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California Commercial Saturation Survey

Prepared for California Public Utilities Commission

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Executive Summary

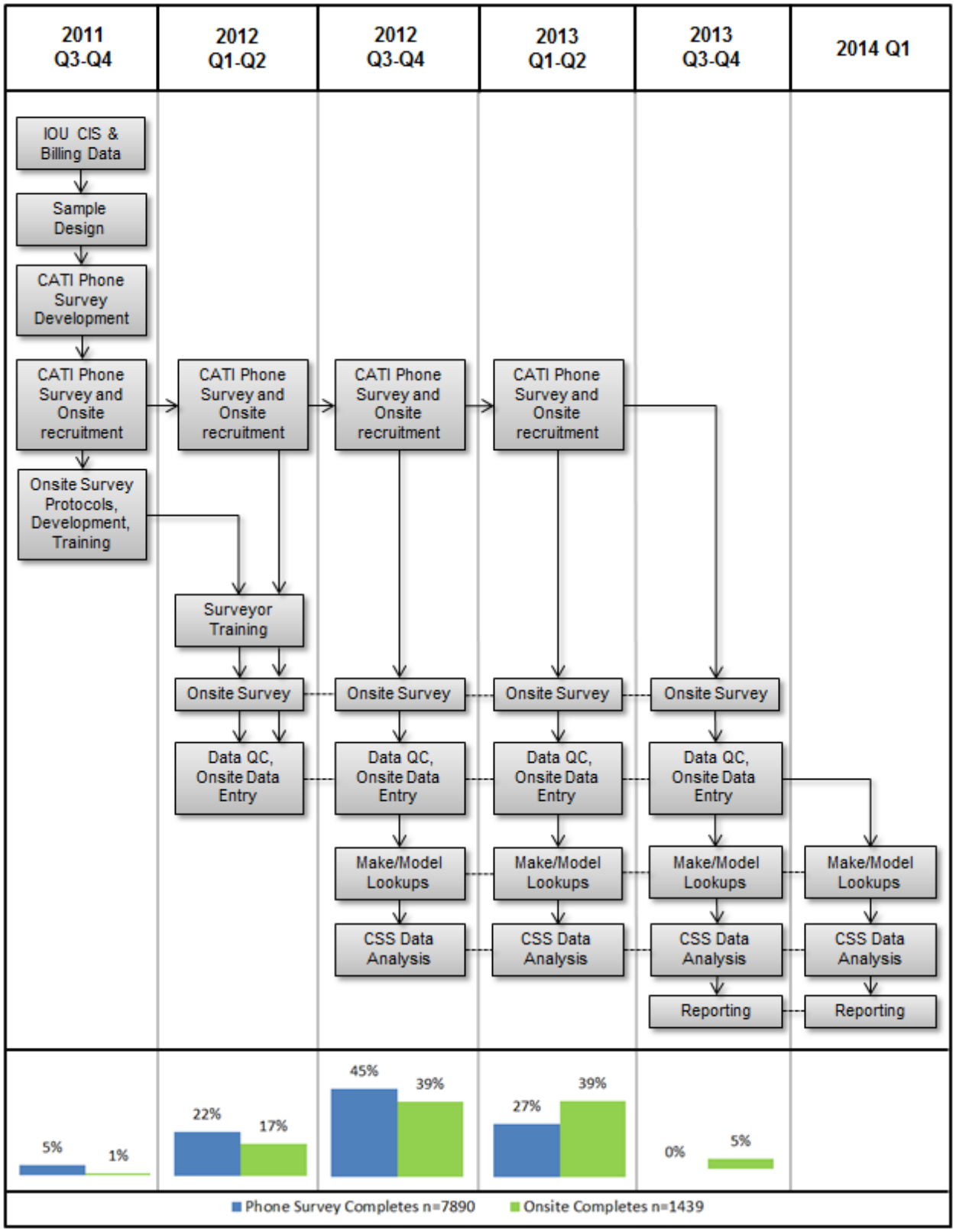
ES.1 Introduction

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.

