Connecticut LED Lighting Study Report (R154)

FINAL

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SUBMITTED TO:
Connecticut EEB

SUBMITTED BY:
NMR Group, Inc.

NMR Group, Inc.

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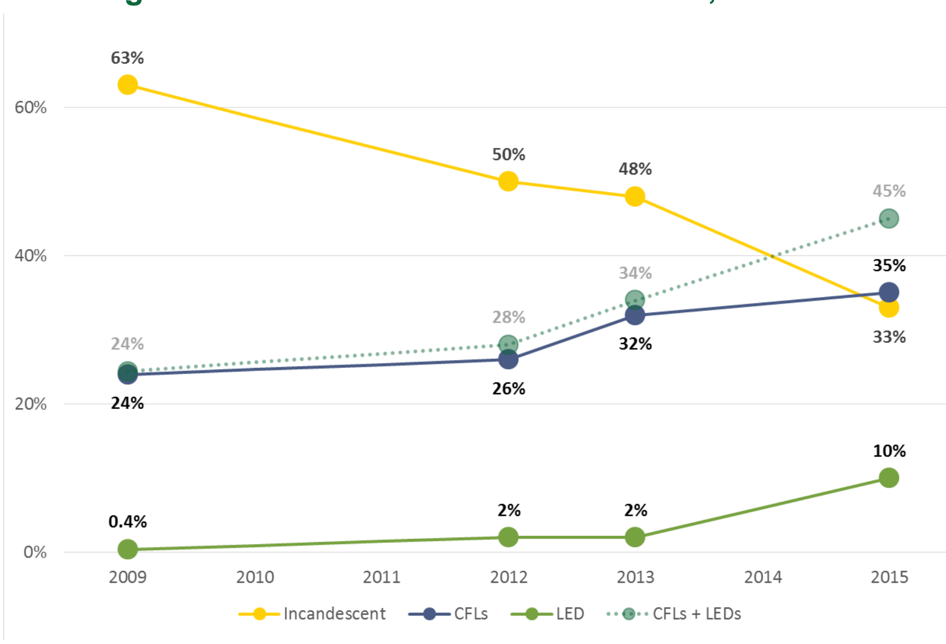
ES Executive Summary

This report presents the results of the Connecticut LED Lighting Study (R154) conducted by NMR Group, Inc., which was designed to assess the current residential market for light-emitting diodes (LEDs) in Connecticut. For the R154 study, NMR collected data through 151 telephone surveys of a random sample of homes throughout Connecticut and 81 on-site lighting inventories conducted with the subset of those telephone survey respondents who agreed to the visit. This executive summary focuses on the highlights from sections of the report, including saturation, penetration, storage, purchases, and energy use. Methodological details can be found in Appendix A.

SOCKET SATURATION TRENDS

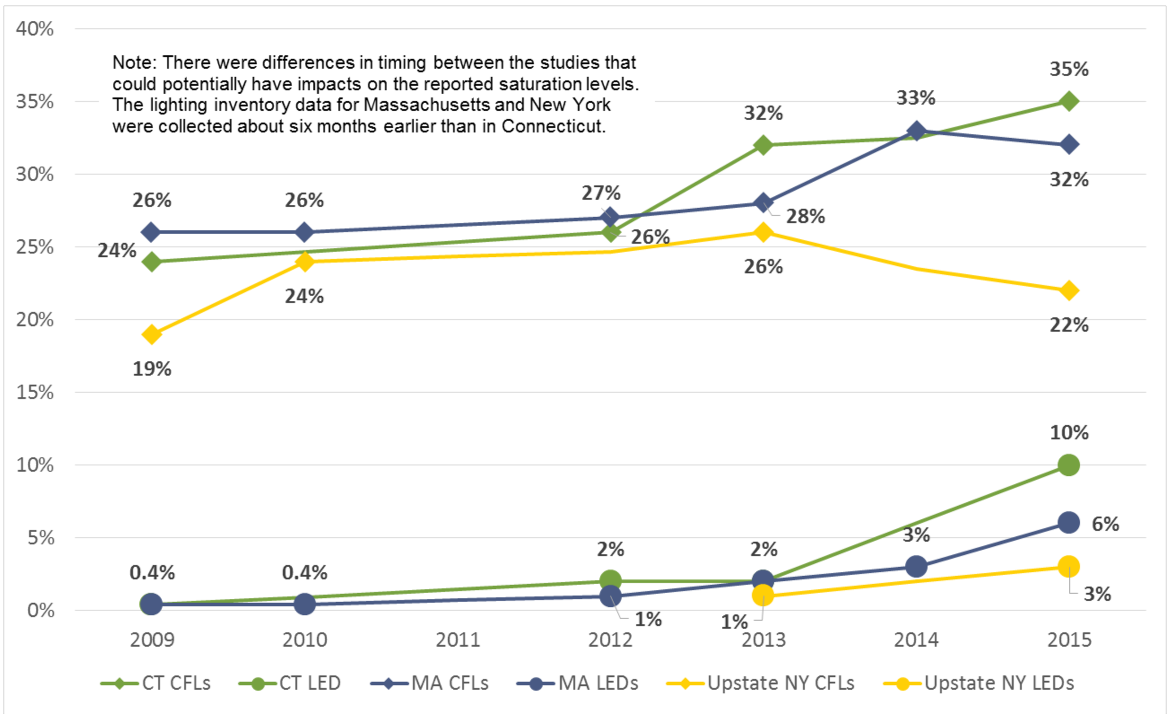
Between 2009 and 2015, Connecticut experienced a steady increase in efficient bulb saturation (the percentage of sockets filled with a specific bulb type) and a corresponding decrease in incandescent bulb saturation. Importantly, LED saturation in Connecticut, which had been rising slowly between 2009 and 2013, increased significantly between 2013 and 2015; LED bulbs now occupy one out of ten sockets in Connecticut (10%), up from just 2% in 2013. CFL saturation growth appears to have slowed, with only relatively small gains in saturation between 2013 and 2015—an increase of only three percentage points (32% to 35%). Combined, LED and CFL saturation has increased an average of six percentage points per year since 2012 (Figure 1). Linear fluorescent saturation has remained at 11% since 2012. Combined efficient bulbs (CFL, LED, and fluorescent) accounted for more than one-half of all sockets (56%) in 2015, meaning that, for the first time, efficient bulbs represent the majority of bulbs in Connecticut households. Additional analysis related to saturation trends over time in Connecticut can be found in Section 2.1.

