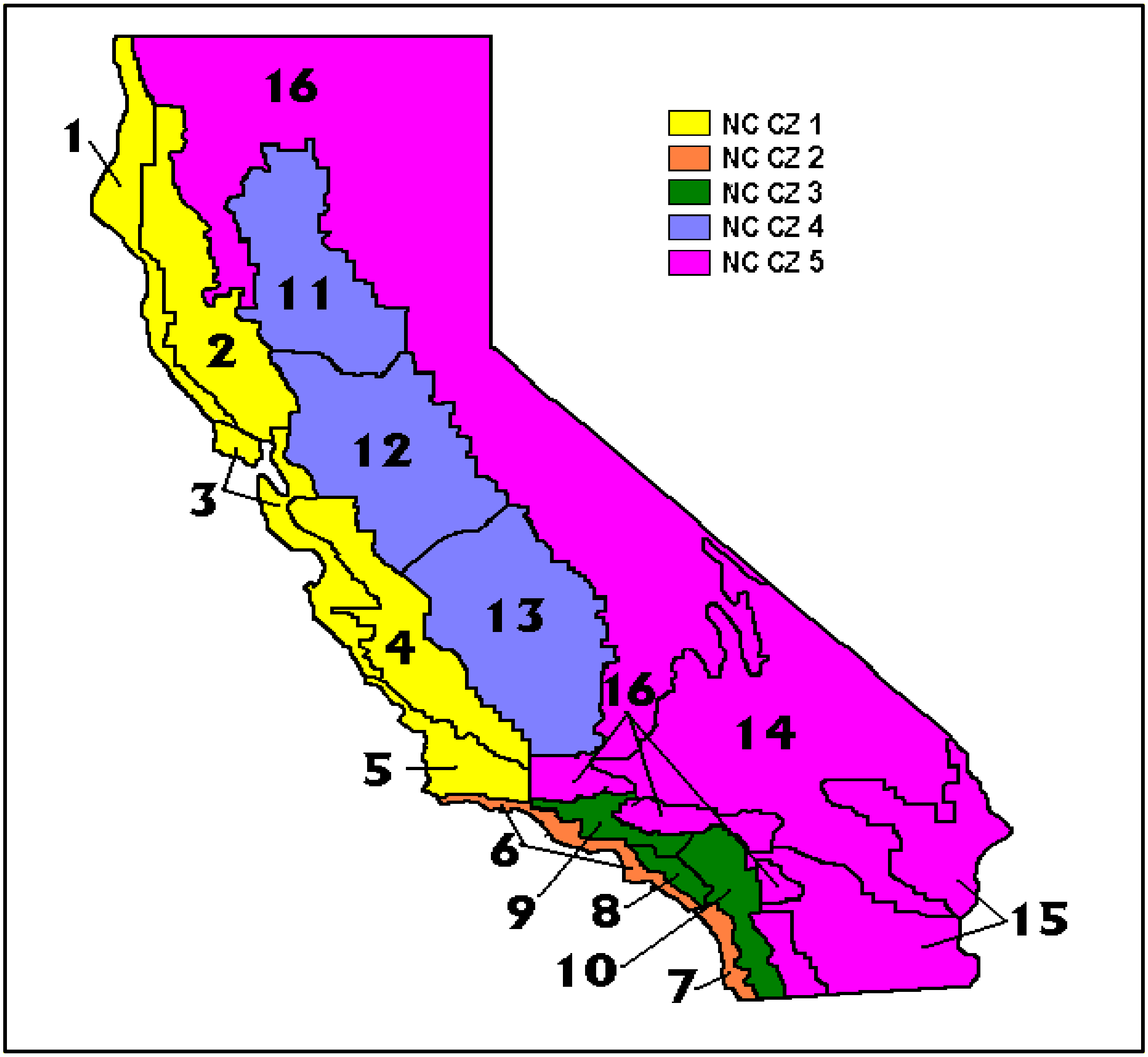


Table 9-16: Square Feet per Ton of Cooling by New Construction Climate Zone

Climate Zone	Region	Average Sq. Ft/ Ton
1	Northern Coastal	345
2	Southern Coastal	384
3	Southern Inland	359
4	Central Valley	346
5	Inland/ Desert	303

9.4 Heating Equipment

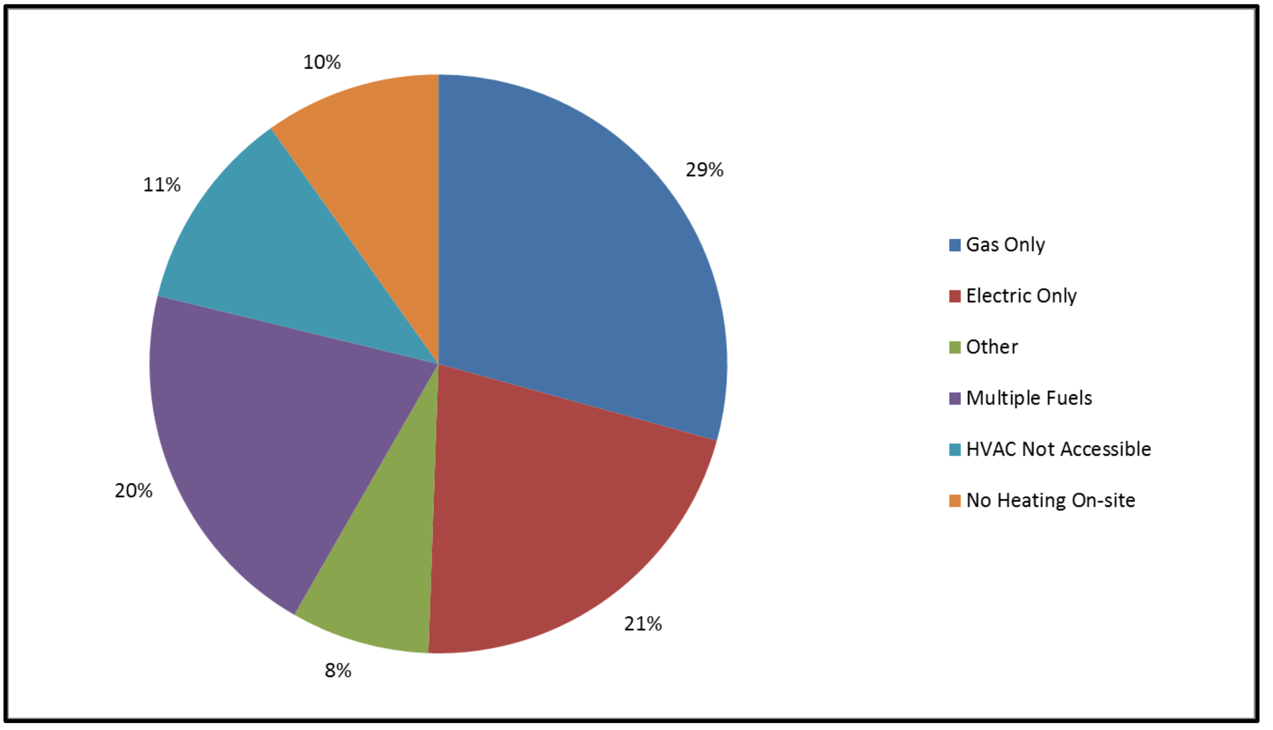
The CSS on-site survey effort collected information on key variables for heating systems including heating equipment type, heating fuel type as well as make and model numbers. For some of the units, the make and model numbers were looked up in order to verify the information that was collected on-site. In cases where the on-site information was incomplete the lookups were able to fill in the missing values. Table 9-17 and Figure 9-11 show the distribution of heating fuel types. Twenty nine percent of businesses are heated solely by natural gas heaters whereas 21% of businesses are heated only by electric. Eight percent of businesses use a combination of heating fuels whereas 8% of businesses use other fuel types like liquid propane gas (LPG), fuel oil or wood. Approximately 10% of all the CSS businesses do not have HVAC systems that provide heating.