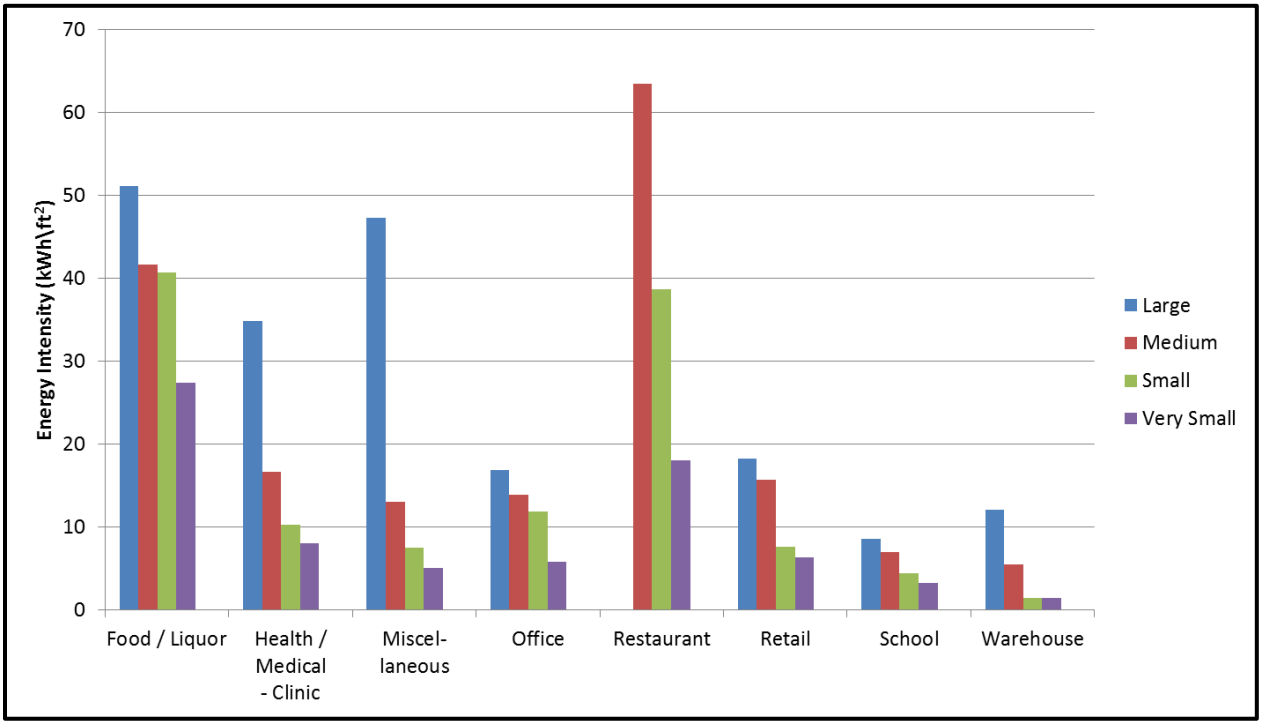
[3] The unknown usage category represents accounts found in the CIS that do not have a matching record in the billing data. As part of the on-site data collection effort, meter numbers were collected and unknown business size was resolved during the meter lookup process. This effort resulted in the on-site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

[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.

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.

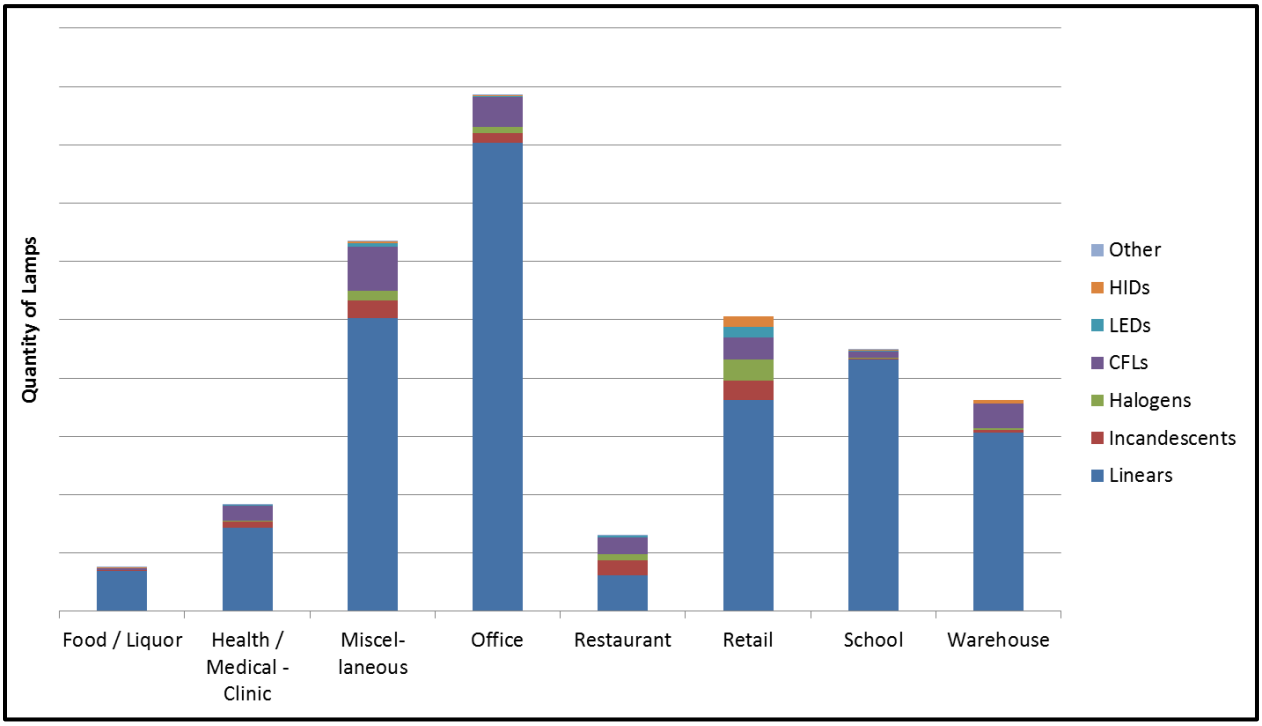
8 The business type definitions between the CSS and CEUS are not exactly the same. The CEUS sample design was based on SIC codes. The CSS sample design was based on NAICs codes. Both studies include appendices with a business type to NAICS/SIC code mapping. Additional information on business type differences 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