Figure 1: Connecticut Saturation Trends, 2009-2015



The use of comparison areas allowed us to place trends in Connecticut saturation in a broader regional context. LED saturation in Massachusetts, a state with similar program activity to Connecticut, appears to be on a similar trajectory to that in Connecticut. Whereas New York, a state that dropped all program support for residential lighting in 2014, has not seen similar increases in LED saturation (Figure 2). Similarly, CFL saturation trends in Massachusetts appear to be similar to Connecticut, while CFL saturation in New York appears to be decreasing in the absence of programs. It should be noted that the lighting inventory data for Massachusetts and New York were collected about six months earlier than in Connecticut; saturation rates in these two states will be studied again this winter with results expected in May 2016. Additional analysis comparing Connecticut to eight comparison areas can be found in Section 2.2.

Figure 2: CFL and LED Saturation in CT, MA, and Upstate NY, 2009-2015



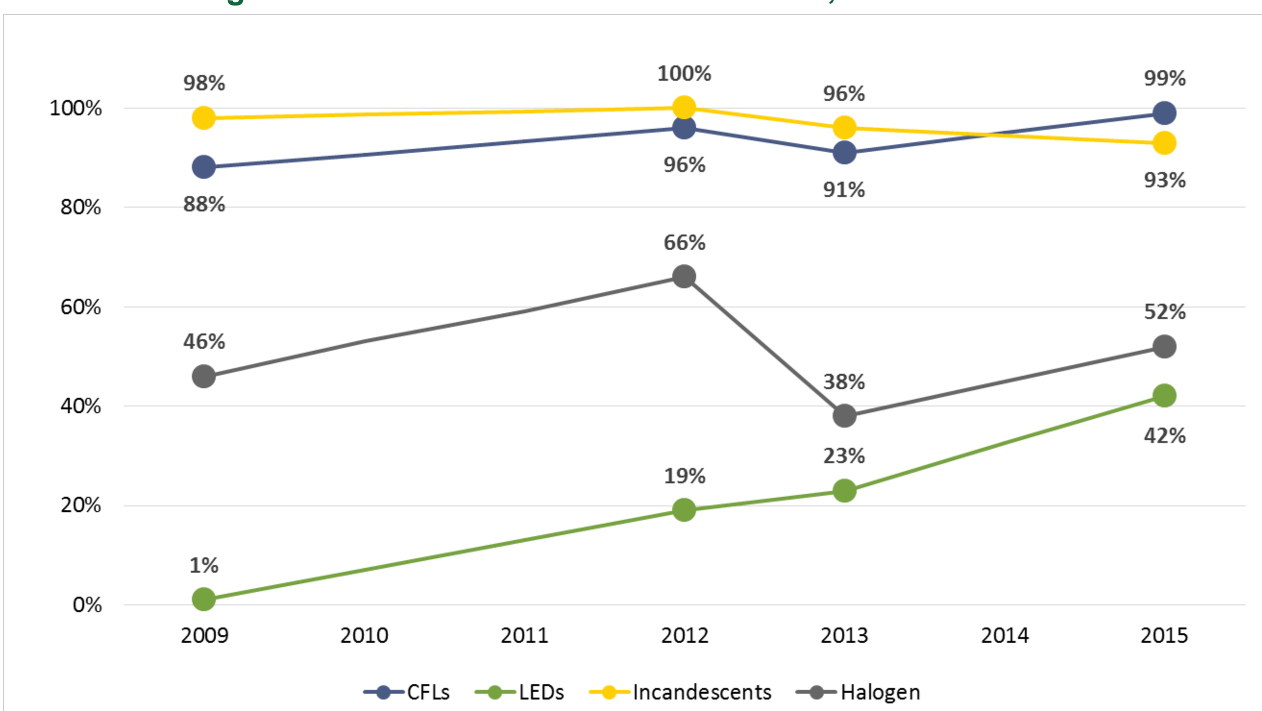
Turning to saturation over time by room type, in Connecticut only three room types persisted in having less than 50% energy-efficient bulb saturation: dining rooms (22%), foyers (39%) and exteriors (46%). LED saturation was highest in kitchens (21%). Dining rooms had among the lowest LED saturation (4%), which is likely due to their special lighting needs and the price and availability of appropriate LEDs to meet them (dining rooms have the highest specialty socket saturation of all room types—71%). Importantly, sockets in room types with the highest hours of use (HOU), based on the 2014 Northeast Residential HOU Study, were among the room types that had the largest increases in LED socket saturation since the 2013 study: exteriors (5.8 hours per day), kitchens (4.2 hours per day), and living spaces (3.5 hours per day). Additional room-by-room saturation analysis can be found in Section 2.3.