Table 9-17: Distribution of Heating Fuel Type by Site

Heating Fuel Type	Share of Businesses
Gas Only	29%
Electric Only	21%
Other	8%
Multiple Fuels	20%
HVAC Not Accessible	11%
No Heating On-site	10%
n	**1,439**

* **The results presented above have been weighted by site weight.** Totals include the count of surveyed sites with no HVAC onsite, and HVAC not surveyed.

Figure 9-11: Distribution of Heating Fuel Type by Site



*** The results presented above have been weighted by site weight**

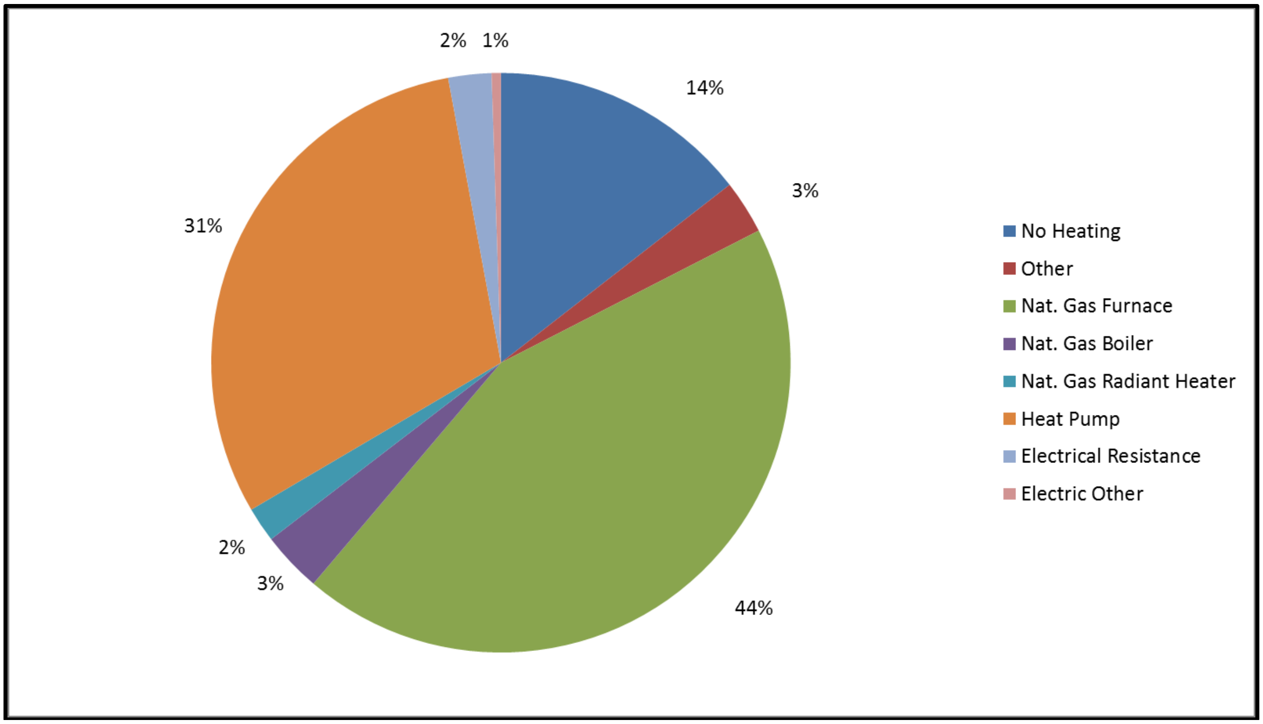
Electric and gas heating represent the largest share of heating types in California businesses and therefore these heating types are broken down further in Table 9-18 and Figure 9-12. Natural gas heating makes up 49% of the units in CSS businesses and 44% of these units are natural gas fired furnaces. Heat pumps make up 31% of heating in CSS businesses and represent 93% of all electric heating types. While 9% of businesses were found to have no heating, when looking at individual units, 14% of units have no heating.

Table 9-18: Heating Fuel Type Distribution

Heating Fuel Type	Percent of HVAC Units	Relative Precision
Natural Gas	49%	6%
Electric	33%	8%
No Heating	14%	13%
Other	3%	30%
Total	**100%**	
Gas Heating Distribution		
Furnace	44%	7%
Boiler	3%	102%
Radiant Heater	2%	37%
Electric Heating Distribution		
Heat Pump	31%	8%
Electrical Resistance	2%	37%
Other	1%	92%
n	**14,302**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-12: Distribution of HVAC Units by Heating Fuel Type



*** The results presented above have been weighted by site weight.**

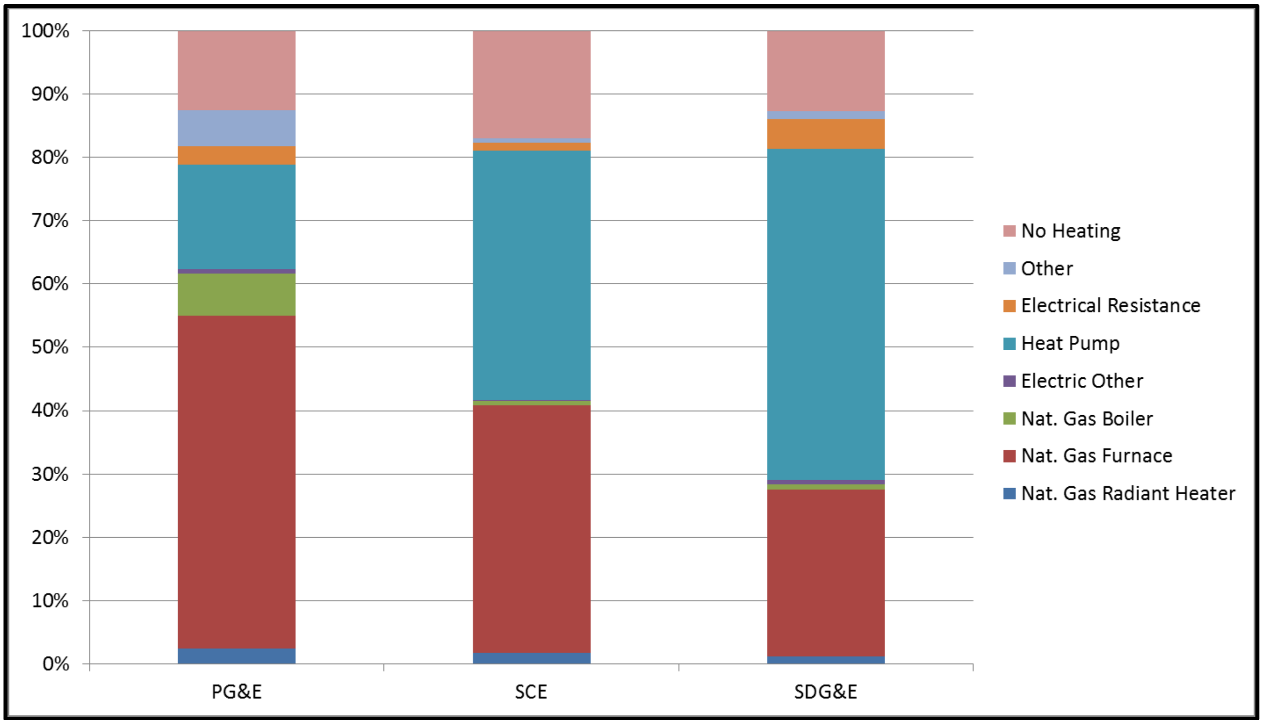
The distribution of heating equipment and heating fuel types are further disaggregated by utility in Table 9-19 and Figure 9-13 to provide information on the variations in technology adoptions in different geographic conditions. From the table it can be clearly seen that heat pumps are more common in SCE and SDG&E territory whereas natural gas furnaces are the predominant heating equipment type in PG&E territory and constitutes around 53% of the HVAC units. Because of the geographic conditions and weather, SCE's territory has approximately 17% of HVAC units that do not provide heating, the most across all the utilities.

