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2010 U.S. Lighting Market Characterization

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DISCLAIMER

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AEO	Annual Energy Outlook
AHS	American Housing Survey
CBECS	Commercial Building Energy Consumption Survey
CFL	Compact Fluorescent Lamp
DOE	U.S. Department of Energy
DSM	Demand-side Management
EIA	Energy Information Administration
FAA	Federal Aviation Administration
FRA	Federal Railroad Administration
HID	High Intensity Discharge
HPS	High Pressure Sodium
kWh	kilowatt hours
LCA	Lighting Controls Association
LED	Light Emitting Diode
Lm/W	Lumens per Watt
LMC	Lighting Market Characterization
LPS	Low Pressure Sodium
MECS	Manufacturing Energy Consumption Survey
MH	Metal Halide
MV	Mercury Vapor
NAICS	North American Industry Classification System
NEMA	National Electrical Manufacturers Association
NEMS	National Energy Modeling System
NFDC	National Flight Data Center
Quad	Quadrillion BTU
RECS	Residential Energy Consumption Survey
SSL	Solid State Lighting
Tlm-hr	Teralumen-hours
TWh	Terawatt hours
W	Watts

Executive Summary

The *2010 U.S. Lighting Market Characterization* is the second report released by the U.S. Department of Energy's Solid State Lighting Program that provides summary estimates of the installed stock, energy use, and lumen production of all lamps operating in the U.S, the first version being released in 2002. The objective of this report is to collect and present in one document the fundamental energy consumption information that DOE needs to plan an effective lighting research and development program. This report answers three main questions:

- How many of each lighting technology are installed in the U.S. in 2010 and where are they installed?
- How much energy is consumed by light sources in the U.S. in 2010?
- How have the U.S. lighting market characteristics changed over the past decade?

The results in this report are provided at both a national level and a sector-specific level. The four sectors represented include three building sectors – residential, commercial, industrial – and one outdoor sector. The estimates have been based primarily on public sources of information, building lighting audits, industry surveys, national lamp shipment data, and interviews with lighting professionals and subject matter experts. A variety of sources were used to ensure all data inputs were reinforced and to improve the accuracy of the analysis.

Light sources in this study were grouped into six broad categories: incandescent, halogen, compact fluorescent, linear fluorescent, high intensity discharge, and solid state/other. Within each of these, the market analysis evaluated subgroups of commonly available lighting products (e.g., reflector lamps, T8 fluorescent tubes, metal halide lamps). In total, 28 lamp types were carried through the analysis, extracting information like average wattage, operating hours and number of sockets from the data set. A complete list of the light source subgroups can be found in Table A.1 of the main report.

Table ES.1 presents a summary of the U.S. lighting characteristics in 2010. More detailed results on the lighting characteristics of each sector analyzed can be found in Section 4 of the main report. The largest sector in terms of number of installed lamps is the residential sector. Residences account for 71 percent of all lamp installations nationwide, at 5.8 billion lamps. The commercial buildings sector is the second largest sector with 25 percent of all installations and 2.1 billion lamps. The outdoor and industrial sectors are significantly smaller, each accounting for roughly 2 percent of all lamps installed, 180 million and 140 million lamps, respectively.

With regard to average daily operating hours, while lamps in the commercial, industrial, and outdoor sectors typically are used for half the day (working hours for commercial and industrial sector lamps and night time hours for outdoor lamps) residential lamps are only used a couple hours a day on average. As for the average wattage characteristics, the residential sector average wattage of 46 W per lamp represents the mix of low wattage, high efficacy CFLs and higher wattage, lower efficacy incandescent lamps installed in the sector. The commercial, industrial and outdoor sector's average wattages are characteristic of the high installed base of fluorescent lamps and high wattage high intensity discharge lamps.

Table ES.1 Summary of Lighting Market Characteristics in 2010

	Lamps	Average Daily Operating Hours	Wattage per Lamp	Annual Electricity Use (TWh)
Residential	5,811,769,000	1.8	46	175
Commercial	2,069,306,000	11.2	42	349
Industrial	144,251,000	13.0	75	58
Outdoor	178,374,000	11.7	151	118
Total	**8,203,700,000**	**4.7**	**48**	**700**

These inputs combined result in a total annual electricity use of U.S. lighting of 700 TWh, or approximately 19 percent of total U.S. electricity use. Figure ES-1 presents the lighting electricity use by sector and lamp type. Nearly half of the lighting electricity is consumed in the commercial sector, which also represents the sector in which the majority of lumens are produced. This sector is dominated by linear fluorescent area lighting. The residential sector's large installed base of low efficacy lighting causes the sector to be the second largest lighting energy consumer, at 175 TWh per year. Ranked by technology, linear fluorescent lighting represents the overall highest electricity consumer at 42 percent lighting electricity. This is following high intensity discharge lighting at 26 percent and incandescent lighting at 22 percent.

While LED lighting has experienced significant growth over the past decade, the impact of this technology has been limited, as of 2010, to mostly niche applications, such as traffic signal lighting. LEDs penetration into general illumination applications in the building sectors is still significantly below 1 percent and the technology will need continued research and marketing support to realize its high potential penetration and energy savings.

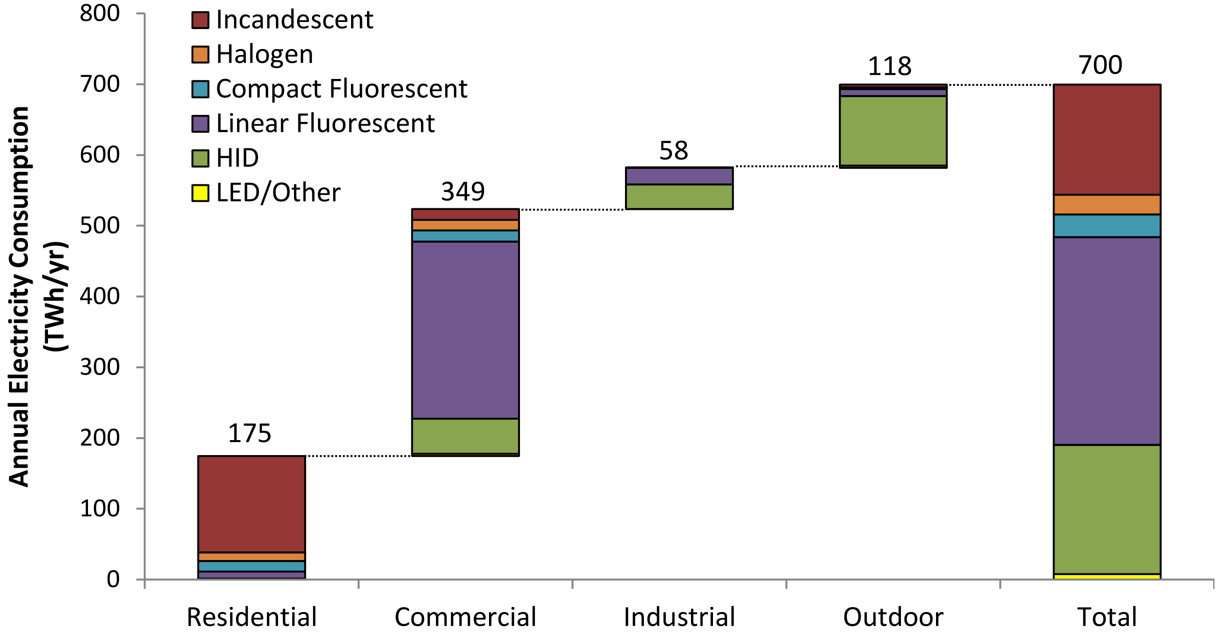

Figure ES-1 U.S. Lighting Electricity Consumption by Sector and Lamp Type in 2010

There have been significant changes in the lighting stock and energy consumption characteristics since 2001 (the baseline year of the previous Lighting Market Characterization). A detailed comparison of the two estimates can be found in Section 5.2 of the main report. Two notable trends include:

- Increased demand for light. The total number of lamps installed in U.S. stationary applications grew from just under 7 billion in 2001 to over 8 billion in 2010. The vast majority of the growth occurred in the residential sector, primarily due to the increase in number of households and the rise in the number of sockets per household, from 43 in 2001 to 51 in 2010.

- Push towards higher efficacy lighting. Investment in more energy efficient technologies, federal and state-level lighting regulations, and public awareness campaigns have been effective in shifting the market towards more energy efficient lighting technologies. Across all sectors the lighting stock has become more efficient, with the average system efficacy of installed lighting increasing from 45 lumens per Watt in 2001 to 58 lumens per Watt in 2010. This rise in efficacy is largely due to two major technology shifts; the move from incandescent to compact fluorescent lamps (CFLs) in the residential sector, and the move from T12 to T8 and T5 fluorescent lamps in the commercial and industrial sectors.

1 Introduction

The lighting market is entering a period of great change with new technology entrants, energy efficiency programs, and government regulations promising to reshape the market in the upcoming years. However, to fully understand where the market is headed, we must first establish its current characteristics. In 2002 the U.S. Department of Energy published the U.S. Lighting Market Characterization Volume I: National Lighting Inventory and Energy Consumption Estimate, or LMC for short, which provided a detailed view of these characteristics for the baseline year of 2001 (Navigant Consulting, Inc., 2002).[1] After almost a decade and significant changes to both the lighting market as well as our nation's energy policy, the Department of Energy (DOE) presents this, the second version of the LMC.

The objective of this report is to collect and present in one document the fundamental energy consumption information that DOE needs to plan an effective lighting research and development program. This report answers three main questions:

- How many of each lighting technology are installed in the U.S. in 2010 and where are they installed?
- How much energy is consumed by light sources in the U.S. in 2010?
- How have the U.S. lighting market characteristics changed over the past decade?

This report is sponsored by DOE's Solid-State Lighting (SSL) Program. The SSL Program focuses on research and development as well as commercialization activities concerning light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs). This report provides the baseline DOE needs to plan an effective program and against which to measure progress. In addition the LMC is intended to be used by both governmental and non-governmental organizations for planning and evaluating lighting opportunities, forecasting the direction of the lighting market, and additional research efforts.

For ease of use and comparison, this LMC is structured similarly to the 2001 study. However, this version expands on the previous effort by utilizing updated data sources and incorporating input from a technical review committee.[2] In addition, this version examines additional topics of particular interest to the lighting community, such as the penetration of LED lighting and prevalence of lighting controls, which were not included in the 2001 study.

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[1] The previous version of the LMC was released in 2002, but provided results for 2001. In this report it is referred to as the 2001 LMC. The previous version of the LMC can be downloaded at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lmc_vol1_final.pdf

[2] The methodologies and results found in this report were presented to a to a technical review committee in the summer and fall of 2011. The committee consisted of twenty members representing government, lighting manufacturers, utilities, and other non-government organization. This final report incorporates their suggestions and insights.

2 Study Scope

The scope of the LMC includes all lighting installed in the U.S. in stationary applications during 2010. Mobile applications, such as automobile headlights, are excluded from this report. As in the 2001 LMC, the lighting inventory and energy use estimates are split amongst four sectors: residential buildings, commercial buildings, industrial buildings, and outdoor. Each of these sectors is further divided into several subsectors. For the residential sector, the subsectors are based on the type of construction of the residence and the room type in which the lamp is located. For the commercial and industrials sectors, the subsectors are based on the principal activity conducted within the building. In the previous 2001 LMC, lighting characteristics were additionally provided by application area within commercial and industrial buildings; however the updated data sources did not contain sufficient data to provide this level of detail. For the building sectors, the subsector classification is in accordance with that used by the Energy Information Administration (EIA) in its end-use consumption surveys and the American Housing Survey (AHS).

The outdoor stationary sector accounts for the remainder of lamps not installed inside buildings. The outdoor subsectors are based on the application where the lamp is used. This includes lamps that may be associated with a specific commercial or industrial building but are installed on the exterior, such as parking lot lights or exterior wall packs. This is in contrast to the 2001 report in which some outdoor lighting was classified in the commercial and industrial sectors. In addition, the 2010 estimates for the outdoor sector include subsectors not previously analyzed, namely stadiums and railroad applications. Table 2.1 lists all of the sectors and subsectors.

Table 2.1 Sectors and Subsectors Analyzed

Residential[3]	Commercial[4]	Industrial[5]	Outdoor
Residence Types	Education	Food	Airfield
Single Family Detached	Food Service	Beverage & Tobacco Products	Billboard
Single Family Attached (Townhouse)	Food Store	Textile Product Mills	Building Exterior
	Health Care – Inpatient	Wood Products	Parking
Multifamily	Health Care – Outpatient	Paper	Railway
Mobile & Manufactured	Lodging	Printing & Related Support	Roadway
	Offices (Non-medical)	Petroleum & Coal Products	Stadium
Rooms	Public Assembly	Plastics & Rubber Products	Traffic Signals
Basement	Public Order and Safety	Nonmetallic Mineral Products	
Bathroom	Religious Worship	Primary Metals	
Bedroom	Retail – Mall & Non-mall	Fabricated Metal Products	
Closet	Services	Machinery	
Dining Room	Warehouse & Storage	Computer & Electronic Products	
Exterior	Other	Electrical Equipment, Appliances & Components	
Garage			
Hall		Transportation Equipment	
Kitchen		Furniture & Related Products	
Laundry/Utility Room		Miscellaneous	
Living / Family Room			
Office			
Other / Unknown			

[3] For definitions of each residential subsector refer to: http://www.census.gov/housing/ahs/files/Appendix%20A.pdf

[4] For definitions of each commercial subsector refer to: http://www.eia.gov/emeu/cbecs/building_types.html

[5] For definitions of each industrial subsector refer to the North American Industry Classification System (NAICS). For further information on the NAICS refer to: http://www.census.gov/eos/www/naics/

The lamp technologies have been categorized as displayed below in Figure 2-1. The categories are based on those used in the 2001 LMC, the categories used in the various data sources, as well as input from members of the technical review committee. Descriptions of each lamp technology can be found in Appendix A.

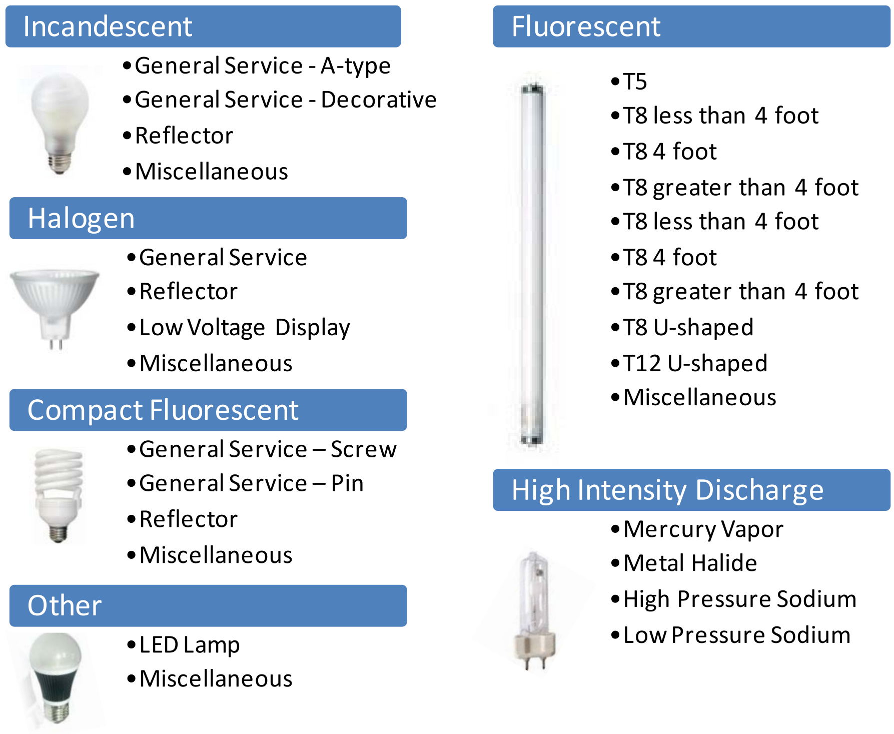

Figure 2-1 Lamp Classification[6]

[6] Low pressure sodium is a discharge lamp, but not a high intensity discharge lamp. It has been classified as such for presentation purposes.

3 Methodology

The methodology used to develop the national lighting inventory for the buildings sectors (residential, commercial, and industrial) involved two major steps. The first step entailed aggregating sets of building lighting data, which were collected through on-site audits as well as through interviews with the building owners, and then scaling the aggregated datasets up to a national level. The building lighting data collected in this step provided data on the lamps installed in each building, including details such as lamp quantities, wattages, and operating hours. More information on the data used in this step and the method of aggregation can be found in Section 3.1 and Section 3.2, respectively.

Because the data used in the first step was collected in various years (prior to 2010) and in selected geographies not necessarily representative of the entire U.S, the second step of the analysis involves statistically adjusting the initial inventory estimates so that the final estimate represents the entire U.S. in the year of 2010. To do so historical national lamp shipment data obtained from the National Electrical Manufacturer's Association (NEMA), the U.S. Census Bureau, and interviews with lamp manufacturers was utilized. Additional detail on the shipments analysis can be found in Section 3.2.1.1.

The analysis for the outdoor sector was developed in a slightly different manner than that of the buildings sector due to a lack of audit and survey data. Due to the varying formats of the data sources utilized, each subsector in the outdoor sector was developed in a unique way based on the available data. In general, the characteristics of the outdoor subsectors were based on interviews with experts, inventory data collected from trade associations or relevant organizations, and the shipment data mentioned above. The data sources used for each outdoor subsector are discussed in Section 3.1.4.

Figure 3-1 illustrates the basic structure of the methods used as well as the key inputs for each method.

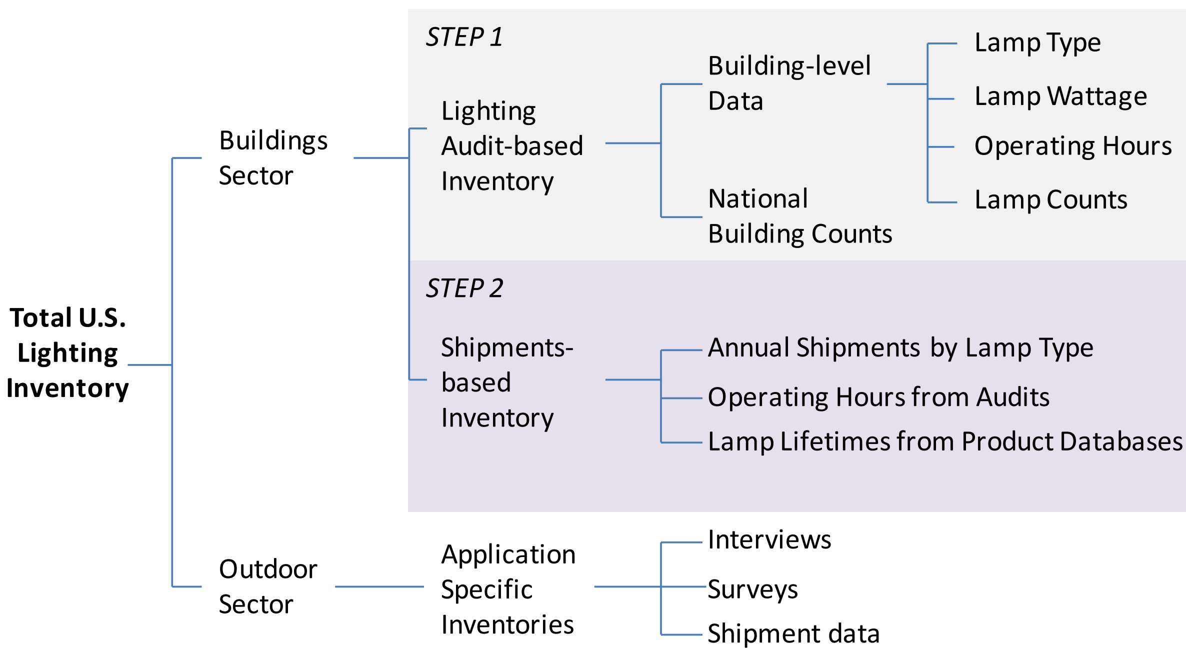

Figure 3-1 National Inventory Calculation Methodology

3.1 Data Collection

The LMC relies primarily on existing data sources. New data was not collected for this study, apart from data collected through interviews and surveys for outdoor subsectors where insufficient existing data sources were available. The reliance on existing data sources allows the LMC to collect and utilize data from a wider variety of geographies and a greater number of buildings than if all data had to be collected in the field.

Because this analysis relies on existing sources, the quality of the analysis is dependent on the quality of the source data. Thus, collecting high quality data—objective, accurate, and recent—was the primary concern in the development of this report. In order to do so, data was drawn from several different sources:

- **National data sources** include surveys conducted by the EIA and the Census Bureau that provide the total number and square footage of buildings in the U.S.
- **On-site sources** consist of lamp inventories developed through on-site audits and, at times, operating hours developed through the use of lighting loggers, for a small random sample of buildings in a specific region of the U.S.
- **Off-site sources** include inventory data collected through mail, telephone, and online surveys as well as additional data collected through interviews.
- **Shipment sources** provide the quantity of annual shipments from manufacturer groups for specific lamp types.

The following sections provide more detail on the key data sources used in this analysis.

3.1.1 National Data Sources

National data was drawn from the U.S. Census Bureau's American Housing Survey (AHS) for the residential sector and from EIA energy consumption surveys for the commercial and industrial sectors.

The EIA releases multiple studies for which a randomly selected sample of building owners are interviewed in order to estimate basic energy use characteristics for U.S. buildings. The 2010 LMC utilized two of these studies: the Commercial Buildings Energy Consumption Survey (CBECS) and the Manufacturing Energy Consumption Survey (MECS). The population estimate for the commercial and industrial sectors were derived from these studies. In the commercial and industrial sectors, the building population is defined by the total floorspace installed in the U.S. per building type.

The residential sector population was developed from the AHS, a bi-annual survey conducted by the U.S. Census Bureau which collects household and demographic data on the nation's housing units. The 2001 LMC used the Residential Energy Consumption Survey (RECS) by the EIA to determine the total population of residences. However, the AHS has been used in this update because it is based on a sample size almost five times as large as that used in the RECS. The residential building population only includes permanently occupied houses. Unoccupied and seasonally occupied houses likely do contain some lamps. However, these lamps are not used in the same manner as the majority of the lighting stock and likely comprise a small portion of total lighting energy use; thus, they have been excluded.

The AHS, CBECS, and MECS provided building population and floorspace estimates for various years. For the residential and commercial sectors, estimates of building stock growth from the EIA's Annual Energy Outlook 2011 were used to adjust the values to reflect the 2010 base year. For the industrial sector, the MECS estimate of total buildings floorspace was projected to the 2010 base year using annual put-in-place construction values from the U.S. Census Bureau as a proxy for floorspace growth. Table 3.1 summarizes the building characteristics of the national surveys used in this report (shown in white) as well as the adjusted 2010 values used in the LMC (shown in blue) (U.S. Census Bureau, 2011; EIA, 2003; EIA, 2006).

Table 3.1 U.S. Building Population and Floorspace Summary

Survey	Sector	Base Year	Number of Buildings (1,000's)	National Floorspace (million ft^2)
AHS	Residential	2009	111,860	238,118
		2010	113,153	240,868
CBECS	Commercial	2003[7]	4,859	71,658
		2010	5,497	81,203
MECS	Industrial	2006	474	10,274
		2010	455	9,866

3.1.2 Residential Data Sources

The residential sector analysis was based on data from five existing building audit studies, which included lighting data from 15 states. A majority of these studies were originally conducted in order to gain a quantitative understanding of the impacts of different utilities demand side management programs. In total, these sources, and consequently the 2010 LMC residential database, contain lighting inventory data for approximately 3,500 separate residences and nearly 200,000 lamps. Some buildings were removed from the final database as they did not contain complete lighting inventories.