PENETRATION, FAMILIARITY, AND SATISFACTION

When examining the market for LEDs, it is important to remember that, at this stage of market adoption, penetration (the percentage of homes with one or more LED bulbs) is likely a better gauge of LED program success than is total saturation. As more households purchase LEDs and penetration rates rise, saturation rates will follow suit. Over the last five years, LED penetration has skyrocketed. In the 2009 study, screw-base general service LED bulbs were present in only one home, while in the 2015 study they were present in 34 of 81 homes (42%). Additionally, LED penetration jumped for all room types from 2013 to 2015; many room types had no LEDs installed as recently as 2013, while LEDs were present in all room types by 2015. Concurrently, incandescent penetration has shown a decrease in all room types over the past few years, which is in line with the decrease in incandescent socket saturation. Additional analysis on penetration by household and room type can be found in Section 3.1.

Similarly, awareness and satisfaction with LEDs are important market indicators for LED programs. The majority (66%) of consumer survey participants were either very or somewhat familiar with LEDs. Those who reported having CFLs or LEDs installed were largely very satisfied or somewhat satisfied with both bulb types; however, when asked, most participants preferred LEDs over CFLs. Additional details on familiarity and satisfaction can be found in Section 3.2.

Figure 3: Connecticut Penetration Trends, 2009-2015



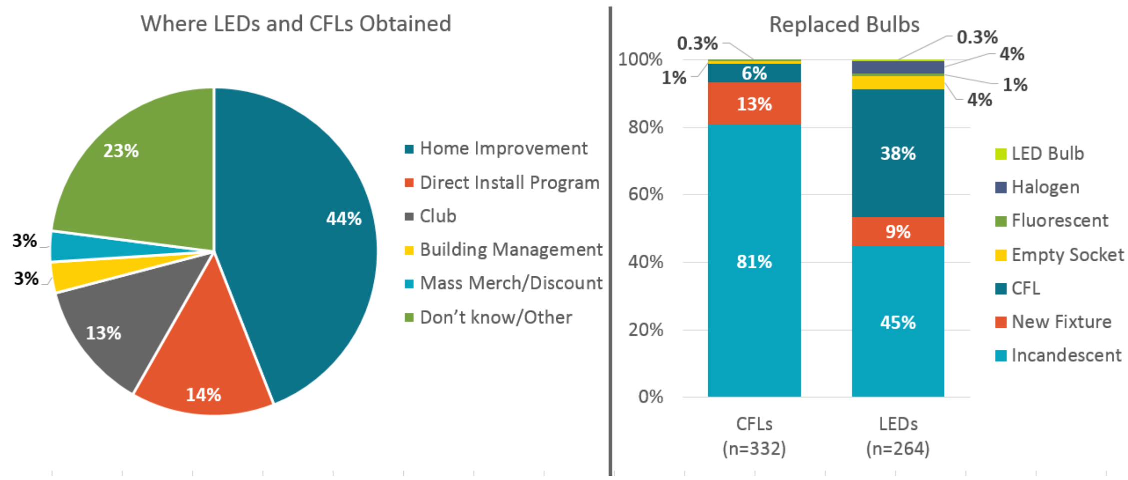
RECENT PURCHASES

More than one-half (55%) of telephone survey respondents reported purchasing screw-base CFLs and nearly two-fifths (37%) reported purchasing screw-base LEDs within the past six months. Approximately one-half (48%) reported purchasing incandescent bulbs, adding to the growing body of evidence suggesting that the implementation of EISA has not completely eroded the market for incandescent bulbs. However, these percentages rely solely on self-reported data and should be treated with some caution—especially considering that most consumers are likely unable to distinguish between halogen and incandescent bulbs.

On-site participants reported that most LEDs and CFLs obtained in the year prior to the study came from home improvements stores. The second most common source from which participants obtained bulbs was through direct-install programs. Study participants who were confirmed as having taken part in a direct-install program (6%) were in line with the proportion of program participants in the state (12%) in 2014. Additional information on sources of new bulbs can be found in Section 4.1.

The following is an examination of the types of bulbs that newly purchased (i.e., excluding self-reported direct-install bulbs) CFLs and LEDs replaced, according to self-reported data provided on-site. The majority (81%) of CFLs replaced incandescents; similarly, a large proportion of LED bulbs also replaced incandescents (45%), though this was followed closely by LEDs replacing CFLs (38%). These newly installed bulbs led to a large drop in the observed wattage of the replaced sockets. Overall, newly installed CFLs reduced the average wattage used in those replaced sockets by 41 watts, and the average energy use in the sockets replaced with LEDs declined by 27 watts. The smaller decrease in delta watts from LEDs reflects the fact that many of these bulbs (two out of five) were reported to have replaced CFLs rather than incandescents (Figure 4). When compared to the Massachusetts panel study, where actual observed bulb changes were recorded, the average changes in wattages were very different: for CFLs, 41 delta watts in Connecticut vs. 28 delta watts in Massachusetts; for LEDs, 27 delta watts in Connecticut vs. 38 delta watts in Massachusetts. Given the nature of self-reported data, we place greater faith in the Massachusetts findings. Additional details on bulb replacements, including comparisons to findings from a Massachusetts panel study, can be found in Section 4.2.