Table 9-19: Heating Fuel Type and Distribution Equipment Type by Utility

Heating Fuel Type	PG&E	Relative Precision	SCE	Relative Precision	SDG&E	Relative Precision
Natural Gas	62%	8%	42%	8%	28%	18%
Electric	20%	17%	41%	9%	58%	11%
No Heating	13%	20%	17%	19%	13%	40%
Other	6%	33%	1%	96%	1%	98%
Total	**100%**		**100%**		**100%**	
Electrical Heating Equipment Type						
Heat Pump	16%	18%	39%	9%	52%	13%
Electrical Resistance	3%	52%	1%	70%	5%	79%
Other	1%	132%	0%	107%	1%	118%
Gas Heating Equipment Type						
Furnace	53%	11%	39%	9%	26%	19%
Boiler	7%	111%	1%	59%	1%	52%
Radiant Heater	2%	54%	2%	53%	1%	114%
n	**5,775**		**6,965**		**1,582**	

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-13: Heating Fuel Distribution by Utility



* **The results presented above have been weighted by site weight.**

9.5 HVAC Characteristics

9.5.1 HVAC Condition

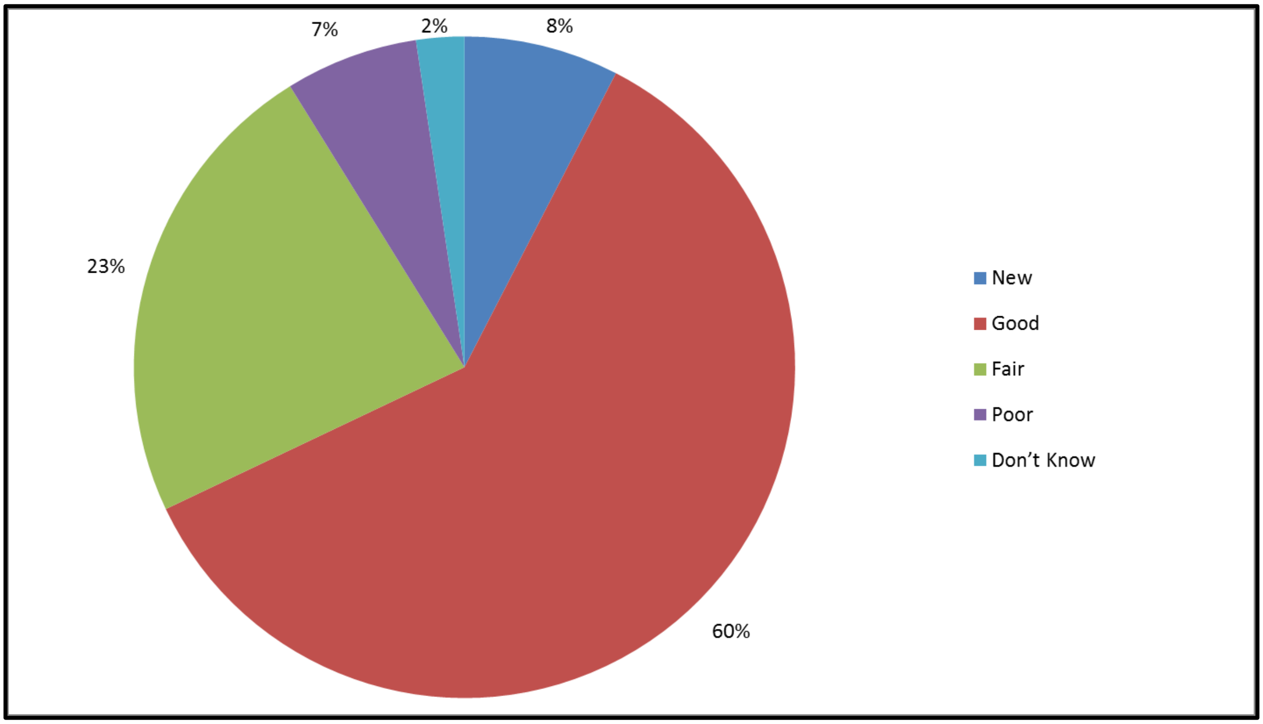
The on-site survey collected information about the condition of the HVAC equipment. The condition of the HVAC unit was classified as good, fair or poor based on surveyors discretion. Typically, the units installed within a few years of the site visit were considered as new units. The table below (Table 9-20 and Figure 9-14) shows that 68% of the HVAC units are either new or in good condition. Only 7% of the units were in poor condition and they are mainly in very small sites. A similar distribution was seen for the PSZ and SSZ units which constitutes a majority of the HVAC units.

Table 9-20: Distribution of HVAC Units by Condition of the Equipment

Condition of the Equipment	Percent of Units (All Units)
New	8%
Good	60%
Fair	23%
Poor	7%
Don't Know	2%
n	**14,302**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-14: Distribution of HVAC Units by Equipment Condition



* **The results presented above have been weighted by site weight.**

9.5.2 HVAC Temperature Control

HVAC temperature control type was also collected as part of the on-site surveys. Table 9-21 shows that 46% of PSZ and SSZ single zone systems are manually controlled whereas 38% are controlled by a programmable thermostat. PTU and Mini's are also largely controlled manually at 76% and 50% respectively. Conversely, programmable thermostats are the most common control type for MZ systems (65%). Fifteen percent of the MZ HVAC systems are controlled by Energy Management Systems (EMS) whereas that percentage is substantially lower for all the

SZ systems. Detailed information about the EMS systems is provided in *Section 10: Energy Management Systems* of this report.

Table 9-21: Distribution of Temperature Control Type by HVAC System Type

Temperature Control Type	MINI	PTU	MZ System	PSZ and SSZ	Other SZ Systems
Programmable Thermostat	41%	15%	65%	38%	19%
Manual	50%	76%	8%	46%	67%
Always On	5%	3%	1%	0%	3%
EMS	2%	0%	15%	5%	0%
Timer	2%	1%	10%	10%	5%
Don't Know	0%	4%	1%	1%	5%
n	**549**	**439**	**1,060**	**11,224**	**1,030**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

9.5.3 HVAC Outside Air Configuration, Economizer

An economizer can save energy in buildings by controlling the amount of outside air flow that is being introduced into the building based on the outdoor, supply and return air conditions. Unlike the economizer, a fixed damper allows a constant amount of outside air flow into the building. As part of the on-site survey effort, surveyors were able to collect the outside air configuration for approximately 73% of the HVAC units. Table 9-22 shows the outside air configuration for the PSZ and SSZ systems by system size. The Small (<65,000 Btuh), Medium (>=65,000 Btuh and <240,000 btuh) and Large (>=240,000 Btuh) size categories are the system sizes used in the cooling efficiency section.

From Table 9-22 it can be seen that the majority of Small units do not allow outside air into the building. The majority of the Large units have either an economizer, or a fixed damper for outside air.

Table 9-22: Outside Air Configuration Distribution by Unit Size

Outside Air	Small	Medium	Large
No Outside Air	49%	29%	9%
Fixed Damper	27%	26%	10%
Economizer	6%	24%	54%
Don't Know	18%	21%	27%
n	**6,852**	**1,802**	**280**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis. Small units have a capacity less than 65,000 Btuh, Medium units have a capacity greater than or equal to 65,000 Btuh and less than 240,000 Btuh, Large units have a capacity of greater than or equal to 240,000 Btuh.