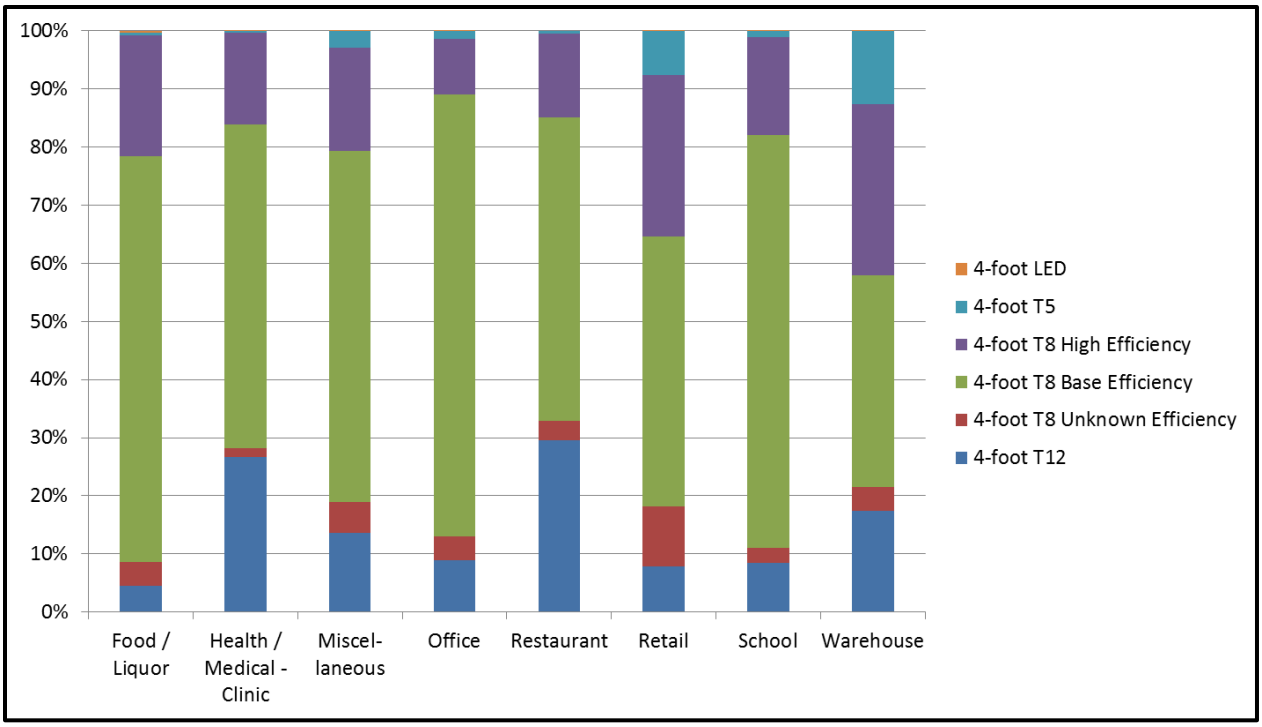


*** The results presented above have been weighted by site weight.**

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.