Figure 4: Recent Purchases



STORAGE BEHAVIOR

Eight out of ten homes in the on-site study had at least one bulb in storage. While incandescent bulbs were still the most commonly stored bulb type, they have begun to show signs of losing ground to CFLs, which have increased in number. Most bulbs are being stored for future use, though 15% of incandescent bulbs are reportedly earmarked for disposal.

Slightly more than four out of five (84%) newly purchased CFLs and LEDs were installed within a year of purchase. Notably, newly purchased LEDs were installed at a much quicker rate than newly purchased CFLs (**Error! Reference source not found.**), likely due to a mixture of consumer satisfaction, high bulb prices, and fewer bulbs per pack.

In addition to first-year in-service rates, NMR calculated lifetime in-service rates based on guidance from the Uniform Methods Project: Residential Lighting Protocol. To calculate lifetime in-service rates, we relied on lighting installation trajectories from other recent studies. Table 1 provides an overview of in-service rates for each year by bulb type. Section 5 contains additional details on storage behavior, including in-service rates.

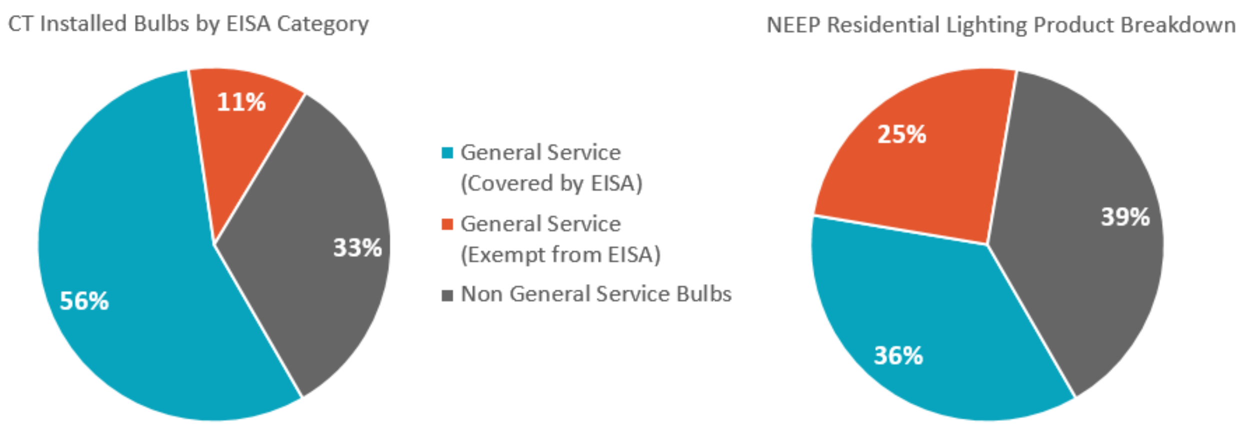
Table 1: Lifetime In-Service Rates

	CFLs	LEDs
First Year ISR	76%	95%
Second Year ISR	86%	97%
Third Year ISR	93%	98%
Fourth Year ISR	97%	100%

EISA COVERAGE, EXEMPTIONS, AND EXCLUSIONS

In order to help understand the residential lighting market in the post-EISA period, we grouped installed bulbs into three categories: covered by EISA, exempt from EISA, and non-general service bulbs (outside the realm of EISA). Just over one-half (56%) of installed bubs in Connecticut were covered by EISA; the remaining 44% were either non-general service bulbs or exempt from EISA. This means that a large proportion of bulbs currently installed in homes are not directly covered by EISA. Supporting these findings, a recent NEEP paper based on secondary research, including shelf stocking studies, showed that nearly two-thirds (64%) of bulbs currently being sold are not covered by EISA, leading NEEP to conclude that great opportunities remain for efficiency programs to remain engaged with the residential lighting market. While there are differences in the findings of the two studies, they reach similar conclusions. The differences in findings can be explained by differences in methodology. The analysis for this study (R154) covers currently installed bulbs, whereas the NEEP estimates cover bulbs available for purchase (and not sales-weighted). Finally, we also analyzed the bulbs covered by EISA to determine what proportion are already compliant. In total 62% of bulbs covered by EISA are already EISA compliant—60% are efficient bulbs (CFLs or LEDS) and 2% are EISA-complaint halogen bulbs. Additional details on this analysis, including additional discussion of methodological differences, can be found in Section 6.