9.5.4 HVAC Age

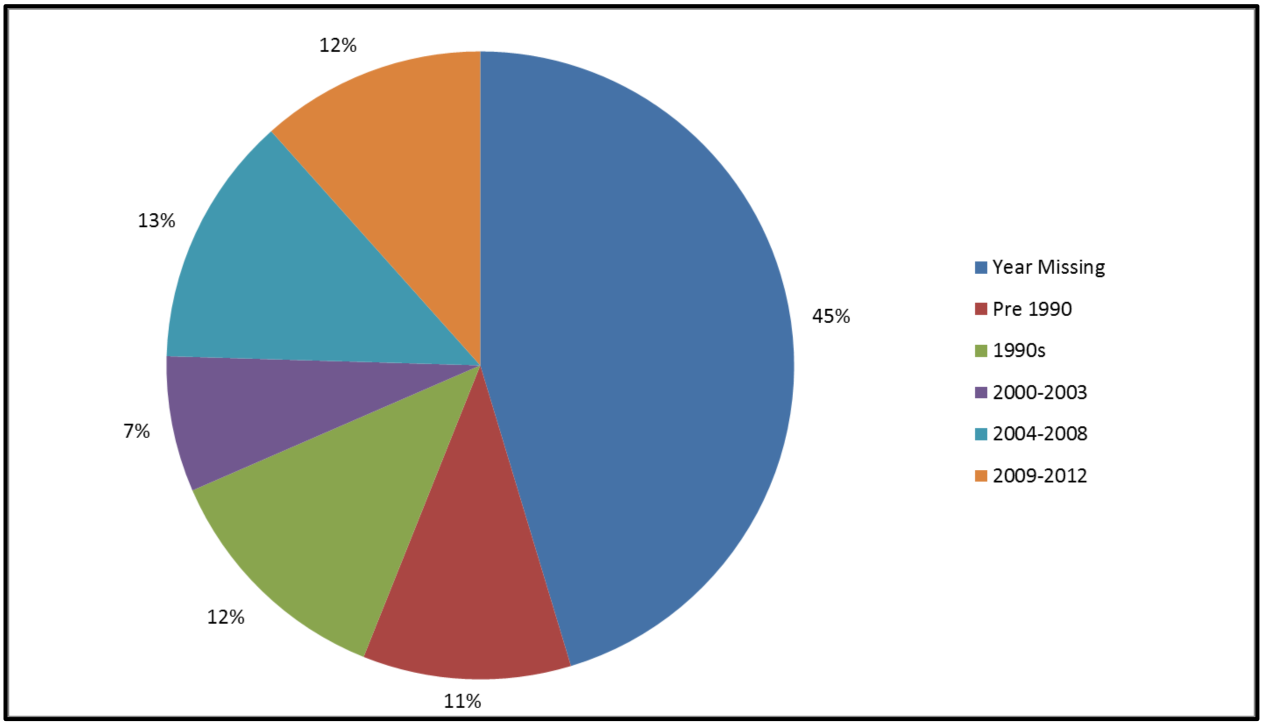
As part of the CSS on-site survey, information was collected from 14,302 units. Out of these units, vintage information was either not available or not accessible for 6,436 units. The following table (Table 9-23) shows the distribution of the surveyed HVAC systems by vintage that was collected from the nameplate or the make and model lookup.

Table 9-23: Distribution of HVAC Units by Age

Age of Unit	Number of HVAC units
Missing Age Info	45%
Pre 1990	11%
1990 to 1999	12%
2000 to 2003	7%
2004 to 2008	13%
2009 to 2013	12%
n	**14,302**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed HVAC units included in the analysis.

Figure 9-15: Distribution of HVAC Units by Age



* **The results presented above have been weighted by site weight.**

9.6 HVAC Maintenance

As part of the site visit, the surveyor also collected information about the HVAC maintenance procedures from the site contact. In cases where the site contact was not familiar with the maintenance related questions, the surveyor tried to get these questions answered from the contractor that maintained the HVAC units. For the sites with HVAC equipment Table 9-24 shows that at least one third of the sites perform periodic maintenance whereas one in four sites performs repairs only when a problem is reported.

Table 9-24: HVAC Maintenance Summary by IOU

Maintenance Schedule	PG&E	SCE	SDG&E
Maintenance Periodically	35%	28%	30%
Only when Problem	25%	23%	24%
Never	33%	41%	26%
Don't Know	7%	8%	20%
Total	**100%**	**100%**	**100%**
n	**508**	**554**	**194**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed sites, with HVAC, included in the analysis.

The survey also asked questions about who performs the HVAC maintenance. The maintenance can be performed by a hired contractor or in house staff. It can be seen from Table 9-25 that more sites have their HVAC maintenance performed by Hired Contractors as opposed to In House Staff. At least one quarter of the sites have maintenance performed by an outside contractor across all of the utilities.

Table 9-25: HVAC Maintenance Provider by IOU

Maintenance Provider	PG&E	SCE	SDG&E
Hired Contractor	33%	26%	29%
In House Staff	15%	12%	18%
Other	2%	2%	2%
Don't Know	10%	4%	12%
No HVAC Maintenance	41%	56%	39%
Total	**100%**	**100%**	**100%**
n	**508**	**554**	**194**

* **The results presented above have been weighted by site weight.** Totals represent the count of surveyed sites, with HVAC included in the analysis.

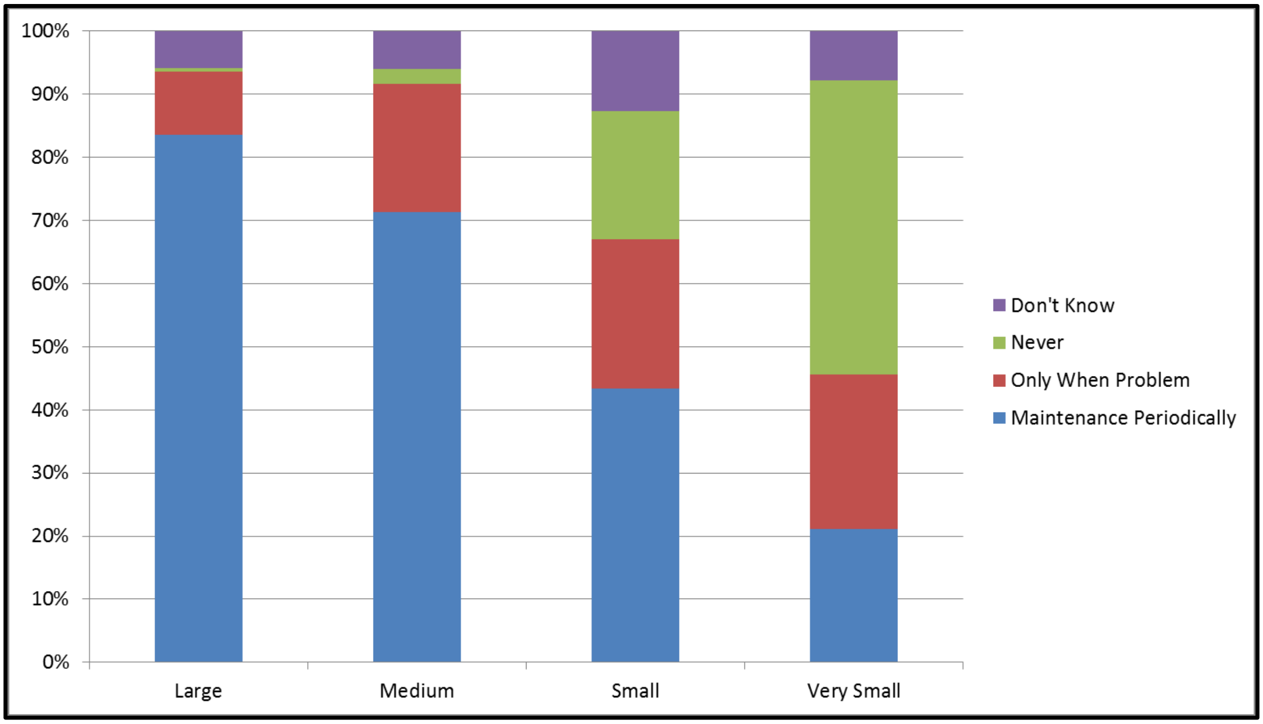
Table 9-26 shows that 84% of the large sites perform maintenance on their HVAC systems periodically and 55% are under some maintenance contract. Figure 9-16 clearly shows that periodic maintenance is predominant in large sites and majority of the smaller sites does not perform any kind of maintenance.