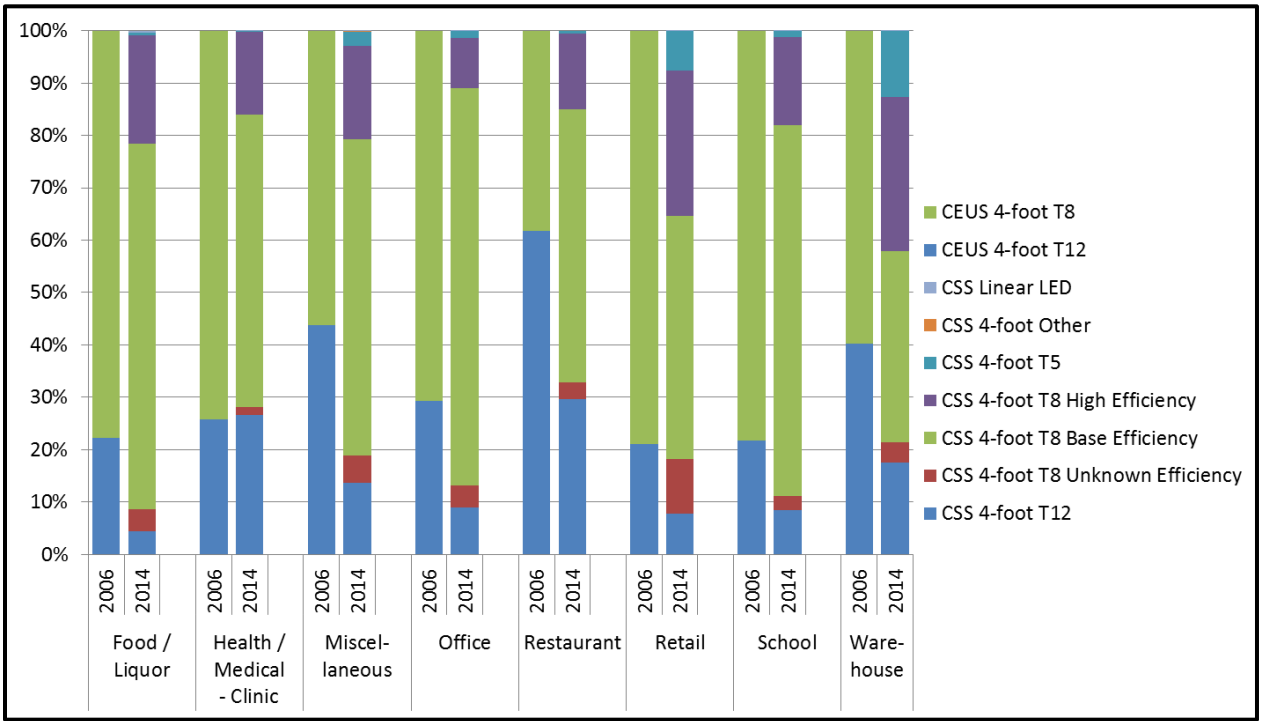
Figure ES-4: Interior Four Foot Linear Lamp Efficiency Distribution by Business Type