These studies were selected for this analysis as they provide detail on lamp inventories, wattages, and operating hours in some instances, utilize the appropriate data collection methodologies, and contain the most up-to-date information on the residential lighting sector. Table 3.2 outlines the key characteristics of the residential sources used in this report. Below is a brief summary of each study utilized.

- *Upstream Lighting Program Evaluation* (KEMA, Inc., 2010): The report evaluated the sponsors' 2006–2008 Upstream Lighting Programs. As part of this evaluation, a complete inventory of all lamps installed in 1,200 randomly selected homes was conducted. The lighting data was collected from July of 2008 to December of 2009 in California. In addition, this report provided

[7] According to the EIA, CBECS 2007 was not released to the public because "it did not yield valid statistical estimates of building counts, energy characteristics, consumption, and expenditures".

the most comprehensive operating hour data of all studies included in the LMC, with lighting loggers applied to 7,299 fixtures.

- *Residential Construction Baseline Studies* (RLW Analytics, 2007a; RLW Analytics, 2007b; RLW Analytics, 2007c; RLW Analytics, 2007d)*:* This entry accounts for four studies conducted in the Pacific Northwest which aimed to determine the penetration rate of energy efficient technologies in new and existing single-family residences, as well as multifamily residences in the Pacific Northwest. Onsite data collection occurred from 2004 to 2006 and included general demographic information, and full lighting inventories for the interior and exterior of the homes.
- *Multi-State CFL Modeling Effort* (NMR Group, Inc., 2010)*:* This study represents a collaboration of numerous energy efficiency program sponsors to explain the drivers to CFL purchases, usage, and saturation in households. Onsite saturation surveys were collected for over 1,400 households from 2008 to 2009 in a range of geographies (see Table 3.2). Data for every region collected in this study was not available at the time of publishing the LM C.
- *Demand-Side Management 2010 Targeted Baseline Study* (Navigant Consulting, Inc., 2011)*:* This study aimed to identify demand-side management (DSM) programs that could be revised or introduced to maximize customer participation and energy savings potential in Arizona. Onsite surveys were conducted at nearly 100 residences.
- *Measurement, Evaluation, and Research Study* (Summit Blue Consulting, LLC, 2008)*:* This study is a quantitative assessment to determine the demand and energy savings resulting from Arizona's Consumer Products Program, a program that helps customers purchase ENERGY STAR products. The lighting inventory of nearly 60 residences was collected through onsite surveys.

Table 3.2 Residential Data Source Key Characteristics

Source	Geographic Region(s)	Building Count	Years of Data Collection
Upstream Lighting Program Evaluation	California	1,232	2006–2009
Residential Construction Baseline Studies	Idaho, Oregon, Washington	1,092	2004–2006
Multi-State CFL Modeling Effort	Connecticut, District of Columbia, Indiana, Massachusetts, Maryland, New York, Ohio, Texas, Wisconsin	984	2008–2010
Demand-Side Management 2010 Targeted Baseline Study	Arizona	92	2010
Measurement, Evaluation, and Research Study	Arizona	61	2009–2010

3.1.3 Commercial and Industrial Data Sources

The commercial and industrial sources are presented together as most of the data sources used include data on both types of buildings. The 2010 LMC utilized four recent studies for these sectors, which covered a total of 18 states and over 3,000 buildings. Some buildings were removed from the final database as they did not to contain complete lighting inventories. Table 3.3 and Table 3.4 outline the key characteristics of the commercial and industrial studies used in this report.

- *California Commercial End-Use Survey* (Itron, Inc., 2006)*:* This study's main purpose was to collect information on the commercial sector's energy in order to support forecasts of California's energy demand. Onsite surveys were conducted in 2,790 buildings across the service regions of California's public utilities. Published in 2006, this study was the oldest used in the LMC.
- *Business Sector Market Assessment and Baseline Study* (KEMA, Inc., 2009)*:* This study aimed to gather a baseline of the current market conditions in Vermont in order to identify opportunities for investment into energy efficiency. An onsite survey was conducted at almost 150 buildings in order to determine their installed stock of energy consuming equipment but only examined buildings that were built prior to 2006.
- *Industrial Assessment Center Data* (DOE, 2011)*:* This source consists of data collected in Industrial Assessment Centers around the country which provide eligible small and medium sized manufacturers no-cost energy assessments. These assessments included lamp counts and characteristics for all sockets. As this data is collected from buildings who sign up for the program, and not a randomly selected set of buildings, and does not include large industrial buildings, there could be a slight bias in the data collected.
- *Measurement, Evaluation, and Research Study* (Summit Blue Consulting, LLC, 2008)*:* This study is a quantitative assessment to determine the demand and energy savings resulting from Arizona's

Consumer Products Program, a program that helps customers purchase ENERGY STAR products. The lighting inventory of over 100 buildings was collected through onsite surveys.

Table 3.3 Commercial Data Source Key Characteristics

Source	Geographic Region(s)	Building Count	Years of Data Collection
California Commercial End-Use Survey	California	2,406	2003–2005
Business Sector Market Assessment and Baseline Study	Vermont	115	2008
Measurement, Evaluation, and Research Study	Arizona	106	2010

Table 3.4 Industrial Data Source Key Characteristics

Source	Geographic Region(s)	Building Count[8]	Years of Data Collection
California Commercial End-Use Survey	California	22	2003–2005
Business Sector Market Assessment and Baseline Study	Vermont	20	2008
Industrial Assessment Center Data	Arkansas, Colorado, Kansas, North Carolina, Massachusetts, New Mexico, Ohio, Oklahoma, Washington, Wyoming	55	2005–2010
Measurement, Evaluation, and Research Study	Arizona	8	2010

3.1.4 Outdoor Data Sources

The outdoor sector covers the eight lighting applications: airfield, billboard, building exterior, parking, railway, roadway, sports lighting, and traffic signal. Railways and sports lighting are two new applications which were not previously evaluated in the 2001 LMC. The following sections provide an overview of these applications as well as the sources and methods used to develop the inventory and energy use estimates for each. Where applicable, the current analysis utilized the same information sources as the 2001 LMC in an effort to maintain consistency between the two reports.

As compared to the building sectors, less inventory data was available for the applications in the outdoor stationary sector. Thus, the analysis of the outdoor sector was conducted in a slightly different manner than the building sectors. However, the same basic building blocks needed in the building sector evaluations – namely lamp inventory, operating hours, distribution of lamp technologies, and

[8] The industrial sector contained a smaller sample size of building lighting data than the other building sectors. The results from this sector were corroborated with national lamp shipment data.

average wattage for each technology - were required in order to estimate the national inventory and energy use for the outdoor stationary applications.

For each of the eight outdoor stationary lighting applications, Table 3.5 provides what sources were used for each building block. Definitions of each outdoor subsector are included in Section 3.2.3

Table 3.5 Outdoor Data Sources

Outdoor Subsector	Source(s)
Airfield Lighting	Federal Aviation Administration (Mai, Logan, Marinelli, & Adams, 2011; NFDC, 2011), Metropolitan Washington Airports Authority (Metropolitan Washington Airports Authority, 2011)
Billboard Lighting	Outdoor Advertising Association of America, Inc. (Laible, 2011), Lamar Advertising Co. (Switzer, 2010)
Building Exterior	See Commercial Data Sources and Industrial Data Sources
Parking	International Parking Institute (International Parking Institute, 2010; Conrad, 2010), Walker Parking Consultants (Monahan, 2010), Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting (Chester, 2010)
Railway	Federal Railroad Administration (Denton, 2011; Federal Railroad Administration, 2009), Federal Highway Administration (FHWA, 2009)
Roadway	DOE Municipal Solid-State Street Lighting Consortium (DOE, 2010), Local Government Interviews (City Governments, 2010), State Department of Transportation (State Governments, 2010), Federal Highway Administration (Anderson, 2010)
Sports Lighting	Stadium Managers Association (Abernathy, Ragain, & Mycka, 2010; Stadium Managers Association, 2010)
Traffic Signals	Federal Highway Administration (Anderson, 2010), Institute of Transportation Engineers (NTOC, 2007), Navigant Consulting (Navigant Consulting, Inc., 2008)

3.2 Inventory and Energy Use Calculation

As shown in Figure 3-2, to determine energy use for each technology the total number of installed lamps was multiplied by the average watts per lamp and the average operating hours. This calculation was applied on the subsector level (per room type and residence type in the residential sector, per building type in the commercial and industrial sectors and per application in the outdoor sector) and then summed or averaged across the subsectors to arrive at total sector energy use estimates.

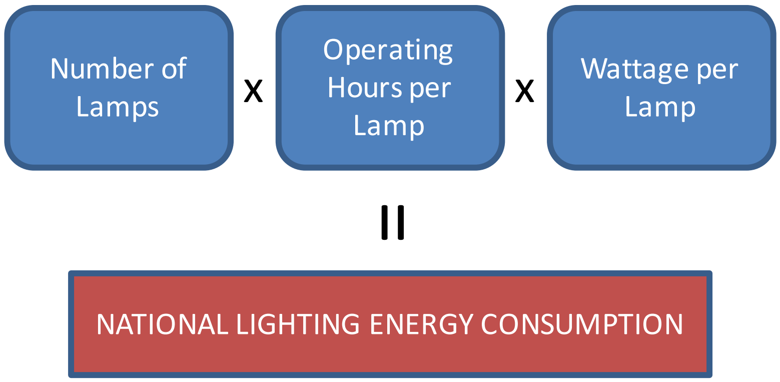

Figure 3-2 Energy Use Calculation

3.2.1 Buildings Sector Inventory and Energy Use Calculation

The inputs to this calculation are discussed below for the buildings sectors. As discussed in Section 3.1, these inputs were primarily derived from building survey and audit data, and shipment data.

3.2.1.1 Number of Lamps

An initial estimate of the number of installed lamps in each subsector was based on the aforementioned audit, survey, and interview data. In this report the term "lamps'" is used in reference to a single lighting unit. While for incandescent, compact fluorescent, linear fluorescent, or HID technologies it does represent the common usage of the term "lamp," for LED sources, "lamp" could refer to an integrated lamp, a luminaire, or an installation (e.g., exit sign, or under cabinet lighting). These subsector values were then weighted based on the discussion in n Section 3.2.2 to determine the total number of lamps in the U.S.

Two adjustments were made to these national inventory values prior to applying shipment data. As the buildings datasets were slightly biased to western U.S. (see Appendix A), inventory values for certain lamp types that are more or less prevalent in the western states than the rest of the country were over and underrepresented in the initial inventory estimates. To account for this bias, regional inventory share estimates were generated for each lamp type suspected of regional bias. Regional estimates that were two standard deviations from mean were considered to be impacted by the regional bias. The affected lamps included CFLs, incandescent a-type, reflector lamps, and linear fluorescent lamps. For these lamps the initial inventory was adjusted so that the final inventory share estimates properly reflect national conditions.

The second adjustment involved recognizing that nearly all exit sign lamps in the commercial and industrial sector had transitioned in 2010 to LEDs. Because some of the building inventories were initially conducted prior to 2010, some of these buildings had instances of incandescent and CFL exit signs. The inventories were adjusted so that LED lamps replaced these incumbent technologies for this application.

The adjusted inventory totals were then finalized using annual lamp shipment data so that the final values represented the entire U.S. in 2010. NEMA provided historical shipments for the U.S. through 2010 for several of the major lamp types considered in this report (NEMA, 2011). In addition, lamp import data was obtained from the U.S. Census Bureau (U.S. Census Bureau, 2011). The import data provides an indication of shipments not domestically manufactured. In general, a five step process was followed to adjust the national inventory estimates using these shipments.

1. Use historical shipments, lamp import quantities, and other available data to estimate the total historical shipments (i.e., NEMA member and non-NEMA member shipments) for each lighting technology.
2. Apply operating hour data from audit and survey sources to determine the range of socket service lifetimes in years for each lamp technology in each subsector.
3. For each subsector, determine the survey baseline year on which initial inventory estimates were based using the date of the original raw data collection. For example, in the residential sector most of the in-house inventories were conducted in 2008, with the remainder conducted in 2007, 2009, and 2010. The average date was 2008 so this was approximated to be the survey baseline year for the residential sector inventory.
4. Determine the portion of annual shipments assigned to each sector by first calculating the shipment installed stock of lamps for each sectors' baseline year (as determined in step 3) using historical shipments and the socket service lifetimes, and second matching this shipment inventory to the initial survey inventory estimate.
5. Determine the 2010 shipment inventory estimate by using the historical lamp shipments (from step 1), the operating hours (from step 2), and the sector breakdown (from step 4).

The inventory estimates derived from this shipments model are very sensitive to the assumptions used for lamp lifetime and NEMA manufacturer market share. Thus, this model was used to calibrate the adjusted inventory values only when market research and input from the technical review committee suggested that the survey and audit data were not properly capturing a recent trend in the lighting market. In all other cases, the shipments model was used only for verification purposes.

3.2.1.2 Operating Hours

The daily hours of operation of installed lights was recorded for each subsector where data was available. Residential sector operating hours were based solely on lighting metering data collected in California. This data was collected through lighting loggers that used photo-sensors to record when lamps were turned on or off. The lighting metering data was collected during different seasons of the year. To ensure that the final operating hours are reflective of the entire U.S. for the entire year, the raw data was adjusted using a seasonality factor and a geographic factor. It is assumed that operating of all indoor lighting is affected by the hours of daylight. The seasonality factor is a varying adjustment to the daily operating hours based on the day time hours of the specific day that the data was collected. The geographic factor is a single adjustment applied to the entire set of operating hours to account for the hours of sunlight in California as compared to the U.S. average.

Commercial and industrial sector operating hours were based on surveys with building owners and operators. All studies used in the commercial and industrial studies provided some survey information on estimated operating hours. The operating hours were originally drawn from multiple geographies, and were provided as average estimates of use over the entire year, so no adjustment factors were applied to them.

For all the building sectors the sample operating hour data was expanded to the entire inventory by developing average operating hours for lamps in similar applications and then weighed by the prevalence of a particular lamp type in the various applications. For the residential sector, the "application" categories were based on the room of installation and the lamp technology type (general service, reflector, linear fluorescent, HID). For the commercial and industrial sector, the "application" categories were based on the "use types" provided in the audit data (area, task, track, display, and exit) and the lamp technology type.

Operating hours for each technology were binned in this fashion for two reasons. First, because operating hour data was not collected for every lamp in the building audits and survey, in order to estimate average operating hour accounting for the distribution of lamps across different applications, each lamp in the database needed an associated estimate of hours of operation. Second, after disaggregating the audit data by building type, room type (for residential only), and lamp type, the sample set to estimate operating hours for some lamp types became too small to reliably approximate hours of operation. Utilizing averages for operating groups based on application combined data for several lamp types and increased the usable samples.

3.2.1.3 Wattage per Lamp

The metric of average watts per lamp includes the lamp wattage (as provided by the building audit and survey data) combined with ballast assumptions for relevant lamp types. For incandescent, halogen, and screw-base CFLs the wattage per lamp were represented solely the lamp wattage. Pin-based CFLs, linear fluorescent lamps, and HID lamps were assumed to be operated by an external ballast. These lighting systems consume additional energy due to the losses in the ballasts. In addition, as some ballasts operate lamps at power levels other than their rated power, this can significantly affect overall system wattage. In order to estimate these effects on externally ballasted lamps, a database of typical ballast input watts and their associated rated lamp watts was developed using manufacturer data and the DOE's Fluorescent Lamps Ballast Standards Rulemaking. (DOE, 2011). Only systems with rated lamp powers similar to the average lamp wattage as provided in the LMC data sources were included in this manufacturer data. The average (system) wattage per lamp for these lamp types listed in the LMC was calculated by multiplying the lamp wattage by the average ratio of system input power by lamp rated power from the manufacturer catalog data for characteristic systems.

$$W_{sys} = W_{lamp}\ x\ \frac{P_{in}}{(W_{rated})}$$

Where:

W_{sys} *= System wattage reported in LMC*

W_{lamp} *= Lamp wattage provided in data sources*

P_{in} *= Rated input power into the ballast from manufacturer data*

W_{rated} *= Rated lamp power for ballast from manufacturer data*

Further information on ballast assumptions is provided in Appendix C.

3.2.2 Sample Weighting in the Buildings Sector

The inventory, operating hours, and wattages provided in the database were for a sample dataset of a few thousand buildings. In order to expand this dataset so that it represented the 2010 U.S. population of buildings, sample weights were use. The sample weight is unique to each sample building and reflects the number of buildings in the U.S. population that the sample building represents. Sample weights were used as it provides a quantifiable method to adjust for the under and over representation of certain segments of the building population in the sample dataset.

3.2.2.1 Residential Sector

For the residential sector we used data from the 2009 American Housing Survey to determine the characteristics of the U.S. population of homes. A single growth rate based on Energy Information Administration estimates of the housing stock growth was applied to the number of homes in the AHS to adjust the baseline year from 2009 to 2010. Over 113 million residences existed in the U.S. in 2010, not including homes that were considered vacant or only seasonally occupied (EIA, 2011a). The sample weight was based on the residence type, the total floorspace of the residence, and the age of the residence. Other weighting categories were considered, such as whether the property was owned or rented, and the household income. However, none of these metrics were found to be significant indicators of the number of lamps in a residence. The calculation for the basic weight is:

$$Sample\ Weight\ (x, y, z) = \frac{\sum Residences\ in\ U.S.\ of\ size(x)\ \&\ type(y)\ \&\ age(z)}{\sum Residences\ in\ Dataset\ of\ size(x)\ \&\ type(y)\ \&\ age(z)}$$

Where:

x = size categories (less than 1,000ft^2; 1,000ft^2 to 2,500ft^2; greater than 2,500 ft^2)

y = type categories (single-family detached; single-family attached; multifamily; mobile or manufactured)

z = age categories (constructed prior to 1980, in the 1980's, in the 1990's, in the 2000's)

Geography was examined as a potential a weighting category, however the sample dataset did not have enough data points from each geographic regions to produce statistically significant results based on geography.

The dataset did not include any lighting data for mobile manufactured homes with a floorspace greater than 2,500 ft^2. According to the AHS, there are just over 1 million of these homes in the U.S., approximately 1 percent of the entire stock. Lighting data for smaller mobile homes was used to approximate the inventory and lighting characteristics in this category.

3.2.2.2 Commercial and Industrial Sectors

For the commercial and industrial sectors we used data from the 2003 CBECS and 2006 MECS to determine the characteristics of the U.S. population of these buildings. The building population and floorspace of commercial buildings were adjusted from a 2003 baseline to a 2010 baseline using growth estimates from the EIA's Annual Energy Outlook 2011. The building population and floorspace of industrial buildings were adjusted from a 2006 baseline to a 2010 baseline using the annual put-in-place construction values as a proxy for the growth in buildings. The use of this proxy method results in a slight decline in industrial building floorspace since 2006.[9]

The sample weight for each building was based on the use type of the building and the total U.S. floorspace dedicated to that use type. The calculation for the basic weight is as follows:

$$Sample\ Weight = \frac{\sum Floor\ space\ in\ U.S.\ of\ type(x)}{\sum Floor\ space\ in\ dataset\ of\ type(x)} \times Floor\ space\ of\ Building$$

Where:
x = Use-type of a building (retail, lodging, machinery manufacturing, etc.)

The dataset did not include any information on four industrial building types: textile mills, apparel manufacturing shops, leather and allied product manufacturing shops, and chemical manufacturing facilities. The calculated lighting characteristics for the entire industrial sector were used to approximate the lighting characteristics in these building subsectors.

3.2.3 Outdoor Inventory and Energy Use Calculation Method

The energy use calculations follow the same basic calculation in the outdoor sector as the building sectors, that being lighting inventory multiplied by average wattage multiplied by average operating hours equals electricity use. However the inputs were derived in different manners according to the data available. The following provides detail on how the outdoor data sources were used to develop the inventory and energy use estimates.

3.2.3.1 Airfield Lighting

Airfield lighting includes all of the runway and taxiway lamps that direct airplane traffic at the nation's airfields. To determine the total number of lit runways, the Federal Aviation Administration's (FAA) National Flight Data Center (NFDC) was consulted. The FAA's Advisory Circular 150/5340-30d, which contains the design and installation details for airport visual aids, was used to determine the recommended spacing for the lamps in the majority of runway lighting systems. The installed base of

[9] The 2001 LMC estimated the total square footage of the industrial sector to be almost 17 billion in 2001. This value is significantly more than what the MECS reported in 2002 or what is being used in this report, and caused the estimated number of lamps in the industrial sector to be considerably greater in the 2001 LMC than this study.

lamps, except those used in taxiway lighting, was calculated using these recommended spacing distances and the runway lengths provided by the NFDC database.

Data on taxiway edge lighting is not included in the NFDC database, so a separate method was used to determine the installed base for these lamps. Because taxiway edge lamps are required by the FAA for all 14 CFR Part 139 certified airports,[10] this analysis considers taxiway edge lighting only for the 549 certified airports. The Metropolitan Washington Airports Authority provided the number of taxiway edge lamps installed in its two major commercial airports, Dulles International Airport and Reagan National Airport. This number of lights was normalized based on the two airports size and the average value was applied to all Part 139 certified airports. Lastly, the FAA provided estimates for typical operating hours, technology mix, and typical lamp wattages for each type of lighting system.

3.2.3.2 Billboard Lighting

Billboard lights include the lamps that illuminate the billboards found along roadways. This analysis only considers non-digital billboards. Digital billboards have not been included in the inventory and energy use section as these billboards had a very limited presence in 2010.

The Outdoor Advertising Association of America, Inc. confirmed that no national inventory of billboard lights currently exists. However, the Outdoor Advertising Association of America was able to provide estimates of the total number of billboards in 2010 broken down by billboard size. Additionally, the Lamar Advertising Company provided the typical values for the number of lamps per billboard, operating hours, and the technology mix for traditional billboard types (Switzer, 2010).

3.2.3.3 Building Exterior Lighting

All lamps that are directly associated with a commercial or industrial building, but installed on the exterior have been included in this application. Examples of these types of lamps are wall pack lights on the building's facade, walkway lights, landscape lights, and the other various flood and area lights used to illuminate the exterior of the building and the surrounding property. In the previous LMC, many of these lamps were categorized in the commercial buildings and industrial buildings sectors. In the current analysis, the estimate for exterior building lights is based on the commercial and industrial audit datasets. The sources used in these datasets often included exterior lighting data for both commercial and industrial buildings. The same method used for the building sectors was applied to the exterior building lighting application to determine the installed base, operating hours, technology mix, and average lamp wattages.

3.2.3.4 Parking Lighting

Parking lighting includes the lamps that illuminate parking lots and stand-alone above grade parking garages. In the 2001 LMC a portion of parking lights, those directly associated with a commercial or industrial building, was included in the commercial and industrial buildings sectors. In this analysis, we have incorporated all parking lights in this outdoor stationary sector.

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[10] A Part 139 certified airport is one that adheres to the regulations contained in 14 CFR 139. This includes most large commercial airports that serve scheduled and unscheduled flights with more than 30 seats. Additional information on this certification can be found at: http://www.faa.gov/airports/airport_safety/part139_cert/

The International Parking Institute confirmed that no national inventory of parking facility lighting has been developed in recent years. In this analysis, the total number of lighting installations is based on the estimated number of total parking spaces. As there is no commonly accepted number of total U.S. off-street parking spaces, and estimates can range from 100 million to two billion, a middle ground value, of 420 million, from a recent University of California study was employed. It assumed that all parking spaces are lit. To convert this value to a total number of lamp installations, typical design guidelines of one lamp per every three garage spaces and per every twenty parking lot spaces, provided by Walker Parking Consultants, are used.