Table 9-26: Maintenance Summary by Business Size

Maintenance Schedule	Large	Medium	Small	Very Small
Maintenance Periodically	84%	71%	43%	21%
Only when Problem	10%	20%	24%	25%
Never	0%	2%	20%	46%
Don't Know	6%	6%	13%	8%
Total	**100%**	**100%**	**100%**	**100%**
n	**96**	**451**	**417**	**292**

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Figure 9-16: Maintenance Summary by Business Size



* **The results presented above have been weighted by site weight.**

The survey also asked the site contact or maintenance contractor on the frequency of maintenance. It can be noted that the HVAC units at the large facilities are maintained frequently compared to the small sites. Table 9-27 shows that at the large sites, HVAC systems are maintained every three months whereas maintenance is performed at very small sites once a year.

Table 9-27: Maintenance Period by Business Size

Business Size	Percent Maintained	Average Maintenance Period (Months)
Large	84%	3
Medium	71%	4
Small	43%	6
Very Small	21%	12
n	**1,256**	

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

10

Energy Management Systems

Energy Management Systems (EMS) consist of a network that combines local distributed control with centralized coordination and management to monitor, control, and optimize the energy usage throughout a business facility. EMS can be used to control and monitor the energy use of appliances and equipment at a site including lighting, HVAC, water heating and process equipment. EMS systems can also be used to control systems during demand response events. The California Strategic Plan notes that EMS are important for the achievement of the Big, Bold, Energy Efficiency Initiatives and integrated energy solutions. The CSS data on EMS provides the IOUs and the CPUC with a better understanding of the current baseline of EMS saturation. This information is useful for future program planning for Energy Efficiency (EE) and Demand Response (DR) and for future potential studies.

The CSS on-site survey collected multi-faceted data on EMS. The data collected included the end uses controlled by the system. The survey collected information on the number of points and the number of controllers. The survey collected self-reported information on DR program participation and determined if the DR implementation methodology is manual, activated through a signal received from a third party, or based on an alternative algorithm. If the EMS system is used for DR, the survey ascertained the loads controlled.

The on-site survey data was also combined with the IOU DR tracking data. Combining these two data sources enabled the Research Team to determine the characteristics of businesses with EMS that participated in DR programs.

10.1 Energy Management System Premise Characteristics

Table 10-1 presents the share of sites by business type with Energy Management Systems in the commercial frame. Schools were the only business type to have EMS in more than 5% of their sites. Fifteen percent of Schools had EMS on-site while only 1% of sites in Restaurants and Warehouses have Energy Management Systems within their business segment.

Table 10-1: Share of Energy Management Systems by Business Type

Business Type	CSS On-sites Completed	Share of sites with EMS	Relative Precision
Food/Liquor	127	4%	21%
Health/Medical - Clinic	128	4%	20%
Miscellaneous	246	2%	13%
Office	246	3%	15%
Restaurant	170	1%	16%
Retail	233	2%	15%
School	161	15%	30%
Warehouse	128	1%	24%
n	**1,439**	**202**	

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis.

Table 10-2 show the share of sites with EMS within CSS businesses by utility, weighted by site weights. PG&E and SDG&E have a slightly larger share of businesses with EMS compared to SCE utility service area.

Table 10-2: Share of Energy Management Systems by Utility, Site Weighted

Utility	CSS On-sites Completed	Share of Sites with EMS	Relative Precision
PG&E	573	3%	9%
SCE	642	2%	8%
SDG&E	224	4%	18%
n	**1,439**	**202**	

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis.

Table 10-3 show the share of businesses by business size weighted by site weights. The data show that Large businesses are significantly more likely to have EMS than Medium, Small, or Very Small businesses. Sixty percent of large businesses are estimated to have an EMS, while less than 1% of very small businesses have EMS. The finding that EMS systems are concentrated in larger sized businesses is consistent with expectations; larger sized businesses have more complicated systems that would benefit from automated EMS.

Table 10-3: Share of Energy Management Systems by Business Size, Site Weighted

Business Size	CSS On-sites Completed	Share of Sites with EMS	Relative Precision
Large	98	60%	22%
Medium	463	22%	17%
Small	484	2%	10%
Very Small	394	0.2%	4%
n	**1,439**	**202**	

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

10.2 EMS Characteristics

Table 10-4 presents information on the self-reported age of installed systems. The data shows that EMS statewide are slightly more likely to have been installed after the last five years than within the last five years.

Table 10-4: Incidence of Energy Management Systems by Age

Age of EMS System	Share of EMS
New (<=5 years)	48%
Old (>5 years)	51%
Don't Know	2%
n	**202**

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis.

Energy Management Systems can come with the capability to be locally controlled, but for some businesses the EMS may be controlled off-site by the corporate office or a third-party. Table 10-5 shows that the largest proportion of EMS are controlled on-site with 62% of EMS systems controlled by on-site personnel. The information collected on-site also indicates that 25% of businesses with EMS report that the system is controlled off-site by a central headquarter. A large majority of businesses controlled off site are businesses in the Retail and School segments. Retails businesses with EMS controlled by a central headquarters likely represent retail chain stores. Schools that are controlled by a central headquarters likely have their EMS controlled through an energy manager at the school administration center.

Table 10-5: Energy Management System Controlled and Operated

EMS Controller	Share of EMS
On-site Personnel	62%
Central Headquarters (Off Site)	25%
External Third-Party	13%
n	**202**

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis.

Energy Management Systems can aid in controlling the energy use of equipment within a single area or multiple areas and buildings. The on-site surveyors collected self-reported information on the business-level control of the EMS. Table 10-6 shows that 68% of Energy Management Systems are used to control equipment within the entire premise.

Table 10-6: Energy Management System Site Controls

EMS Site Level Controls	Share of EMS
All/Entire Premise	68%
Part of Premise	31%
Unknown	1%
n	**202**

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis.

The data collected during the CSS on-site study included information on the end uses controlled by the Energy Management System. EMS can control multiple end uses simultaneously; Table 10-7 shows the share of end uses controlled by EMS weighted by site.[1] HVAC is the end use most commonly controlled by EMS with 78% of businesses with EMS controlling their HVAC units, followed by 59% for indoor lighting and 34% for outside lighting. Table 10-8 shows the distribution of number of end uses controlled by EMS. These data indicated 45% of Energy Management Systems controlled one end use, while 55% controlled more than one end use.

[1] Refrigeration is not included in this list because those control systems were recorded in the Remote Refrigeration Rack Controller section of the study and the analysis can be found in the refrigeration section of the report.

Table 10-7: Share of Energy Management Systems by End-Use Controls

End Use Controls	Share of End Use
HVAC Units	78%
Inside Lighting	59%
Outside Lighting	34%
HVAC Auxiliary	17%
Central Plant (chiller, boiler)	8%
On-Site Generation	5%
Process Equipment	0.4%
Other	1%

*** The results presented above have been weighted by site weights.**

Table 10-8: Distribution of Number of End-Use Controls Controlled by Energy Management Systems

Number Controlled End-Uses	Share of End Use
1	45%
2	24%
3	21%
4	5%
5	5%
6	0.6%

*** The results presented above have been weighted by site weights.**

10.3 Demand Response Energy Management System Participation

Energy Management Systems provide an opportunity for the business to automate their participation in utility DR programs. These systems enable the business to respond to a DR signal sent from the IOU, a third party, corporate head-quarters, or to have a pre-set control strategy for on-site personnel to implement during DR events. The CSS study collected self-reported data to determine if the Energy Management System is used for DR. When the self-reported data was compared to the IOU tracking data a majority of respondents who self-reported their EMS was used for DR appear to have misreported their participation. Due to the high level of confusion concerning DR program participation, the IOU tracking data was used to analyze EMS and participation in DR programs.

