Energy Research and Development Division
FINAL PROJECT REPORT

LIGHTING ELECTRICITY USE IN CALIFORNIA

Baseline Assessment to Support AB 1109 (Task 2.18)

Prepared for: California Energy Commission
Prepared by: California Lighting Technology Center

MAY 2014
CEC-500-2014-039

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Contract Number: 500-08-053

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ACKNOWLEDGEMENTS

The author wishes to thank Kelly Cunningham, Thomas Herbert and Hairong Si of the California Lighting Technology Center for their valuable contributions to this report.

PREFACE

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Lighting Electricity Use in California: Baseline Assessment to Support AB 1109 is the final report for the Task 2.18 – AB 1109 Baseline project (contract number 500-08-053) conducted by the California Lighting Technology Center. The information from this project contributes to Energy Research and Development Division's Buildings End-Use Energy Efficiency Program

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ABSTRACT

The California Legislature mandated a reduction in lighting energy use in the commercial and residential building sectors per Assembly Bill 1109, Lighting Efficiency and Toxins Reduction Act (Assembly Bill 1109, Huffman, Chapter 534, Statutes of 2007). Under Assembly Bill 1109, electrical energy-use reductions between 2007 and 2018 must reach 50 percent for residential interior lighting and 25 percent for commercial interior and outdoor lighting. To measure savings against these goals, lighting energy use in 2007 must be quantified and a baseline established. This work describes the methods used and results obtained to determine this 2007 baseline.

Based on trend analysis of historical data, California consumed a total of 57,213 gigawatt-hours of electricity in 2007 for residential interior, commercial interior and outdoor lighting. Commercial interior lighting consumed approximately 50 percent of this total at 28,714 gigawatt-hours while outdoor lighting and residential interior lighting consumed the remainder at 12,423 gigawatt-hours and 16,076 gigawatt-hours, respectively.

Following a period of aggressive economic growth and increased electricity consumption in the mid to late 2000's, lighting energy use in all sectors appears to be declining. The general decline in lighting electricity use, as a percentage of total electricity use, is the result of several influencing factors including efficiency programs, economic conditions, technology improvements, building codes, and appliance standards. Between 2007 and 2010, lighting electricity reductions are estimated at 4,525 gigawatt-hours for sectors affected by Assembly Bill 1109. In the residential sector, lighting electricity use per occupied household is down by approximately seven percent. Electricity use intensity (kilowatt-hours/square foot) for commercial interior lighting is down by more than 13 percent and electricity use for outdoor lighting has declined by almost six percent when normalized with total occupied California households. These results are encouraging, and demonstrate that California may be on its way to meeting the Assembly Bill 1109 energy savings goals.

Keywords: Assembly Bill 1109, lighting, consumption, energy, electricity, commercial buildings, residential buildings, outdoor

Please use the following citation for this report:

Jackson, Cori and Konstantinos Papamichael. (California Lighting Technology Center, University of California, Davis). 2013. ***Lighting Electricity Use in California – Baseline Assessment to Support AB 1109.*** California Energy Commission. Publication number: CEC-500-2014-039.

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EXECUTIVE SUMMARY

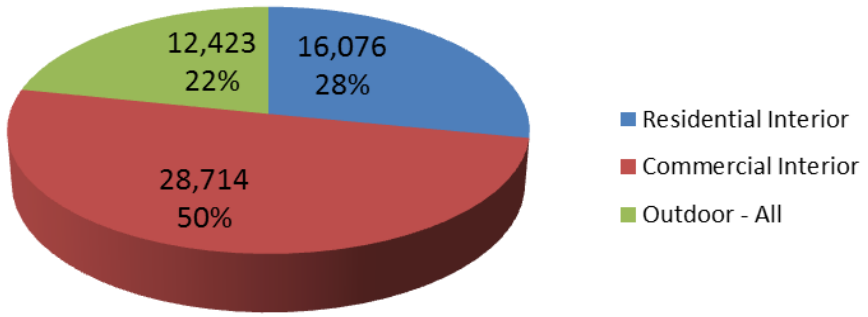
The California legislature has mandated that lighting electrical energy use in the state's commercial and residential building sectors must be reduced. Assembly Bill 1109, Lighting Efficiency and Toxins Reduction Act (Huffman, Chapter 534, Statues of 2007), signed in 2007, mandates that between 2007 and 2018 electrical energy use reductions must reach 50 percent for residential interior lighting and 25 percent for commercial interior and outdoor lighting. To measure progress against these goals, a 2007 lighting energy use baseline must first be determined.

Historical data from existing lighting surveys and studies have been used to conduct trend analysis estimating California's 2007 lighting electricity use. The analysis contained in this report is based on a collection of secondary data sources and publications produced between 1995 and 2010; it does not use any new primary data such as building audits or owner surveys. Existing data was used to create a timeline of lighting electricity use between 1995 and 2010 for each sector affected by AB 1109. Some regional data, collected by the United States Department of Energy, was included to supplement the California information when California data was not available.

Lighting energy use, for this analysis, is compared in an absolute and normalized (isolating energy-use fluctuations resulting from non-efficiency measures, and allows for a true comparison of savings – see Chapter 1 of report for more information) manner California's electricity use, in whole, typically grows over time due to growth in the state's population and building stock. The lighting electricity savings expected by 2018 cannot only be compared to a 2007 baseline in an absolute manner. A normalized quantity is required to isolate potential savings from energy-use increases attributable to changes in population or building stock. For commercial lighting use, absolute values were normalized to commercial floor space. Residential and outdoor lighting use was normalized to occupied California households. Both values are provided in this report.

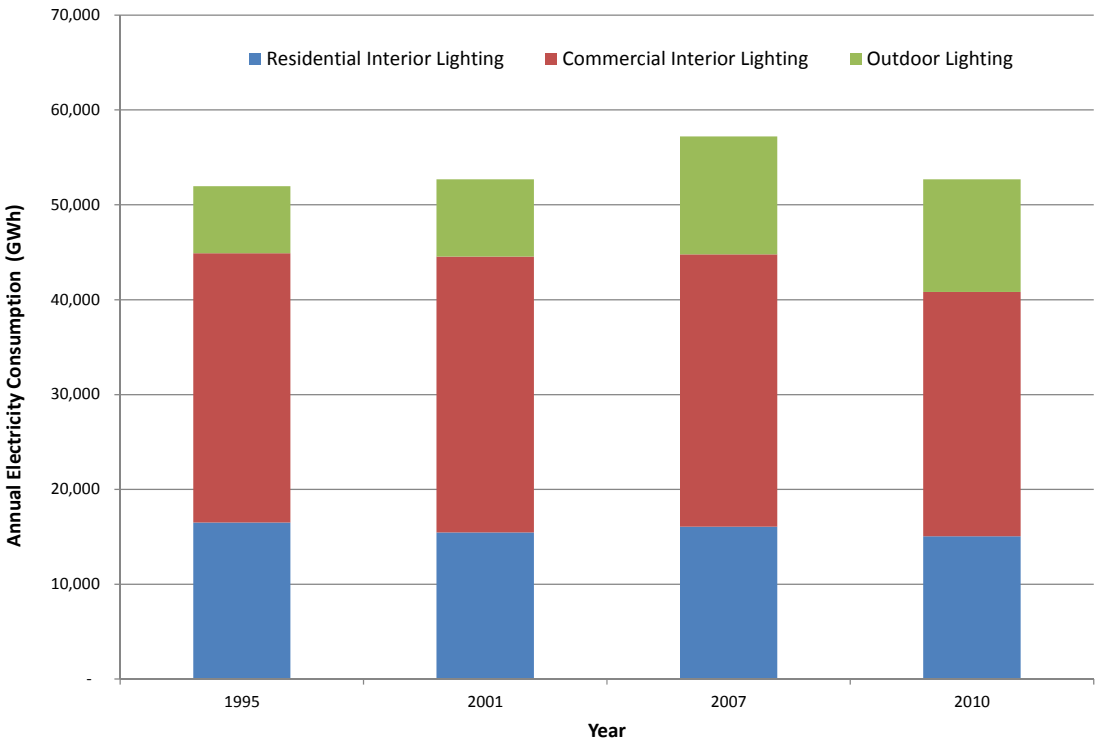
Based on trend analysis of historical data, in 2007 California is estimated to have consumed a total of 57,213 gigawatt-hours of electricity for residential interior, commercial interior and outdoor lighting (Figure 1). Commercial interior lighting consumed approximately 50 percent of this total at 28,714 gigawatt hours, while outdoor lighting and residential interior lighting accounted for 12,423 gigawatt hours and 16,076 gigawatt hours, respectively.

Figure 1: California Lighting Electricity Use (Gigawatt Hours) – 2007



Trends show that lighting electricity consumption for affected sectors peaked between 2006 and 2008 Figure 2). Between 2004 and 2005, new residential construction hit a 15-year high, increasing demand for residential electricity (Department of Finance 2011). Following these record-high years, residential interior lighting use peaked in 2006 at 16,429 gigawatt hours. Commercial interior lighting peaked that same year at 28,876 gigawatt hours. Overall, exterior lighting shows a slow yet steady increase throughout much of the analysis period, peaking in 2008 at 12,776 gigawatt hours.

Figure 2: California Lighting Electricity Consumption, All Sectors, Select Years



Following this period of aggressive growth, lighting electricity use in all sectors appears to be dropping. Between 2008 and 2010, electricity use, across the commercial and residential sectors declined, resulting in a similar decline in lighting electricity use. Lighting electricity reductions between 2007 and 2010 is estimated at 4,525 gigawatts. Residential lighting electricity use per occupied California household is down by more than seven percent. Commercial interior lighting electricity use is down by approximately 13 percent and outdoor lighting electricity use has declined by nearly six percent. The combination of total reduced electricity use and lighting consumption contributed to the decline in residential lighting electricity use, even though the population increased during the analysis period. Similarly, even though commercial building floor stock increased total electricity use and the portion attributed to lighting declined in lighting electricity since its peak in 2003. These estimates were based on absolute reductions normalized to account for growth in population and building stock. These results are encouraging, and they demonstrate that California may be on its way to meeting its lighting energy reduction goals mandated by Assembly Bill 1109.

CHAPTER 1:
Background & Methodology

1.1 Background

In 2007, California approved AB 1109 (AB 1109, Huffman, Chapter 534, Statutes of 2007), requiring regulations to reduce California's lighting electrical energy use.

> 25402.5.4. (a) On or before December 31, 2008, the commission shall adopt minimum energy efficiency standards for all general purpose lights on a schedule specified in the regulations. The regulations, in combination with other programs and activities affecting lighting use in the state, shall be structured to reduce average statewide electrical energy consumption by not less than 50 percent from the 2007 levels for residential lighting and by not less than 25 percent from the 2007 levels for indoor commercial and outdoor lighting, by 2018.