*** 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**

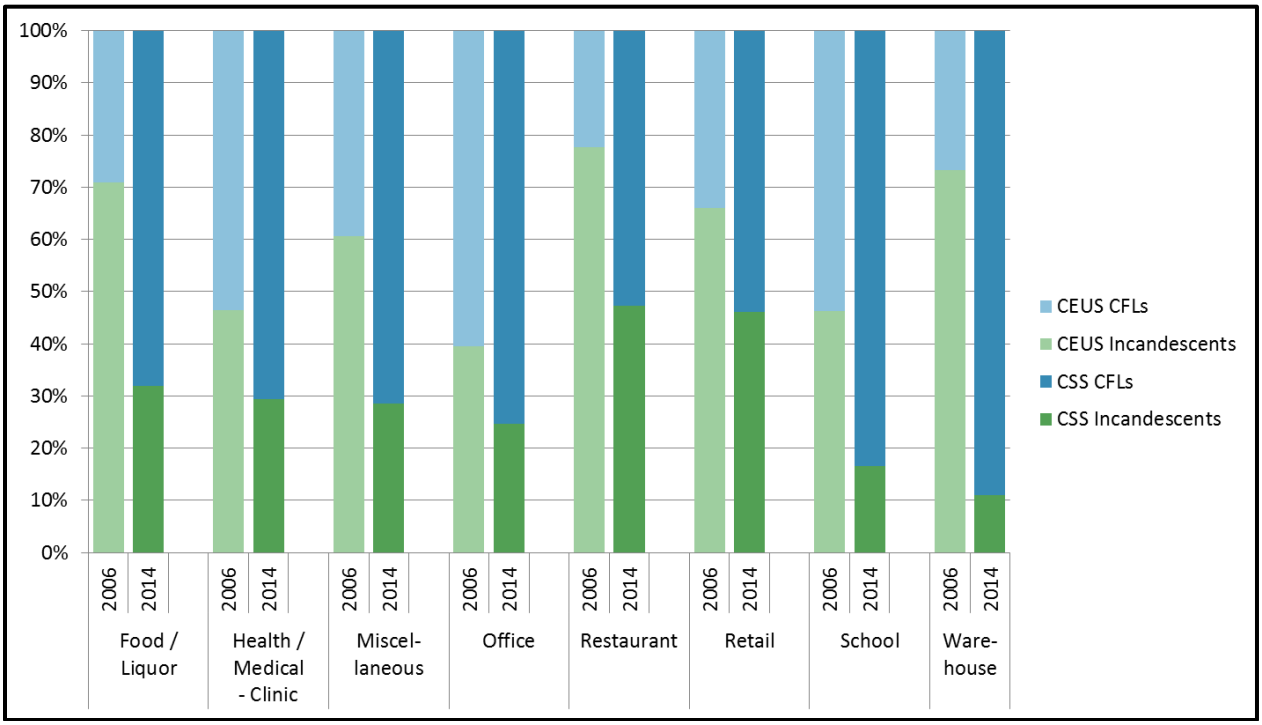
*** The results presented above have been weighted by site weight.** *n*'s represent the number of surveyed sites included in the analysis. *** denotes that participant and non-participant percentages are significantly different at a 1% significance level, ** denotes a 5% significance level, and * denotes 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

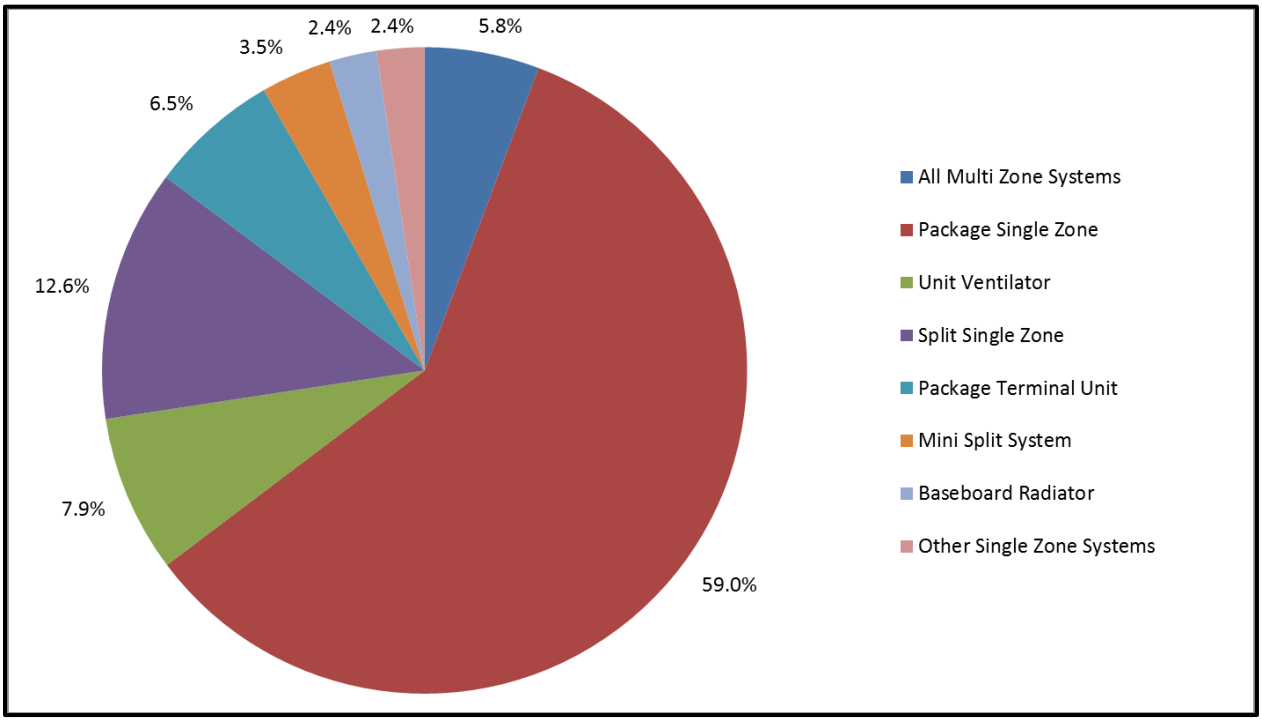
Heating, ventilation, and air conditioning (HVAC) systems represent a significant fraction of energy use and peak demand within the commercial sector. The 2006 California Commercial End Use Survey (CA CEUS) estimated that HVAC end uses account for approximately 29% of the electricity use in the commercial 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.