Figure 5: Bulbs by EISA Category



REMAINING POTENTIAL ENERGY SAVINGS

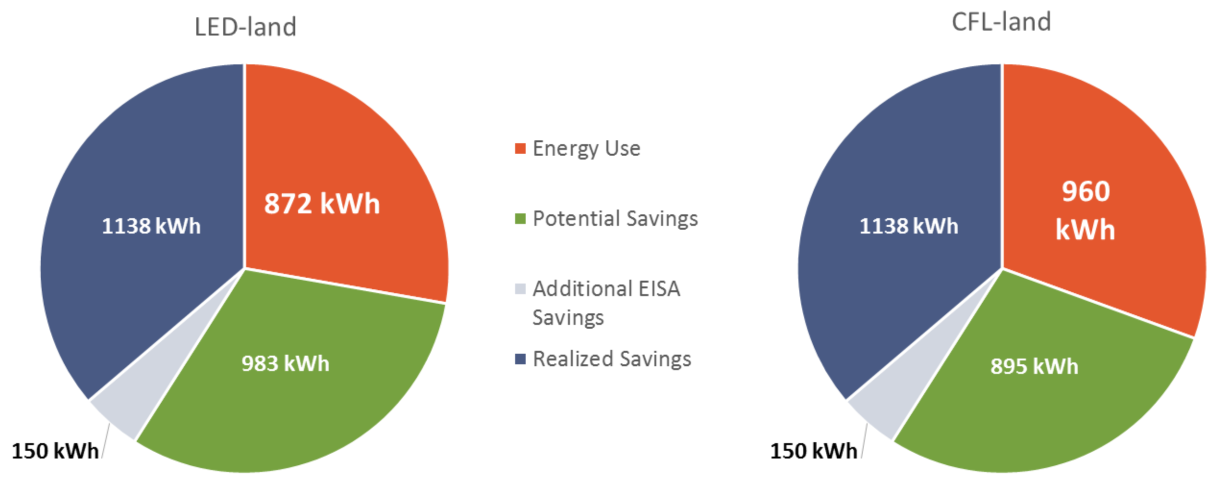
One of the main goals of this study was to update the residential energy potential for energy-efficient lighting in Connecticut. Using saturation figures from this study and hours of use (HOU) values from a study completed in 2014, we found that, while inefficient bulb types fill fewer than one-half of the sockets in Connecticut homes (44%), they are responsible for two-thirds (67%) of the energy used for lighting in these homes.

To help illustrate remaining potential energy savings in the residential lighting market, we calculated potential savings for five scenarios, including if all sockets currently filled with inefficient bulb types were replaced with CFLs (CFL-land) or LEDs (LED-land) and annual household energy usage if all currently installed non-EISA-compliant General Service bulbs covered by EISA were replaced with a minimum EISA-compliant bulb (EISA-land).

To calculate potential savings we compared estimated average energy usage from CFL- and LED-land to current estimated energy usage minus expected additional savings due to EISA (EISA-land). Note that because only 56% of the of the bulbs found in Connecticut households are covered by EISA and 62% of those bulbs are already EISA complaint, additional savings due to EISA are only a small portion of remaining savings potential.

Not including additional EISA savings, remaining energy savings potential in LED-land is equal to 86% of the savings that have already been achieved (Figure 6). To help put estimated lighting energy use in context, according to data provided by Eversource, households in Connecticut served by Eversource used an average of 8,395 kWh in 2014. This means that current estimated lighting electric usage represents nearly one-quarter (24%) of average annual electric usage. Details for this analysis and additional findings can be found in Section 7.

Figure 6: Potential Electric Usage



RECOMMENDATIONS AND CONSIDERATIONS

Recommendation 1: The PAs should continue with existing plans to educate consumers about and provide incentives for LED bulbs in future program cycles.

Rationale: While consumers are adopting LEDs in non-program states, they appear to be adopting them at a greater pace in program states. Evidence from Connecticut and the comparison areas of Massachusetts and New York indicates that programs appear to have a strong impact on saturation levels, increasing energy-efficient bulb saturation in program states (CT and MA) and decreasing energy-efficient bulb saturation where programs no longer exist (NY). Further, as the potential energy savings analysis in this report demonstrates, there are substantial savings yet to be realized in the residential lighting market, and EISA at most only applies to just over one-half of all bulbs currently installed in Connecticut.

Recommendation 2: The PAs should carefully observe and assimilate information coming from ongoing and planned saturation studies in the Northeast. In particular, Massachusetts is once again studying residential lighting markets in Massachusetts and New York. This study will offer further insight into the results of exiting the residential lighting market.

Rationale: The residential lighting market is in a period of rapid change, which creates opportunities to see significant changes in saturation across even partial years. This could lead to different outcomes or conclusions from upcoming evaluations outside of Connecticut.

Recommendation 3: When updating the program savings document, the PAs should consider findings from this study regarding in-service rates. Based on bulbs found in storage and installed, we calculate a first-year in-service rate of 95% for LEDs and 76% for CFLs. In addition, we have calculated in-service rates for years two, three, and four based on guidance from the Uniform Methods Project: Residential Lighting Protocol. Lifetime in-service rates are available in Table 1.

Rationale: While the in-service rate figures are based on self-reported purchases, any bias in the responses are likely to apply equally to both installed and stored bulbs. The UMP Lighting Protocol suggests that lifetime in-service rates can be calculated based on first-year installation rates and installation trajectories from other recent studies.

Consideration 1: The PAs should consider plans for future primary residential lighting research in Connecticut to supplement and supplant information gathered in other areas in the Northeast.