Implementing AB 1109, also referred to as the Huffman Bill, requires de-terminating California's 2007 lighting energy use baseline, using metrics that facilitates the regulations development and monitoring the progress for each of the three affected lighting sectors. Before this important step, a clear definition and interpretation of the AB 1109 language was required. The following sections present and discuss the components of the Huffman Bill, and the assumptions required to determine the 2007 lighting baseline.

1.1.1 Bill Interpretation and Definitions

Before data analysis, the California Lighting and Technology Center (CLTC) analyzed the AB 1109 language to determine the affected sectors, baseline requirements and metrics required to demonstrate savings. The bill affects three lighting categories:

- Indoor commercial lighting
- Indoor residential lighting
- Outdoor lighting

Interior commercial lighting and interior residential lighting are fairly well defined market segments; however, the outdoor lighting definition as it relates to a specific sector or segment of the California building population was not provided in the bill and using this term is vague. Descriptions and analysis of each affected lighting market segment are provided with adopted definitions for the three affected sectors.

1.1.1.1 Indoor Commercial Lighting

A commercial lighting definition was not provided in AB 1109. Review of other state documents, codes and standards was conducted in order to best align the adopted definition for commercial lighting with existing legislation. The most relevant definition was found in the California Energy Code, California Code of Regulations (CCR) Title 24, Part 6 – Section 101 (Title 24). Per Title 24, the commercial building market consists of all commercial facilities intended for nonresidential use and whose operations will affect commerce, including

warehouses, office buildings, and other buildings where employment may occur. Some industrial and agricultural facilities such as data centers, clean rooms and manufacturing or food processing operations are not included under the current Title 24 definition of commercial buildings. There is also a lack of available end-use electricity data for the industrial and agriculture sector. Using the Title 24 definition for commercial buildings will not address all nonresidential spaces. After review and discussion with the California Energy Commission's Efficiency and Renewable Energy Division, the definition for commercial interior lighting definition used in this report is:

> *Definition:*
> *Indoor commercial lighting consists of all permanently installed lighting in the interior spaces of nonresidential buildings, excluding industrial and agricultural facilities.*

1.1.1.2 Indoor Residential Lighting

Indoor residential lighting is the most clearly defined market segment; however the definition was aligned with Title 24 for consistency. Residential buildings include low-rise and high-rise residential buildings as defined in Title 24. The following definition is identical to that contained in Title 24 and is used in this report:

> *Definition:*
> *Indoor residential lighting consists of all permanently installed lighting in the interior of residential buildings.*

1.1.1.3 Outdoor Lighting

The outdoor lighting definition as it pertains to a specific sector or segment of the California building population is not provided in AB 1109, and the term in the bill is vague. The term "outdoor lighting" is used synonymously with the term "exterior lighting" within the lighting industry; however, the term "outdoor lighting" does not describe a specific lighting market segment such as commercial buildings, residential buildings, industrial facilities, or agricultural facilities.

Four interpretations are possible based on the sentence structure and overall content of the bill. In addition, the current Title 24 outdoor lighting definition could be applied to ensure consistency across state regulations and documentation. Affected market segments for outdoor lighting may be interpreted to include any of the following market segments:

- Outdoor commercial lighting
- Outdoor commercial and outdoor residential lighting
- Outdoor stationary lighting, a term used to describe the sector consisting of roadway, parking, aviation and athletic facilities (and which excludes outdoor commercial or outdoor residential lighting)
- All outdoor lighting – including segments such as industrial lighting and roadway lighting

The definition contained in Title 24 combines and applies to portions of several of these market segments. As Title 24 does not apply to all California building types, the Title 24 outdoor lighting definition does not apply to all outdoor light points. To maintain consistency with the definition of commercial interior lighting, a definition was adopted that includes all outdoor light points within the commercial and residential sectors, including street lighting, and excluding outdoor lighting in the agricultural and industrial sectors due to lack of historical data. This definition is used in the study.

> *Definition:*
> *Outdoor lighting is all permanently installed lighting in outdoor spaces including lighting for the exteriors of both residential and commercial/nonresidential buildings. It includes electrical lighting for streets, parking lots, signs, building entrances, outdoor sales areas, outdoor canopies, landscape lighting, lighting for building facades and hardscape lighting.*

1.2 Methodology

Historical data from existing lighting surveys and studies have been used to conduct trend analysis to estimate California's 2007 lighting electricity use. This is the baseline year that savings will be counted to demonstrate the electrical energy reductions required by AB 1109. The analysis contained in this report is based on a collection of secondary data sources and publications produced between 1995 and 2010; it does not use any new primary data such as additional building audits or owner surveys. Data source descriptions and citations are provided in Appendix A.

AB 1109 specifically calls for the measurement and savings of "average statewide electrical energy consumption." Electrical energy consumption clearly means energy use over time, so the unit of choice for estimating the baseline and future energy savings is the kilowatt-hour (kWh). The baseline period for comparison is "2007 levels," so it must also be assumed, although it is not explicitly stated, that measurements are necessary for average statewide electrical energy consumption and average annual statewide electrical energy consumption, to compare use to 2007 levels.

To estimate lighting electricity use in each sector affected by AB 1109, CLTC applied the formula provided in Equation 1. Data points for total sector electricity and lighting factors were mined from the secondary sources described in the sections that follow.

Equation 1: Sector Electricity Consumption from Lighting

$$E_{SL} = E_S F_L$$

$$S = \text{Sector} = \begin{Bmatrix} RI = \text{Re}\,sidential\_Interior \\ CI = Commercial\_Interior \\ O = Outdoor \end{Bmatrix}$$

E_{SL} = sector electricity consumed by lighting

E_S = total sector electricity consumption

F_L = lighting factor (percent of electricity used for lighting in the sector)

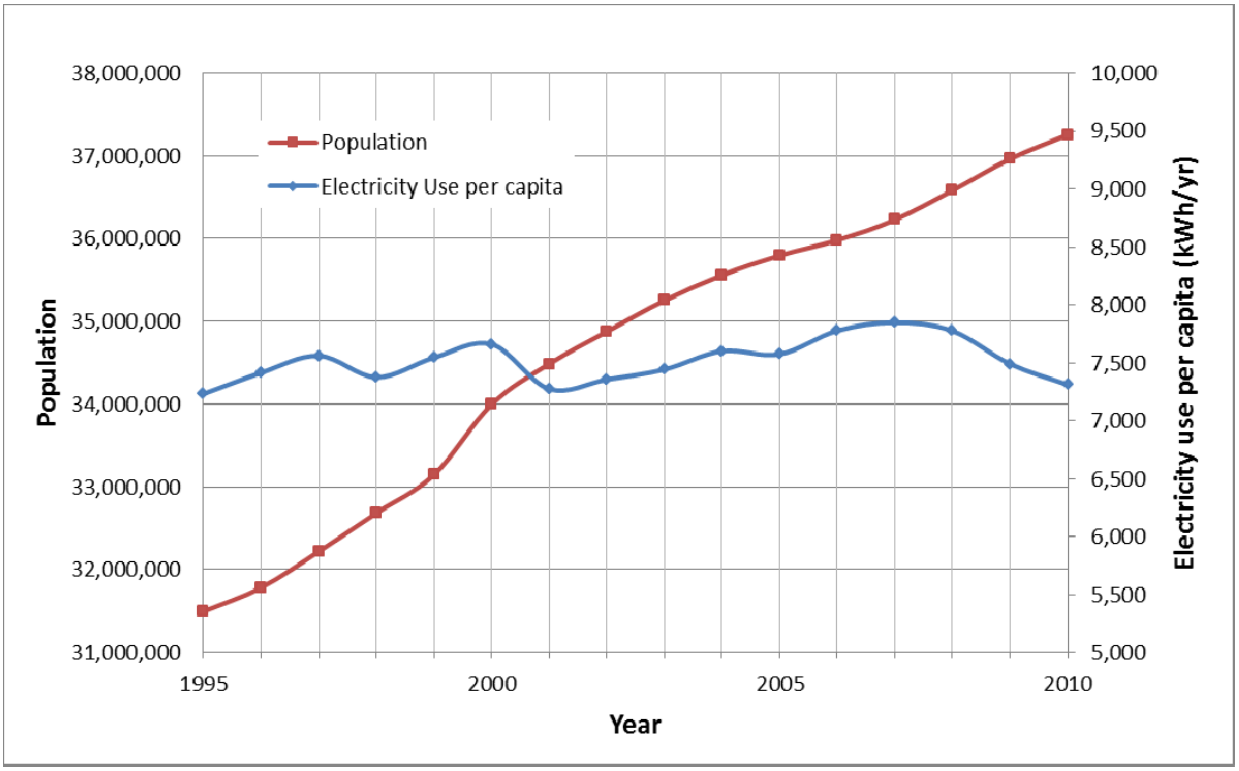
The total electricity consumed by lighting, across all sectors affected by AB 1109, is the sum of these values.

Equation 2: Total Electricity Consumption from Lighting

$$\sum_S E_{SL} = \sum_S E_S F_L$$

Once the total electricity use per affected sector was calculated, changes over time were compared in both an absolute and normalized manner. Normalization isolates changes in energy use due to equipment and building energy-efficiency improvements from fluctuations resulting from population change. Due to growth in population and building stock, total energy use typically grows over time (Figure 3). Assuming a change to California's population increases electricity use beyond any energy-efficiency reductions, then electricity savings achieved by 2018 cannot only be identified in an absolute manner. A normalized quantity is required to isolate overall reductions from increases attributed to changes in population or building stock.

Figure 3: California Electricity Use per Capita and Population, 1995–2010



Source: California Lighting Technology Center calculations.

1.2.1 Information Sources

The sources used in this analysis provide estimates of commercial, residential and outdoor lighting electricity consumption at both the state and national level. Outdoor lighting is the sum of commercial exterior lighting, residential exterior lighting, and street lighting. Results for this sector are an aggregation of exterior end-use values taken from each of the three sectors. Each source is briefly described in Appendix A - Sources, along with links to additional information.

The major analysis components rely on data from the California Energy Commission's (Energy Commission) Electricity Supply Analysis Division for electricity consumption estimates and appliance and end-use energy surveys for the residential and commercial sectors; and baseline lighting studies prepared over the course of the last 15 years. The U.S. Department of Energy (DOE) also provided supplementary data on electricity use at the national level, including end-use estimates for lighting specifically. Whenever possible, lighting use estimates are based on secondary data specific to California, and not national averages.