Table 10-9 presents the share of businesses with Energy Management Systems who are also demand response participants in the IOU tracking data, by business size. The combining the CSS on-site data for EMS with the program tracking data indicates that 38% of businesses with EMS participate in IOU DR programs. The relatively low share of businesses with EMS that participate in DR indicates that there is substantial remaining DR potential at businesses with

EMS.

The analysis presented in Table 10-9 indicates that for businesses with EMS, those with larger business size are more likely to participate in DR programs than smaller sized ones. Data presented in the CSS Telephone Survey Report for the non-residential frame indicated that large sized sites are significantly more likely to participate in DR programs than smaller sized sites. Therefore, the finding that larger businesses with EMS are significantly more likely to participate in DR is consistent with the overall pattern of DR participation in the non-residential frame.

Table 10-9: Share of Demand Response Participants with EMS by Business Size

Business Size	Yes Demand Response	No Demand Response
Large	74%	26%
Medium	42%	58%
Small	20%	80%
Very Small	0%	100%
Total	**38%**	**62%**
n	**115**	**87**

* **The results presented above have been weighted by site weights.** Totals represent the count of surveyed sites included in the analysis. Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

11

Commercial On-Site Generation

The state of California has a long history of investing in distributed generation programs and technologies. The California legislature implemented laws creating incentives for grid-tied PV systems in 1996 and Californians participated in the national Million Solar Roofs Initiative begun in 1997.[1] The California Self Generation Incentive Program (SGIP) established by AB 970, was designed in response to the energy crisis of 2000[2] and initially conceived as a peak-load reduction program to support the installation of distributed generation and combined heat and power (CHP) technologies on the customer side of the meter. Since its conception, the SGIP has been frequently updated, and currently focuses on goals of peak-load and greenhouse gas reductions, as well as market transformation for distributed generation technologies. The SGIP is one of the longest-running and most successful distributed generation programs in the country. The California Solar Initiative (CSI) began in 2007 as a program designed to rebate the installation of solar technologies on residential and commercial facilities. These programs, in combination with others offered by the California IOUs have encouraged the installation of distributed generation technologies. In addition, the California Long-Term Energy Efficiency Strategic Plan[3] calls for improved integration of DSM, including distributed generation, as it strives to reach the goal of having all commercial new construction, and 50% of commercial existing buildings,, to achieve zero net energy by 2030.

To help provide information on distributed generation technologies within the commercial sector, the CSS study collected information on the distributed generation technologies found on-site. The study collected information on the types of technologies, the number of technologies, and if the technology is a back-up system or a primary generation system.

1 Laying the Foundation for a Solar America: The Million Solar Roofs Initiative. Final Report October 2006. http://www.nrel.gov/docs/fy07osti/40483.pdf. Accessed 1/28/2014.

2 The SGIP program was not formerly implemented until 2001.

3 The California Long-Term Energy Efficiency Strategic Plan: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/

11.1 Sources of Data

11.1.1 Phone and On-Site Surveys

Data collection on energy generation was collected from several sources. The CSS on-site surveys were the primary source, but additional information was collected through the CSS/CMST Telephone Survey, IOU customer information systems, billing data, California Solar Initiative (CSI) PowerClerk,[4] and the Self-Generation Incentive Program.[5] The on-site survey data collected specific information on the type of system, fuel, and size of the distributed generation systems. The phone survey collected self-reported customer information on the power generation programs and the installed technology types. The CIS data combined with on-site information were used to develop business classifications and the billing data was used to develop annual consumption business size information. The CSI PowerClerk and SGIP data was used for system lookups, in the event the on-site customer contact was not knowledgeable about the system details. Table 11-1 lists the number of phone surveys completed, the number of on-site surveys, and the number of on-site surveys where distributed generation systems were observed.

Table 11-1: Phone and On-Site Survey Completes and Sites with Distributed Generation

Business Type	Phone Survey Completes	CSS On-Sites Completes	On- Sites with Generation
Food/Liquor	486	127	17
Health/Medical - Clinic	633	128	28
Miscellaneous	1637	246	43
Office	1313	246	53
Restaurant	595	170	2
Retail	1019	233	29
School	479	161	33
Warehouse	745	128	11
n	**6,907**	**1,439**	**216**

11.2 On-Site Generation Equipment Overview

The survey form was designed to collect data on a wide array of generation technology types, including cogeneration, wind turbines, and fuel cells. However, many of these technology types are more commonly found in larger business types such as hospitals that were not surveyed by CSS. As such, only three types of equipment were captured in the CSS survey: Emergency

4 PowerClerk – CSI Application Portal. https://csi.powerclerk.com/CSILogin.aspx.

5 SGIP Project Information. https://www.selfgenca.com/

generators, Photovoltaic/solar (PV) systems, and a very small number of Cogeneration systems (less than 1%, as seen in Table 11-3).

In addition to the technical details of the power generation systems, the on-site survey collected details on whether a system received incentives or rebates, whether or not they have performance metering, and the first year of operation.

Table 11-2 displays the share of the different on-site generation technology by business types, compared to the population. Most business types do not show a huge difference between the share of emergency generators and photovoltaic (PV) systems. The data collected from schools, however, showed that 15% of them had PV systems installed, compared to only 2% with emergency generators. Similarly, 5% and 4% Offices and Food/Liquor stores, respectively, were found to have emergency generators installed, as opposed to only 1% of each of the same business types with PV systems.

Table 11-2: Share of On-Site Generation Technology Types by Business Type

Business Type	Share of Weighted Businesses with On Site Generation	Photovoltaic Systems	Cogeneration Systems	Emergency Generators
Food/Liquor	4%	1%	0%	4%
Health/Medical - Clinic	6%	3%	0%	4%
Miscellaneous	4%	3%	0%	1%
Office	6%	1%	<1%	5%
Restaurant	2%	0%	0%	1%
Retail	2%	1%	0%	1%
School	17%	15%	<1%	2%
Warehouse	2%	1%	0%	<1%
Total Number of Sites	**216**	**79**	**2**	**161**
Total Number of Systems	**274**	**82**	**2**	**190**

*** The results presented above have been weighted by site weight.**

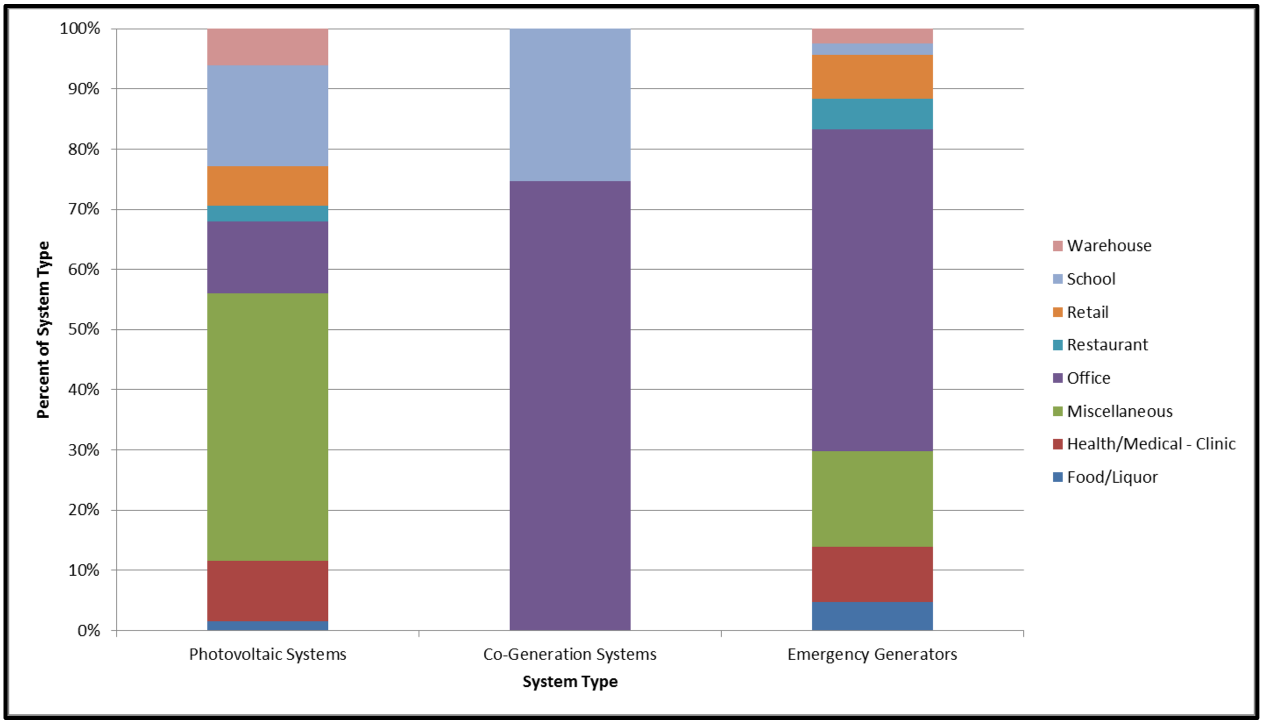
Table 11-3 shows the systems found on-site, distributed by system type across business type. When splitting out these systems by Distributed Generation and Backup/Emergency Generation, Primary or Distributed Generation make up about 40% of the total on-site generation systems, while the other 60% are Backup/Emergency Generators.