Rationale: Given the rapid state of change in the market, it is likely that the market will change enough over the next 12 months to merit further study. While secondary research relying on other states may benefit Connecticut, firsthand research in Connecticut may offer greater insight. Specifically, the PAs should consider a low-income-specific study that investigates trends among low-income households. While this study included low-income households, the total sample size was insufficient to deeply explore differences among subsamples. In addition, the PAs should consider the *benefits of a panel study, which could directly observe changes taking place in Connecticut. The R154 sample could serve as a starting point. At a minimum, the PAs should consider fielding a larger saturation study in 2016-2017, as the market is currently experiencing rapid change. In addition, it may be possible to coordinate future research efforts with the efforts of others in the region to expand the scope of studies or leverage allocated resources.*

Consideration 2: The PAs should carefully consider future support for standard CFLs. While CFL saturation growth appears to have slowed or plateaued, avoiding backsliding is an important consideration. Any changes in program support for CFLs should be well coordinated with changes or adjustments to program support for LEDs.

Rationale: Evidence from the New York comparison area suggests that CFL saturation has receded in the absence of programs, while halogen saturation has increased. This is an indication of potential backsliding in the absence of program support for CFLs and LEDs. Still, consumers in Connecticut appear ready to adopt LEDs as an alternative to CFLs—they self-reported that 38% of LEDs installed in the past year replaced a CFL. To avoid potential drops in delta watts, it is important that consumers understand that LEDs and CFLs are both more efficient than halogen and incandescent alternatives.

Consideration 3: The PAs should carefully consider whether or not they should use delta watt findings from this study when updating the program savings document or instead explore the possibility of updating delta watts through a market adoption model approach.

Rationale: A market adoption model would describe likely lighting market changes and responses to federal lighting standards and program activity, drawing on the most recent market assessment data available. The model would provide information on market-level bulb sales by technology, program-induced sales, and changes in delta watts. In the model, users can manipulate assumptions about program activity to see the likely impact of various scenarios on expected sales and other outcomes.

While this study explored delta watts, findings are based on self-reported data. On-site participants were not only asked to recall whether a CFL or LED had been purchased within the past year, they were also asked to recall the bulb type and wattage it had replaced. Comparing findings from this study to actual observed findings in Massachusetts reveals significant differences and draws into question the self-reported findings from this study. In addition, even actual observed delta watts offer a snapshot of history and do not factor in changes in market conditions. If the PAs were to pursue a market adoption model, it would offer a forecast of delta watts.

1

Section 1: Introduction

This report presents the results of the Connecticut LED Lighting Study (R154), which was designed to assess the current residential market in Connecticut with a special emphasis on light-emitting diodes (LEDs). NMR Group, Inc. (NMR), conducted this study at the request of the Connecticut Energy Efficiency Board (EEB). The study results draw on telephone surveys completed with random sample of households in Connecticut and on-site lighting inventory visits completed with a subset of survey participants.

1.1 BACKGROUND

Energize CT's Retail Lighting Program is part of the Residential Retail Products Program, the objective of which is "to increase consumer awareness, acceptance and market share of ENERGY STAR® lighting, appliances and consumer electronics."[1] The Lighting Program specifically promotes the sale of ENERGY STAR lighting products. The program continues to support both CFLs and LEDs, but has shifted focus increasingly toward LED bulbs. In 2015, the program discontinued incentives for specialty CFLs because, as stated in the 2015 annual update, "There are better performing LED alternatives on the market at good price points." In addition, the recent ENERGY STAR V2.0 revisions make it unlikely that any CFLs will be eligible for ENERGY STAR designation moving forward.

Incentives are applied at the wholesale level to manufacturers, allowing consumers to pay a discounted price at the point of purchase. Historically, the Retail Lighting Program has concentrated on home improvement and big-box stores, but it has made recent efforts to expand to hard-to-reach retail stores.

The EEB, Eversource, and the United Illuminating Company (UI) have been tracking numerous lighting market indicators through on-site lighting inventories since 2009. Over time, the purpose of lighting inventories has shifted focus from simply tracking CFL adoption to incorporating metrics for all types of bulbs—program-supported and non-program-supported, efficient and non-efficient. The current effort (R154) continues to track metrics for all bulb types but, in deference to the shift in program focus, this study had a special focus on the market for LEDs.

1.2 STUDY OBJECTIVES

The R154 study was developed for the EEB with the overall goal of assessing trends in the Connecticut lighting market, with special emphasis on LEDs, and providing information to inform updates to parameters used in the calculation of energy and demand savings for the 2016 to 2018 program cycle. These same estimates could also be incorporated into future

[1] 2015 Annual Update of the 2013-2015 Electric and Natural Gas Conservation and Load Management Plan – Public Act 11-80 Section 33.
http://www.energizect.com/sites/default/files/2015%20C%26LM%20Plan%20Update%20FINAL%2012-22-14.pdf

program savings documents (PSDs) and could inform the EEB's decisions regarding the future of residential lighting programs.

The R154 study had the following four main objectives:

- To provide a basis for reliable estimates of the current use of various bulb types and updated calculations of Connecticut socket and savings lighting potential. These results will be used in combination with inputs from previously conducted Connecticut studies.
- To provide data on baselines and delta watts suitable for the PSD, savings estimates, and program planning.
- To provide data on first-year in-service rates suitable for the PSD, savings estimates, and program planning.
- To provide the customer, product, and market data needed to support program targeting and planning needs.

1.3 METHODOLOGY

For the R154 study, NMR collected data through 151 telephone surveys of a random sample of homes throughout Connecticut and 81 on-site lighting inventories conducted with the subset of those telephone survey respondents who agreed to the visit. The phone survey was fielded between July and August of 2015, and the on-site visits took place between July and September of 2015.