1.2.2 Sector Electricity Consumption

California electricity consumption forecasts, by sector, are prepared by the Energy Commission's Electricity Supply Analysis Division. This division has historically presented a range of consumption scenarios based on different environmental and economic assumptions. The division relies on pricing, economic and other demographic data and projections provided

by third party groups such as Moody's Analytics and Itron. Historic electricity consumption values for the major California industry sectors are provided in ESAD's periodic electricity forecasts which support analyses and recommendations of the Integrated Energy Policy Report (IEPR).

Electricity consumption estimates used in this analysis represents the Energy Commission's *mid energy-demand* case. This scenario assumes input parameters in between the high and low energy demand cases. The Energy Commission's Revised California Energy Demand Forecast, February 2012 noted:

> *The high energy demand case incorporates relatively high economic/demographic growth, relatively low electricity and natural gas rates, and relatively low efficiency program and self-generation impacts. The low energy demand case includes lower economic/demographic growth, higher assumed rates, and higher efficiency program and self-generation impacts. The mid case uses input assumptions at levels between the high and low cases.*

Additional information regarding the energy modeling and demand scenarios used for the forecast may be found in Chapter 1 of the Revised California Energy Demand Forecast, 2012–2022. The annual sector electricity use (Table 1), is used in Equation 1 for E_s.

Table 1: California Electricity Use by Sector (Gigawatt Hours per year), 1995–2010

	Residential	Commercial	Industrial	Mining	Agricultural	TCU	Street Lighting	Total
1995	69,032	77,682	46,230	6,179	14,147	12,808	1,620	227,698
1996	71,331	79,998	46,532	6,361	16,708	13,002	1,658	235,590
1997	72,777	83,672	48,154	6,291	17,358	13,627	1,701	243,580
1998	74,622	85,466	46,441	6,000	13,359	13,371	1,757	241,015
1999	75,677	88,581	47,733	5,715	16,951	13,746	1,658	250,060
2000	79,579	93,255	48,184	6,101	17,321	14,249	1,718	260,408
2001	75,191	91,354	44,757	5,770	18,896	13,091	1,763	250,822
2002	76,870	93,091	44,915	5,679	20,962	13,274	1,731	256,521
2003	81,750	97,032	42,569	5,894	20,151	13,159	1,759	262,314
2004	83,944	98,834	43,986	6,594	21,840	13,268	1,769	270,236
2005	85,747	99,530	44,260	6,684	19,093	13,986	1,780	271,081
2006	89,655	102,746	43,985	6,911	20,305	14,405	1,776	279,782
2007	89,063	104,381	44,220	6,968	22,867	14,989	1,793	284,281
2008	90,888	105,625	43,775	7,028	19,740	15,509	1,832	284,398
2009	90,008	102,317	39,485	7,653	19,861	15,829	1,668	276,821
2010	87,390	100,185	39,447	7,564	20,763	15,403	1,591	272,342

http://www.energy.ca.gov/2011_energypolicy/documents/2011-08-30_workshop/mid-case/

TCU = Transportation, communication and utilities

1.2.3 Lighting Factors

In California, electricity used for lighting has historically been a larger percentage of total electricity consumption than in other regions of the country. DOE reports that, in the West, lighting and other appliances account for approximately 31 percent of delivered energy; the national average is five percent lower, at 26 percent. Lighting constitutes 18 percent of electricity consumption in the Northeast region of the U.S., more than 10 percent less than in California (DOE Buildings Energy Data Book Table 2.1). Due to these regional variations, lighting electricity use estimates must be based on localized data if they are to produce accurate results.

Past California lighting surveys and data sets were collected and analyzed to create a timeline of lighting electricity use of sector percentage between 1995 and 2010 (Table 2). Some regional data, collected by DOE was included to supplement the California information, when California data was not available. Shaded cells represent values that have been calculated from existing data points.

California lighting and appliance saturation surveys and studies were conducted in 1995, 2001, 2002, 2005, and 2009. Regional data, prepared at the national level, was used to estimate commercial interior lighting electricity use for 2010 and residential interior lighting electricity use for 2005. Street lighting electricity use estimates were provided by the Energy Commission's Electricity Supply Analysis Division, as no other existing studies or surveys was available for this outdoor sector. The values in Table 2 are used in Equation 1 for F_L.

Table 2: California Lighting Electricity Use by Sector (Percent of Total Sector Electricity Use*)

	Residential Lighting			Commercial Lighting			Outdoor	
	Total	Interior	Exterior	Total	Interior	Exterior	Street	Total
1995	**28.0%**	**23.9%**	**4.1%**	**40.0%**	**36.6%**	**3.4%**	**0.7%**	**3.1%**
1996	27.5%	23.4%	4.1%	39.2%	35.8%	3.4%	**0.7%**	3.1%
1997	27.0%	22.8%	4.2%	38.4%	35.0%	3.4%	**0.7%**	3.1%
1998	26.4%	22.2%	4.2%	37.6%	34.2%	3.4%	**0.7%**	3.2%
1999	25.9%	21.7%	4.3%	36.8%	33.4%	3.4%	**0.7%**	3.2%
2000	25.4%	21.1%	4.3%	36.0%	32.6%	3.4%	**0.7%**	3.2%
2001	24.9%	20.6%	4.4%	35.2%	31.8%	**3.4%**	**0.7%**	**3.2%**
2002	**24.4%**	**20.0%**	**4.4%**	35.1%	31.1%	4.0%	**0.7%**	3.4%
2003	24.0%	19.5%	4.5%	34.9%	30.3%	4.6%	**0.7%**	3.8%
2004	23.6%	19.1%	4.6%	34.7%	29.5%	5.2%	**0.7%**	4.0%
2005	23.2%	**18.6%**	4.6%	**34.5%**	**28.7%**	**5.8%**	**0.7%**	4.3%
2006	23.1%	18.3%	4.7%	34.1%	28.1%	6.0%	**0.6%**	4.3%
2007	22.9%	18.1%	4.8%	33.6%	27.5%	6.1%	**0.6%**	4.4%
2008	22.7%	17.8%	4.9%	33.1%	26.9%	6.2%	**0.6%**	4.5%
2009	**22.5%**	**17.5%**	**5.0%**	32.3%	26.3%	6.0%	**0.6%**	4.4%
2010	22.3%	17.2%	5.1%	31.6%	**25.7%**	5.8%	**0.6%**	4.4%

*Outdoor lighting values are a percent of **total** California electricity use (not sector use). Shaded cells contain calculated values. Non-shaded cells contain data points taken from secondary sources.

1.2.4 Computation Methods

For years where no primary data existed, lighting use was estimated by interpolating between primary data points obtained from past surveys and studies. For residential lighting, the 1995 California baseline prepared for the Energy Commission and the results of the 2002 California Residential Appliance Saturation Survey (RASS) were used to linearly interpolate interior and exterior lighting use for the years 1996 to 2001. Between 2002 and 2009, annual residential lighting use was also linearly interpolated to reconcile results from the 2009 RASS and the 2002 RASS. The 2005 reported value for residential interior lighting of 18.6 percent of residential electricity use[1] aligns with the linear decrease in estimated electricity use in this sector between 2002 and 2009.

In the commercial sector, primary data exists for 1995, 2001 and 2005. For commercial interior lighting use, results from the 1995 California Lighting Baseline and the 2005 Commercial End Use Survey (CEUS) were used to linearly interpolate lighting use for 1996 to 2004. As no primary California data existed beyond 2005, a national report of the U.S. Lighting Inventory was used to estimate interior lighting use for 2010 (Navigant 2012, page xii). This report estimates that in 2010, 19 percent of all electricity was consumed by lighting, and 49.8 percent of this amount is consumed by commercial interior lighting. These factors were applied to California electricity consumption to obtain the 2010 lighting factor for interior commercial lighting. This estimate aligns well with the downward trend in this sector between 1995 and 2005. This estimate was used along with the 2005 CEUS results to estimate interior commercial lighting use for 2006–2009.

In the commercial exterior sector, an outdoor lighting assessment conducted in 2001 shows no increase in lighting use in the exterior sector between 1995 and 2001; therefore, exterior commercial lighting use as a percentage of total commercial electricity use was held constant during this period (Pierce 2). Exterior commercial lighting use increased between 2001 and 2005, and a linear interpolation was used to estimate annual lighting use percentages for the years 2002, 2003 and 2004. No appropriate primary data points were found for years beyond 2005, so for the period of 2006 to 2010, commercial exterior lighting use was estimated to change proportionally to commercial floor space and overall commercial electricity use.

Street lighting electricity use percentages in Table 2 were provided by the Energy Commission's Electricity Supply Analysis Division. These values are taken from their mid energy demand case. No other primary data points were identified to supplement these estimates, but one federal study estimates that street lighting electricity use increases approximately 1.0 percent per annum, which correlates with the Energy Commission figures (Navigant 2010, page 9).

Outdoor lighting is the sum of commercial exterior lighting, residential exterior lighting, and street lighting. As such, results for this sector are an aggregation of exterior end-use values taken from the various source described in this section.

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[1] In 2005, total residential electricity use attributed to lighting and appliances was 24.1 million Btu per household, approximately 31% of the total electrical use. Of this, 60% is attributed to indoor lighting, equating to 18.6% of total residential electricity use.

1.2.5 Demographics

Residential lighting electricity use depends on a number of demographic factors including population, persons per household and total number of occupied households in the state. The Energy Commission's Electricity demand forecasting group provides California population and housing unit estimates based on growth rates from groups such as Moody's Analytics and IHS Global Insight (Cavalec 4). The most recent values are provided in the Revised Energy Demand Forecast for 2012-2022, February 2012. Values do not include adjustments to reconcile results to the 2010 Census; therefore, CLTC did not use the estimated growth rates, housing and population estimates provided by the Energy Commission. Instead, CLTC calculated annual population and occupied housing units based on reported values from the 1990, 2000 and 2010 California census. CLTC chose to use the occupied housing units metric because vacant homes use very little electricity for lighting, and including vacant units would underestimate the actual lighting use per occupied California household.

Census values were used with reported new housing unit starts, obtained from the California Department of Finance (DOF), to estimate annual occupied housing units for each year between 1990 and 2010. For years between 1990 and 2000, it was found that this method slightly underestimated the number of occupied housing units when compared to reported values from the 2000 Census. Between 2000 and 2010, this method overestimated occupied housing units. To reconcile the calculated values to Census values, a weighted average adjustment, proportional to new housing starts, was applied to account for the difference (Table 3, column 6). Between 1990 and 2000, this resulted in an average increase in residential housing units of 1.03 percent. The growth rate slowed between 2000 and 2010, to approximately 0.75 percent. Table 3 provides annual population and occupied housing units for California for the years 1995 to 2010.