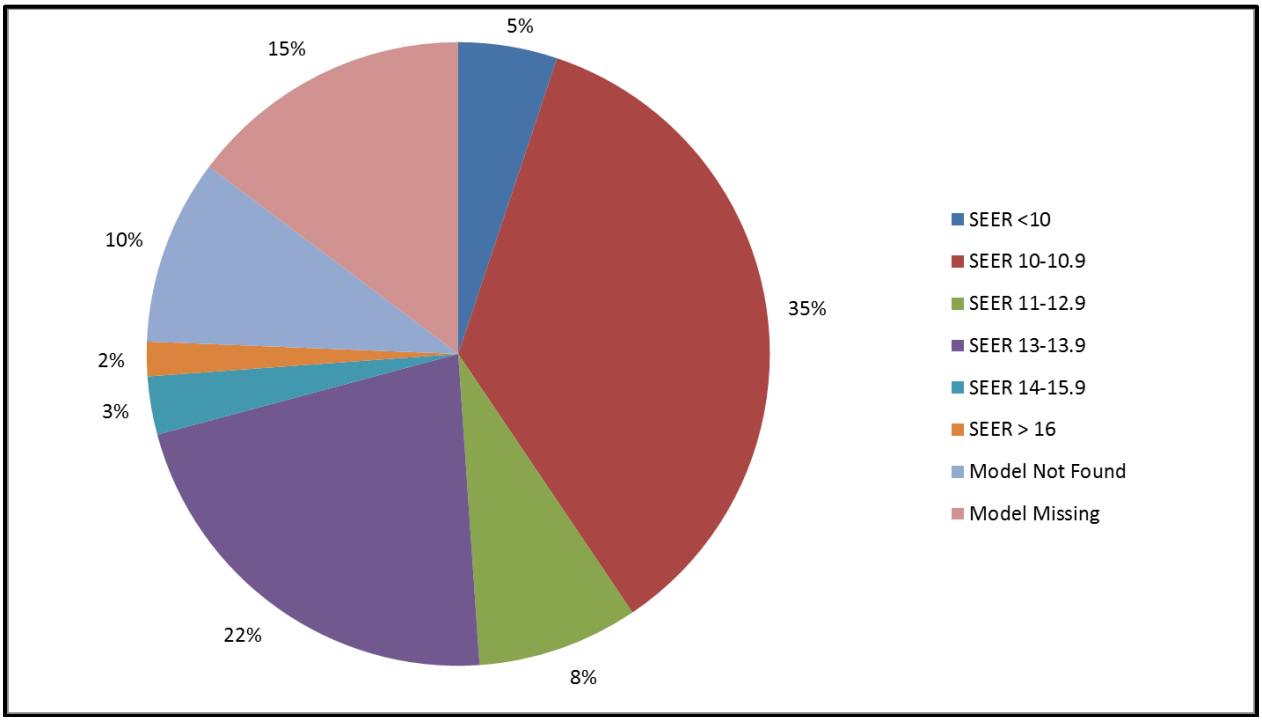
Figure ES-7: Distribution of HVAC Units by System Type