Table 11-3: Distribution of On-Site Generation Systems by Business Type

Business Type	Photovoltaic Systems	Cogeneration Systems	Emergency Generators
Food/Liquor	2%	0%	5%
Health/Medical - Clinic	10%	0%	9%
Miscellaneous	45%	0%	16%
Office	12%	75%	53%
Restaurant	3%	0%	5%
Retail	7%	0%	7%
School	16%	25%	2%
Warehouse	6%	0%	3%
Total Number of Sites	**79**	**2**	**161**
Total Number of Systems	**82**	**2**	**190**

*** The results presented above have been weighted by site weight.**

Figure 11-1: Distribution of On-Site Generation Systems by Business Type



*** The results presented above have been weighted by site weight.**

The average generation capacity of the on-site generation systems were also compared, broken down by business consumption size (Table 11-4). The Large businesses show an average generation capacity of 471 kW for PV systems and 627 kW for emergency backup generators. Cogeneration system size was collected for one of the two generators found. Across all systems, PV systems had an average capacity of 92 kW and 147 kW for emergency generators.

Table 11-4: Average Generation Capacity (kW) by System Type and Business Size

Business Size	Photovoltaic System Average Size (kW)	Emergency Generator Average Size (kW)	Cogeneration System Average Size (kW)[6]
Large	471	627	500
Medium	161	152	0
Small	60	51	0
Very Small	5	5	0
Weighted Average	**92**	**147**	**500**

*** The results presented above have been weighted by site weight.**

11.3 Distributed Generation

The Distributed Generation data was separated into two sets of data; Photovoltaic (PV) Systems and Cogeneration Systems. As shown in Table 11-3, Photovoltaic systems made up the large majority of Distributed Generation systems, less than 1% of the systems found were Cogeneration systems. Cogeneration systems are typically found in business types that were not covered by the CSS study.

11.3.1 Cogeneration Systems

The survey was designed to collect details for Cogeneration systems, including which end-use the generated heat is used for, whether they were used for demand response programs, the percent of electricity sold back to utilities, along with other details. The two Cogeneration systems found were in SCE's territory at an Office and a School. Both of the Cogeneration systems were Internal Combustion Engines (ICE). Generation capacity was only available for one of the systems, which was a 500kW system. One of the systems used the waste heat for space heating, whereas this information was unavailable for the other system.

11.3.2 Photovoltaic (PV) Systems

PV systems are found in all CSS business types. The data specific to PV systems that was collected included make and model of the PV panels,[7] the system's mounting type, and the system tracking type. As shown in Table 11-5, the largest percentages of PV systems are installed in the Miscellaneous (44%), School (17%) and Office (12%) business types. The average size of the installed PV systems varies from 5 kW to 240 kW. The small 5 kW average

6 The average size presented for Cogeneration Systems is based on a single system.

7 Make and model information of the PV panels were identified for 40% of the systems.

for Restaurants is due to the fact that within the CSS sample of on-sites there is only one Restaurant with a PV system and the observed system was very small. The right most column in Table 11-5 presents information on the share of businesses with PV systems for all CSS business types. These data indicate that only a very small percentage of CSS businesses have PV systems. Schools have the highest share of businesses with PV systems with 15% of Schools having PV systems.

Table 11-5: Distribution and Average Size of PV Systems by Business Type

Business Type	Distribution of PV Across Business Types	Average PV System Size (kW)	Percent of Business Type that have PV Systems
Food/Liquor	2%	133	1%
Health/Medical - Clinic	10%	44	3%
Miscellaneous	44%	49	3%
Office	12%	93	1%
Restaurant	3%	5	<1%
Retail	7%	240	1%
School	17%	73	15%
Warehouse	6%	211	1%
n	**82**		

* **The results presented above have been weighted by site weight.** The n represents the count of surveyed systems included in the analysis.

For many business types, PV systems are more common in Small and Very Small businesses. The size classification of businesses in this Study, however, is based on their IOU annual electricity consumption. Given that the business size variable is based on a business's IOU annual electricity consumption, it is possible that PV systems are more common in Small and Very Small sized businesses because the PV system has reduced the businesses electricity consumption from the IOUs.

To gather some information of the influence of PV systems on the business's IOU electricity consumption, IOU electricity intensities (EI) for businesses with PV systems are compared to those without PV systems (shown in Table 11-6). For businesses with PV systems, the business EI represents the IOU electricity consumption divided by the business floor area. If PV systems are significantly reducing the IOU electricity consumption of businesses, the EI for businesses with PV systems should be less than for businesses without PV.[8] The data presented in Table

[8] For PV systems to lead to a lower average EI for businesses with PV than for businesses without PV, it must be assumed that all sized businesses are equally likely to install PV or that businesses with PV and those without PV are similar prior to the installation of PV. This statement is unlikely to be accurate. Section 3 of the Commercial Saturation Survey and Market Share Tracking Phone Survey Findings presents data on DG program participation within the non-residential frame that indicates that DG tend to be Large sites. Therefore, even if

11-6 provides some, but not conclusive support for the hypothesis that PV systems have reduced the energy intensity of sites with PV relative to those without.

The CSS on-site survey included 79 sites with PV systems. Analysis of the impact of PV systems on the IOU electricity consumption and the IOU business EI may require more PV sites or an examination of the IOU energy consumption of the 79 sites over time.