The International Parking Institute conducted a survey of its membership on a variety of lighting issues relevant to this report. The operating hours, technology mix, and average system wattages were all drawn from this survey.

3.2.3.5 Railway Lighting

Railway Lighting is one of the new application areas not previously evaluated in the 2001 LMC.

There are two general types of railway signals considered in this analysis: wayside signals and highway-rail crossing signals. Wayside signals are colored control signals, similar to roadway traffic signals, and are used to prevent train collisions. Highway-rail crossing signals are located where highways and railways cross at the same grade. Their purpose is to alert roadway traffic when trains are approaching.

The Federal Railroad Administration (FRA) confirmed that no national census of railway lamps has recently been conducted, but provided an estimate of the technology mix and typical wattages for all railway lamps. The number of wayside installations was based on typical signal spacing estimates and the total miles of lit track, which were provided by the FRA. The Office of Safety Analysis at the FRA maintains a database containing the number of highway rail crossings, which was accessed for this analysis.[11]

The number of lamps per installation varied from 2 to 8 depending on crossing type, and was based on FRA estimates and the Federal Highway Administration's Manual on Uniform Traffic Control Devices, which provided minimum numbers of lamps required. The hours of operation for these lamps are based on the volume of train traffic, as most signals only activate during the presence of a train.

3.2.3.6 Roadway Lighting

Roadway lighting includes lamps that illuminate streets and those that illuminate highways. Street lights are found in typically urban and sub-urban settings where pedestrian traffic, residences, or commercial properties lie adjacent to the roadway, and therefore these lights are responsible for illuminating the roadway as well as the nearby walkways and building fronts. Highway lights are found on roadways that independently serve transportation purposes and are only responsible for illuminating the roadway.

The national inventory of street lighting was estimated from data collected through interviews with City Departments of Transportation as well as data provided by the DOE's Municipal Solid-State Street

[11] The FRA database of highway rail crossings can be found at: http://www.fra.dot.gov/rrs/pages/fp_801.shtml

Lighting Consortium. The lighting data provided by these sources included the number, the type, and the application for every roadway light owned by the city. Combined, these two sources provided street lighting inventory data for 25 local governments.

The highway lighting estimate is based on interviews with various State Departments of Transportation and the Federal Highway Administration. These interviews provided the technology mix, operating hours, and lamp wattages of highways lamps for a sample set of states that was considered representative of the U.S. The total number of U.S. highway lamps is based on Federal Highway Administration estimates for the total U.S. lighted highway miles and average roadway spacing of 200 feet between lamps.

3.2.3.7 Sports Lighting

Sports lighting is the other new application not previously evaluated in the 2001 LMC. Sports lighting includes the lamps that illuminate the outdoor playing fields at sports stadiums. The indoor sports lights and other lights installed inside of stadiums have been included in the commercial sector.

The Stadium Managers Association, a trade association dedicated to efficient management of stadiums throughout the world, conducted a survey of its membership to collect lighting data. The survey collected information on the total number of stadium lights, operating hours, the technologies installed and the associated wattages of each technology.

3.2.3.8 Traffic Signal Lighting

Traffic signal lighting includes the lamps that illuminate street signals, such as stop lights and pedestrian road crossing signals. Three types of stop lights are considered in this analysis: the tri-colored ball, the turn arrow, and the bimodal arrow. In addition, three pedestrian crossing signals are considered: the walking person, the stop hand and the countdown.

To determine the inventory of these traffic lights, an estimate of 300,000 signalized intersections, from the Institute of Transportation Engineers, was used. This estimate was adjusted based on information provided by the Federal Highways Administration. The number of each signal type per each signalized intersection(approximately 10 colored ball signals, 3 arrow signals, 8 walking person and hand signals and 0.21 countdown signals), as drawn from a 2008 DOE analysis, was multiplied by the total number of signalized intersections to determine the total number of signals. This analysis was also used to determine operating hour data for each type of traffic signal.

The Energy Policy Act of 2005 required all traffic signals manufactured after January 1, 2006 to meet or exceed ENERGY STAR performance criteria, effectively requiring all new and replacement signals to be LEDs. Prior to this mandate, traffic signals were predominantly lit by incandescent lamps. Based on the turnover rate of incandescent traffic signals and interviews with experts, it was assumed that approximately 95 percent of traffic signals have been converted to LEDs. A complete conversion has not yet occurred as some incandescent bulbs manufactured before 2006 remain on the market today.

4 Lighting Inventory and Energy Consumption Estimates

The objectives of the LMC analysis were to develop an accurate depiction of the nation's lighting inventory and lighting electricity consumption for the baseline year of 2010. The remainder of this report provides detailed results concerning these objectives, and compares the findings to the 2001 LMC results as well as other comparable energy use estimates.

Section 4.1 provides the cumulative results for all lamp technologies by sector. The following four sections take a closer look at the same results, but focus in on the subsector level: Section 4.2.1 provides detail on the residential sector, Section 4.2.2 the commercial sector, Section 4.2.3 the industrial sector, and Section 4.2.4 the outdoor sector.

In addition, Section 4.3 examines in further detail the predominate applications of LED lighting in each of the sectors. Finally, Section 4.4 examines the prevalence of lighting controls.

4.1 Cumulative Results

Table 4.1 presents the estimate of the installed lamps in the U.S. by lamp technology and sector. The total installed base of lamps in the U.S. for 2010 was estimated to be 8.2 billion. This represents an overall growth of 17 percent relative to 2001's estimate of nearly 7.0 billion lamps. When comparing the installed base estimates in each sector from 2001 to those presented here for 2010, it is important to note that the definitions for the commercial, industrial, and outdoor sectors used in this report are not identical to those used in the 2001 report. As discussed in Section 2, for this report all outdoor lighting associated with commercial and industrial buildings (e.g., parking lot lighting and building exterior lighting) were classified in the outdoor sector; this is in contrast to the 2001 report in which some outdoor lighting was classified in the commercial and industrial sectors. In addition, the 2010 estimates for the outdoor sector include subsectors not previously analyzed, namely stadiums and railroad applications; however, these additional subsectors contribute a very low percentage of the total installed base of the outdoor sector.

In general, the bulk of lamp inventory growth has been in the residential sector, which accounts for more than double the number of lamps in the remaining sectors combined. Accounting for changes in outdoor lamp classifications, compared to 2001 the lamp inventory in the residential and commercial sectors have increased by 26 percent and 13 percent, respectively, largely due to an increase in number of homes and floor space. In contrast, the industrial sector lamp inventory has decreased by 54 percent over the past ten years, mostly due to a reduction in manufacturing floorspace and a movement toward higher lumen output technologies, such as HID. After accounting for the differences in categorization of buildings-related outdoor lighting, the outdoor sector has seen a moderate decline of 16 percent relative to 2001.

Table 4.1 Estimated Inventory of Lamps in the U.S. by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**3,602,809,000**	**77,597,000**	**402,000**	**17,814,000**	**3,698,622,000**
General Service - A-type	2,028,184,000	42,930,000	387,000		2,071,501,000
General Service - Decorative	980,054,000				980,054,000
Reflector	433,929,000	19,421,000	15,000		453,365,000
Miscellaneous	160,642,000	15,246,000		17,814,000	193,702,000
Halogen	**256,990,000**	**47,596,000**	**71,000**	**4,021,000**	**308,678,000**
General Service	26,785,000	969,000	3,000		27,757,000
Reflector	168,876,000	19,499,000	63,000		188,438,000
Low Voltage Display	19,348,000	25,644,000			44,992,000
Miscellaneous	41,981,000	1,484,000	5,000	4,021,000	47,491,000
Compact Fluorescent	**1,322,525,000**	**216,183,000**	**406,000**	**12,053,000**	**1,551,167,000**
General Service - Screw	1,121,452,000	40,498,000	91,000		1,162,041,000
General Service - Pin	5,386,000	136,207,000	201,000		141,794,000
Reflector	114,754,000	39,478,000	114,000		154,346,000
Miscellaneous	80,933,000			12,053,000	92,986,000
Linear Fluorescent	**572,897,000**	**1,654,753,000**	**128,625,000**	**29,124,000**	**2,385,399,000**
T5	3,636,000	108,066,000	9,245,000		120,947,000
T8 Less than 4ft	3,020,000	14,090,000	708,000		17,818,000
T8 4ft	64,022,000	907,727,000	78,425,000		1,050,174,000
T8 Greater than 4ft	1,369,000	27,914,000	3,349,000		32,632,000
T12 Less than 4ft	7,025,000	7,294,000	14,000		14,333,000
T12 4ft	331,790,000	410,460,000	24,006,000		766,256,000
T12 Greater than 4ft	28,685,000	109,066,000	10,830,000		148,581,000
T8 U-Shaped	1,155,000	45,897,000	546,000		47,598,000
T12 U-Shaped	316,000	10,828,000	1,021,000		12,165,000
Miscellaneous	131,879,000	13,411,000	481,000	29,124,000	174,895,000
High Intensity Discharge	**1,434,000**	**34,851,000**	**14,155,000**	**93,087,000**	**143,527,000**
Mercury Vapor	206,000	1,025,000	1,424,000	4,177,000	6,832,000
Metal Halide	45,000	30,422,000	9,407,000	29,514,000	69,388,000
High Pressure Sodium	1,183,000	3,355,000	3,324,000	57,941,000	65,803,000
Low Pressure Sodium		49,000		1,455,000	1,504,000
Other	**55,114,000**	**38,326,000**	**592,000**	**22,275,000**	**116,307,000**
LED	9,175,000	38,029,000	592,000	19,219,000	67,015,000
Miscellaneous	45,939,000	297,000		3,056,000	49,292,000
TOTAL	**5,811,769,000**	**2,069,306,000**	**144,251,000**	**178,374,000**	**8,203,700,000**

Table 4.2 presents the distribution of lamps by end-use sector. It is essentially the same information presented in Table 4.1, but instead portrayed as percentages so as to more easily depict technological trends by sector. Similar to 2001, linear fluorescent and incandescent lamps are estimated to comprise the vast majority of the installed base in 2010. While the overall shares of linear fluorescent and HID lamps have remained largely unchanged relative to 2001, incandescent lamp shares have decreased from 62 percent in 2001 to 45 percent in 2010, while the CFL inventory shares have correspondingly increased from 3 percent in 2001 to 19 percent in 2010.

In the residential sector, the most obvious trend is seen in the transition from general service incandescent lamps (decreasing from 79 percent in 2001 to 52 percent in 2010) to screw-base general service CFLs (increasing from 2 percent in 2001 to 19 percent in 2010). In addition, there has been significant movement toward directional lamps (such as incandescent reflector, halogen reflector, and halogen low voltage display), which now comprise 10 percent of the residential installed base.

In the commercial sector, the most evident trend is seen in the migration from T12 linear fluorescent lamps to T8 and T5 linear fluorescent lamps. In 2001, T8 lamps comprised less than 34 percent of the commercial installed base of linear fluorescent lamps, with the remaining base being overwhelmingly T12 lamps. In contrast, in 2010, T5s, T8s, and T12s constituted 7 percent, 61 percent, and 33 percent of the installed base of linear fluorescent lamps, respectively. This trend can be largely attributed to federal regulations[12], utility-based incentive programs, and a further interest in energy conservation.

While the industrial sector depicts many of the same trends as the commercial sector, one unique trend is an increase in the prevalence of HID lamps, which doubled in share relative to 2001. This movement from lower lumen output fluorescent lamps to higher lumen output HID lamps may also account for part of the reduction in overall number of lamps installed in the industrial sector. Although the data indicates a migration toward HID sources (likely in high bay applications), it is uncertain whether this trend will persist as fixture sales data indicates a recent increase of high lumen output linear fluorescent systems in the industrial sector, potentially replacing HID systems in low-bay applications.

The outdoor sector groups all incandescent, halogens, CFLs, and linear fluorescents in miscellaneous categories. This was done as many of the data sources used for the outdoor sector did not provide inventory detail beyond the general lamp technology level. After accounting for the different classifications of building exterior lighting, the primary trend evident in this sector is a movement from mercury vapor lamps toward metal halide lamps, which constituted only 8 percent of the outdoor HID installed base in 2001 and has increased to 32 percent in 2010.

[12] Further information on federal energy conservation standards for fluorescent lamps and ballasts can be found at: http://www1.eere.energy.gov/buildings/appliance_standards/

Table 4.2 Distribution of Lamps (%) by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**62.0%**	**3.7%**	**0.3%**	**10.0%**	**45.1%**
General Service - A-type	34.9%	2.1%	0.3%		25.3%
General Service - Decorative	16.9%				11.9%
Reflector	7.5%	0.9%	0.0%		5.5%
Miscellaneous	2.8%	0.7%		10.0%	2.4%
Halogen	**4.4%**	**2.3%**	**0.0%**	**2.3%**	**3.8%**
General Service	0.5%	0.0%	0.0%		0.3%
Reflector	2.9%	0.9%	0.0%		2.3%
Low Voltage Display	0.3%	1.2%			0.5%
Miscellaneous	0.7%	0.1%	0.0%	2.3%	0.6%
Compact Fluorescent	**22.8%**	**10.4%**	**0.3%**	**6.8%**	**18.9%**
General Service - Screw	19.3%	2.0%	0.1%		14.2%
General Service - Pin	0.1%	6.6%	0.1%		1.7%
Reflector	2.0%	1.9%	0.1%		1.9%
Miscellaneous	1.4%			6.8%	1.1%
Linear Fluorescent	**9.9%**	**80.0%**	**89.2%**	**16.3%**	**29.1%**
T5	0.1%	5.2%	6.4%		1.5%
T8 Less than 4ft	0.1%	0.7%	0.5%		0.2%
T8 4ft	1.1%	43.9%	54.4%		12.8%
T8 Greater than 4ft	0.0%	1.3%	2.3%		0.4%
T12 Less than 4ft	0.1%	0.4%	0.0%		0.2%
T12 4ft	5.7%	19.8%	16.6%		9.3%
T12 Greater than 4ft	0.5%	5.3%	7.5%		1.8%
T8 U-Shaped	0.0%	2.2%	0.4%		0.6%
T12 U-Shaped	0.0%	0.5%	0.7%		0.1%
Miscellaneous	2.3%	0.6%	0.3%	16.3%	2.1%
High Intensity Discharge	**0.0%**	**1.7%**	**9.8%**	**52.2%**	**1.7%**
Mercury Vapor	0.0%	0.0%	1.0%	2.3%	0.1%
Metal Halide	0.0%	1.5%	6.5%	16.5%	0.8%
High Pressure Sodium	0.0%	0.2%	2.3%	32.5%	0.8%
Low Pressure Sodium		0.0%		0.8%	0.0%
Other	**0.9%**	**1.9%**	**0.4%**	**12.5%**	**1.4%**
LED	0.2%	1.8%	0.4%	10.8%	0.8%
Miscellaneous	0.8%	0.0%		1.7%	0.6%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4.3 lists the average number of lamps observed in a typical building within each building sector. For residences, a “building” is a single housing unit, even if part of a multifamily structure. For the commercial and industrial sectors a building is a single stand-alone building. Outdoor is not shown because the data cannot be shown on a per building basis. Table 4.4 lists the average number of lamps per thousand square feet using the lamp counts from Table 4.1 and the floorspace estimates from Table 3.1.

As seen in Table 4.3 the average residence in 2010 is estimated to have 51 lamps installed; this represents a 20 percent growth in lamps per household relative to 2001. This increase has occurred despite a slight decrease in the total square footage of household in the U.S. from an average of 2,090 square feet in 2001 to an average of 1,900 in 2010. The slight decrease in average floor spaces results in a slightly larger increase in the average number of lamps per thousand square feet (from 21 in 2001 to 27 in 2010) and suggests that newer homes have been built with more lamps per floorspace than existing homes

For the commercial sector, the 2010 analysis estimates there are an average of 376 lamps per building in 2010, an overall 5 percent reduction from 2001. This takes into account the reclassifying the outdoor lamps originally classified in the buildings sector in the 2001 report into the outdoor sector. A similar decline of 7 percent on the basis of lamps per floorspace is also indicated by the data, from 29 to 26 lamps per thousand square feet.

In the industrial sector, the lamps per building would appear to have declined by 78 percent, from 1,440 lamps per building in 2001 to 317 lamps per building in 2010. However, this is largely due to a definitional change of the term “building” in the 2001 LMC and 2010 LMC. The 2001 LMC used the number of “establishments” in MECS as an indicator of the number of buildings. As establishments can consist of multiple stand-alone buildings, the 2010 LMC instead used the number of individual buildings reported in MECS. Using the estimate of 17 billion square feet of industrial floorspace in 2001, the total lamps per floorspace has declined by a much more moderate 20 percent, from 19 in 2001 to 15 lamps per thousand square feet in 2010. Both of these declines may be a result of a move to higher lumen output lamps or may be within the uncertainty of the 2001 and 2010 estimates.

Table 4.3 Average Number of Lamps per Building by End-Use Sector in 2010

	Residential	Commercial	Industrial
Incandescent	**31.8**	**14.1**	**0.9**
General Service - A-type	17.9	7.8	0.9
General Service - Decorative	8.7		
Reflector	3.8	3.5	0.0
Miscellaneous	1.4	2.8	
Halogen	**2.3**	**8.7**	**0.2**
General Service	0.2	0.2	0.0
Reflector	1.5	3.5	0.1
Low Voltage Display	0.2	4.7	
Miscellaneous	0.4	0.3	0.0
Compact Fluorescent	**11.7**	**39.3**	**0.9**
General Service - Screw	9.9	7.4	0.2
General Service - Pin	0.0	24.8	0.4
Reflector	1.0	7.2	0.3
Miscellaneous	0.7		
Linear Fluorescent	**5.1**	**301.0**	**282.7**
T5	0.0	19.7	20.3
T8 Less than 4ft	0.0	2.6	1.6
T8 4ft	0.6	165.1	172.4
T8 Greater than 4ft	0.0	5.1	7.4
T12 Less than 4ft	0.1	1.3	0.0
T12 4ft	2.9	74.7	52.8
T12 Greater than 4ft	0.3	19.8	23.8
T8 U-Shaped	0.0	8.3	1.2
T12 U-Shaped	0.0	2.0	2.2
Miscellaneous	1.2	2.4	1.1
High Intensity Discharge	**0.0**	**6.3**	**31.1**
Mercury Vapor	0.0	0.2	3.1
Metal Halide	0.0	5.5	20.7
High Pressure Sodium	0.0	0.6	7.3
Low Pressure Sodium		0.0	
Other	**0.5**	**7.0**	**1.3**
LED	0.1	6.9	1.3
Miscellaneous	0.4	0.1	
TOTAL	**51.4**	**376.4**	**317.0**

Table 4.4 Average Number of Lamps per Thousand Square Feet by End-Use Sector in 2010

	Residential	Commercial	Industrial
Incandescent	**16.8**	**1.0**	**0.0**
General Service - A-type	9.4	0.5	0.0
General Service - Decorative	4.6		
Reflector	2.0	0.2	0.0
Miscellaneous	0.7	0.2	
Halogen	**1.2**	**0.6**	**0.0**
General Service	0.1	0.0	0.0
Reflector	0.8	0.2	0.0
Low Voltage Display	0.1	0.3	
Miscellaneous	0.2	0.0	0.0
Compact Fluorescent	**6.2**	**2.7**	**0.0**
General Service - Screw	5.2	0.5	0.0
General Service - Pin	0.0	1.7	0.0
Reflector	0.5	0.5	0.0
Miscellaneous	0.4		
Linear Fluorescent	**2.7**	**20.4**	**13.0**
T5	0.0	1.3	0.9
T8 Less than 4ft	0.0	0.2	0.1
T8 4ft	0.3	11.2	7.9
T8 Greater than 4ft	0.0	0.3	0.3
T12 Less than 4ft	0.0	0.1	0.0
T12 4ft	1.5	5.1	2.4
T12 Greater than 4ft	0.1	1.3	1.1
T8 U-Shaped	0.0	0.6	0.1
T12 U-Shaped	0.0	0.1	0.1
Miscellaneous	0.6	0.2	0.0
High Intensity Discharge	**0.0**	**0.4**	**1.4**
Mercury Vapor	0.0	0.0	0.1
Metal Halide	0.0	0.4	1.0
High Pressure Sodium	0.0	0.0	0.3
Low Pressure Sodium		0.0	
Other	**0.3**	**0.5**	**0.1**
LED	0.0	0.5	0.1
Miscellaneous	0.2	0.0	
TOTAL	**27.0**	**25.5**	**14.6**

Table 4.5 lists the average wattage per lamp for each end-use sector. The average wattages for externally ballasted lamps account for ballast losses and operation at ballast factors less than one. See Section 3.2.1.3 for further detail on the calculation of average wattage per lamp. In general, relative to the 2001 characteristics, each sector has seen a movement to higher efficacy, and therefore often lower wattage, light sources. Technological trends that contributed to this decrease in overall wattage per lamp include a migration from incandescent lamps to CFLs, from T12 linear fluorescent lamps to T8 and T5 lamps, and from mercury vapor lamps to metal halide lamps. These trends are discussed in more detail in the sector specific results.

Table 4.5 Average Wattage per Lamp by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**56**	**53**	**46**	**68**	**58**
General Service - A-type	64	58	46		64
General Service - Decorative	44				44
Reflector	69	79	65		70
Miscellaneous	45	7		68	44
Halogen	**65**	**68**	**68**	**149**	**68**
General Service	50	46	36		50
Reflector	68	78	64		69
Low Voltage Display	44	60			53
Miscellaneous	82	99	145	149	88
Compact Fluorescent	**16**	**19**	**31**	**22**	**17**
General Service - Screw	17	20	17		17
General Service - Pin	22	19	45		19
Reflector	17	20	16		18
Miscellaneous	18			22	18
Linear Fluorescent	**24**	**37**	**39**	**63**	**35**
T5	19	36	58		37
T8 Less than 4ft	16	20	23		19
T8 4ft	26	30	30		30
T8 Greater than 4ft	41	54	73		56
T12 Less than 4ft	16	35	33		26
T12 4ft	27	43	39		36
T12 Greater than 4ft	50	78	84		73
T8 U-Shaped	27	31	30		31
T12 U-Shaped	27	42	41		41
Miscellaneous	16	31	42	63	25
High Intensity Discharge	**126**	**350**	**403**	**240**	**282**
Mercury Vapor	193	362	451	219	288
Metal Halide	79	349	434	247	317
High Pressure Sodium	150	356	295	241	248
Low Pressure Sodium		185		107	110
Other	**47**	**12**	**11**	**30**	**32**
LED	11	12	11	20	14
Miscellaneous	54	11		93	56
AVERAGE	**46**	**42**	**75**	**151**	**48**

Table 4.6 presents the distribution of installed wattage across lamp types within each sector. The installed wattage by lamp type was calculated by multiplying the lamp inventories in Table 4.1 by the wattages per lamp in Table 4.5. While on an inventory basis HID lamps are relatively minor players, they account for over 10 percent of the total installed wattage. This is largely due to their use in applications that require high lumen output. This is in contrast to CFLs, which represent nearly 20 percent of all installed base of lamps, but their high efficacy results in their accounting for only 7 percent of total installed wattage.