*** 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.

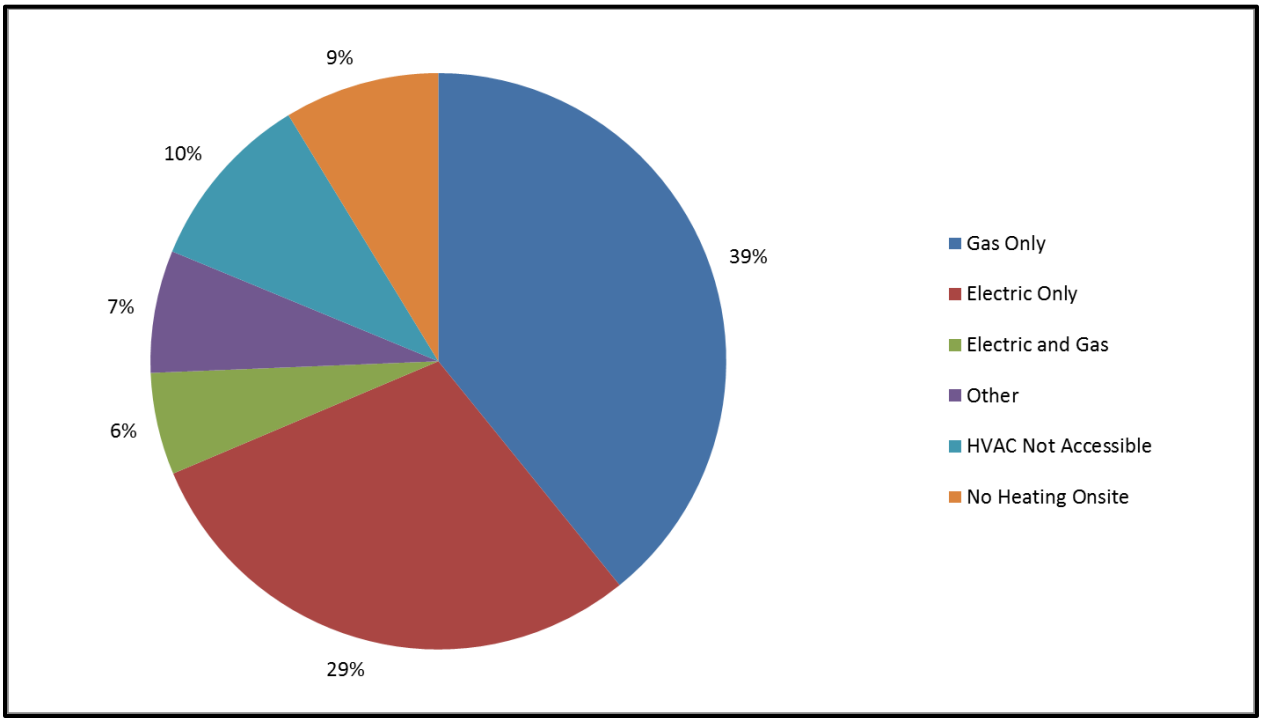
Figure ES-8: Efficiency Distribution for CSS Small PSZ and SSZ Units



*** 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.

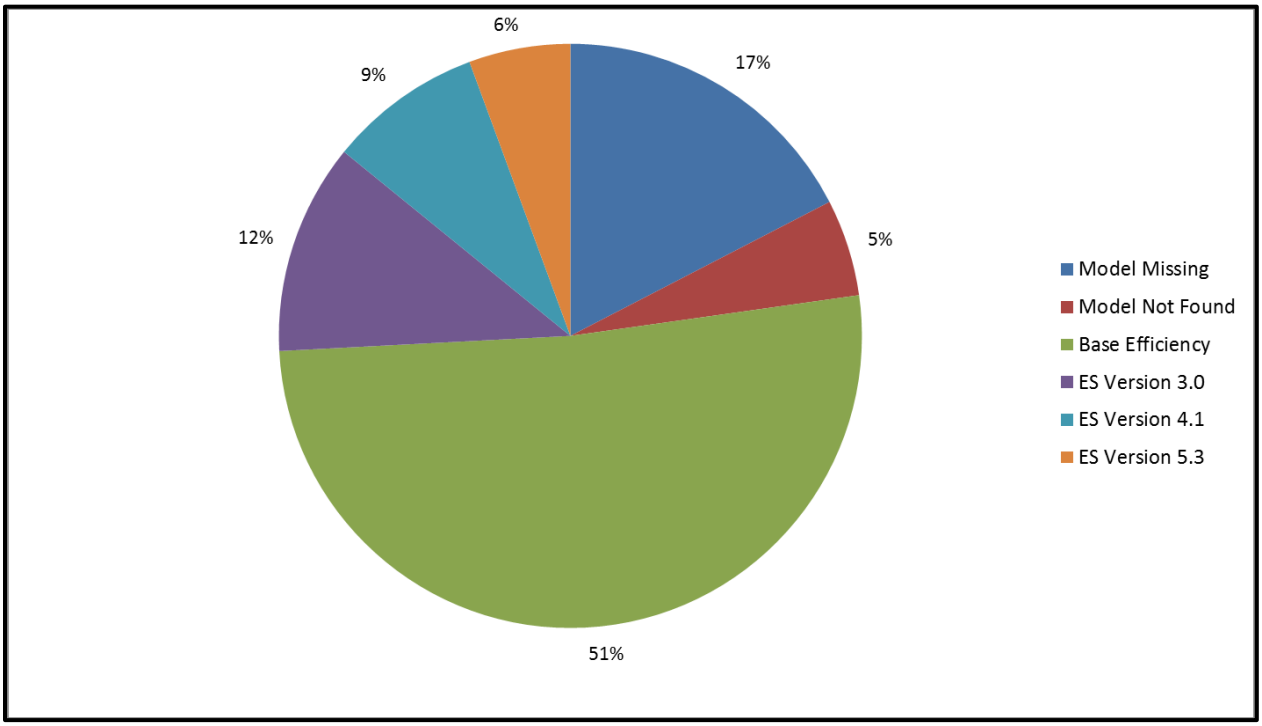
Table ES-5: TV Type Distribution, Average Age, and Screen Size