By 2010 Energy Commission housing unit projections (Table 3, column 3), compared to occupied housing units calculated for this analysis, were higher by approximately 3.2 percent. Portions of this difference are attributed to the increase in vacant homes and the slowing of residential new construction due to the U.S. mortgage crisis and general downturn in the California economy. In addition, new housing starts are based on issued California building permits, and it must be assumed that some permitted projects did not result in completion due to the same economic conditions previously mentioned. The negative adjustments between 2000 and 2009 (Table 3, column 4) account for these variances.

Table 3: California Population and Housing Units, 1990 to 2010

Year	Population	CEC Housing Units Projection	Persons per Household	Occupied Housing Units	New Housing unit starts	Adjustment
1995	31,493,525	10,956,456	2.86	10,937,911	85,293	1,198
1996	31,780,829	11,045,479	2.85	11,024,402	94,283	1,324
1997	32,217,708	11,139,126	2.87	11,120,009	111,716	1,569
1998	32,682,794	11,244,534	2.87	11,233,293	125,707	1,765
1999	33,145,121	11,365,121	2.88	11,360,765	140,137	1,968
2000	**33,994,571**	**11,479,399**	**2.87**	**11,502,870**	148,540	-58,078
2001	34,485,623	11,589,123	2.90	11,593,332	148,757	-58,163
2002	34,876,194	11,724,688	2.92	11,683,926	167,761	-65,594
2003	35,251,107	11,868,278	2.94	11,786,093	195,682	-76,511
2004	35,558,419	12,027,273	2.94	11,905,264	212,960	-83,266
2005	35,795,255	12,199,804	2.94	12,034,958	208,972	-81,707
2006	35,979,208	12,353,209	2.93	12,162,223	164,280	-64,233
2007	36,226,122	12,469,310	2.92	12,262,271	113,034	-44,196
2008	36,580,371	12,561,244	2.93	12,331,109	64,962	-25,400
2009	36,961,664	12,685,302	2.94	12,370,671	36,421	-14,240
2010	**37,253,956**	**12,805,711**	**2.96**	**12,392,852**		

Source: California Lighting Technology Center calculations. Bolded cells (years: 2000, 2010) contain data from state census.

1.2.6 Normalization Factors

Lighting is installed as residential communities and commercial areas expand. Residential and commercial lighting is attributed to buildings, street and area lighting. Lighting electricity use within the residential sector is positively correlated to residential new construction. Residential lighting use increases with each new housing unit. New neighborhoods require new street and area lighting while growing population density in existing neighborhoods often increases lighting needs. In the commercial sector, new street and area lighting is required when commercial facilities expand or new commercial zones are constructed. Increased commercial activity is often localized around new residential areas or conversely, new commercial facilities often lead to new housing. Growth in both sectors is tied together and while the exact relationships are highly varied, more people and activity requires more lighting. For these reasons, lighting use must be normalized to account for increases in population and commercial activity. Normalization isolates energy-use fluctuations resulting from non-efficiency measures, and allows for a true comparison of savings.

1.2.6.1 Residential Sector

In the residential sector, lighting energy use and savings are calculated and compared using a variation of a normalized population metric. The normalization factor chosen for this analysis is the occupied housing unit.

- Lighting electricity use per occupied housing unit
    - [kWh_{annual} / H]
    - H = occupied housing unit

Increases in California population lead directly to increases in residential energy use, and by association, increases in residential lighting energy use. A per-person normalization would include population increases where new California residents move into households with existing residents. This situation could lead to overstated savings since increases in human population may not always correlate to proportional increases in lighting energy use. The occupied household was selected for the residential normalization factor because it accounts for the actual lighting-use unit, and not the individual person.

1.2.6.2 Commercial Sector

In the commercial sector, CLTC used the common normalization factor of commercial floor stock. Increases in commercial building stock contribute directly to increases in commercial building energy use. Lighting is one component of this increase.

- Lighting electricity use per unit area of commercial floor stock
    - [kWh_{annual} / commercial square footage (CSF)]
    - CSF = total California commercial square footage

1.2.6.3 Outdoor Sector

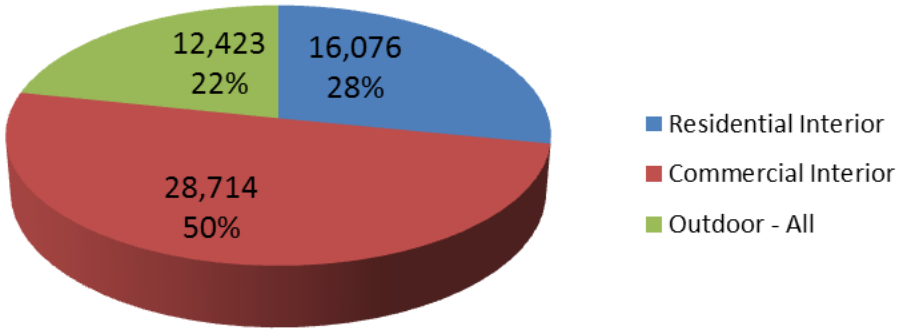
Increases in outdoor lighting installations occur in conjunction with new building construction or increases in population that lead to increased lighting needs. Assuming the outdoor sector is defined to include all exterior light points, the energy-use metric should include accommodation for growth in all sectors. A normalized lighting energy-use metric for all outdoor lighting installations should therefore include a normalization that encompasses increases in both residential and commercial building sectors. While expanding commercial activity was not explicitly correlated to increased residential activity, for this analysis, it is assumed that increased commercial building results in increased residential construction, and population density; therefore, number of occupied housing units. The normalization factor selected for outdoor lighting is the occupied household.

- Outdoor lighting electricity use per occupied housing unit
    - [kWh_{annual} / H]
    - H = Occupied housing unit

CHAPTER 2:
Results

In 2007, California is estimated to have consumed 57,213 gigawatt hours (GWh) of electricity for residential, commercial and outdoor lighting (Figure 4). Commercial interior lighting consumed 28,714 GWh, approximately 50 percent of the overall total, while outdoor lighting and residential interior lighting consumed approximately12,423 GWh and 16,076 GWh, respectively.

Figure 4: California Lighting Electricity Use (GWh per year) – 2007



Residential interior lighting peaked in 2006 at 16,429 GWh. Commercial interior lighting use peaked that same year at 28,876 GWh. Overall, exterior lighting shows a slow yet steady increase throughout the analysis period, peaking in 2008 at 12,776 GWh.

Table 4: 2007 California Lighting Use (GWh)

Year	Interior		Exterior	Total
	Residential	Commercial		
1995	16,507	28,400	7,064	51,971
2001	15,458	29,091	8,141	52,690
2007	**16,076**	**28,714**	**12,423**	**57,213**
2010	15,053	25,769	11,866	52,688

Source: California Lighting Technology Center calculations

Following these peaks, electricity use for lighting appears to be dropping in all sectors. For example, energy consumption per household and per person for interior residential lighting shows a slight decrease by the end of the analysis period. Use for this sector in 2007 is estimated at 1,311 kWh per year per occupied household. By 2010, this value had dropped by roughly 7

percent to 1,215 kWh per occupied household, demonstrating that California appears to be making progress towards its goal of 50 percent savings by 2018.

Encouraging results may also be seen in the outdoor and commercial interior sectors. Estimates for 2007 indicate lighting use density for the commercial interior sector was 4.3 kWh per year per square foot of commercial floor space (kWh_{annual} / CSF). This value dropped to approximately 3.7 kWh_{annual} / CSF, a decrease of approximately 13 percent. This reduction is more than half of that required by AB 1109. In the outdoor sector, a decrease of almost 6 percent is evident from the analysis between 2007 and 2010. In 2007, outdoor lighting consumed approximately 1,013 kWh per year per occupied household (kWh_{annual} / H). By 2010, this value dropped to 957 kWh_{annual} / H.

Table 5: California Lighting Electricity Use (GWh per year) – Data Table, 1995 to 2010

	Residential Interior	Residential Exterior	Commercial Interior	Commercial Exterior	Street Lighting	Outdoor - Total	Total - All Sectors
1995	16,507	2,803	28,400	2,641	1,620	7,064	51,971
1996	16,658	2,931	28,618	2,720	1,658	7,309	52,585
1997	16,589	3,025	29,275	2,845	1,701	7,571	53,435
1998	16,592	3,138	29,231	2,906	1,757	7,801	53,625
1999	16,404	3,220	29,600	3,012	1,658	7,889	53,893
2000	16,805	3,424	30,429	3,171	1,718	8,313	55,547
2001	15,458	3,272	29,091	3,106	1,763	8,141	52,690
2002	15,374	3,382	28,912	3,724	1,731	8,836	53,123
2003	15,968	3,664	29,373	4,463	1,759	9,886	55,228
2004	16,005	3,830	29,142	5,139	1,769	10,739	55,886
2005	15,949	3,982	28,565	5,773	1,780	11,535	56,049
2006	16,429	4,237	28,876	6,152	1,776	12,164	57,470
2007	**16,076**	**4,281**	**28,714**	**6,349**	**1,793**	**12,423**	**57,213**
2008	16,155	4,443	28,427	6,501	1,832	12,776	57,359
2009	15,751	4,473	26,927	6,101	1,668	12,242	54,921
2010	15,053	4,426	25,769	5,849	1,591	11,866	52,688
Max	**16,805**	**4,473**	**30,429**	**6,501**	**1,832**	**12,776**	**57,470**

2.1 Residential Interior Lighting

The electricity consumption attributed to interior residential lighting, relative to all residential electricity consumption, dropped at a fairly steady rate over the analysis period. It is estimated that in 1995 this sector consumed nearly 24 percent of all residential electricity in California. By 2007, residential interior lighting electricity consumption had decreased from 24 percent to 18 percent. A progressive decline of electricity use is attributed to interior residential lighting as well as the absolute amount of electricity consumed by this sector (Figure 5). Electricity

consumption for interior residential lighting per occupied household and per person shows a slight decrease by the end of the analysis period (Figure 6) and in 2007 is estimated at 1,311 kWh per year per occupied household. By 2010, this value had dropped by roughly seven percent to 1,215 kWh per occupied household, demonstrating that California appears to be making progress towards its goal of 50 percent reductions in residential lighting electricity consumption by 2018..