Table 4.6 Distribution (%) of Installed Wattage by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**78.8%**	**4.8%**	**0.2%**	**4.5%**	**55.2%**
General Service - A-type	48.8%	2.9%	0.2%		34.0%
General Service - Decorative	16.0%	0.0%			10.9%
Reflector	11.2%	1.8%	0.0%		8.1%
Miscellaneous	2.7%	0.1%		4.5%	2.2%
Halogen	**6.4%**	**3.8%**	**0.0%**	**2.2%**	**5.4%**
General Service	0.5%	0.1%	0.0%		0.4%
Reflector	4.3%	1.8%	0.0%		3.3%
Low Voltage Display	0.3%	1.8%			0.6%
Miscellaneous	1.3%	0.2%	0.0%	2.2%	1.1%
Compact Fluorescent	**8.4%**	**4.9%**	**0.1%**	**1.0%**	**6.9%**
General Service - Screw	7.0%	1.0%	0.0%		5.0%
General Service - Pin	0.0%	3.0%	0.1%		0.7%
Reflector	0.7%	0.9%	0.0%		0.7%
Miscellaneous	0.5%			1.0%	0.4%
Linear Fluorescent	**5.4%**	**71.8%**	**46.9%**	**6.8%**	**21.2%**
T5	0.0%	4.5%	4.9%		1.2%
T8 Less than 4ft	0.0%	0.3%	0.2%		0.1%
T8 4ft	0.6%	31.8%	21.7%		8.0%
T8 Greater than 4ft	0.0%	1.8%	2.3%		0.5%
T12 Less than 4ft	0.0%	0.3%	0.0%		0.1%
T12 4ft	3.3%	20.4%	8.6%		7.0%
T12 Greater than 4ft	0.5%	9.9%	8.5%		2.8%
T8 U-Shaped	0.0%	1.6%	0.2%		0.4%
T12 U-Shaped	0.0%	0.5%	0.4%		0.1%
Miscellaneous	0.8%	0.5%	0.2%	6.8%	1.1%
High Intensity Discharge	**0.1%**	**14.2%**	**52.8%**	**83.0%**	**10.3%**
Mercury Vapor	0.0%	0.4%	5.9%	3.4%	0.5%
Metal Halide	0.0%	12.4%	37.8%	27.1%	5.6%
High Pressure Sodium	0.1%	1.4%	9.1%	51.9%	4.2%
Low Pressure Sodium		0.0%		0.6%	0.0%
Other	**1.0%**	**0.5%**	**0.1%**	**2.5%**	**1.0%**
LED	0.0%	0.5%	0.1%	1.5%	0.2%
Miscellaneous	0.9%	0.0%		1.1%	0.7%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4.7 presents the operating hours per day for each lamp type in each sector. The operating hours displayed represents the average daily hours throughout the year and account for differences between high use and low use days. See Section 3.2.1.2 for details on the operating hour calculation. As the operating hours represent sector averages, some of the extremities of use, such as lamps operating around the clock, are lost.

The 2010 average operating hour estimates for the residential sector seem to indicate lower usage characteristics (by approximately 10 percent) than those estimated in 2001. While this could be indication of reduced operation of lighting (potentially due to increased use of lighting controls; see Section 4.4 for further discussion), it is also possible that the difference could be attributed to the datasets used for the two reports. The 2001 LMC used unadjusted metering data from a study conducted in Tacoma, Washington, while the 2010 LMC's operating hours were based on geographically and seasonally adjusted metering data collected in southern California. It is important to note that though the operating hour estimates presented below is considered to be the best for the purposes of this report, operating hour data vary widely from source to source depending on the sample size, the residence types considered, the occupant's habits, the sample geographies, and other factors. Appendix D further details on residential operating hour estimates.

Compared to the 2001 LMC, average operating hours estimated for the commercial and industrial sectors in 2010 are 13 higher and 4 percent lower, respectively. Outdoor operating hour estimates have increased 11 percent since 2001. As both the 2001 and 2010 LMC utilized building owner and industry expert interviews to develop the average use characteristics for these sectors, this variation could potentially indicate slight changes in lighting use or be within the uncertainty of the estimates. Of particular interest in the commercial and industrial sectors is the average operating hours for LEDs which are higher than other lamp technologies. This is primarily due to the large number of LED exit sign installations that are operated 24 hours per day.

Table 4.7 Average Daily Operating Hours by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**1.8**	**10.4**	**12.6**	**9.0**	**2.0**
General Service - A-type	1.8	10.5	12.7		1.9
General Service - Decorative	1.8				1.8
Reflector	1.7	9.8	11.9		2.1
Miscellaneous	**1.9**	10.8		9.0	3.2
Halogen	**1.9**	**12.4**	**11.7**	**10.5**	**3.5**
General Service	2.0	12.1	11.7		2.4
Reflector	1.9	12.4	11.7		3.0
Low Voltage Display	1.7	12.6			7.9
Miscellaneous	**2.0**	10.1	11.7	10.5	3.0
Compact Fluorescent	**1.8**	**10.4**	**13.1**	**9.0**	**3.2**
General Service - Screw	1.8	10.7	13.0		2.1
General Service - Pin	1.9	10.4	13.2		10.1
Reflector	1.8	10.0	13.0		3.9
Miscellaneous	**1.9**			9.0	2.8
Linear Fluorescent	**1.9**	**11.1**	**12.5**	**14.0**	**9.0**
T5	2.5	11.7	12.6		11.5
T8 Less than 4ft	2.1	11.2	12.6		9.7
T8 4ft	1.9	11.1	12.6		10.6
T8 Greater than 4ft	1.7	11.0	12.6		10.8
T12 Less than 4ft	2.0	11.3	12.0		6.7
T12 4ft	1.9	11.1	12.4		7.1
T12 Greater than 4ft	1.7	11.1	12.5		9.4
T8 U-Shaped	2.1	11.0	12.6		10.8
T12 U-Shaped	1.9	11.0	12.5		10.9
Miscellaneous	**2.1**	11.0	12.3	14.0	4.8
High Intensity Discharge	**2.5**	**11.1**	**16.8**	**12.3**	**12.3**
Mercury Vapor	2.4	11.1	16.5	10.8	11.8
Metal Halide	2.1	11.1	16.5	12.1	12.2
High Pressure Sodium	2.5	11.0	17.9	12.5	12.5
Low Pressure Sodium		11.2		11.5	11.4
Other	**1.5**	**20.8**	**22.3**	**9.8**	**5.5**
LED	2.1	20.8	22.3	9.3	15.0
Miscellaneous	1.4	14.8		12.6	2.2
AVERAGE	**1.8**	**11.2**	**13.0**	**11.7**	**4.7**

Table 4.8 presents the electricity consumed by lighting technologies in 2010, calculated by summing the sector specific electricity consumption values in Section 4.2.[13] Total electricity consumed by lighting in the U.S. in 2010 was estimated to be 700 TWh, or roughly 7.5 quads of primary energy. Linear fluorescent lamps consumed the greatest amount of energy, constituting 42 percent of total lighting electricity consumption. This is followed by HID lamps at 26 percent and incandescent lamps at 22 percent of total electricity consumption.

Lighting in the commercial sector consumes the largest amount of electricity, approximately half of the total, due to its high operating hour characteristics and large lamp inventories. The residential sector's large installed stock makes it the second greatest consumer of electricity despite the low operating hours and wattages. Outdoor lamps grew faster than the industrial sector since 2001, taking the place of the third greatest lighting electricity consumer. The industrial sector was the smallest in terms of electricity use, comprising only 8 percent of the total.

[13] While these estimates are based on the multiplication of lamp inventories by wattage by operating hours, doing so on a sector level by multiplying together Table 4.1, Table 4.5, Table 4.7 will not reproduce the electricity consumption values presented in Table 4.8. This is because wattages, and operating hours provided are weighted only by inventory and do not account for correlations between wattage per lamp and hours of use.

Table 4.8 Annual Lighting Electricity Consumed (TWh) by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**136**	**15**	**0**	**4**	**156**
General Service - A-type	84	9	0		94
General Service - Decorative	28	0	0		28
Reflector	19	5	0		24
Miscellaneous	5	0	0	4	9
Halogen	**12**	**15**	**0**	**1**	**28**
General Service	1	0	0		1
Reflector	8	7	0		15
Low Voltage Display	1	7			8
Miscellaneous	2	1	0	1	4
Compact Fluorescent	**15**	**16**	**0**	**1**	**32**
General Service - Screw	13	3	0		16
General Service - Pin	0	10	0		10
Reflector	1	3	0		4
Miscellaneous	1		0	1	2
Linear Fluorescent	**10**	**250**	**23**	**10**	**294**
T5	0	16	2		19
T8 Less than 4ft	0	1	0		1
T8 4ft	1	111	11		123
T8 Greater than 4ft	0	6	1		7
T12 Less than 4ft	0	1	0		1
T12 4ft	6	71	4		81
T12 Greater than 4ft	1	35	4		40
T8 U-Shaped	0	6	0		6
T12 U-Shaped	0	2	0		2
Miscellaneous	2	2	0	10	14
High Intensity Discharge	**0**	**49**	**35**	**98**	**183**
Mercury Vapor	0	1	4	4	9
Metal Halide	0	43	25	29	97
High Pressure Sodium	0	5	6	65	76
Low Pressure Sodium	0	0	0	1	1
Other	**1**	**3**	**0**	**3**	**8**
LED	0	3	0	2	5
Miscellaneous	1	0		1	3
TOTAL	**175**	**349**	**58**	**118**	**700**

Finally, Table 4.9 presents the total lumen production for the U.S. in each sector in 2010. These were calculated by multiplying together the subsector level (by building type and room type) estimates of lamp inventory, wattage per lamp, and an assumed system efficacy (including ballast losses where appropriate). These subsector lumen production estimates were then summed to calculate the total lighting service for each lamp technology in each sector. Potential fixture losses have not been included in these values. The efficacy assumptions used for the lumen output are discussed in Appendix C.

Light production is presented in Teralumen hours (Tlm-hr). For sense of scale, one Tlm-hr is the amount of light used by approximately 35,000 homes each year. As seen on the next page, the commercial sector accounts for the vast majority of the lumen production, due to its long operating hours and large inventory of lamps. This is followed by the outdoor sector and industrial sector which both have the long operating hours and high wattage lamps to thanks for the relatively high lumen production. The residential sector uses the least amount of light of all of the sectors analyzed. Relative to 2001, the 2010 estimates of lumen production remains largely unchanged.

Table 4.9 Annual Lumen Production (Tlm–hr) by End-Use Sector in 2010

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**1,640**	**180**	**0**	**50**	**1,870**
General Service - A-type	1,080	120	0		1,200
General Service - Decorative	310				310
Reflector	190	60	0		250
Miscellaneous	60	0		50	110
Halogen	**170**	**240**	**0**	**20**	**430**
General Service	20	0	0		20
Reflector	110	100	0		210
Low Voltage Display	10	130			140
Miscellaneous	30	10	0	20	70
Compact Fluorescent	**780**	**880**	**0**	**50**	**1,710**
General Service - Screw	670	180			850
General Service - Pin	0	580	0		580
Reflector	60	130	0		180
Miscellaneous	50			50	100
Linear Fluorescent	**670**	**19,180**	**1,800**	**750**	**22,400**
T5	0	1,480	210		1,700
T8 Less than 4ft	0	80	10		90
T8 4ft	80	8,690	850		9,620
T8 Greater than 4ft	0	490	90		590
T12 Less than 4ft	0	60	0		60
T12 4ft	400	5,030	300		5,730
T12 Greater than 4ft	70	2,670	330		3,060
T8 U-Shaped	0	430	10		440
T12 U-Shaped	0	120	10		130
Miscellaneous	100	120	10	750	980
High Intensity Discharge	**10**	**3,720**	**2,680**	**7,320**	**13,720**
Mercury Vapor	0	60	150	120	330
Metal Halide	0	3,130	1,860	1,730	6,730
High Pressure Sodium	10	520	660	5,410	6,610
Low Pressure Sodium	0	10		60	60
Other	**50**	**180**	**0**	**180**	**410**
LED	0	180	0	80	270
Miscellaneous	50	0		100	150
TOTAL	**3,320**	**24,380**	**4,480**	**8,370**	**40,550**

4.2 Sector Specific Results

The following four sections examine the cumulative results for all lamp technologies by sector focusing on the subsector level results. Specifically, details on the installed base, average system wattage and operating hour characteristics of all lamps are evaluated by the defined subsectors within the residential, commercial, industrial and outdoor sectors.

As discussed in Section 3, the tables for the residential, commercial and industrial sectors were extracted directly from the building survey data, scaled to a national level (based on size and building type), and adjusted with shipment data to account for any geographic bias and to better characterize the lighting market in 2010, the base year of this analysis. The subsector results for the outdoor sector were developed in a slightly different manner due to a lack of audit and survey data. Each subsector in the outdoor sector was developed in a unique way based on the available data.

4.2.1 Residential Results

The numbers of households considered in this analysis are provided in Table 4.10, by residence type and size. As discussed in Section 3.1.1, the values were drawn from the 2009 AHS and adjusted to reflect 2010 conditions. Each "residence" represents a single housing unit, even if part of a multifamily structure.

Table 4.10 Estimated Number of Residences by Size and Type in 2010

	Single Family Detached	Single Family Attached	Multifamily	Mobile Home	Total
Less than 1,000ft^2	5,385,000	1,014,000	14,493,000	2,334,000	23,226,000
1,000ft^2 to 2,500ft^2	48,920,000	3,742,000	7,699,000	3,759,000	64,121,000
Greater than 2,500ft^2	19,699,000	1,288,000	4,027,000	793,000	25,806,000
Total	**74,004,000**	**6,044,000**	**26,220,000**	**6,886,000**	**113,153,000**

Table 4.11 presents the average number of lamps by residence type and room type in 2010. It is important to note that the values represent total number of lamps in a typical residence in all rooms of each room type. For this reason, bathrooms (of which there are usually multiple in a single residence) are reported to contain the most number of lamps among all residence types; this is followed by bedrooms, kitchens and living rooms. As seen below, in general, the average number of lamps per household tracks fairly well with the size characteristics of each of the home types (meaning larger residence types have more lamps installed than smaller residence types).

Table 4.11 Average Number of Lamps per Household by Residence and Room Type in 2010

	Single Family Detached	Single Family Attached	Multifamily	Mobile Home	Average
Basement(s)	1.5	1.8	0.2	0.2	1.2
Bathroom(s)	10.5	8.6	5.1	7.1	8.9
Bedroom(s)	9.7	8.0	4.4	6.6	8.2
Closet(s)	1.7	1.1	0.7	0.7	1.4
Dining Room(s)	4.1	3.6	1.7	2.5	3.4
Exterior(s)	5.4	2.7	1.1	2.9	4.1
Garage(s)	4.0	1.4	0.5	0.6	2.9
Hall(s)	5.6	4.7	2.2	1.4	4.5
Kitchen(s)	7.2	6.8	4.4	4.4	6.4
Laundry / Utility Room(s)	1.4	0.7	0.2	1.0	1.1
Living / Family Room(s)	7.5	6.0	4.1	5.6	6.5
Office(s)	1.7	0.9	0.5	0.2	1.3
Other	2.0	2.0	0.3	1.3	1.6
TOTAL	**62.4**	**48.0**	**25.4**	**34.6**	**51.4**

Table 4.12 presents the lamp technology distribution by room type. Appendix C presents this same information in a more disaggregated form (distinguishing each lamp type separately). As seen below, there can be significant variation between the room types. Lighting in bathrooms and dining rooms is predominately incandescent, largely due to the high volume of decorative lamps and fixtures in those applications. While CFLs seem to be significant players in almost every room type, linear fluorescent lamps seem to only have significant penetration in several applications, the highest of which are garages, basements, and utility rooms.

Table 4.12 Lamp Distribution of Residences by Room Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Total
Basement(s)	40%	1%	30%	28%	0%	0%	100%
Bathroom(s)	74%	2%	20%	3%	0%	1%	100%
Bedroom(s)	67%	3%	28%	2%	0%	0%	100%
Closet(s)	60%	2%	20%	17%	0%	1%	100%
Dining Room(s)	81%	3%	15%	1%	0%	0%	100%
Exterior(s)	59%	14%	24%	2%	0%	2%	100%
Garage(s)	35%	1%	13%	51%	0%	0%	100%
Hall(s)	72%	4%	22%	2%	0%	1%	100%
Kitchen(s)	45%	7%	23%	22%	0%	3%	100%
Laundry / Utility Room(s)	50%	2%	19%	28%	0%	0%	100%
Living / Family Room(s)	61%	5%	29%	3%	0%	1%	100%
Office(s)	58%	6%	27%	8%	0%	0%	100%
Other	53%	6%	17%	24%	0%	0%	100%
Average	**62%**	**4%**	**23%**	**10%**	**0%**	**1%**	**100%**

Table 4.13 presents the average wattage per lamp by residence type and room type. As discussed earlier, the wattages presented include ballast effects, where appropriate. Because these numbers represent average wattages across the different lamp types in each room, the variations in wattage are fairly small. Appendix C also presents this same information in a more disaggregated form (distinguishing each lamp type separately).

Table 4.13 Average Wattage per Lamp by Residence Type and Room Type in 2010

	Single Family Detached	Single Family Attached	Multifamily	Mobile Home	Average
Basement(s)	41	36	29	67	41
Bathroom(s)	49	43	42	44	47
Bedroom(s)	48	43	45	40	47
Closet(s)	47	45	40	45	46
Dining Room(s)	45	38	44	36	44
Exterior(s)	56	49	42	55	54
Garage(s)	44	41	33	46	43
Hall(s)	47	40	40	41	46
Kitchen(s)	42	35	30	35	40
Laundry / Utility Room(s)	44	39	37	43	43
Living / Family Room(s)	48	47	47	41	48
Office(s)	48	40	46	52	47
Other / Unknown	48	39	42	36	46
Average	**47**	**41**	**41**	**42**	**46**

Table 4.14 presents the average operating hours per day by residence type and room type. As seen below for every residence type, exterior lighting represents the application which has the highest operating hours. This is closely followed by lighting found in kitchens and living rooms. The applications which have the lowest operating hours include closets, halls, and miscellaneous applications otherwise undefined.

Table 4.14 Average Daily Operating Hours by Residence Type and Room Type in 2010

	Single Family Detached	Single Family Attached	Multifamily	Mobile Home	Average
Basement(s)	1.6	1.7	1.4	1.9	1.6
Bathroom(s)	1.6	1.6	1.6	1.6	1.6
Bedroom(s)	1.6	1.6	1.6	1.6	1.6
Closet(s)	1.4	1.4	1.3	1.4	1.4
Dining Room(s)	1.9	1.9	1.9	1.9	1.9
Exterior(s)	2.6	2.7	2.7	2.6	2.6
Garage(s)	1.5	1.5	1.5	1.6	1.5
Hall(s)	1.5	1.5	1.5	1.5	1.5
Kitchen(s)	2.3	2.3	2.3	2.3	2.3
Laundry / Utility Room(s)	1.5	1.4	1.3	1.5	1.5
Living / Family Room(s)	2.0	2.0	2.0	2.1	2.0
Office(s)	1.9	1.8	1.8	1.8	1.8
Other / Unknown	1.0	1.0	0.9	0.9	1.0
Average	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**

Table 4.15 presents the lighting electricity use by room type. The bathroom and living room/family room use the most energy for lighting, consuming 242 kWh per year and 228 kWh per year, respectively. Outdoor lights are used for the most hours, but only rank as the fifth energy consumer because of the limited number of installations. At the bottom of the list is lights used in laundry/utility room(s) which only consumes 25 kWh per year in the typical house.

Table 4.15 Lighting Electricity Use by Room Type in 2010

	Operating Hours per Day	Average Lamps per Residence	Electricity Use per Room (kWh/yr)	Electricity Use Rank
Basement(s)	1.6	1.2	28	11
Bathroom(s)	1.6	8.9	242	1
Bedroom(s)	1.6	8.2	222	3
Closet(s)	1.4	1.4	32	10
Dining Room(s)	1.9	3.4	105	7
Exterior(s)	2.6	4.1	214	5
Garage(s)	1.5	2.9	69	8
Hall(s)	1.5	4.5	111	6
Kitchen(s)	2.3	6.4	215	4
Laundry / Utility Room(s)	1.5	1.1	25	13
Living / Family Room(s)	2.0	6.5	228	2
Office(s)	1.8	1.3	41	9
Other / Unknown	1.0	1.6	26	12
TOTAL	**1.8**	**51.4**	**1,556**	

Table 4.16 provides both electricity use and the electricity use density by residence type. As expected, there is a direct correlation between the size of a home and the amount of lighting electricity consumed. Similarly, when comparing the density of electricity use across residence types single-family detached homes rank the highest.

Table 4.16 Lighting Electricity Use by Residence Type in 2010

	Average Floorspace	Installed Wattage (W/ft^2)	Electricity Use per Building (kWh/yr)	Intensity ($kWh/yr/ft^2$)	Intensity Rank
Single Family Detached	2,178	1.4	1,922	0.9	1
Single Family Attached	1,816	1.1	1,279	0.7	2
Multifamily	1,050	1.0	679	0.6	4
Mobile	1,395	1.0	975	0.7	3

4.2.2 Commercial Results

Fourteen commercial building space types were examined for the 2010 lighting market analysis. Table 4.17 displays the number of buildings, total square footage and average floorspace per building for each space type on a national level. As previously mentioned in Section 3.1.3, these sector characteristics were collected from the 2003 CBECS database and scaled to 2010 via the EIA's Annual Energy Outlook 2011 total square footage estimates.

Table 4.17 Estimated Number and Floorspace of Commercial Buildings in 2010

	Average Square Feet	Number of Buildings	Total Square Feet
Education	25,580	454,000	11,604,995,000
Food Service	5,569	349,000	1,943,960,000
Food Store	5,553	266,000	1,475,012,000
Health Care - Inpatient	238,125	9,000	2,238,962,000
Health Care - Outpatient	10,397	142,000	1,478,538,000
Lodging	35,887	167,000	5,989,372,000
Offices (Non-medical)	14,816	968,000	14,348,165,000
Public Assembly	14,220	326,000	4,629,540,000
Public Order and Safety	15,352	83,000	1,281,086,000
Religious Worship	10,146	435,000	4,412,108,000
Retail - Mall & Non-Mall	17,035	772,000	13,154,052,000
Services	6,511	731,000	4,759,999,000
Warehouse and Storage	16,881	702,000	11,844,758,000
Other	22,000	93,000	2,042,686,000
TOTAL	**14,773**	**5,497,000**	**81,203,232,000**

Table 4.18 illustrates the distribution of lamp technologies across the commercial sector by space type. For the entire commercial sector, linear fluorescent lighting technology is by far the most prevalent at 80 percent of lamp inventory, and represents over half of lamp installations for all subsectors except lodging, which has some characteristics similar to the residential sector including increased use of CFLs and incandescent lamps. In addition, food service has a large prevalence of incandescent lamps possibly due to their greater demand for warmer color temperature and high color rendering index lamps. Also, of note is the higher prevalence of HID lamps in warehouse and storage building, likely due to the greater number of high bay applications in this subsector.