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.

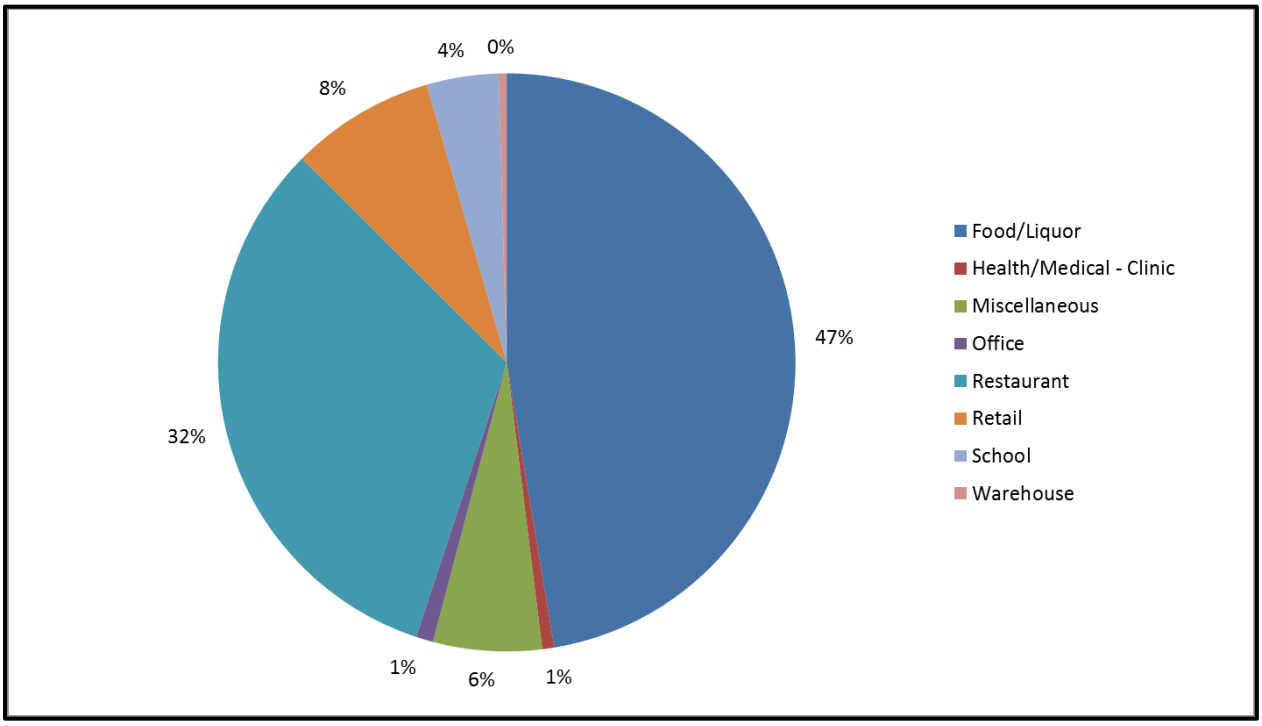
Table ES-6: Distribution of Businesses with Different Types of Refrigeration

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.