Figure 5: California Residential Indoor Lighting Electricity Use, 1995–2010

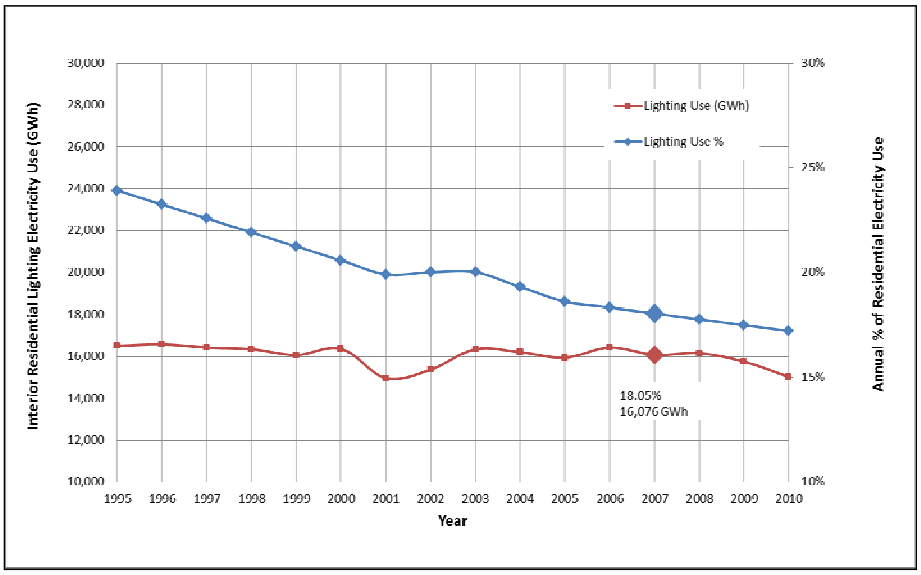


Figure 6: California Residential Indoor Lighting Electricity Use per Person & Occupied Household, 1995-2010

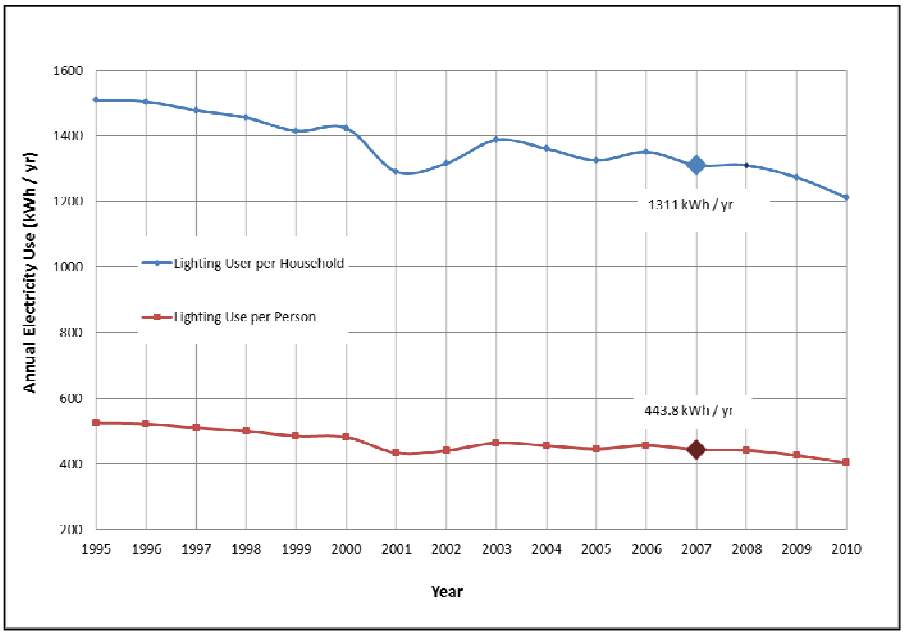


Table 6: Interior Residential Lighting Use Data Table, 1995–2010

				Interior Residential Lighting			
Year	Population	Persons per Household	Occupied Housing Units	% of Total Residential Electricity Use	Total Use (GWh)	Household Use (kWh / yr)	Per Person Use (kWh / yr)
1995	31,493,525	2.86	10,937,911	23.9%	16,507	1509.2	524.1
1996	31,780,829	2.85	11,024,402	23.4%	16,658	1511.0	524.2
1997	32,217,708	2.87	11,120,009	22.8%	16,589	1491.8	514.9
1998	32,682,794	2.87	11,233,293	22.2%	16,592	1477.1	507.7
1999	33,145,121	2.88	11,360,765	21.7%	16,404	1443.9	494.9
2000	**33,994,571**	**2.87**	**11,502,870**	21.1%	16,805	1461.0	494.4
2001	34,485,623	2.90	11,593,332	20.6%	15,458	1333.4	448.3
2002	34,876,194	2.92	11,683,926	20.0%	15,374	1315.8	440.8
2003	35,251,107	2.94	11,786,093	19.5%	15,968	1354.9	453.0
2004	35,558,419	2.94	11,905,264	19.1%	16,005	1344.4	450.1
2005	35,795,255	2.94	12,034,958	18.6%	15,949	1325.2	445.6
2006	35,979,208	2.93	12,162,223	18.3%	16,429	1350.8	456.6
2007	36,226,122	2.92	12,262,271	18.1%	16,076	1311.0	443.8
2008	36,580,371	2.93	12,331,109	17.8%	16,155	1310.1	441.6
2009	36,961,664	2.94	12,370,671	17.5%	15,751	1273.3	426.2
2010	**37,253,956**	**2.96**	**12,392,852**	17.2%	15,053	1214.6	404.1

Source: California Lighting Technology Center calculations, population provided by Energy Commission Electricity Supply Analysis Division

2.2 Commercial Interior Lighting

Energy use for commercial interior lighting shows a steady decline during the course of the analysis period in both absolute and normalized terms. In 2007, interior commercial lighting consumed approximately 28,700 GWh annually. This energy consumption increased slightly compared to consumption reported in the 1995 California Lighting Efficiency Technology Report – Volume 1 California Baseline, although during that time, California added approximately 1.2 million square feet of commercial floor space to its building inventory (Census 2010). On average, California consumed 4.3 kWh_{annual} / CSF in 2007, down from 5.23 kWh_{annual} / CSF in 1995, a decline of 18 percent. By 2010, this value further declined by an additional 10 percent (Figure 7).

The increase in California commercial floor space during the analysis period is contrasted by the steady decline in lighting energy use intensity for this sector (Figure 8). The downward trend of commercial lighting electricity consumption as a portion of total commercial electricity consumption is also illustrated. Factors influencing these trends are discussed in Chapter 3.

Figure 7: Interior Commercial Lighting Electricity Use Intensity, 1995–2010, kWh per Square Foot of Commercial Floor Space

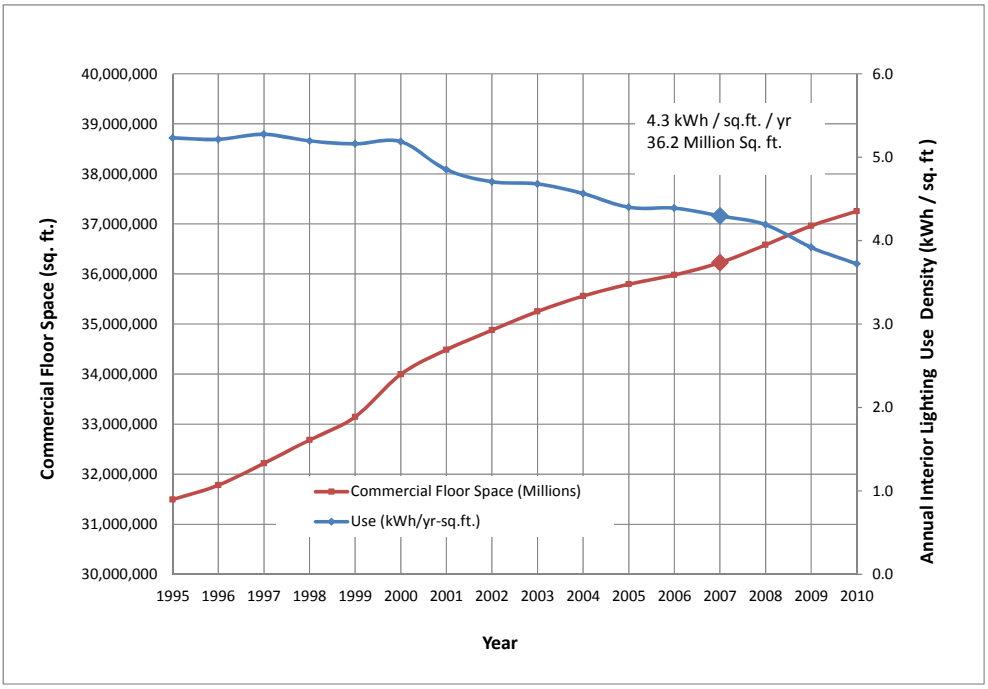


Figure 8: Interior Commercial Lighting Electricity Use, 1995–2010, Percent of Total Commercial Electricity Use and Absolute Annual Use in GWh