In addition to data from the 2015 R154 study, in order to better understand the market in the state and examine trends, this report also includes information from previously completed on-site lighting studies in Connecticut from 2009, 2011, and 2013.[2] The methods for the 2015 study differed slightly from previous efforts; we have outlined the major differences in Appendix A. This report also explores the saturation of energy-efficient residential lighting products in Connecticut over time *in reference* to eight comparison areas: California, Georgia, Kansas, Maine, Massachusetts, Rhode Island, and New York (Upstate and Downstate). While the timing of visits in these comparison areas does not directly align with those conducted in Connecticut, the trends observed provide useful context.

Additional methodological details related the consumer survey and the on-site saturation survey—including sampling error and weighting schemes—can be found in Appendix A.

[2] NMR, R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall Report, 2015. http://tinyurl.com/R86-Study

2 Section 2: Changes in Socket Saturation over Time

The Connecticut EEB has been tracking socket saturation (the percentage of sockets filled with a specific bulb type) since 2009. In this section, we explore trends in socket saturation in both Connecticut and comparison areas, the percent of installed bulbs covered by EISA, and room-by-room saturation trends over time in Connecticut. Some of the highlights include the following:

- ***Examining data over time and between comparison areas, we see that efficient bulb saturation is on the rise, with corresponding decreases in incandescent bulb saturation.***
- ***Efficient bulb saturation increases are being driven primarily by large increases in LED saturation.***
- ***Halogen, linear fluorescent, and CFL saturation have held steady since 2013.***
- ***Massachusetts, a state with similar residential lighting programs, shows similar trends to Connecticut.***
- ***New York, a state that dropped all program support for residential lighting in 2014, has not seen similar increases in LED saturation and shows some signs of backsliding with increases in inefficient bulb saturation.***
- ***In Connecticut, only three room types had less than 50% energy-efficient bulb saturation in 2015: dining rooms (22%), foyers (39%), and exteriors (46%).***
- ***LED saturation was highest in kitchens (21%), and among the lowest was dining rooms (4%), which is likely due to their special lighting needs.***

2.1 SATURATION BY HOUSEHOLD

Saturation for all bulb types in Connecticut between 2009 and 2015 is displayed in Figure 7 below. To aid in understanding trends, we have interpolated data to represent years in which saturation studies are not available (2010, 2011, and 2014). The figure clearly shows a downward trend in incandescent bulb saturation (yellow) from filling nearly two-thirds of all sockets in 2009 (63%) to filling only one-third of all sockets in 2015 (33%).

Not surprisingly, there is a corresponding increase in both CFL and LED saturation during the same timeframe. Notably, LED saturation has quintupled from 2% in 2013 to 10% in 2015. In contrast, the feared spike in halogen saturation following the full implementation of EISA in 2014—especially the phase-out of the 60-watt incandescent—has not materialized in Connecticut. To help highlight the overall trends in efficient and inefficient bulb saturation between 2009 and 2015, we present the combined efficient (CFL, LED, and fluorescent) and combined inefficient (incandescent and halogen) bulb saturation trends in Figure 8.

Fluorescent bulb saturation has remained steady at 11% since 2012, though this may begin to change in the near future with the introduction to the market of linear LED conversion kits and replacement bulbs targeted to the residential market. Note, however, that conversion kits and replacement bulbs are generally not compatible with older magnetic ballasts often associated with T12 fluorescent lighting. Replacing older linear fluorescents with LEDs represents a higher level of effort and additional costs since it often requires fixture or ballast replacements, which require the assistance of an electrician.