Table 4.18 Lamp Distribution by Commercial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Total
Education	1%	2%	10%	85%	1%	2%	100%
Food Service	20%	1%	8%	67%	1%	3%	100%
Food Store	1%	1%	3%	94%	1%	1%	100%
Health Care - Inpatient	1%	1%	13%	84%	0%	1%	100%
Health Care - Outpatient	1%	1%	9%	88%	0%	1%	100%
Lodging	18%	2%	25%	53%	0%	2%	100%
Offices (Non-medical)	1%	1%	14%	82%	0%	1%	100%
Public Assembly	8%	1%	21%	58%	3%	9%	100%
Public Order and Safety	1%	1%	6%	89%	1%	2%	100%
Religious Worship	4%	1%	8%	84%	1%	2%	100%
Retail - Mall & Non-Mall	5%	6%	6%	79%	3%	1%	100%
Services	1%	1%	4%	90%	3%	1%	100%
Warehouse and Storage	0%	2%	6%	86%	5%	1%	100%
Other	2%	4%	9%	79%	2%	3%	100%
Average	**4%**	**2%**	**10%**	**80%**	**2%**	**2%**	**100%**

Table 4.19, shows the average wattage for each commercial space type. The wattages displayed account for any ballast effects where relevant. In general, the wattage values across space types for each lighting technology do not display significant variation.

Table 4.19 Average Wattage per Lamp by Commercial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Average
Education	86	73	21	35	352	13	37
Food Service	44	66	19	41	224	13	42
Food Store	74	69	20	43	258	14	44
Health Care - Inpatient	75	73	18	32	192	7	30
Health Care - Outpatient	74	78	20	37	194	10	36
Lodging	55	74	17	34	224	11	34
Offices (Non-medical)	58	74	19	33	275	8	31
Public Assembly	55	80	20	39	420	6	44
Public Order and Safety	81	76	18	35	329	10	37
Religious Worship	96	97	20	39	260	12	42
Retail - Mall & Non-Mall	42	65	22	35	347	30	45
Services	63	69	18	43	406	10	51
Warehouse and Storage	72	69	18	50	348	23	64
Other	88	40	20	38	333	12	44
Average	**53**	**67**	**19**	**37**	**342**	**12**	**42**

The average operating hours by lighting technology for each commercial building space is provided in Table 4.20. The average operating hours for each space type are clearly influenced by the dominant technology, linear fluorescent. The "other" category which is mainly populated by LED-based lighting is characterized by high daily operating hours as the majority of these lamps are used in exit sign applications.

Table 4.20 Average Daily Operating Hours per Lamp by Commercial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Average
Education	10.5	12.4	10.4	11.0	11.1	23.5	11.2
Food Service	10.2	12.0	10.3	11.1	10.5	23.1	11.2
Food Store	10.5	12.3	10.4	11.3	11.2	23.0	11.4
Health Care - Inpatient	10.0	12.2	10.4	11.0	9.2	23.6	11.1
Health Care - Outpatient	10.0	12.3	10.3	11.0	11.1	23.6	11.1
Lodging	10.3	12.2	10.3	11.0	11.2	23.7	11.0
Offices (Non-medical)	10.1	12.3	10.4	11.0	11.1	23.6	11.1
Public Assembly	10.3	12.1	10.4	11.1	10.9	13.2	11.1
Public Order and Safety	10.1	12.4	10.4	11.0	11.2	23.7	11.2
Religious Worship	10.0	12.1	10.4	11.0	10.5	23.7	11.2
Retail - Mall & Non-Mall	10.6	12.5	10.4	11.4	11.1	22.8	11.5
Services	10.1	12.4	10.4	11.0	11.0	23.6	11.2
Warehouse and Storage	10.3	12.4	10.4	11.0	11.2	23.3	11.1
Other	9.9	12.5	10.4	11.0	11.2	23.7	11.4
Average	**10.4**	**12.4**	**10.4**	**11.1**	**11.1**	**20.8**	**11.2**

Table 4.21 depicts the consumption of annual lighting energy per building and per square foot for each space type. The installed wattage, which includes ballast losses, represents weighted averages across all lighting technologies for each building type subsector. Hospital buildings consume the largest amount of lighting electricity per building due to their substantial area footprint. The final column in Table 4.21 provides a ranking of electricity use per floorspace in order to compare all subsectors by a common metric. Based on this ranking, grocery stores have the most energy intense lighting characteristics.

Table 4.21 Lighting Electricity Use by Commercial Buildings in 2010

	Average Lamps per 1,000 ft^2	Installed Wattage (W/ft^2)	Electricity Use per Building (kWh/yr)	Intensity ($kWh/yr/ft^2$)	Intensity Rank
Education	17	0.6	65,100	2.5	13
Food Service	32	1.3	30,100	5.4	4
Food Store	40	1.8	40,800	7.3	1
Health Care - Inpatient	26	0.8	768,100	3.2	10
Health Care - Outpatient	37	1.3	55,900	5.4	5
Lodging	18	0.6	85,300	2.4	14
Offices (Non-medical)	33	1.0	60,800	4.1	9
Public Assembly	24	1.0	58,900	4.1	8
Public Order and Safety	19	0.7	43,200	2.8	12
Religious Worship	27	1.1	45,100	4.4	6
Retail - Mall & Non-Mall	34	1.5	107,800	6.3	2
Services	28	1.4	37,400	5.7	3
Warehouse and Storage	17	1.1	71,900	4.3	7
Other	18	0.8	70,500	3.2	11

4.2.3 Industrial Results

The MECS database provides data for the 21 subsectors shown below in Table 4.22. The total floorspace presented is based on the 2005 MECS and has been adjusted to a 2010 baseline using industrial construction value growth as a proxy for floorspace growth.

Table 4.22 Estimated Number and Floorspace of Industrial Buildings in 2010

	Average Square Feet	Number of Buildings	Total Square Feet
Apparel	25,216	4,000	106,592,000
Beverage and Tobacco Products	24,031	9,000	222,788,000
Chemicals	10,101	65,000	654,919,000
Computer and Electronic Products	39,465	11,000	453,257,000
Electrical Eq., Appliances & Components	61,056	5,000	284,246,000
Fabricated Metal Products	25,708	46,000	1,188,840,000
Food	18,146	43,000	788,399,000
Furniture and Related Products	46,336	12,000	534,882,000
Leather and Allied Products	28,417	1,000	20,166,000
Machinery	34,637	24,000	820,089,000
Nonmetallic Mineral Products	12,570	28,000	347,625,000
Paper	34,044	13,000	431,171,000
Petroleum and Coal Products	5,013	12,000	62,419,000
Plastics and Rubber Products	53,103	14,000	728,861,000
Primary Metals	15,527	29,000	452,297,000
Printing and Related Support	26,575	15,000	390,838,000
Textile Mills	65,506	3,000	227,589,000
Textile Product Mills	46,875	3,000	126,758,000
Transportation Equipment	40,636	31,000	1,275,267,000
Wood Products	6,299	57,000	357,228,000
Miscellaneous	12,829	31,000	391,799,000
Total	**21,672**	**455,000**	**9,866,031,000**

It is important to note that facility lighting characteristics including lamp inventory, wattage and operating hours for textile mills, apparel, leather and allied products and chemicals were not available within the industrial survey database. To address this issue, the average lighting characteristics of the remaining 17 subsectors were assumed to be representative for building types where survey data was unavailable.

Table 4.23 provides the distribution of lamp technologies in industrial buildings for 2010. The industrial buildings database represents a limited sample size, and therefore, lamp classifications for several building types were not available and are not included in the results. This is most evident when considering the incandescent, halogen and CFL results per building type. It is likely that these lamp technologies are used to some extent within each industrial building subsector, however, the vast majority of the installed stock are the fluorescent installations followed by HID.

Table 4.23 Lamp Distribution by Industrial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Total
Apparel	0.3%	0.1%	0.3%	89.1%	9.9%	0.4%	100.0%
Beverage and Tobacco Products	0.0%	0.1%	0.2%	90.4%	7.1%	2.2%	100.0%
Chemicals	0.3%	0.1%	0.3%	89.1%	9.9%	0.4%	100.0%
Computer and Electronic Products	0.4%	0.0%	0.1%	96.4%	3.1%	0.0%	100.0%
Electrical Eq., Appliances & Components	0.0%	0.0%	0.1%	88.0%	11.8%	0.0%	100.0%
Fabricated Metal Products	0.3%	0.1%	0.2%	83.4%	15.8%	0.1%	100.0%
Food	1.4%	0.1%	0.3%	73.5%	24.8%	0.0%	100.0%
Furniture and Related Products	0.0%	0.1%	0.2%	87.7%	12.1%	0.0%	100.0%
Leather and Allied Products	0.3%	0.1%	0.3%	89.1%	9.9%	0.4%	100.0%
Machinery	0.2%	0.1%	0.2%	87.9%	10.9%	0.7%	100.0%
Nonmetallic Mineral Products	0.3%	0.1%	0.2%	66.7%	32.7%	0.0%	100.0%
Paper	0.0%	0.1%	0.2%	34.1%	65.6%	0.0%	100.0%
Petroleum and Coal Products	1.1%	0.1%	0.3%	87.7%	9.2%	1.7%	100.0%
Plastics and Rubber Products	0.8%	0.0%	0.2%	93.1%	5.1%	0.8%	100.0%
Primary Metals	0.0%	0.0%	2.1%	88.9%	7.4%	1.5%	100.0%
Printing and Related Support	0.5%	0.0%	0.1%	91.6%	6.6%	1.2%	100.0%
Textile Mills	0.3%	0.1%	0.3%	89.1%	9.9%	0.4%	100.0%
Textile Product Mills	0.0%	0.1%	0.4%	93.6%	5.9%	0.0%	100.0%
Transportation Equipment	0.0%	0.0%	0.1%	97.7%	2.2%	0.0%	100.0%
Wood Products	0.0%	0.1%	0.2%	89.2%	10.5%	0.0%	100.0%
Miscellaneous	0.5%	0.0%	0.1%	94.4%	4.0%	1.0%	100.0%
Average	**0.3%**	**0.0%**	**0.3%**	**89.2%**	**9.8%**	**0.4%**	**100.0%**

The average system wattage by lamp technology for industrial buildings is provided in Table 4.24. These wattages account for ballast effects for externally ballasted lamps.

Table 4.24 Average Wattage per Lamp by Industrial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Average
Apparel	46	68	30	39	404	11	75
Beverage and Tobacco Products		63	17	35	444	14	63
Chemicals	46	68	30	39	404	11	75
Computer and Electronic Products	55	63	17	33	503		48
Electrical Eq., Appliances & Components		63	17	31	453		81
Fabricated Metal Products	54	63	17	53	462	3	118
Food	54	63	17	55	391		138
Furniture and Related Products		63	17	40	567		103
Leather and Allied Products	46	68	30	39	404	11	75
Machinery	15	66	17	44	449	13	87
Nonmetallic Mineral Products	24	69	17	59	335		149
Paper		63	17	42	290		205
Petroleum and Coal Products	112	63	17	53	453	13	90
Plastics and Rubber Products	15	63	17	48	388	3	65
Primary Metals		63	44	35	352	20	59
Printing and Related Support	71	63	17	34	453	5	62
Textile Mills	46	68	30	39	404	11	75
Textile Product Mills		63	17	38	452		62
Transportation Equipment		90	17	34	453		43
Wood Products		63	17	54	417		92
Miscellaneous	63	63	17	36	440	10	52
Average	**46**	**68**	**31**	**39**	**403**	**11**	**75**

Table 4.25 presents the average daily operating hours per building type. Operating hours are based on annual estimates and thus take into account seasonal periods of high and low lighting use. The average across the sector is greater than any other sector largely due to the long business hours found at many manufacturing facilities.

Table 4.25 Average Daily Operating Hours per Lamp by Industrial Building Type in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	HID	Other	Average
Apparel	12.6	11.7	13.0	12.5	16.9	22.3	13.0
Beverage and Tobacco Products		11.7	13.0	12.5	17.5	20.4	13.0
Chemicals	12.6	11.7	13.0	12.5	16.9	22.3	13.0
Computer and Electronic Products	12.9	11.7	13.0	12.5	16.5		12.7
Electrical Eq., Appliances & Components		11.7	13.0	12.6	16.1		13.0
Fabricated Metal Products	13.0	11.7	13.0	12.6	16.7	23.1	13.2
Food	13.0	11.7	13.0	12.4	16.6		13.5
Furniture and Related Products		11.7	13.0	12.4	16.6		12.9
Leather and Allied Products	12.6	11.7	13.0	12.5	16.9	22.3	13.0
Machinery	12.1	11.9	13.0	12.4	16.3	22.3	12.9
Nonmetallic Mineral Products	11.9	10.5	13.0	12.5	17.0		14.0
Paper		11.7	13.0	12.4	18.3		16.3
Petroleum and Coal Products	12.1	11.7	13.0	12.4	17.2	22.2	13.0
Plastics and Rubber Products	13.2	11.7	13.0	12.6	17.0	23.1	12.9
Primary Metals		11.7	13.2	12.6	16.0	22.2	13.0
Printing and Related Support	12.4	11.7	13.0	12.6	16.5	22.2	12.9
Textile Mills	12.6	11.7	13.0	12.5	16.9	22.3	13.0
Textile Product Mills		11.7	13.0	12.3	16.2		12.5
Transportation Equipment		12.0	13.0	12.5	16.1		12.6
Wood Products		11.7	13.0	12.1	16.0		12.5
Miscellaneous	11.0	11.6	13.0	12.6	15.8	22.6	12.8
Average	**12.6**	**11.7**	**13.1**	**12.5**	**16.8**	**22.3**	**13.0**

Table 4.26 displays the lighting electricity consumption for the industrial sector in 2010. The metrics are the same as those discussed earlier for the commercial sector, while operating hours do not display significant variation across the subsectors, wattage is slightly more variable. The final column in Table 4.26 provides a ranking of electricity use per floorspace in order to compare all subsectors by a common metric Paper facilities are ranked as the greatest electricity consumer based on this metric, consuming 10.8 kWh per square feet, while textile product mills represents the least at 1.6 kWh per sq. ft. per building.

Table 4.26 Lighting Electricity Use by Industrial Buildings in 2010

	Average Lamps per 1,000 ft^2	Installed Wattage (W/ft^2)	Electricity Use per Building (kWh/yr)	Intensity ($kWh/yr/ft^2$)	Intensity Rank
Apparel	15	1.1	154,800	6.1	8
Beverage and Tobacco Products	11	0.7	93,600	3.9	19
Chemicals	15	1.1	58,500	5.8	11
Computer and Electronic Products	23	1.1	228,300	5.8	12
Electrical Eq., Appliances & Components	20	1.6	511,000	8.4	3
Fabricated Metal Products	10	1.2	167,000	6.5	6
Food	8	1.1	110,400	6.1	9
Furniture and Related Products	10	1.0	242,500	5.2	14
Leather and Allied Products	15	1.1	117,100	4.1	18
Machinery	9	0.8	143,400	4.1	17
Nonmetallic Mineral Products	10	1.5	106,700	8.5	2
Paper	8	1.7	366,400	10.8	1
Petroleum and Coal Products	7	0.6	17,300	3.5	20
Plastics and Rubber Products	14	0.9	232,200	4.4	15
Primary Metals	20	1.2	93,900	6.0	10
Printing and Related Support	21	1.3	181,200	6.8	4
Textile Mills	15	1.1	440,600	6.7	5
Textile Product Mills	5	0.3	74,300	1.6	21
Transportation Equipment	26	1.1	220,800	5.4	13
Wood Products	9	0.9	27,500	4.4	16
Miscellaneous	24	1.2	78,800	6.1	7

4.2.4 Outdoor Results

As discussed in Section 3.2.3 the outdoor sector comprises eight different applications including building exterior, airfield, billboard, railway, stadium, traffic signals, parking and roadway. Table 4.27 shows the lamps installed in each of these applications. Combined these applications represent over 178 million lamp installations for 2010 compared to the estimated 73 million lamps in 2002. However, the previous 2002 LMC classified several outdoor parking lot and building exterior lamps within the commercial and industrial sectors. In addition, the railway and stadium applications are new to this version of the report. The building exterior, parking and roadway applications are by far the largest applications, cumulatively representing nearly 90 percent of the outdoor lamps and almost two-thirds of all HID lamps installed in the U.S.

Table 4.27 Estimated Inventory of Outdoor Lamps by Subsector (1,000's)

	Incandescent	Halogen	CFL	Linear Fluorescent	MV	MH	HPS	LPS	LED	Other	Total
Building Exterior	14,775	2,621	12,052	12,468	1,815	9,865	7,919	274	1	294	**62,084**
Airfield	414	512							98		**1,024**
Billboard				5	5	502			7		**519**
Railway	549								427		**976**
Stadium		64			7	839	120				**1,030**
Traffic Signals	785								14,908		**15,693**
Parking	992	824		16,595	429	14,191	14,205		2,231	2,701	**52,168**
Roadway	300		2	55	1,922	4,116	35,698	1,182	1,546	61	**44,882**
Total	**17,815**	**4,021**	**12,054**	**29,123**	**4,178**	**29,513**	**57,942**	**1,456**	**19,218**	**3,056**	**178,376**

Table 4.28 provides the average system wattage of outdoor sector lamps. This wattage takes into account ballast losses for all externally ballasted lamps. The use of high lumen output lamps to illuminate large open spaces causes the outdoor lamp wattages to be relatively high. The exceptions are building exterior lamps which are often used for smaller area illumination such as in landscaping light and wall packs.

Table 4.28 Average Wattage per Lamp by Subsector in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	MV	MH	HPS	LPS	LED	Other	Average
Building Exterior	61	74	22	42	79	72	78	74	28	68	55
Airfield	92	65							17		71
Billboard				148	400	400			125		394
Railway	18								14		16
Stadium		4375			1,000	1,554	1,000				1,661
Traffic Signals	130								9		15
Parking	112	108		73	350	224	201		60	97	153
Roadway	181		44	50	243	233	230	78	71	62	221
Average	**68**	**148**	**22**	**60**	**185**	**215**	**204**	**77**	**20**	**93**	**132**

Table 4.29 presents the average daily operating hours per application. The operating hours for most applications are relatively high, at over 12 hours per day. This is because many outdoor lamps are used to provide continual lighting service during dusk, dawn and night-time hours. Parking lamps, and specifically, lamps in above grade parking decks, are used on average the longest, while stadium lights are typically only lit during events and thus are used the least of all lamps in the sector.

Table 4.29 Average Daily Operating Hours per Lamp by Subsector in 2010

	Incandescent	Halogen	CFL	Linear Fluorescent	MV	MH	HPS	LPS	LED	Other	Average
Building Exterior	8.4	8.2	9.0	8.7	8.9	8.8	8.9	9.1	8.9	8.9	9
Airfield	12.0	12.0							12.0		12
Billboard				12.0	12.0	12.0			24.0		12
Railway	10.7								9.8		10
Stadium		1.0			1.0	1.0	1.0				1
Traffic Signals	8.0								8.0		8
Parking	15.9	17.9		18.0	13.5	15.0	16.0		16.3	13.1	16
Roadway	12.0		12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12
Average	**9.0**	**10.5**	**9.0**	**14.0**	**10.8**	**12.1**	**12.5**	**11.4**	**9.3**	**12.6**	**11.7**

Table 4.30 provides the electricity consumption of each of the outdoor applications. In terms of energy use, parking and roadways lamps with their high prevalence, wattages, and operating hours are the dominant applications. Though LEDs have penetrated the outdoor sector quicker than any of the building sectors, they still are responsible for only approximately 1 percent of the energy consumed by the sector.

Table 4.30 Lighting Electricity Use by Outdoor Subsectors in 2010 (TWh/yr)

	Incandescent	Halogen	CFL	Linear Fluorescent	MV	MH	HPS	LPS	LED	Other	Total
Building Exterior	3	1	1	2	1	3	2	0	0	0	12
Airfield	0	0		0					0		0
Billboard	0			0	0	1			0		1
Railway	0			0					0		0
Stadium	0	0		0	0	1	0				1
Traffic Signals	0			0					0		1
Parking	1	1		8	1	20	20		1	1	52
Roadway	0		0	0	2	5	43	1	0	0	51
Total	**4**	**1**	**1**	**10**	**4**	**29**	**65**	**1**	**2**	**1**	**118**

4.3 Solid-State Lighting

Solid-state lighting is one of the most efficacious lighting technologies available and the primary focus of the U.S. DOE lighting research and development efforts. The 2001 LMC reported that SSL, specifically LEDs, was found in approximately 1.6 million lamps or installations, or less than 0.1 percent of the total installed base of lighting. The vast majority, nearly 90 percent, were exit signs in the commercial and industrial sectors. The remainder of the LED installations in 2001 was primarily in outdoor traffic signal applications. Over the last decade the installed base of LED lighting has grown to over 67 million lamps, luminaires, and exit signs. While this represents a 40 fold increase in installed lamps, LEDs still only represented approximately 1 percent of the total installed base of lighting in 2010. This section details several characteristics of the LED installations in the residential, commercial, industrial, and outdoor sectors.

It was estimated that in 2010 approximately 9.2 million LED lamps were installed in the residential sector, accounting for 0.2 percent of the installed inventory of residential lighting. According to the LMC database, approximately one-third of these residential LED lamps were screw based lamps. These lamps were most often found in common replacement applications such as torchieres and table lamps. Screw-based LEDs represent less than 0.1 percent of the installed stock of all residential screw based lamps. The remainder, non-screw based, of the residential LEDs were installed in specialty applications such as under cabinet and landscape applications.

In the commercial and industrial sectors the majority of the LED lamps were installed in exit sign applications, as shown in Table 4.31. Although only 20 percent of LED lamps in the commercial sector are in non-exit sign applications, this represents significant growth from 37,000 non-exit sign LED lamps in 2001 to nearly 7.5 million non-exit sign LED lamps in 2010. These lamps range in wattages from 2 to 57, and are installed in applications ranging from display, track, task, and area lighting. Overall, non-exit sign LED lamps represent less than 1 percent of non-exit lighting in the commercial and industrial sectors.

Table 4.31 LED Exit Signs and Lamps in Commercial and Industrial Sectors

	LED Exit Signs	LED Lamps	Total
Commercial	30,558,000	7,471,000	38,029,000
Industrial	580,000	12,000	592,000
Total	**31,139,000**	**7,482,000**	**38,621,000**

The outdoor sector has seen the greatest penetration and growth in LED lamps due largely to their long lifetime (low maintenance cost) and high efficacy (low operating cost). While in 2001 it was estimated that 97,000 LED lamps or luminaires were installed in the outdoor sector, this report estimates that in 2010 the outdoor installed base of LED lamps or luminaires grew to 19 million. Across the entire outdoor sector, LEDs comprised 10 percent of the installed stock and experienced far greater shares in certain individual subsectors, as depicted by Figure 4-1. Similar to the 2001 analysis, traffic signals still represent the outdoor application in which LEDs have both the greatest percentage penetration (95 percent) and absolute number of installations. LEDs in parking and roadway applications have the next highest number of installed LED lamps or luminaires, representing three to four percent of lighting inventory in those applications.