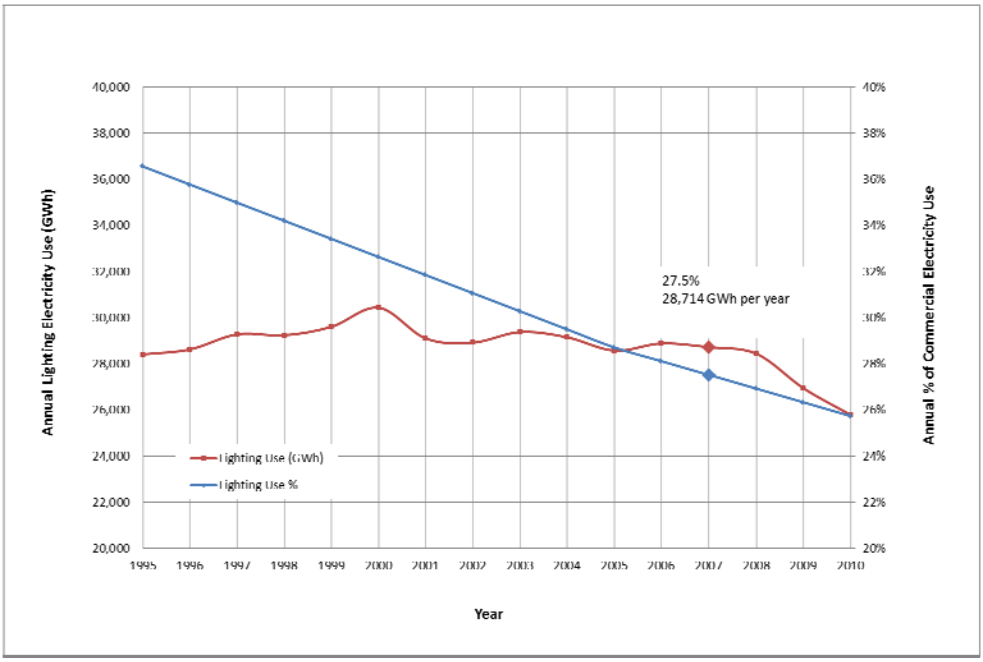


Table 7: Interior Commercial Lighting Use Data Table, 1995–2010

		Normalization Factor		Interior Lighting			
Year	Population	Commercial Floor Space (Millions)	Annual % Change	% of Total commercial Electricity Use	Lighting Use (GWh)	kWh / yr / sqft	Annual % Change
1995	31,493,525	5,429		36.6%	28,400	5.23	
1996	31,780,829	5,489	1.1%	35.8%	28,618	5.21	-0.32%
1997	32,217,708	5,550	1.1%	35.0%	29,275	5.27	1.15%
1998	32,682,794	5,628	1.4%	34.2%	29,231	5.19	-1.52%
1999	33,145,121	5,737	1.9%	33.4%	29,600	5.16	-0.66%
2000	33,994,571	5,868	2.3%	32.6%	30,429	5.19	0.50%
2001	34,485,623	5,997	2.2%	31.8%	29,091	4.85	-6.47%
2002	34,876,194	6,144	2.4%	31.1%	28,912	4.71	-2.99%
2003	35,251,107	6,278	2.2%	30.3%	29,373	4.68	-0.57%
2004	35,558,419	6,385	1.7%	29.5%	29,142	4.56	-2.45%
2005	35,795,255	6,494	1.7%	28.7%	28,565	4.40	-3.63%
2006	35,979,208	6,580	1.3%	28.1%	28,876	4.39	-0.23%
2007	36,226,122	6,684	1.6%	27.5%	28,714	4.30	-2.11%
2008	36,580,371	6,783	1.5%	26.9%	28,427	4.19	-2.44%
2009	36,961,664	6,871	1.3%	26.3%	26,927	3.92	-6.50%
2010	37,253,956	6,926	0.8%	25.7%	25,769	3.72	-5.06%

Source: California Lighting Technology Center calculations, population provided by California Energy Commission, Energy Supply Analysis Division

2.3 Outdoor Lighting

Outdoor lighting electricity consumption, consisting of exterior residential, exterior commercial and street lighting consumption, experienced substantial growth during much of the analysis period. For 1995 to 2001, outdoor lighting consumption per household remained static; however, during the residential construction boom of the last decade, outdoor lighting energy use per household grew dramatically, due in part to the increasing size of a typical single family residence in California. Between 1995 and 2007, yearly outdoor lighting consumption grew by 367 kWh per household, a 57 percent increase. The total state electricity consumption attributed to outdoor lighting increased from 3.1 percent to approximately 4.4 percent by 2010. Figure 9 An increase in outdoor lighting electricity use between 2001 and 2008 is followed by an evident decline by 2010 (Figure 9). Figure 10 highlights this increase compared to the increase in residential households during the same period.