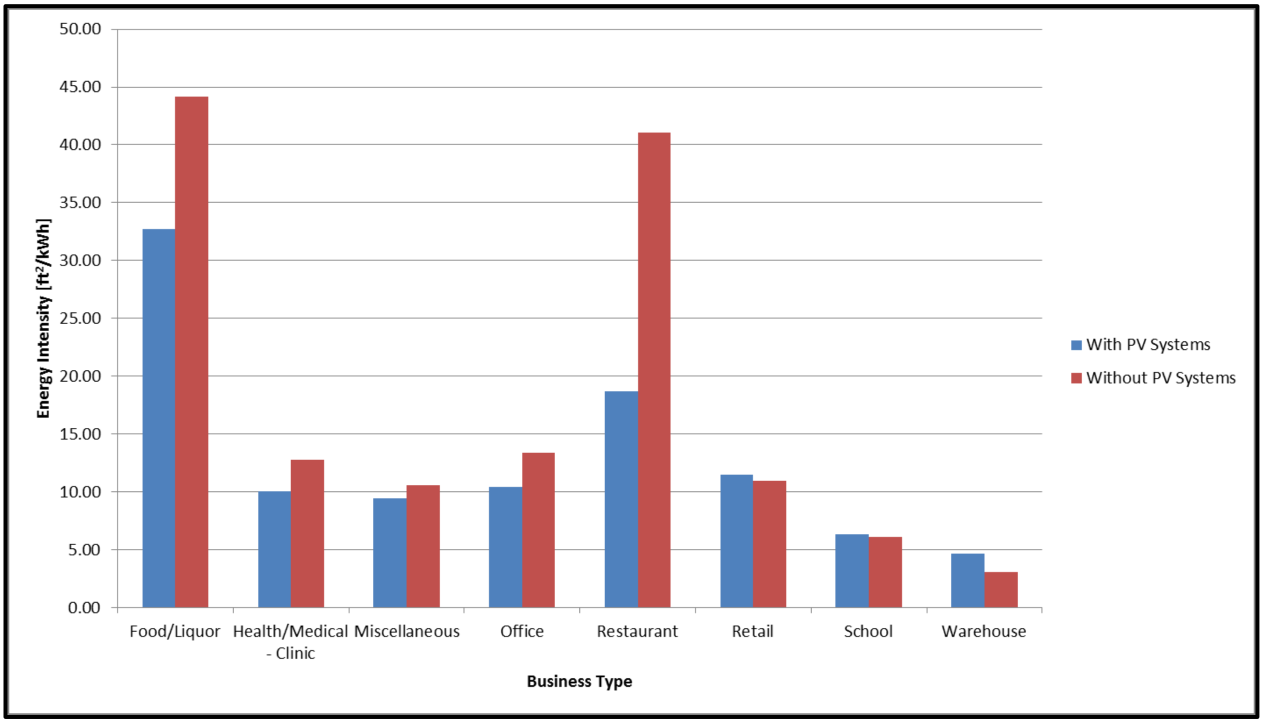
Table 11-6: Energy Intensities of Business Types with PV and without PV

Business Type	With PV Systems	Without PV Systems
Food/Liquor	32.75	44.20
Health/Medical - Clinic	10.04	12.74
Miscellaneous	9.41	10.54
Office	10.42	13.38
Restaurant	18.66	41.09
Retail	11.51	10.96
School	6.35	6.06
Warehouse	4.64	3.02

*** The results presented above have been weighted by site weight.**

PV reduces a business's EI it may not reduce it to the degree where the average for businesses with PV is less than those without.

Figure 11-2: Energy Intensities of Business Types with PV and without PV



* **The results presented above have been weighted by site weight.**

PV Year of Operation, by Business Type

The year of PV system installation and initial operation was collected, where possible, for PV systems. For 56% of the observed systems a self-reported year of installation and operation was collected. These data are presented in Table 11-7. The majority of systems for which the year of installation was available were installed between 2009 and 2012.

Table 11-7: Distribution of PV Systems by Year of Operation

Business Type	2000-2003	2004-2008	2009-2012	2013
Food/Liquor	0%	59%	41%	0%
Health/Medical - Clinic	10%	6%	84%	0%
Miscellaneous	0%	12%	88%	0%
Office	8%	4%	84%	4%
Restaurant	0%	100%	0%	0%
Retail	5%	53%	24%	18%
School	0%	6%	83%	11%
Warehouse	0%	89%	11%	0%
n	**4**	**10**	**28**	**4**

* **The results presented above have been weighted by site weight**. Totals represent the count of surveyed systems included in the analysis.

Emergency Generators

Emergency or backup generators identified on-site were either Internal Combustion Engines or Gas Turbines.[9] Gas Turbines made up less than 1% of the weighted distribution of systems, and all but one was found in Large businesses. In addition to the type of system, information collected for emergency generators include system fuel type, test frequency, and whether or not the system was used for demand response (DR).[10]

Table 11-8 provides the distribution of emergency generators by business type. Fifty three percent of the emergency generators are found in Offices, followed by Miscellaneous businesses at 16% of systems. The average size of these systems ranged from 12 kW in Restaurants to 253 kW in Miscellaneous businesses. Warehouses have an average emergency generator size of 698 kW due to the presence of two very large generators within Warehouses visited during the CSS on-site study.[11] From 1% to 5% of all businesses were found to have emergency generators.

Table 11-8: Distribution and Average Size of Emergency Generators, by Business Type

Business Type	Percent of Businesses with Emergency Generators	Distribution Across Business Types	Average Emergency Generator Size (kW)
Food/Liquor	4%	5%	43
Health/Medical - Clinic	4%	9%	117
Miscellaneous	1%	16%	253
Office	5%	53%	122
Restaurant	1%	5%	12
Retail	1%	7%	91
School	2%	2%	92
Warehouse	1%	2%	698
n		**190**	

* **The results presented above have been weighted by site weight**. Totals represent the count of surveyed systems included in the analysis.

Emergency Generators are concentrated in the Large and Medium sized businesses (see Table 11-9). Fifty eight percent of Large sized businesses are found to have Emergency Generators while 13% of Medium businesses have Emergency Generators. The average size of Emergency Generator also declines as the size of the business declines.

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[9] There was one system where the surveyor was not able to determine its technology type.

[10] Thirteen percent of the sites with Emergency Generators were also participants of DR programs. Less than 3% of systems were customer self-reported during the on-site survey to be used for demand response.

[11] There are two large warehouses that have very large emergency generators and these sites represent 76% of the Warehouse business type.

Table 11-9: Distribution and Average Size of Emergency Generators, by Business Size

Business Size	Percent of Businesses with Emergency Generators	Distribution Across Business Types	Average Emergency Generator Size (kW)
Large	58%	16%	627
Medium	13%	27%	152
Small	5%	57%	51
Very Small	<1%	<1%	5

* **The results presented above have been weighted by site weight.** Large sites have annual usage over 1,750,000 kWh, Medium have greater than 300,000 kWh and less than or equal to 1,750,000, Small have max annual usage greater than 40,000 kWh and less than or equal to 300,000, Very Small have annual usage less than or equal to 40,000 kWh.

Emergency Generators Year of Operation, by Business Type

The year of installation and initial operation for Emergency Generators was collected for 62% of the systems surveyed.[12] The distribution of Emergency Generator age by business type is presented in Table 11-10. In contrast to the age distribution for PV systems presented in Table 11-7, the majority of Emergency Generators were installed prior to 2004.

Table 11-10: Distribution of Emergency Generators by Age by Business Type

Business Type	Pre-2000	2000-2003	2004-2008	2009-2012
Food/Liquor	38%	41%	21%	0%
Health/Medical – Clinic	30%	58%	12%	0%
Miscellaneous	23%	14%	30%	33%
Office	16%	3%	16%	66%
Restaurant	0%	0%	0%	0%
Retail	0%	70%	14%	17%
School	51%	13%	11%	25%
Warehouse	54%	46%	0%	0%
n	**50**	**34**	**20**	**13**

* **The results presented above have been weighted by site weight**. Totals represent the count of surveyed systems included in the analysis.

[12] The survey form specifically asked for “Year System began Operation”. In some cases, this wasn’t available from the site contact, so the year of installation may have been reported instead.

Emergency Generator Test Frequency

The CSS study collected self-reported information on the frequency of testing for Emergency Generators. Information on the frequency of testing is presented in Table 11-11. These data show that weekly testing is the most common testing interval followed by monthly testing.

Table 11-11: Distribution of Emergency Generators Test Frequency

Test Frequency	Distribution
Annually	6%
Semi-Annually	3%
Quarterly	5%
Bi-Monthly	4%
Monthly	33%
Bi-Weekly	2%
Weekly	47%
Other[13]	2%

* **The results presented above have been weighted by site weight**. Totals represent the count of surveyed systems included in the analysis.

[13] One system was reported as being tested once every 7 months while the other reported once every 3 years.