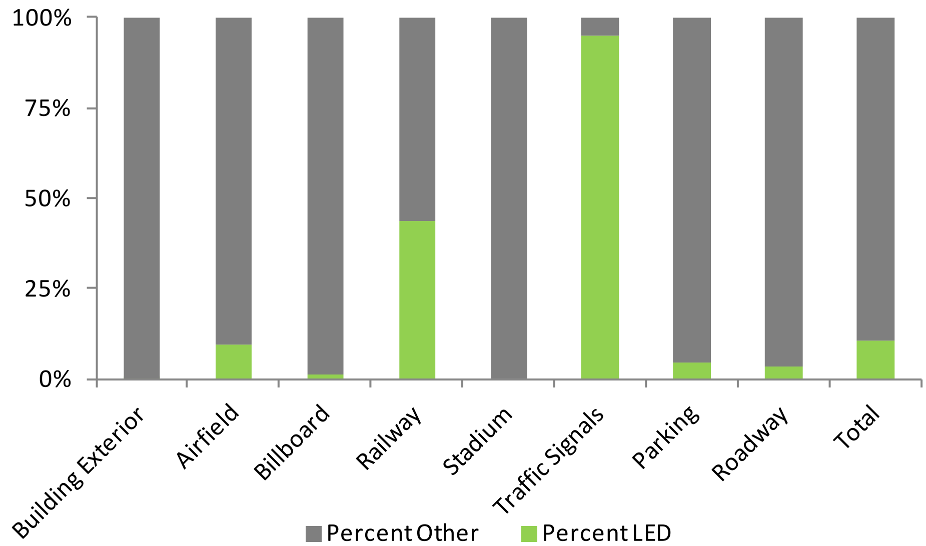

Figure 4-1 LED Prevalence in the Outdoor Sector

Overall LED lamps consume approximately 3 TWh of electricity per year, constituting less than 0.5 percent of national lighting energy use. DOE's SSL Program is helping to propel this market forward through funding research and development projects, conducting market research such as this report, and engaging in commercialization support initiatives such as the L-Prize, CALiPER, and the Gateway programs.[14] These efforts will support future improvements in efficacy and light quality, and reductions in cost that will make LEDs an even more viable option for the lighting market.

[14] For further information on each of these initiatives, see the DOE SSL Program website at: http://www1.eere.energy.gov/buildings/ssl/

4.4 Lighting Controls

In recent years, lighting controls have garnered increased attention as a potential method of more intelligently operating lighting systems to save energy. Lighting controls, which include various dimming and sensor technologies used separately or in conjunction with other systems such as timers and daylighting, can, if used properly, yield very significant energy savings, as they use feedback from the lit environment to provide adequate lighting levels only when needed.

Lighting controls can save energy by either reducing input wattage or limiting hours of operation. The average operating hours presented in this report account for the use of certain controls, such as timers and EMS, because they are based on building surveys and metering data. However, the LMC analysis does not account for the use of controls that reduce wattage, such as dimmers or daylighting systems.

For this analysis, we estimated the prevalence of lighting controls in the residential and commercial sectors. Lighting controls data was extracted from several building audit studies, spanning several geographic regions and years of data collection. This data was then scaled to a national level using the methodology described in Section 3.2.2. Unlike the lamp inventory and operating hour estimates presented earlier, no additional data was available to account for any geographic bias or to bring up to the year 2010. In addition, the industrial and outdoor sectors were not included in this analysis due to insufficient data. The following discussion provides a brief description of each of the lighting control types examined in this study:

- **Dimmers** allow users to manually regulate the level of lighting in a building by adjusting the voltage reaching the lamp. As voltage input is reduced, either by way of a step function or a continuous function, the lumen output of the system is proportionally decreased.
- **Light sensors**, or photocells, also work by dimming or by on/off cycling. In response to detected light levels, light sensors regulate the lumen output in order to supplement available natural light with an optimized level of artificial lumen output.
- **Motion detectors**, or occupancy sensors, switch the lamp on for a set period of time in response to detected motion and are useful in areas that are sporadically occupied. This control type saves energy by reducing hours of operation of lighting.
- **Timers** provide lighting service on a preset schedule, without the need for manual operation. This control type also saves energy by reducing hours of operation.
- **Energy management systems** are information and control systems that monitor occupancy and lighting in the built environment in order to provide centralized lighting control. They often combine several of these control technologies to reduce energy consumption.

As depicted in Table 4.32, lighting controls are more frequently installed in the commercial sector than in the residential, with an estimated 31 percent of lamps in the commercial sector being used in conjunction with lighting controls. This is in contrast to only 14 percent of residential lamps being used with lighting controls.

Table 4.32 Prevalence of Lighting Controls by Sector

	None	Dimmer	Light Sensor	Motion Detector	Timer	EMS	Total
Residential	86%	12%	1%	1%	0%	0%	100%
Commercial	70%	3%	0%	5%	4%	18%	100%

Table 4.33 presents the prevalence of lighting controls in the residential sector by lamp type. Even though incandescent lamps have a longer history of control compatibility, they are not the technology most likely to be used with lighting controls in the residential sector. Instead, the analysis indicates that halogen and HID lamps are more likely to be used in conjunction with lighting controls, mostly with dimmers and light sensors, respectively. However, because incandescent lamps represent a much larger share of the residential sector inventory than the other lamp types, the 13 percent of incandescent lamps used with dimmers represent the vast majority of residential lamps used with lighting controls.

Table 4.33 Prevalence of Lighting Controls in the Residential Sector by Lamp Type

	None	Dimmer	Light Sensor	Motion Detector	Timer	Other	Total
Incandescent	86%	13%	1%	1%	0%	0%	100%
Halogen	66%	25%	4%	3%	2%	0%	100%
CFL	90%	7%	1%	1%	1%	0%	100%
Linear Fluorescent	98%	1%	0%	0%	0%	0%	100%
HID	60%	8%	21%	0%	0%	11%	100%
Other	77%	11%	1%	3%	7%	0%	100%

Table 4.34 presents the prevalence of lighting controls in the residential sector by room type. As seen below, lighting controls are most likely to be found in the dining room and the living room, with dimmers being the predominate lighting control type. Also, as expected the vast majority of light sensors and motion sensors are installed in exterior applications.

Table 4.34 Prevalence of Lighting Controls in the Residential Sector by Room Type

	None	Dimmer	Light Sensor	Motion Detector	Timer	Other	Total
Basement(s)	90%	8%	0%	0%	1%	1%	100%
Bathroom(s)	96%	4%	0%	0%	0%	0%	100%
Bedroom(s)	85%	14%	0%	0%	0%	0%	100%
Closet(s)	98%	1%	0%	0%	0%	0%	100%
Dining Room(s)	63%	37%	0%	0%	0%	0%	100%
Exterior(s)	80%	2%	8%	7%	4%	0%	100%
Garage(s)	97%	0%	1%	0%	1%	0%	100%
Hall(s)	92%	8%	0%	0%	0%	0%	100%
Kitchen(s)	88%	11%	0%	0%	0%	0%	100%
Laundry / Utility Room(s)	99%	1%	0%	0%	0%	0%	100%
Living / Family Room(s)	73%	26%	0%	0%	1%	0%	100%
Office(s)	86%	13%	0%	0%	0%	0%	100%
Other	90%	8%	1%	0%	1%	0%	100%

Table 4.35 presents the prevalence of lighting controls by residence type. As seen below, single family attached homes are most likely to use lighting controls. This is likely due to the more recent construction of much of this base in buildings.

Table 4.35 Prevalence of Lighting Controls in the Residential Sector by Residence Type

	None	Dimmer	Light Sensor	Motion Detector	Timer	Other	Total
Single Family Detached	87%	11%	1%	1%	1%	0%	100%
Single Family Attached	72%	26%	0%	1%	0%	1%	100%
Multifamily	81%	18%	0%	0%	0%	0%	100%
Mobile Home	91%	7%	2%	0%	1%	0%	100%

In contrast to the residential sector, Table 4.36 indicates that the likelihood of finding lighting controls in the commercial sector is not greatly impacted by the lamp type. Approximately 25 percent of all lamp types are used in conjunction with lighting controls. Energy management systems, which often include multiple control types, predominate as the most often utilized controls scheme.

Table 4.36 Prevalence of Lighting Controls in the Commercial Sector by Lamp Type

	None	Dimmer	Light Sensor	Motion Detector	Timer	EMS	Total
Incandescent	76%	5%	0%	0%	2%	16%	100%
Halogen	73%	5%	0%	1%	3%	18%	100%
CFL	77%	0%	0%	3%	2%	18%	100%
Linear Fluorescent	68%	3%	1%	7%	4%	17%	100%
HID	71%	0%	2%	1%	6%	20%	100%
Other	85%	0%	0%	0%	0%	15%	100%

The choice of lighting controls also depends on the building type and how and to what extent the space is used. As seen in Table 4.37, in the commercial sector, lighting controls are most popular in retail settings, in which 40 percent of lamps operate on an EMS and 7 percent operate on a timer. Lighting controls are also very common in non-medical office buildings and food stores (i.e., not restaurants), where they are used on 48 percent and 40 percent of lamps, respectively. Lighting controls are uncommon in public order and safety, religious worship, lodging, and food service buildings (i.e., restaurants).

Table 4.37 Prevalence of Lighting Controls in the Commercial Sector by Building Type

	None	Dimmer	Light Sensor	Motion Detector	Timer	EMS	Total
Education	83%	4%	0%	9%	2%	3%	100%
Food Service	95%	2%	0%	0%	2%	1%	100%
Food Store	60%	4%	1%	0%	4%	31%	100%
Health Care - Inpatient	92%	1%	0%	1%	1%	6%	100%
Health Care - Outpatient	78%	0%	0%	12%	8%	1%	100%
Lodging	95%	1%	0%	0%	0%	4%	100%
Offices (Non-medical)	52%	4%	0%	14%	5%	24%	100%
Public Assembly	77%	2%	0%	0%	1%	20%	100%
Public Order and Safety	96%	0%	0%	0%	0%	4%	100%
Religious Worship	95%	3%	0%	2%	0%	0%	100%
Retail - Mall & Non-Mall	50%	0%	1%	2%	7%	40%	100%
Services	81%	19%	0%	1%	0%	0%	100%
Warehouse and Storage	85%	0%	1%	3%	1%	9%	100%
Other	88%	2%	1%	4%	4%	0%	100%

Lighting controls equate to energy savings only if they are used. For automated control types, such as time clocks and occupancy sensors, this is a nonissue. However, dimmers, the most popular control in the residential sector, typically require users to manually adjust the level of light output. Nonetheless, if used properly, light controls can yield huge energy savings. For example, a 2007 National Research Council Canada study found that occupancy sensing, daylight harvesting, and individual occupant dimming control working together in an office building produce average energy savings of 47 percent. If installed alone, the occupancy sensors would have produced an estimated average 35 percent savings, daylight harvesting 20 percent, and individual dimming control 10 percent (Newsham, 2007).

5 Summary Results

In 2010, the total energy consumption in the United States was 97.8 quadrillion Btus (quads) of primary energy according to the EIA's AEO 2011. Roughly 40 quads (or 41 percent) of this energy was consumed for electricity use. The breakout of the total electricity consumption by each sector is displayed in Figure 5-1 below.

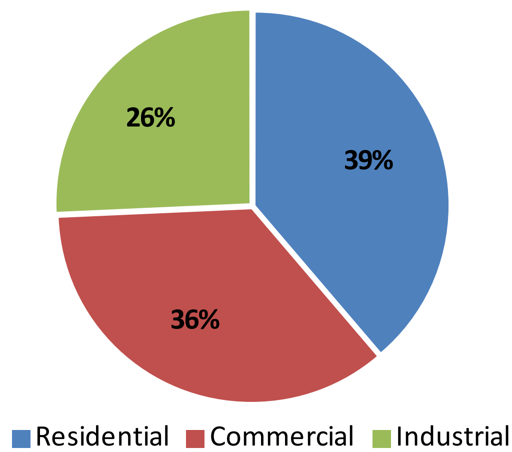

Figure 5-1 U.S. Primary Energy Consumption for Electricity Production in 2010[15]

In 2010, the total amount of electricity consumed by lighting technologies was estimated to be 700 TWh of site energy, or 7.5 quads of primary energy.[16] Thus, lighting accounted for 7 percent of the total energy and 18 percent of the total electricity consumed in the U.S. in 2010.[17] This is the equivalent to the total energy consumed by nearly 40 million homes and the energy produced by 228 500-MW coal burning power plants (D&R International, Ltd., 2011).

The following section summarizes the results presented in section 4 of this report.

5.1 Lighting Market Characteristics

Figure 5-2 displays the breakdown of the inventory estimates, total lighting electricity consumption, and the lumens produced by sector. The residential sector accounts for the overwhelming majority of installed lamps, at 71 percent of installed base of lighting. However, in terms of electricity consumption, the sector only consumes 175 TWh, or 25 percent of the total. Due to the relatively low efficacy of residential light sources (primarily incandescent), the residential sector only accounts for 8 percent of the lumens produced.

The commercial sector is the greatest energy consumer, accounting for half of the total lighting electricity consumption. In addition, the commercial sector represents the sector in which the greatest

[15] Commercial sector includes public street and highway lighting, interdepartmental sales, and other.
[16] Based on site to source electricity conversion of 3.14 from AEO
[17] Based on a total electricity consumption of 40.3 quads of source energy for residential, commercial, and industrial sectors from AEO

number of lumens is produced. This is largely due to the longer operating hours found in the commercial sector as compared to the residential sector. Both the industrial and outdoor sectors make up a relatively small portion of the total installed stock of lamps, each approximately 2 percent. However, the use of high lumen output lamps and high operating hours result in these sectors consisting of greater shares of total electricity consumption and lumen production.

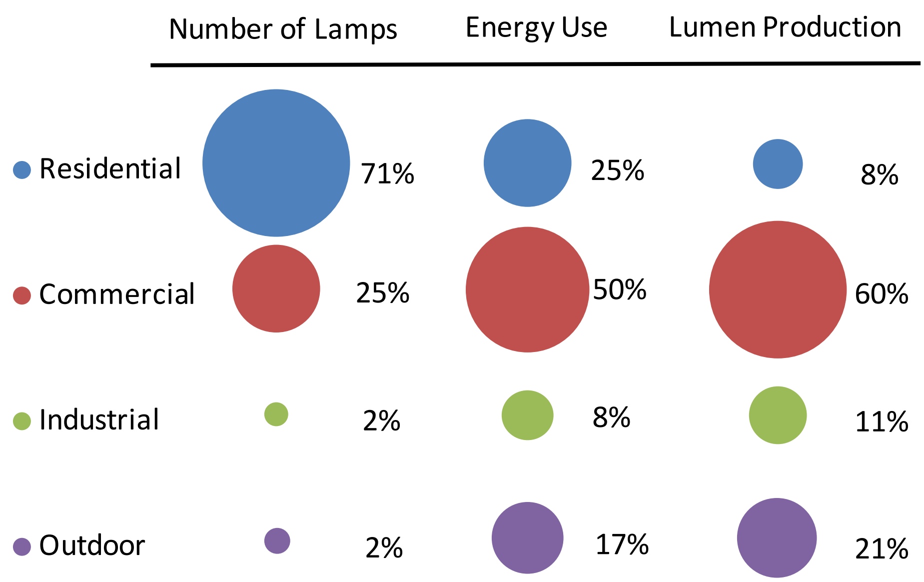

Figure 5-2 U.S. Lighting Lamp Inventory, Electricity Consumption and Lumen Production in 2010

Figure 5-3 portrays the same electricity consumption values from Figure 5-2, except this time disaggregated by lamp technology. At 42 percent of the total, fluorescent lamps are the largest electricity consuming technology due primarily to their high level operating hours in the commercial and industrial sectors. This is a shift from 2001, when incandescent lamps were the largest consumers of electricity and fluorescent lamps were the second largest. In 2010, incandescent lamps were still responsible for 22 percent of the total electricity consumption.

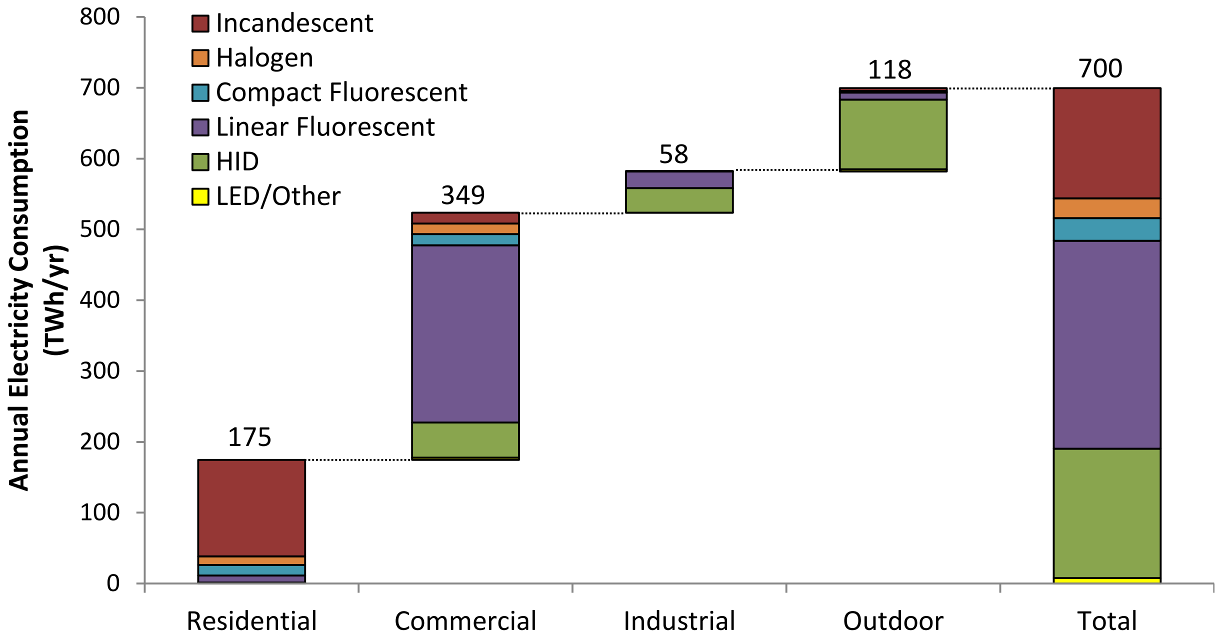

Figure 5-3 U.S. Lighting Electricity Consumption by Sector and Lamp Type in 2010

Focusing on the residential sector, incandescent lamps are the largest electricity consuming lamps. These lamps make up 78 percent of the total sector consumption, followed by CFLs, halogen lamps, and linear fluorescent lamps, which consume 9 percent, 7 percent, and 6 percent, respectively. In the commercial sector, fluorescent lamps consume the most energy, accounting for 72 percent of the sector's lighting electricity consumption. At 4 percent of the total, incandescent lamps have fallen from the second largest electricity consumer in 2001 to the fourth, now trailing HID lamps and CFLs, which consume 14 percent and 5 percent, respectively. The industrial sector is dominated by two lamp technologies. HID lamps are the main electricity consumer at 60 percent of the total lighting electricity use, while fluorescent lamps, at nearly 40 percent, make up most of the balance. Though the technology mix varies widely in the outdoor sector depending on the subsector (traffic signals are almost entirely LED lamps while HID lamps are relied on exclusively for sports lighting), on a sector-wide basis HID lamps are the principal technology, accounting for 83 percent of the sector's total electricity consumption.

To understand the energy use of lighting and the savings that can be realized by switching to more efficient lighting sources, it is important to recognize the relationship between lumens produced and electricity use. Wattage is a measure of power input while lumens produced is an output measure. The lumen output per watt of electrical power input is the lamp's efficacy (lm/W) and is the key measure of a lamp's energy performance. Figure 5-4 provides the lumen production for each sector by lamp type in teralumen-hours per year. Annual lumen production was calculated by multiplying the wattage per lamp by its average efficacy and associated operating hours per year.

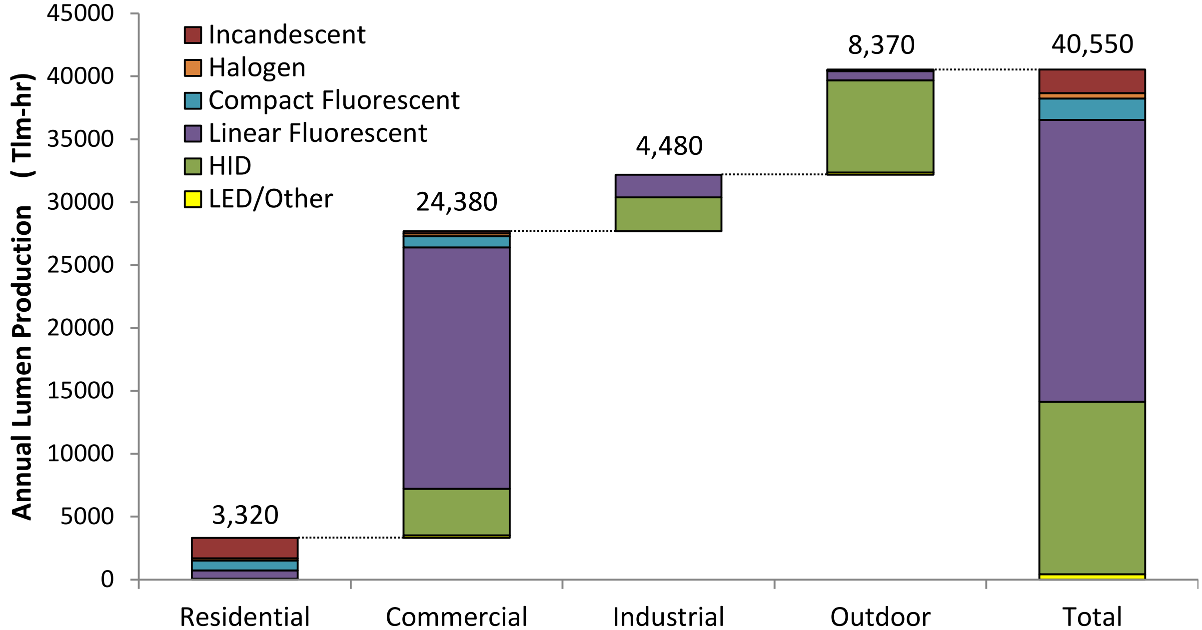

Figure 5-4 U.S. Lumens Production by Sector and Lamp Type in 2010

The commercial sector uses more light than all the other sectors combined, largely due to its high average operating hours and large floorspace. The outdoor sector produces second greatest amount of lumens, also due to the use of high lumen output lamps for long operating hours (in this case, during most of the night). The industrial sector uses the third most light. The residential sector, which houses the largest quantity of installed lighting stock predominately utilizes low lumen output lamps for relatively few hours per day and thus uses the least amount of lumens relative to the other three sectors.

Across all sectors, fluorescent lamps, responsible for approximately 55 percent of annual lumen production nationally, produce the most lumens of all the technologies. HID light sources are the second most important, producing about 34 percent of the total national light output. Because incandescent lamps are most often found in sockets that are turned on relatively infrequently, and given their characteristically low lumen outputs, the total lumen production of the technology only accounts for 5 percent of the total.

In summary, Table 5.1 and Table 5.2 present the sectoral lighting energy consumption estimates in terms of both delivered (end-use) and primary (source) energy. It also provides the estimated average annual energy consumption for lighting per building and by technology.

Table 5.1 U.S. Annual Lighting Energy Use Estimates by Sector in 2010

`	Electricity Use Per Building (kWh/yr)	Number of Buildings	Total Site Energy Consumption (Twh/yr)	Total Primary Energy Consumption (quads/yr)	Percent of Total
Residential	1,542	113,153,000	175	1.9	25%
Commercial	63,501	5,497,000	349	3.7	50%
Industrial	127,380	455,000	58	0.6	8%
Outdoor	N/A	N/A	118	1.3	17%
Total			**700**	**7.5**	**100%**

Table 5.2 U.S. Annual Lighting Energy Use Estimates by Sector and Source in 2010

`	Incandescent		Halogen		CFL		Linear Fluorescent		HID		Other		Total	
	Twh	Quad	Twh	Quad	Twh	Quad	Twh	Quad	Twh	Quad	Twh	Quad	**Twh**	**Quad**
Residential	136	1.46	12	0.13	15	0.16	10	0.11	0	0.00	1	0.01	175	1.87
Commercial	15	0.16	15	0.16	16	0.17	250	2.68	49	0.53	3	0.04	349	3.74
Industrial	0	0.00	0	0.00	0	0.00	23	0.25	35	0.37	0	0.00	58	0.62
Outdoor	4	0.04	1	0.02	1	0.01	10	0.11	98	1.05	3	0.03	118	1.26
Total	**156**	**1.67**	**28**	**0.30**	**32**	**0.34**	**294**	**3.14**	**183**	**1.96**	**8**	**0.08**	**700**	**7.49**

5.2 2010 Lighting Market Characteristics Compared to 2001 Values

Compared to 2001, there have been substantial changes in the nation's lighting inventory which are discussed in more detail in Section 4. In general, lamp quantities have increased while average wattages have decreased as a result of more efficient technologies gaining market share Table 5.3 provides a sectoral overview of these changes.