Figure 9: California Outdoor Lighting Electricity Use, 1995–2010

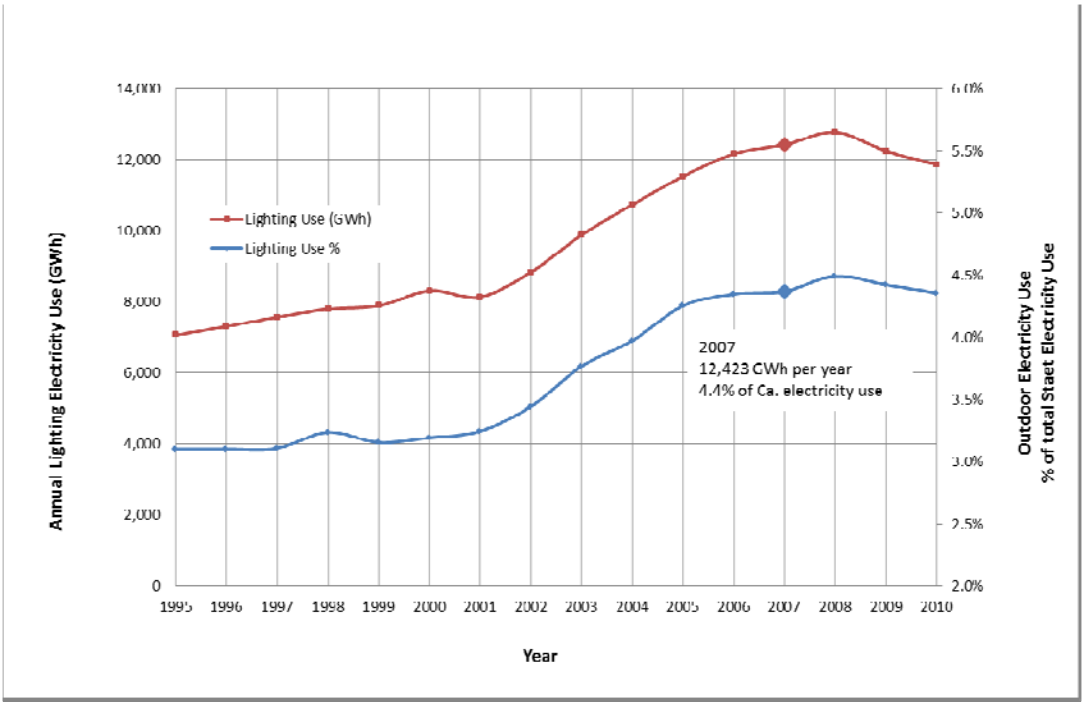


Figure 10: Outdoor Lighting Electricity Use per Household, 1995–2010

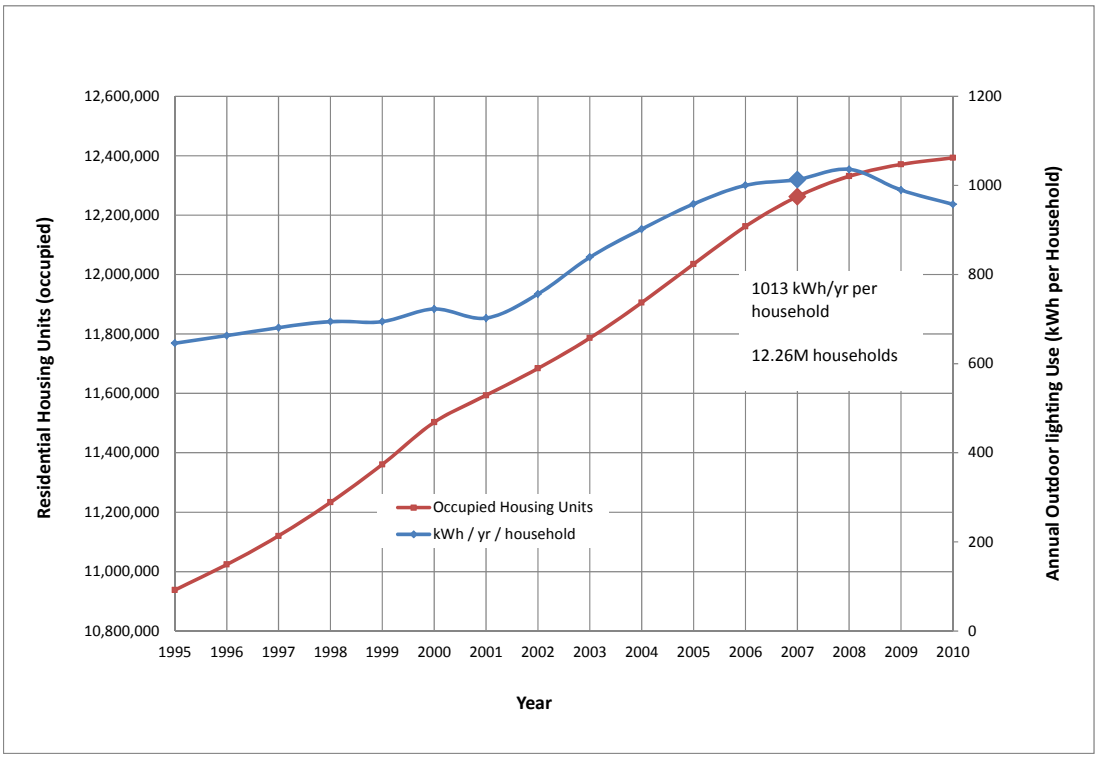


Table 8: Outdoor Lighting Electricity Use, 1995–2010

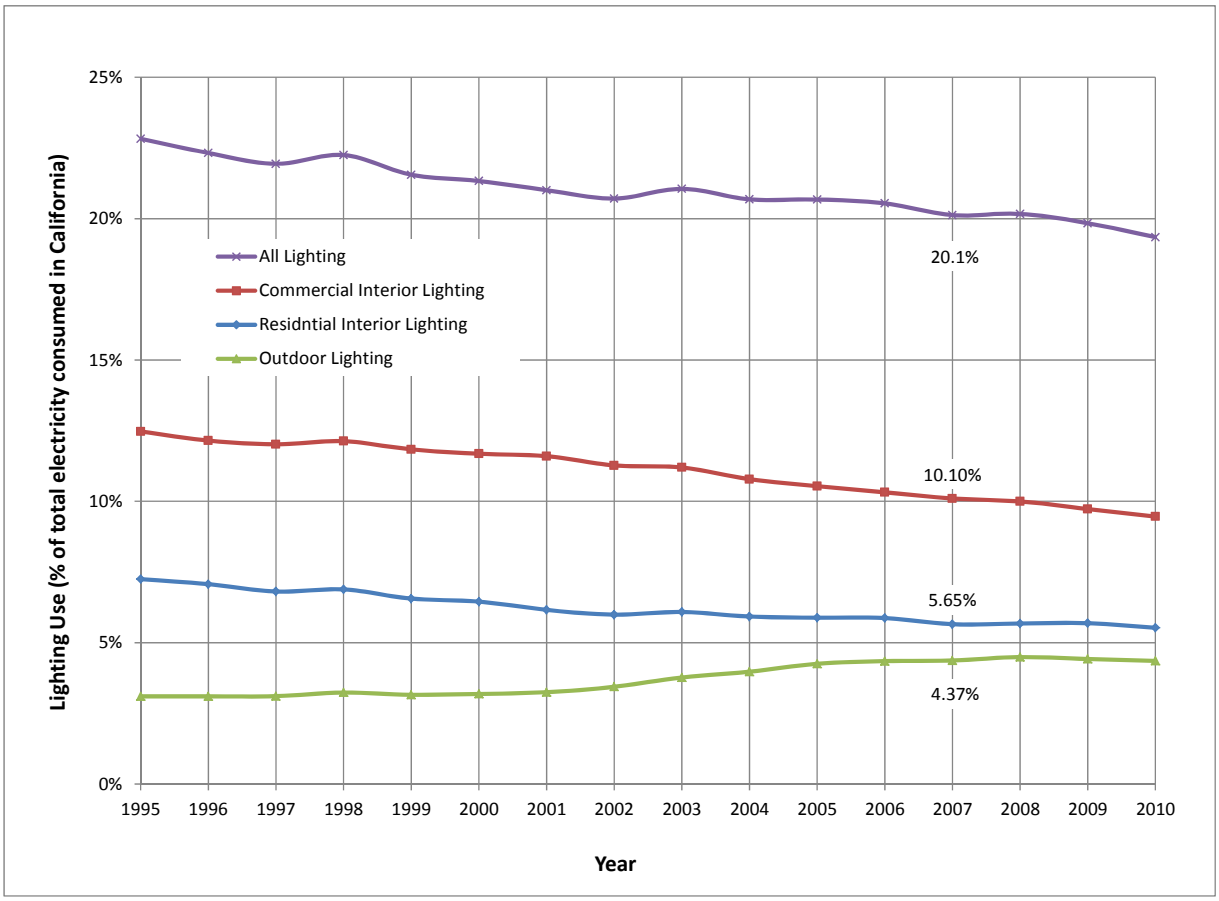
		Normalization Factor	Outdoor Lighting			
Year	Population	Occupied Housing Units	% of Total State Electricity Use	Lighting Use (GWh)	kWh / yr / household	Annual % Change
1995	31,493,525	10,937,911	3.1%	7,064	645.8	
1996	31,780,829	11,024,402	3.1%	7,309	663.0	2.7%
1997	32,217,708	11,120,009	3.1%	7,571	680.8	2.7%
1998	32,682,794	11,233,293	3.2%	7,801	694.5	2.0%
1999	33,145,121	11,360,765	3.2%	7,889	694.4	0.0%
2000	33,994,571	11,502,870	3.2%	8,313	722.7	4.1%
2001	34,485,623	11,593,332	3.2%	8,141	702.2	-2.8%
2002	34,876,194	11,683,926	3.4%	8,836	756.3	7.7%
2003	35,251,107	11,786,093	3.8%	9,886	838.8	10.9%
2004	35,558,419	11,905,264	4.0%	10,739	902.0	7.5%
2005	35,795,255	12,034,958	4.3%	11,535	958.4	6.3%
2006	35,979,208	12,162,223	4.3%	12,164	1000.2	4.4%
2007	36,226,122	12,262,271	4.4%	12,423	1013.1	1.3%
2008	36,580,371	12,331,109	4.5%	12,776	1036.1	2.3%
2009	36,961,664	12,370,671	4.4%	12,242	989.6	-4.5%
2010	37,253,956	12,392,852	4.4%	11,866	957.5	-3.2%

Source: California Lighting Technology Center calculations, population provided by the Energy Commission's Electricity Supply Analysis Division

CHAPTER 3:
Discussion

Lighting electricity consumption, as a percentage of overall electricity consumption, has declined in California during the years 1995 to 2010. At the sector level, only outdoor lighting generally increased during the analysis period, growing from 3.1 percent of California electricity use in 1995 to more than 4 percent in 2008. By 2010, this sector begins to show a slight decline. Figure 11 shows the usage trends in each sector for the period 1995 to 2010. The general decline in lighting electricity use, as a percentage of total electricity use, is the result of several influencing factors including efficiency programs, economic conditions, technology improvements, building codes, and appliance standards. Each of these influential factors is briefly discussed, although no attribution of savings to individual factors is available.

Figure 11: California Lighting Electricity Use, All Sectors, 1995–2010, Sector Use as a Percentage of Total California Electricity Use



Source: California Lighting Technology Center calculations

3.1 Codes & Standards

California energy codes were first enacted in 1978. Energy codes were intended to reduce the amount of energy consumed by buildings and provide a way for California to reduce energy costs and promote energy-efficient design practices. California's Building Energy Efficiency Standards, contained in the California Code of Regulations, Title 24, Part 6, is updated approximately every three years. Lighting and lighting controls for nonresidential and residential buildings are regulated by these standards.

With each code iteration, lighting power densities (LPDs) or maximum allowable lighting power density measured in watts per square foot have declined, while controls requirements have expanded. This combination of regulations has served to decrease the amount of electricity consumed by lighting in both residential and commercial buildings. Interior lighting has been included in each code cycle since Title 24's inception. Beginning in 2001, Title 24 included provisions affecting outdoor nonresidential lighting.

The savings from energy codes on lighting energy consumption are often overshadowed by sector growth. The Energy Commission's Electricity Supply Analysis Division is working to isolate the savings attributed to building standards, but results were not available during the preparation of this report.

In addition to building standards, appliance codes also serve to decrease electrical energy consumption in California. California's Title 20 Appliance Efficiency Standards regulate the performance of various types of equipment and appliances sold and installed in California buildings. Lighting products are one major component of regulated technologies in Title 20. Specifically, appliance codes are cited in AB 1109 as a primary method to be employed in achieving the required lighting use reductions.

3.2 Technology Improvements

Lighting technology continues to improve in terms of efficiency and product longevity. From 1995 to 2010, the conversion from incandescent lamps to compact fluorescent lamps (CFLs) proved to be an important element in the broad adoption of energy-efficient lighting solutions in California. During the analysis period, CFL penetration in the residential market reached approximately 25 percent, compared to less than two percent in 1995. Energy saving from these measures is currently estimated at 40 W per socket on average, resulting in an estimated 16 percent savings statewide from this measure alone. During the same period there were significant savings from the conversion from T12 to T8 linear fluorescent lamps, from mercury lamps and incandescent lamps to metal halide and high pressure sodium lamps, and from the greater lighting controls usage. New technologies continue to emerge in both the interior and exterior markets. The conversion from fluorescent and high intensity discharge (HID) luminaires to light emitting diode (LED) luminaires began in earnest in the late-2000's, and the DOE estimates that savings from this technology could exceed 40 percent by 2030, compared to 2010 levels (Navigant 2010, 36).

3.3 Economy and Environment

In 2007, California entered an economic recession fueled by a steep decline in the residential housing market. Similarly, in 2001, the commercial sector experienced some limited decline as the technology sector experienced noteworthy contraction. Associated declines in electrical energy use can be seen in the historical assessments contained in this report. In particular, electricity use across the commercial and residential sectors declined between 2008 and 2010, resulting in a similar decline in lighting electricity use. The combination of reduced electricity use and lighting energy consumption contributed to the absolute decline in residential lighting electricity use, even though the population increased during the analysis period. Similarly, in the commercial sector, building floor stock increased, but declines in total electricity use and the portion attributed to lighting resulted in an absolute decline in lighting electricity consumption since its peak in 2003.

3.4 Recent and Projected Savings

Lighting electricity reductions between 2007 and 2010 are estimated at 4,525 GWh for sectors affected by AB 1109. In the residential sector, lighting electricity use per household is down by seven percent. Electricity use per square foot of floor space is down 13 percent for commercial interior lighting, and it has declined almost six percent for outdoor lighting based on use per occupied household. These results are encouraging, and they demonstrate that California may be on its way to meeting its goals for energy savings.

From the historical data presented in this report, it is clear that lighting energy use has been slowly increasing in the state of California, albeit with a dip from 2008 onward, due in part to the economic downturn. Overall use may increase when the economy recovers; in the same way that lighting energy use fell and then increased following the 2001 recession. This slight historical upward trend has been composed of a slow downward trend *per capita* and per square foot, counterbalanced by California's steadily increasing population and building stock. It has also been counterbalanced by a strong increase in the use of outdoor lighting, which has almost doubled since 2001.

A simple extrapolation of these trends forward in time may not be adequate to capture all the likely influences on the lighting market. This inadequacy is because the lighting market over the period 2012 to 2018 will be subject to several new influences which current models may not capture. Such influencing factors include:

- The introduction of LED lamps to residences, office and warehouse spaces, and retail stores.
- The forthcoming lamp regulations in the Federal Energy Independence and Security Act (EISA, 2007)
- New regulations on lighting for retrofit projects, under Title 24, 2013 code.
- Expanded state regulation of lamps expected in the forthcoming Title 20 regulation updates

To meet the lighting use reduction goals of AB1109, the Energy Commission must enact "regulations, in combination with other programs and activities" (AB 1109, Huffman, Chapter 534, Statutes of 2007). To inform the development of these regulations, programs, and other activities, a detailed projection of lighting energy use is required, which would break down the lighting market by lamp type, building type and other relevant characteristics. This projection would attempt to quantify the effects of the influences listed previously, and to identify remaining opportunities that could be captured by regulations, technology improvements and efficiency programs.

GLOSSARY

Term	Description
AB 1109	AB 1109, authored by Assemblyman Jared Huffman, requires California to reduce its lighting electrical energy consumption in the commercial, residential and outdoor sectors. By 2018, reductions must meet 25 percent for commercial interior and outdoor lighting, and 50 percent for residential interior lighting, compared to 2007 levels.
CBECS	Commercial Buildings Energy Consumption Survey
CCR	California Code of Regulations
CEUS	Commercial End-Use Survey
CFL	Compact Fluorescent Lamp
CLASS	California Lighting and Appliance efficiency Saturation Survey
CLTC	California Lighting Technology Center
CSF	Commercial Square Footage is used to describe the size of California's commercial building stock expressed as the area of these buildings measured in square feet.
DOE	US Department of Energy
DOF	US Department of Finance
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
ESAD	Electrical Supply Analysis Division (of the California Energy Commission)
GWh	Gigawatt-hour
HID	High intensity discharge (lamp)
IEPR	Integrated Energy Policy Report
Indoor Commercial Lighting	Indoor commercial lighting consists of all permanently installed lighting in the interior spaces of nonresidential buildings, excluding industrial and agricultural facilities.
Indoor Residential Lighting	Indoor residential lighting consists of all permanently installed lighting in the interior of residential buildings.
kWh	Kilowatt-hour

LED	Light emitting diode
LPD	Lighting Power Density is the amount of electricity used by lighting per unit area of illuminated space. LPD is typically expressed in kilowatt-hours per square foot (kWh/sf).
Outdoor Lighting	Outdoor lighting is all permanently installed lighting in outdoor spaces including lighting for the exteriors of both residential and commercial/nonresidential buildings. It includes electrical lighting for streets, parking lots, signs, building entrances, outdoor sales areas, outdoor canopies, landscape lighting, lighting for building facades and hardscape lighting.
PIER	Public Interest Energy Research
RASS	(California) Residential Appliance Saturation Survey
SSL	Solid state lighting is a type of lighting that uses a solid-state source that emits light via electroluminescence.
TCU	Transportation, Communication and Utilities

APPENDIX A:
Sources

The following secondary sources were used to estimate the lighting electricity use in California between 1995 and 2010. Information on these sources, the survey methods employed and links to additional information are provided.