In the residential sector, the number of lamps grew faster than the growth in residences due to the larger floor space and a greater number of lamps per square foot in newer homes. However the prominence of CFLs caused a large decrease in average wattage and partially explains the decline in electricity use. The decline in operating hours seen in the residential sector may not be indicative of a true market trend, but instead is likely symptomatic of differences in sources between the two studies and the relatively small sample size of residences used in the 2001 LMC.

In the commercial sector, the installed lamp base has increased but this increase lagged the growth in commercial floor space. This difference is partially due to the changes in the lamp application classification of sectors between the two reports as previously discussed in Section 2. Another change between the two reports is the decrease in average wattage and electricity use for which the shift to T8 and T5 lamps from T12 lamps is partially responsible.

In the industrial sector, the large decrease in the number of lamps is largely due to the different floor space values used in the two studies. On a lamps per square foot basis there was approximately a 20 percent decline in installed stock. The shift from fluorescent lamps to higher lumen output HID lamps is most likely responsible for the wattage increase as well as the lamp decrease between the 2010 and 2001 results for the industrial sector.

The outdoor sector experienced the greatest relative increase in lamp quantities from 2001. This is partially due to new applications considered in the current report, the classification differences between the two reports, and the increasing popularity of outdoor lighting.

Table 5.3 2010 Sector Lighting Characteristics Comparison to 2001 Values

	Lamps (million)		Average Daily Operating Hours		Wattage per Lamp		Electricity Use (TWh)	
	2001	2010	2001	2010	2001	2010	2001	2010
Residential	4,611 →	5,812	2.0 →	1.8	63 →	46	208 →	175
Commercial	1,966 →	2,069	9.9 →	11.2	56 →	42	391 →	349
Industrial	327 →	144	13.5 →	13.0	65 →	75	108 →	58
Outdoor	73 →	178	10.5 →	11.7	205 →	151	58 →	118
Total	**6,977** →	**8,203**	**4.8** →	**4.7**	**62** →	**48**	**765** →	**700**

Much of the reduction in lighting electricity use over the past ten years has occurred due to the migration toward higher efficacy light sources and an increase in overall stock efficacy. The average efficacy, in lumens per watt, is depicted for each sector for 2010 in Figure 5-5. [18] The efficacy displayed is calculated based on total lumen production divided by total energy used for each sector. This is different than the average efficacy of the installed stock because a higher wattage lamp, such as an incandescent lamp, consumes more energy than a similarly used lower wattage lamp, such as a CFL, and thus is weighted more in the calculation. An average efficacy based on installed stock would weight every installed lamp equally.

In addition, the averages for the 2001 LMC are provided for comparison. In order to ensure that an equitable comparison is made, the same average efficacies for each lamp technology were assumed for the 2001 and 2010 data. This assumption likely overestimates the efficacies of 2001 lamps as significant progress has been made in increasing the efficacy of several lamp types over the past decade (e.g., linear fluorescent T8 lamps, CFLs, and metal halide lamps). The efficacy assumptions are presented in Appendix C of this report.

As evident in the table, the most inefficient lighting sector in 2010 is the residential sector. The continued reliance of this sector upon incandescent lamps resulted in an average efficacy of 19 lm/W, significantly below the remaining three sectors which all have average efficacies at or above 70 lm/W. However, the residential sector did see a significant improvement in efficacy from 17 lm/W in 2001 due largely to the growth of CFLs. The commercial sector efficacy also improved markedly, increasing from

[18] The lamp efficacies depicted do not account for fixture losses but do include ballast effects.

51 lm/W in 2001 to 70 lm/W in 2010. The industrial and outdoor sector efficacies increased slightly relative to 2001; however, this is largely due to a migration from mercury vapor lamps to metal halide lamps. Overall, the average efficacy of the entire lighting stock, based on energy use and lumen production, has increased from 45 lm/W in 2001 to 58 lm/W in 2010.

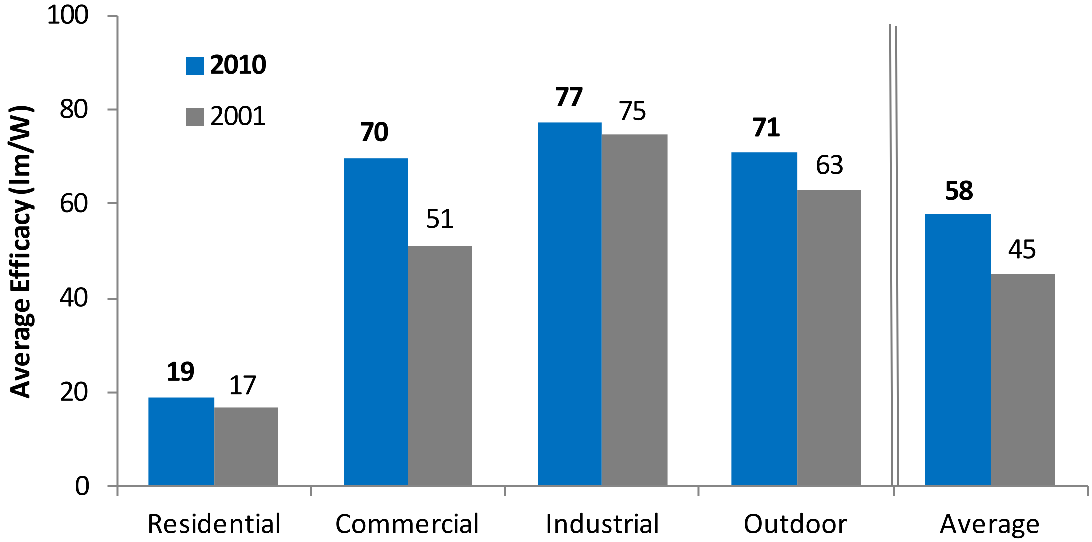

Figure 5-5 Average Efficacy by Sector

6 Comparison of Lighting Electricity Consumption Estimates

The previous sections of this report provide discussion and analysis comparing the 2010 LMC results to those of the 2001 LMC. Though the 2001 LMC values are shown in Table 6.1 for comparison, this discussion focuses on comparing the 2010 LMC results to those of the other studies listed.

Table 6.1 Annual Lighting Electricity Consumption Estimates

Sector	Model Year	Annual Lighting Electricity Consumption (TWh/yr)
Residential		
LMC, 2002	2001	208
EIA, AEO 2011	2010	208
LMC, 2011	**2010**	**175**
Commercial		
LMC, 2002	2001	391
CBECS, 2003	2003	393
EIA, AEO 2011	2010	299
LMC, 2011	**2010**	**349**
Industrial		
LMC, 2002	2001	108
MECS, 2006	2003	58
LMC, 2011	**2010**	**58**
Outdoor		
LMC, 2002	2001	87[19]
LMC, 2011	**2010**	**118**

In the residential sector the estimate of energy use is approximately 16 percent less than what EIA's AEO predicts. The AEO 2011 uses equipment stocks from the 2005 RECs analysis and projects those forward to 2010, while the 2010 LMC utilizes the 2009 AHS.

The commercial sector results for electricity consumption are in good agreement with other available estimates. Compared to the 2003 CBECS, lighting electricity consumption has declined from 393 TWh in 2003 to 349 TWh in 2010. The decrease, as discussed in Section 2, can be largely attributed to the shift to T8 and T5 lamps from T12 lamps. Differences in calculation methods also cause some discrepancies. The lighting model utilized for the 2003 CBECS calculates energy consumption as a function of average lamp wattage per square foot and average annual operating hours. Over 5,000 buildings were surveyed across the U.S. To estimate the total energy consumption of lighting in commercial buildings, each sample building is weighted to represent a specified number of the total U.S. building population. In addition, the 2003 CBECS results include exterior and parking lot lamps which are classified as part of the outdoor sector in the 2010 LMC analysis. The 2011 AEO also provides estimates for lighting electricity consumption from commercial buildings. The AEO uses the results developed in the 2003 CBECS and projects floorspace growth, market penetration, efficiency improvements and the cost of

[19] The 2001 LMC outdoor electricity consumption value has been adjusted from the original value of 58 TWh in 2001 to account for the classification differences and allow for a more accurate comparison between the two reports.

lighting to 2010. These projections result in an estimate for commercial sector lighting electricity consumption of 299 TWh, which is within 15 percent of the 2010 LMC estimate of 349 TWh.

The industrial sector results for the 2010 LMC indicate that lighting consumed approximately 58 TWh. The 2006 MECS indicated that electricity consumption from industrial lighting was approximately 58 TWh in 2006. Both the MECS and the 2010 LMC estimates reflect a significant slowdown in manufacturing lighting use from the 2001 LMC, when the sector was estimated to consume 108 TWh. AEO 2011 does not provide lighting energy use estimates for the industrial sector.

The only comparable study found that provided lighting energy use for the entire outdoor sector was the 2001 LMC.

Appendix A. Lamp Category Descriptions

Table A.1 Lamp Category Descriptions

Lamp Category		Description
INCANDESCENT	General Service – A type	Standard incandescent lamps greater than 15 Watts and with an a-type bulb and of all base types.
	General Service – Decorative	Standard incandescent lamps greater than 15 Watts with a globe, bullet, candle, tubular, or other decorative-shaped bulb and of all base type.
	Reflector	Reflectorized incandescent lamps greater than 15 Watts and with an ER, BR, PAR, or other reflector-shaped bulb and of all base types.
	Miscellaneous	All other types of incandescent lamps not previously listed, such as night lights, bug lights and lamps less than 15 Watts, as well as incandescent lamps of unknown characteristics.
HALOGEN	General Service	Halogen lamps with a tungsten halogen capsule with an a-type, globe, candle or other decorative-shaped bulb meant as a direct replacement for general service incandescent lamps, including all base types and wattages.
	Reflector – Other	Reflectorized lamps with a tungsten halogen capsule and a parabolic, elliptical or other reflector-shaped bulb and of all base types.
	Reflector – Low Voltage	Reflectorized lamps that operate at 24 Volts or less, most typically multifaceted reflectors and other display lamps, of all base types.
	Miscellaneous	All other types of halogen lamps not previously listed, such as those with a quartz envelope not employing a decorative bulb, and halogens of unknown characteristics.
CFL	General Service – Screw	Compact fluorescent lamps with an a-type, globe, spiral or other decorative-shaped bulb meant as a direct replacement for general service incandescent lamps having a screw-in base, including all wattages.
	General Service – Pin	Compact fluorescent lamps with an a-type, globe, spiral or other decorative-shaped bulb having a non-screw-in base, such as a pin base, including all wattages.
	Reflector	Reflectorized compact fluorescent lamps with an R, PAR, or other reflector-shaped bulb and of all base types.
	Miscellaneous	All other types of CFLs not previously listed as well as CFLs of unknown characteristics.
LINEAR FLUORESCENT	T5	Bi-pin linear T5 lamps of all wattages and exact metric lengths
	T8 Less than 4ft	Bi-pin linear T8 fluorescent lamps less than 4 feet in length, predominantly 2 feet
	T8 4ft	Bi-pin linear T8 fluorescent lamps 4 feet in length
	T8 Greater than 4ft	Single and bi-pin linear T8 fluorescent lamps greater than 4 feet in length, predominantly 8 feet
	T12 Less than 4ft	Bi-pin linear T12 fluorescent lamps less than 4 feet in length, predominantly 2 feet
	T12 4ft	Bi-pin linear T12 fluorescent lamps 4 feet in length
	T12 Greater than 4ft	Single and bi-pin linear T12 fluorescent lamps greater than 4 feet in length, predominantly 8 feet
	T8 U-Shaped	U-shaped T8 fluorescent lamps having medium bi-pin bases
	T12 U-Shaped	U-shaped T12 fluorescent lamps having medium bi-pin bases
	Miscellaneous	All other fluorescent and not previously listed, as well as fluorescent lamps of unknown characteristics
HID	Mercury Vapor	Mercury vapor lamps, of all base types
	Metal Halide	Metal halide lamps, including ceramic metal halide, of all base types
	High Pressure Sodium	High pressure sodium lamps of all base types
	Low Pressure Sodium	Low pressure sodium lamps of all base types
OTHER	LED	LED lamps and luminaires greater than or equal to 2 watts of all shapes, sizes, & bases not including LED screens or decorative walls
	Miscellaneous	Other lamps that do not fall into any of the previous categories, such as fiber optic lights, induction lamps, as well as lamps of unknown characteristics

Appendix B. Sample Dataset Characteristics

The following plots provide details of the building sector data sets juxtaposed with details of the national building stock. These plots are intended to display how representative the sample data sets are. In most categories the distribution of the sample sets is fairly close to the true conditions. The greatest deviations are found in the geographic distribution plots. As was discussed in Section 3.2, national shipment data as well as other statistical adjustments used to offset these deviations.