California Baseline – Volume 1 – Lighting Efficiency Technology Report

The California Energy Commission, under Senate Bills (SB) 639 (Rosenthal, Chapter1067, Statutes of 1993) and 1065 (Peace, , Chapter 611, Statutes of 1995), was charged with the task of studying and recommending options for improving lighting energy efficiency in California. This report, part of that effort, looks at the characteristics of lighting in residential and commercial buildings, and describes baseline energy use as of 1995. This energy use was estimated using an analytical model that was developed to calculate the energy savings potential of the various options to be studied (paraphrased from report Abstract).

Heschong Mahone Group, September 1999. ***Lighting Efficiency Technology Report, Vol.1: California Baseline***. California Energy Commission, Publication Number: <http://www.energy.ca.gov/efficiency/lighting/VOLUME01.PDF>

California Outdoor Lighting Baseline Assessment

This California Outdoor Lighting Baseline Assessment was prepared by the New Buildings Institute in 2002 on behalf of the Energy Commission, Public Interest Energy Research Program (PIER). The report is the first to specifically evaluate outdoor lighting energy use in California. Energy demand and consumption was estimated for both day and nighttime lighting in a variety of functional settings (parking lots, walkways, security areas, etc.). Data was collected from 303 commercial on-site visits to 20 different commercial and industrial business types. The report was also intended to provide a framework for future assessments.

Pierce, Sam. November 2002. ***Outdoor Lighting Baseline Assessment.*** California Energy Commission, Public Interest Energy Research (PIER) Program.

<http://www.energy.ca.gov/title24/2005standards/archive/outdoor_lighting/documents/2003-05-06_LGHT-BASELINE.PDF>

California Lighting and Appliance Efficiency Saturation Study (CLASS)

The 2005 California Statewide Lighting and Appliance Efficiency Saturation Study (CLASS) is a follow-on study to the 2000 Statewide Lighting and Appliance Efficiency Saturation Study. Each of these studies were paid for by Public Purpose funds for the purpose of understanding

current levels of appliance and lighting saturation and efficiencies in the existing residential sector.

Subsequent to the 1999-2000 study, a tremendous amount of Public Purpose funds were invested in energy conservation programs that served customers of the four California investor owned utilities. These Public Purpose dollars were invested in a multitude of ways, all with the goal of achieving lasting energy savings in California's energy markets. The overarching goals of the 2004-05 update study was to provide revised baselines of saturation and efficiency characteristics for use in understanding future energy savings potential and past accomplishments in the residential sector.

RLW Analytics. August 2005. ***California Lighting and Appliance Efficiency Saturation Study.*** Last accessed November 28, 2012: http://www.fypower.org/pdf/2005_CLASS_FinalReport.pdf.

California Residential Appliance Saturation Study (RASS)

The Residential Appliance Saturation Study (RASS) provides energy consumption estimates for residential end-uses, including appliance saturations for households within the California investor-owned utility (IOU) territories. Studies were conducted in 2003 and 2010. The 2003 study represents the first instance in California of the large IOUs collaborating to perform a residential survey. The study provides a wealth of data for 21,920 residential customers, statistically weighted to the population they represent. This data was collected using a two-stage direct mail survey, and non-response follow up using telephone and in-person interviews. The results have been prepared to allow comparison across utility service territories, climate zones, and other variables of interest. The results were also used to generate a Conditional Demand Analysis model.

The 2010 study, funded by the Energy Commission, updates the 2003 RASS, with the same utilities participating. The study was conducted by mail, with the option to complete online. The survey requested information on appliances, equipment, and general consumption patterns. These estimates were developed using conditional demand analysis with data from 24,464 individually metered and 1,257 master-metered households. The results are statistically weighted to the utility population to allow comparison across utility service territories, forecast climate zones, and other variables of interest.

Information on interior and exterior residential lighting consumption used in this report was taken from the 2003 and 2009 RASS. Information was taken from the following documents:

KEMA Inc. October 2010. ***California Statewide Residential Appliance Saturation Study***. California Energy Commission, Publication Number: CEC-200-2010-004. <http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-ES.PDF>

KEMA-Xenergy, Itron, RoperASW. June 2004. ***California Statewide Residential Appliance Saturation Study – Volume 2, Study Results and Final Report.*** California Energy Commission. Publication Number: 300-00-004. <http://www.energy.ca.gov/reports/400-04-009/2004-08-17_400-04-009VOL2B.PDF>.

California Commercial End - Use Survey (CEUS)

The CEUS is a comprehensive study of commercial sector energy use in California, primarily designed to support the state's energy demand forecasting activities. A stratified random sample of 2,790 commercial facilities was collected from the service areas of five major utility service providers. The sample was stratified by utility service area, climate region, building type, and energy consumption level.

For each utility service area, floor stocks, fuel shares, electric and natural gas consumption, energy-use indices (EUIs), energy intensities, and 16-day hourly end-use load profiles were estimated for twelve common commercial building type categories.

Information on interior commercial lighting from the CEUS report was utilized in this document.

Itron Inc. March 2006. ***California Commercial End-Use Survey.*** California Energy Commission. Publication Number: CEC-400-2006-005. Last accessed October 2, 2012: <http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF>.

California Energy Demand Forecast

The Electricity Supply Analysis Division of the Energy Commission prepares electricity demand forecasts, and maintains historical data for California, including each of its major utility service territories. Their forecasts are used to support development of California's IEPR and are based on demographic information, environmental factors and economic information. Forecasts are periodically updated to reflect changes conditions affected these projections. Information on California's energy demand forecast, including demographic information affecting this use, may be found in the following reports. Electricity use by sector, including demographic information and commercial building projections are utilized and referenced in this report. Information was taken from the following documents:

Kavalec, Chris. 2011. ***Draft Staff Report – Updated California Energy Demand Forecast 2011-2022.*** California Energy Commission, Electricity Supply Analysis Division. Publication Number: CEC-200-2011-006-SD.

Kavalec, Chris, Nicholas Fugate, Tom Gorin, Bryan Alcorn, Mark Ciminelli, Asish Gautam, Glen Sharp, and Kate Sullivan. 2012. ***Revised California Energy Demand Forecast 2012-2022.*** California Energy Commission, Electricity Supply Analysis Division. Publication number: CEC-200-2012-001-SD-V1.

California Energy Commission; California Energy Analysis Supply Analysis Division; ***Mid_Statewide_Demand_Preliminary_Forecast_Forms***, August 2011. < http://www.energy.ca.gov/2011_energypolicy/documents/2011-08-30_workshop/mid-case/>.

U.S. Lighting Market Characterization - Volume 1: National Lighting Inventory and Energy Consumption Estimate

This report was prepared by Navigant Consulting, Inc. for DOE's Energy Efficiency and Renewable Energy Building Technologies Program in 2002. The Lighting Market Characterization study is a multiyear program, consisting of two phases, to evaluate light sources in the United States, and identify opportunities for saving energy. This report, phase I, provides an estimate of installed lighting technologies for 2001 and their associated energy consumption. The report is intended to provide information about three main areas: 1) the amount of energy consumed by light sources in the U.S., 2) the number/location/area illuminated of these sources, and 3) the performance attributes of installed lighting technologies. The study draws data from existing sources such as the Commercial building energy consumption Survey and the Manufacturing energy Consumption Survey, end-use metering studies, and building audits.

Navigant Consulting Inc. September 2002. ***U.S. Lighting Market Characterization. Volume I: National Lighting Inventory and Energy Consumption Estimate***. U.S. Department of Energy, Building Technologies Program.

Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010-2030

This report, prepared by Navigant Consulting on behalf of DOE, estimates the energy savings impacts of solid state lighting if it were to achieve certain market impacts projected by DOE. It projects energy savings for solid-state lighting (SSL) assuming these products achieve certain performance and price objectives. Information on street lighting growth rates was taken from this report.

Navigant Consulting Inc. February 2010. ***Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 – 2030.*** U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

Commercial Buildings Energy Consumption Survey (CBECS)

These reports, conducted by the Energy Information Administration (EIA), provide basic statistical information about energy consumption and expenditures in U.S. commercial buildings, and information about energy-related characteristics of these buildings. The EIA is funded by Congress to promote sound policymaking, efficient markets, and public understanding of energy use.

The survey used a list-supplemented, four-stage, area sampling design, including advanced statistical weighting methods, to select the buildings for interview by field workers. Weighting factors were determined from many sources, including Census data and past CBECS information collected specifically for this purpose. Where interviews yielded insufficient information, energy supplier records were used.

Due to the survey's complexity, Relative Standard Errors (RSE) are computed for each estimate in the report (rather than computing an overall confidence interval) using the Jackknife Replication method. All published estimates had an RSE less than 50 percent.

Purpose and funding source: About EIA
< http://www.eia.gov/about/>

Standard Error information source: Estimation of Standard Errors
< http://www.eia.gov/emeu/cbecs/tech_std_errors.html>

All other details: CBECS: Sample Design
< http://www.eia.gov/emeu/cbecs/2003sample.html>

California Department of Finance (DOF)

DOF prepares, explains and administers California's financial plan. Information on residential new home construction, reported by the DOF, was utilized in this report.

http://www.dof.ca.gov/html/fs_data/latestecondata/documents/BBAnnualResConstCA-US.xls.

Assembly Bill 1109, Chapter 534, Statues of 2007

AB 1109, authored by Assemblyman Jared Huffman, requires California to reduce its lighting electrical energy consumption in the commercial, residential and outdoor sectors. By 2018, reductions must meet 25 percent for commercial interior and outdoor lighting, and 50 percent for residential interior lighting, compared to 2007 levels.

Huffman, Jared. ***Assembly Bill 1109, Chapter 534,*** October 2007.
<http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1101-1150/ab_1109_bill_20071012_chaptered.pdf>.

U.S. Census – California

The U.S. Census counts every resident in the United States. It is mandated by Article I, Section 2 of the Constitution and takes place every 10 years. The data collected by the decennial census determine the number of seats each state has in the U.S. House of Representatives and is also used to distribute billions in federal funds to local communities. The census includes state-level demographic profiles that include information on race, age and housing status. The most recent census information on California was made available to the public in May 2012, for the 2010 census. Information on population, occupied housing units and persons per household, taken from the 2010, 2000, and 1990 surveys was utilized in this analysis.

U.S. Census of Population and Housing, 1990*: Summary Population and Housing Characteristics: California.* Washington: Government Printing Office, 1992.

U.S. Census of Population and Housing, *2000: Summary Population and Housing Characteristics: California.* Washington: Government Printing Office, November 2002.

U.S. Census of Population and Housing, *2010: Summary Population and Housing Characteristics: California.* Washington: Government Printing Office, May 2012.