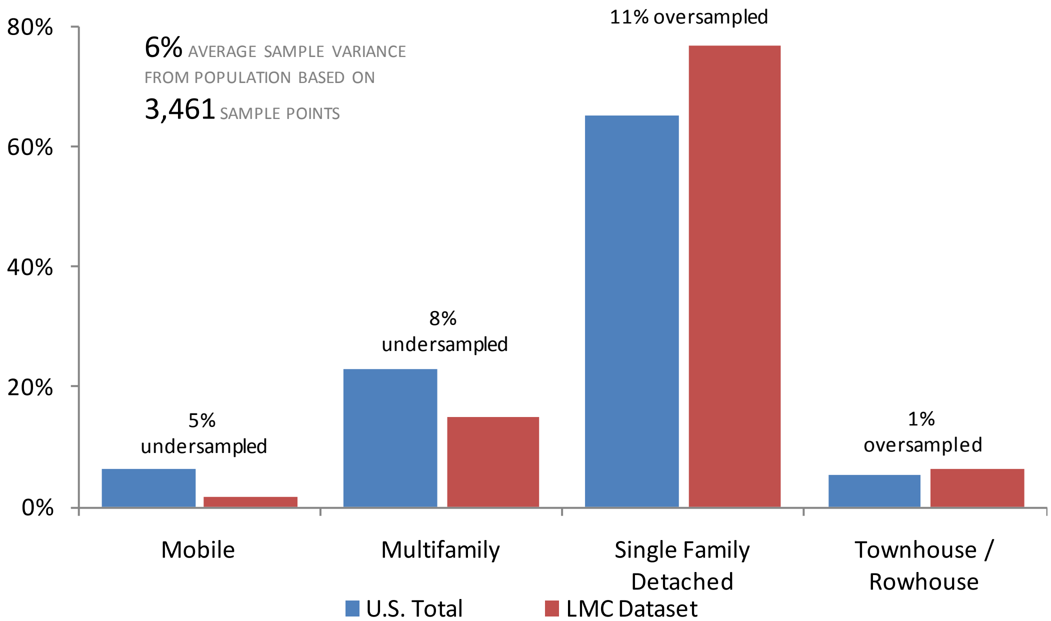

Figure B-1 Residential Sector Distribution by Residence Type

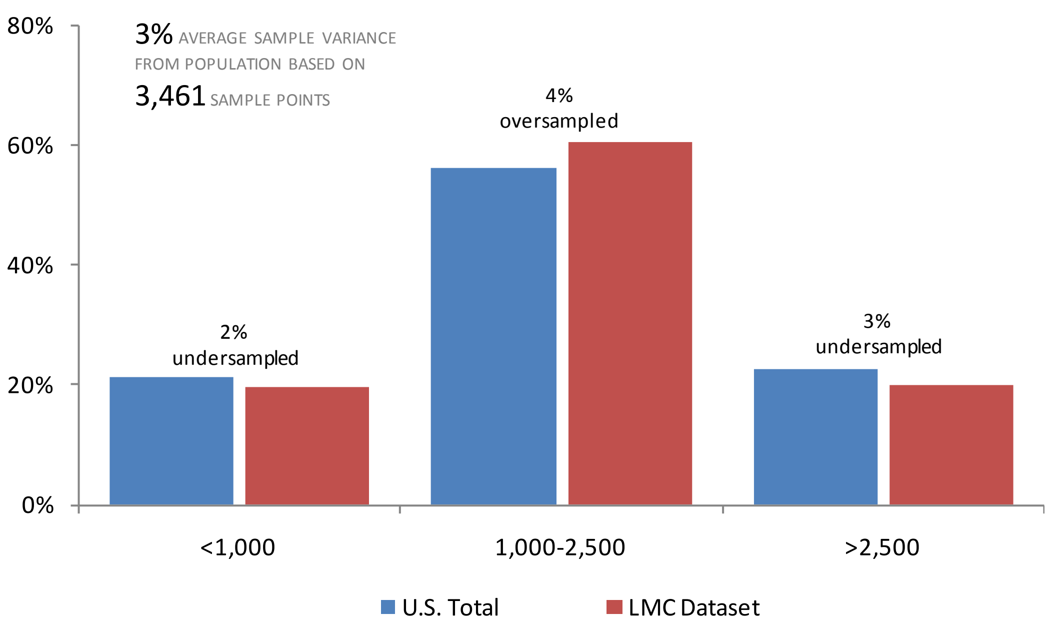

Figure B-2 Residential Sector Distribution by Residence Size

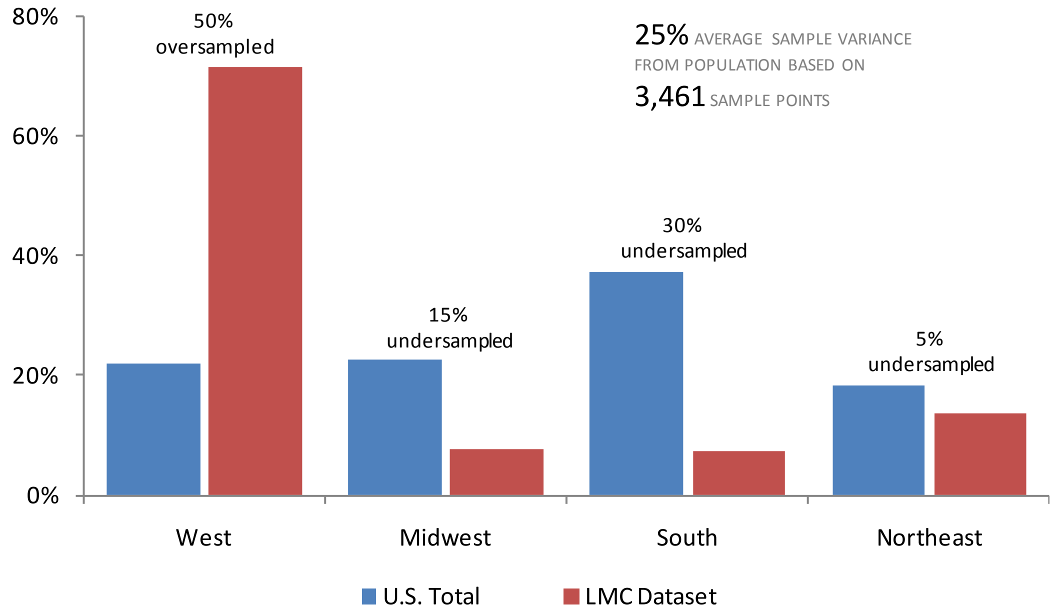

Figure B-3 Residential Sector Distribution by Geographic Region

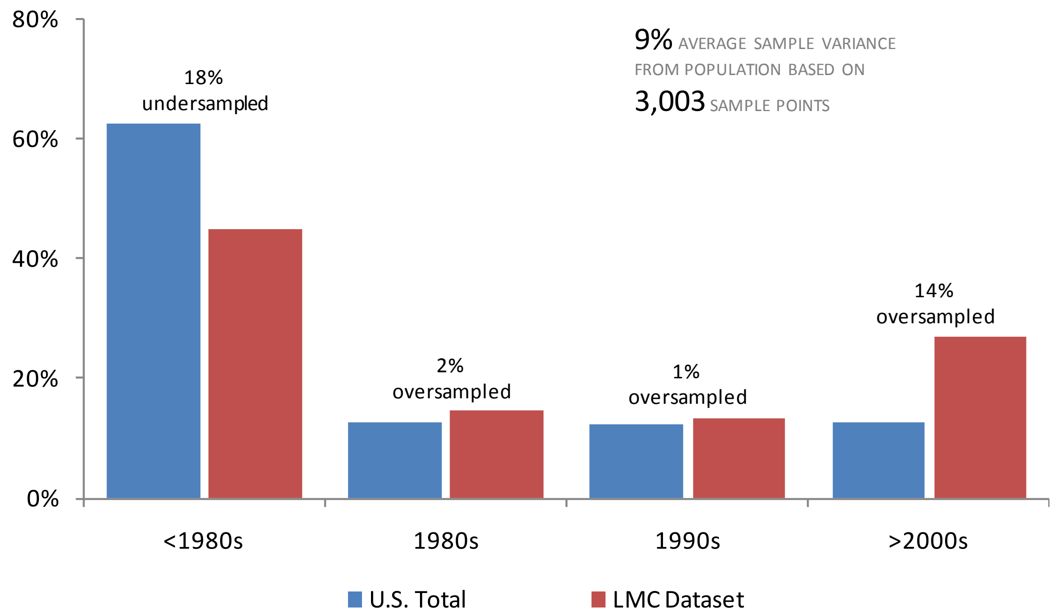

Figure B-4 Residential Sector Distribution by Year Built

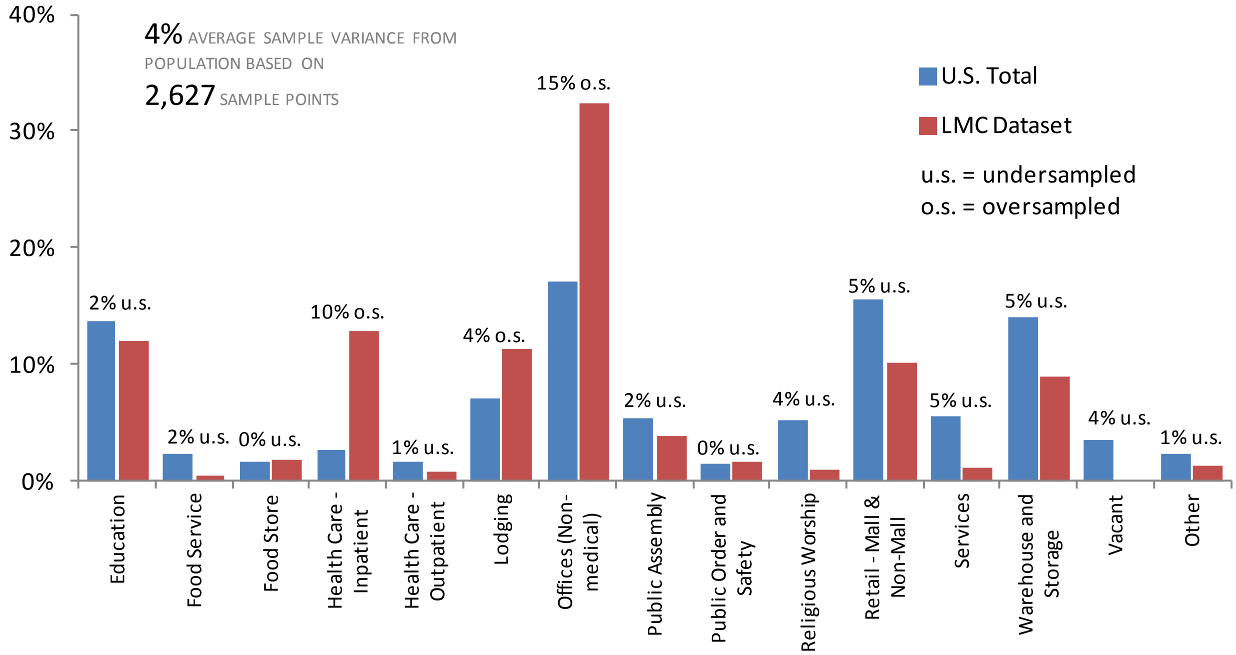

Figure B-5 Commercial Sector Distribution by Building Type

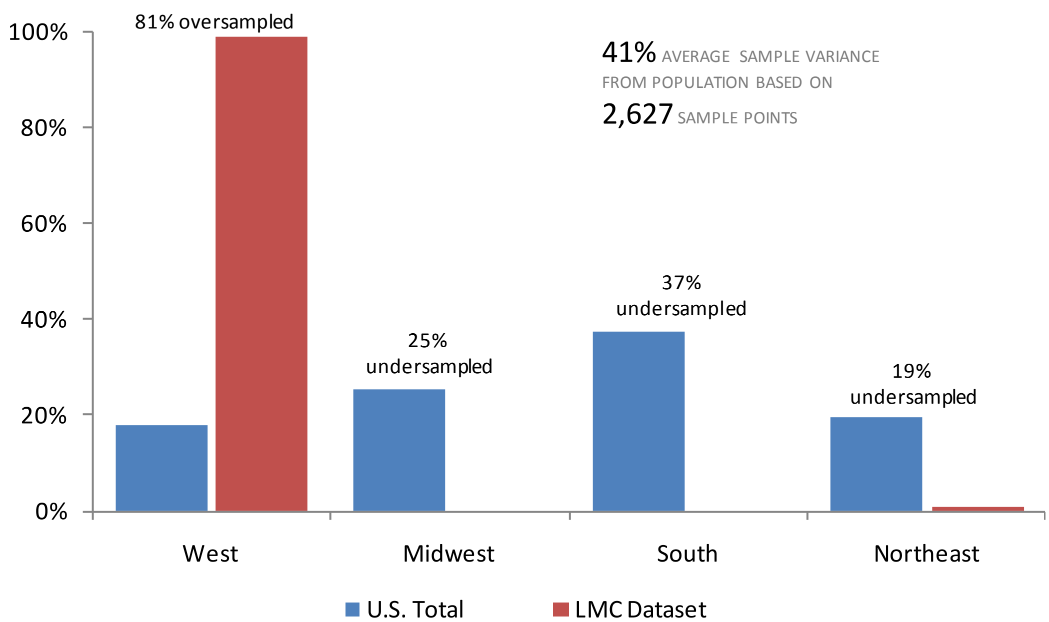

Figure B-6 Commercial Sector Distribution by Geographic Region

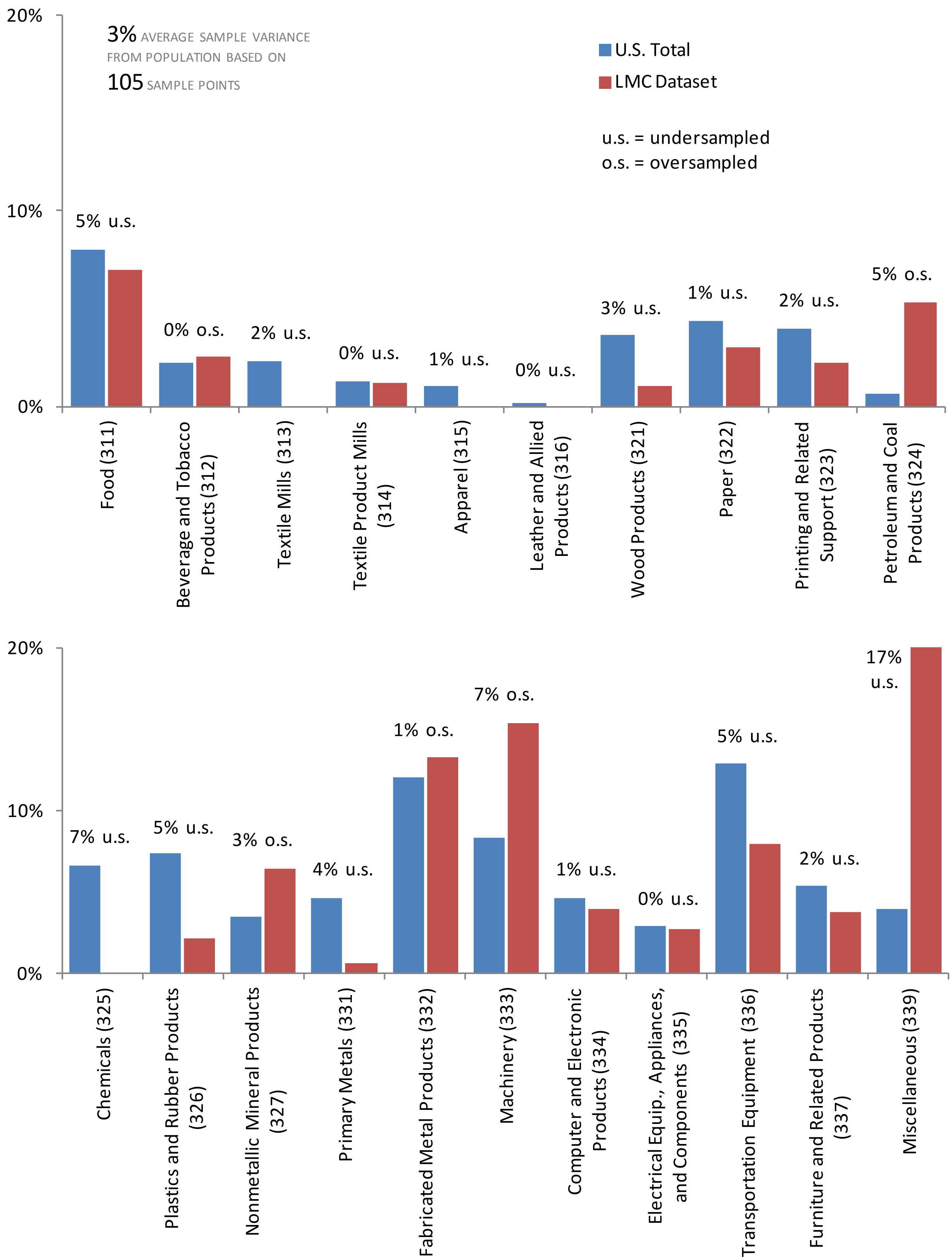

Figure B-7 Industrial Sector Distribution by Building Type

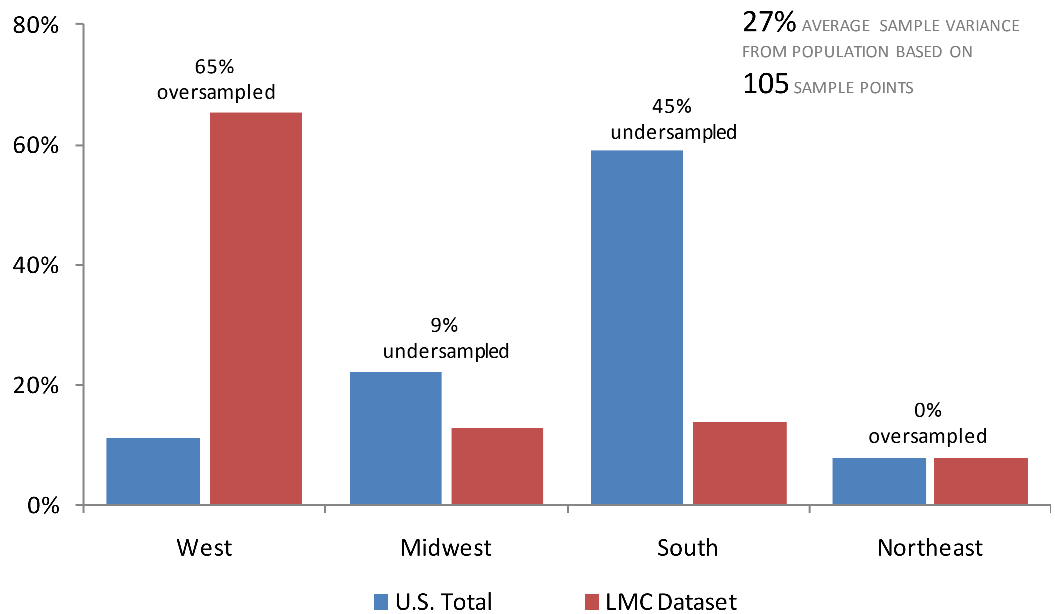

Figure B-8 Industrial Sector Distribution by Geographic Region[20]

[20]The total consumption of energy is used as a proxy for square footage as MECS does not provide floorspace estimates by region.

Appendix C. Efficacy and Wattage Assumptions

The total electricity consumption estimate provided in this report takes into account ballast effects for non-integrated lamps. Similarly, the lumen output estimate is dependent on the system efficacies. Limited ballast data and no efficacy data was provided in the data sources discussed in Section 3.1. The assumed values used for these inputs are provided below. The ballast values used are based on manufacturer catalog data for the commercial and industrial sectors.

Table C.1 Ballast Prevalence in Non-Integrated Lamps

	Residential			Other Sectors		
	Electronic	Magnetic	Ballast Factor	Electronic	Magnetic	Ballast Factor
CFL - Pin	100%	0%	1.0	100%	0%	1.0
T5	100%	0%	1.0	100%	0%	1.0
T8	100%	0%	0.78	100%	0%	0.88 - 0.94
T12	10%	90%	0.59	10%	90%	0.88 - 1.1
Mercury Vapor	0%	100%	1.0	0%	100%	1.0
Metal Halide	90%	10%	1.0	10%	90%	1.0
High Pressure Sodium	0%	100%	1.0	0%	100%	1.0
Low Pressure Sodium				0%	100%	1.0

The lamp efficacy values depicted on the next page in Table C.2 are sector efficacies values based on a lamp's total lumen production divided by its energy use. Thus these values take into account ballast effects. Also, since these efficacies are based energy use instead of lamp count these efficacy values do not indicate stock efficacy but instead energy use weighted efficacy.

The original efficacies (used to develop the lumen production) were derived from manufacturer catalogs. Lamp efficacies were calculated for each lamp type for each subsector and varied based on the average lamp wattage for the subsector.

Table C.2 System Efficacy Assumptions

	Residential	Commercial	Industrial	Outdoor	All Sectors
Incandescent	**12.1**	**11.7**	**11.8**	**12.2**	**12.0**
General Service - A-type	12.9	12.4	11.9		12.8
General Service - Decorative	10.9				10.9
Reflector	10.2	10.4	10.2		10.3
Miscellaneous	11.9	11.3		12.2	12.0
Halogen	**14.3**	**16.3**	**12.9**	**16.5**	**15.4**
General Service	15.0	14.7	14.3		15.0
Reflector	14.1	14.6	12.9		14.3
Low Voltage Display	16.8	18.1			18.0
Miscellaneous	13.8	15.3	13.0	16.5	14.8
Compact Fluorescent	**52.1**	**55.2**	**62.8**	**54.6**	**53.7**
General Service - Screw	53.0	54.4	53.3		53.3
General Service - Pin	59.1	58.4	68.6		58.4
Reflector	43.1	44.9	41.9		44.3
Miscellaneous	52.1			54.6	53.3
Linear Fluorescent	**67.3**	**76.6**	**77.7**	**73.7**	**76.3**
T5	53.3	90.4	84.8		89.5
T8 Less than 4ft	55.4	71.0	71.4		70.6
T8 4ft	72.9	78.5	78.5		78.4
T8 Greater than 4ft	87.0	80.5	78.5		80.3
T12 Less than 4ft	51.8	56.1	48.5		55.8
T12 4ft	66.7	70.8	71.5		70.5
T12 Greater than 4ft	74.5	77.1	78.1		77.2
T8 U-Shaped	77.3	75.7	76.9		75.7
T12 U-Shaped	63.3	64.6	64.5		64.6
Miscellaneous	62.7	74.9	79.8	73.7	72.6
High Intensity Discharge	**62.4**	**75.2**	**76.7**	**74.6**	**75.1**
Mercury Vapor	29.3	37.9	38.8	30.5	35.2
Metal Halide	49.0	72.8	75.5	60.0	69.6
High Pressure Sodium	70.1	107.5	104.7	83.6	86.9
Low Pressure Sodium		143.5		89.2	92.1
Other	**37.7**	**55.9**	**40.3**	**58.6**	**53.8**
LED	40.7	55.8	40.3	45.3	51.9
Miscellaneous	37.5	66.2		75.8	57.5
AVERAGE	**19.1**	**69.8**	**77.4**	**71.1**	**58.0**

Appendix D. Residential Operating Hours

The residential operating hours used in the 2010 LMC were developed from lighting logger data from approximately 7,299 sockets initially collected primarily in southern California as part of the CPUC Upstream Lighting Report effort. This data was used as it was the most recent, most comprehensive data set that was available to the DOE for this report. It is important to note that though this data is considered to be the best for the purposes of this report, operating hour data varies widely from source to source depending on the sample size, the residence types considered, the occupant's habits, the sample geographies, and other factors. For this reason it is suggested that when conducting any in depth analysis concerning the impact of energy conservation measures field work be conducted to gather operating hour data applicable the project.

For comparison, the LMC 2010 average residential operating hours by room type are depicted below in Table D.1 along with similar data from several other recent studies (Navigant Consulting, et al, 2010), (NMR, 2007), (NMR, et al, 2009). Each of these studies used lighting loggers to record the operating hour data. The overall residential average lighting operating hours of these studies, that is simply the average of the averages, is 2.5 hours a day. Noticeably, the range of these averages is quite large, spanning from 1.8 to 3.2 hours a day, indicating the difficulty of determining a true national average.

The LMC 2010 operating hours average falls at the low end of this range. At 3.2 hours per day the Efficiency Maine residential average lies at the other end, and is approximately 80 percent more than the LMC 2010 value. The Efficiency Maine, and all of the other non LMC studies, only monitored CFL lamps. A tendency of consumers to use CFLs to replace their most used lamps could explain in part these studies greater operating use values.

Table D.1. Comparison of Residential Operating Hours

	2010 LMC	EmPOWER	Efficiency Maine	New England	2001 LMC
Years of Collection	2008 -2009	2010	2006-2007	2007-2008	Pre 1996
Geography	California (adjusted)	Maryland (unadjusted)	Maine (unadjusted)	New England (unadjusted)	Oregon, Washington (unadjusted)
Number of Sockets Logged	7,299	200	153	657	4,884
Lamps Considered	All sockets	CFLs Only	CFLs Only	CFLs Only	All sockets
Basement	1.6	2.6	2.4		
Bathroom	1.6	1.7	1.0		1.8
Bedroom	1.6	1.2	1.3		1.1
Closet	1.4	0.2			1.1
Dining	1.9	4.4	8.7	3.0	2.5
Exterior	2.6	6.	5.5		2.1
Garage	1.5		1.1		1.5
Hall	1.5	1.8	1.3		1.5
Kitchen	2.3	5.3	4.4	3.0	3.0
Laundry / Utility Room	1.5	1.7			2.0
Living /Family Room	2.0	3.3	3.7	3.0	2.5 / 1.8
Office / Den	1.8	2.0	3.4	3.0	1.7
Other / Unknown	1.0	6.18		2.0	0.8
Average	**1.8**	**2.9**	**3.2**	**2.5**	**2.0**

Appendix E. Supplementary Residential Results

Additional detail is provided on the residential sector due to the greater availability of data sources for this sector. Table E.1 provides the breakdown of the general service lamp shapes in the residential sector. The classic a-type is by far the most common incandescent shape, and thus most common general service lamp shape. Halogen general service lamps, which are relatively new to the scene, are almost evenly split between a-type and the smaller bullet shape. A vast majority of the CFL general service lamps are spiral shaped.

Table E.1 Lamp Shape by Technology

	Incandescent	Halogen	CFL
A-Type	68%	46%	4%
Globe	14%	2%	4%
Bullet	4%	52%	1%
Flame / Candle	3%	-	2%
Spiral	-	-	89%
Other Decorative	12%	-	1%

The remaining tables in this section provide further detail on the installed lamp characteristics by room type. Table E.2 provides the breakdown of lamp installations by room type and Table E.3 provides the average wattage of lamps by room type.

Table E.2 Lamp Technology Occurrences by Room Type

	Basement	Bathroom	Bedroom	Closet	Dining Rm	Exterior	Garage	Hall	Kitchen	Utility Rm	Living Rm	Office	Other
Incandescent	**40%**	**74%**	**67%**	**60%**	**81%**	**59%**	**35%**	**72%**	**45%**	**50%**	**61%**	**58%**	**53%**
General Service - A-type	32%	32%	49%	54%	31%	32%	32%	38%	18%	42%	35%	36%	37%
General Service - Decorative	2%	34%	11%	2%	44%	12%	1%	21%	8%	3%	14%	7%	6%
Reflector	6%	4%	4%	3%	3%	10%	2%	11%	16%	3%	9%	12%	7%
Miscellaneous	0%	3%	3%	2%	4%	4%	1%	2%	2%	3%	3%	2%	3%
Halogen	**1%**	**2%**	**3%**	**2%**	**3%**	**14%**	**1%**	**4%**	**7%**	**2%**	**5%**	**6%**	**6%**
General Service	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	1%	0%	0%
Reflector	1%	1%	1%	1%	1%	11%	0%	3%	4%	1%	3%	4%	4%
Low Voltage Display	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	0%
Miscellaneous	0%	0%	1%	0%	0%	2%	0%	0%	1%	0%	1%	2%	1%
Compact Fluorescent	**30%**	**20%**	**28%**	**20%**	**15%**	**24%**	**13%**	**22%**	**23%**	**19%**	**29%**	**27%**	**17%**
General Service - Screw	27%	17%	26%	18%	14%	19%	12%	17%	16%	18%	26%	21%	14%
General Service - Pin	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Reflector	2%	1%	1%	1%	1%	3%	1%	3%	5%	1%	2%	4%	2%
Miscellaneous	1%	2%	1%	1%	0%	2%	1%	1%	2%	1%	1%	2%	1%
Linear Fluorescent	**28%**	**3%**	**2%**	**17%**	**1%**	**2%**	**51%**	**2%**	**22%**	**28%**	**3%**	**8%**	**24%**
T5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
T8 Less than 4ft	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
T8 4ft	3%	0%	0%	2%	0%	0%	6%	0%	2%	4%	0%	1%	3%
T8 Greater than 4ft	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
T12 Less than 4ft	0%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%
T12 4ft	21%	2%	1%	9%	0%	1%	33%	1%	11%	18%	2%	4%	17%
T12 Greater than 4ft	1%	0%	0%	1%	0%	0%	7%	0%	0%	1%	0%	0%	0%
T8 U-Shaped	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
T12 U-Shaped	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Miscellaneous	3%	1%	1%	4%	1%	1%	4%	1%	7%	5%	1%	3%	3%
High Intensity Discharge	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Mercury Vapor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Metal Halide	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
High Pressure Sodium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Low Pressure Sodium													
Other	**0%**	**1%**	**0%**	**1%**	**0%**	**2%**	**0%**	**1%**	**3%**	**0%**	**1%**	**0%**	**0%**
LED Lamp	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Miscellaneous	0%	1%	0%	1%	0%	2%	0%	1%	3%	0%	0%	0%	0%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table E.3 Lamp Technology Wattages by Room Type

	Basement	Bathroom	Bedroom	Closet	Dining Rm	Exterior	Garage	Hall	Kitchen	Utility Rm	Living Rm	Office	Other
Incandescent	**67**	**56**	**59**	**62**	**49**	**62**	**72**	**55**	**60**	**63**	**61**	**62**	**63**
General Service - A-type	70	62	64	63	60	65	73	60	62	64	70	65	66
General Service - Decorative	41	47	42	51	41	44	53	39	45	45	42	45	46
Reflector	66	82	64	67	63	80	70	67	67	72	65	66	66
Miscellaneous	24	48	41	54	40	48	57	41	43	56	42	60	55
Halogen	**54**	**64**	**66**	**45**	**53**	**87**	**91**	**60**	**48**	**59**	**69**	**68**	**61**
General Service	-	54	58	22	35	69	65	65	31	100	61	60	55
Reflector	48	62	60	53	55	89	80	61	55	54	61	62	57
Low Voltage Display	50	51	40	44	45	35	91	45	44	50	45	42	44
Miscellaneous	121	75	97	35	66	94	123	66	42	71	135	95	84
Compact Fluorescent	**18**	**16**	**17**	**17**	**16**	**17**	**19**	**16**	**17**	**17**	**18**	**18**	**18**
General Service - Screw	18	15	17	17	16	17	19	16	17	17	18	17	18
General Service - Pin	-	18	17	22	23	19	36	16	17	14	22	49	21
Reflector	16	17	16	18	19	19	18	16	18	17	16	15	18
Miscellaneous	18	16	19	17	18	18	19	17	17	17	21	19	17
Linear Fluorescent	**26**	**24**	**23**	**24**	**22**	**28**	**29**	**22**	**22**	**25**	**24**	**24**	**26**
T5	-	-	15	26	-	-	37	15	19	26	19	-	26
T8 Less than 4ft	21	12	15	15	-	-	16	15	16	17	17	12	12
T8 4ft	26	25	25	26	26	27	26	26	26	26	26	25	26
T8 Greater than 4ft	-	46	-	36	33	-	41	-	45	-	41	41	41
T12 Less than 4ft	-	14	21	14	-	19	17	16	13	20	18	-	17
T12 4ft	27	28	28	26	27	27	27	28	26	26	27	27	27
T12 Greater than 4ft	48	48	41	46	51	52	52	-	45	42	53	52	53
T8 U-Shaped	-	27	25	-	-	27	28	-	27	27	27	-	-
T12 U-Shaped	27	26	-	-	-	-	-	-	27	-	-	27	-
Miscellaneous	17	18	18	16	19	25	16	18	14	17	20	17	17
High Intensity Discharge	**-**	**-**	**-**	**-**	**-**	**154**	**164**	**-**	**51**	**-**	**215**	**-**	**221**
Mercury Vapor	-	-	-	-	-	197	178	-	-	-	-	-	-
Metal Halide	-	-	-	-	-	-	-	-	-	-	79	-	-
High Pressure Sodium	-	-	-	-	-	146	150	-	51	-	280	-	221
Low Pressure Sodium	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	**41**	**114**	**54**	**73**	**63**	**62**	**67**	**56**	**14**	**87**	**36**	**67**	**21**
LED Lamp	4	10	16	-	3	12	11	6	12	-	11	2	12
Miscellaneous	77	118	59	73	86	70	95	62	14	87	53	77	60
TOTAL	**41**	**47**	**47**	**46**	**44**	**54**	**43**	**46**	**40**	**43**	**48**	**47**	**46**

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