Figure 7: Efficient Bulb Saturation, 2009-2015

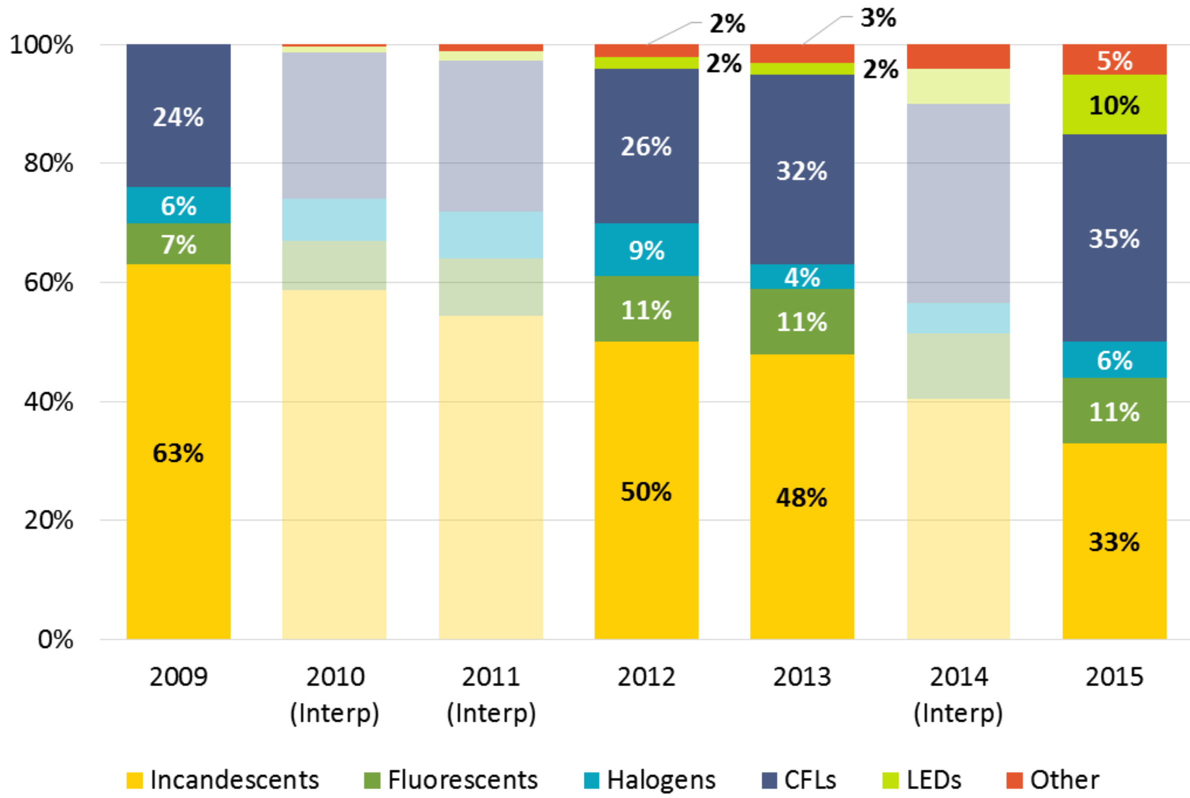


Figure 8: Efficient and Inefficient Bulb Saturation, 2009-2015

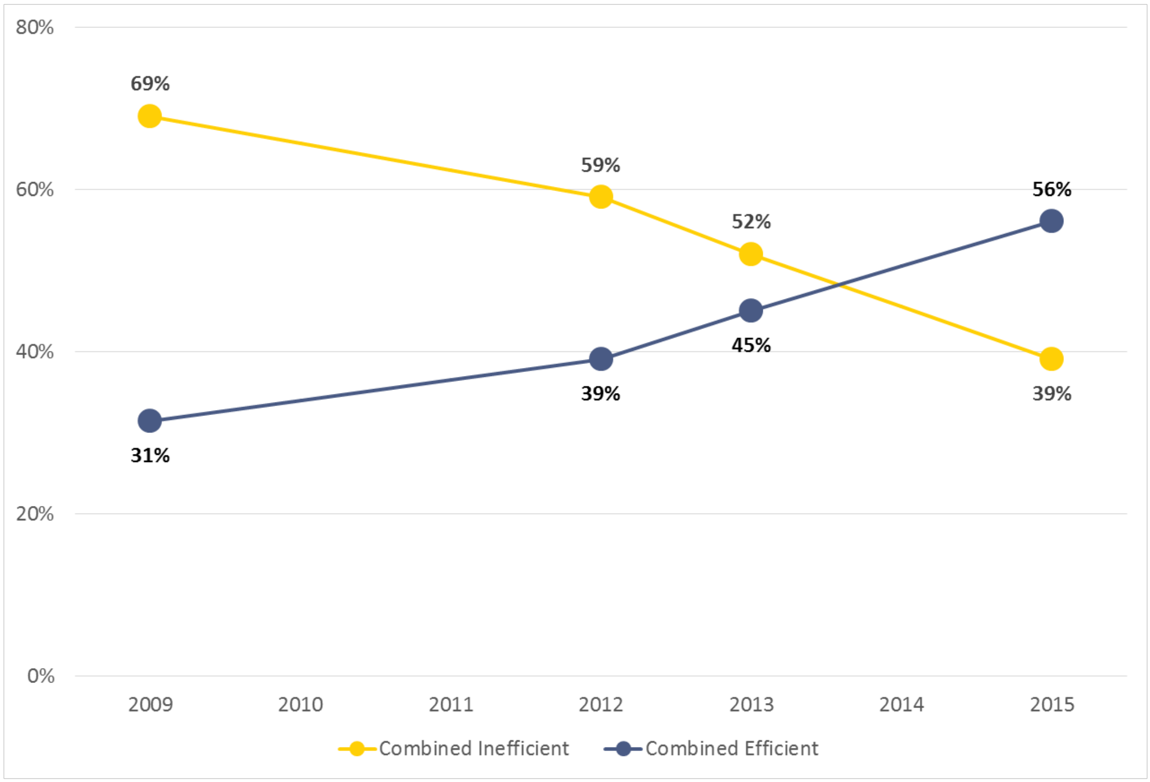


Table 2 provides the same data shown in Figure 7 as well as combined saturation figures for efficient and inefficient bulb types and notations for significant differences between 2015 and previous years. The data show the following:

- **LEDs** occupied less than 1% of all sockets in Connecticut in 2009. Saturation slowly increased between 2009 and 2013 to 2% of all sockets and has since increased to 10% of all sockets, a statistically significant increase compared to 2009, 2012, and 2013.
- **CFL** saturation has increased steadily since 2009, and in 2015 CFLs accounted for about one out of every three sockets in Connecticut (35%), a statistically significant increase compared to 2009.
- **Incandescent** saturation has decreased dramatically since 2009. Between 2009 and 2015, incandescent saturation decreased thirty percentage points (63% to 33%). The percentage of sockets filled with incandescent bulbs is significantly lower in 2015 than it was in all three prior studies (2009, 2012, and 2013).
- **Linear fluorescent** saturation has remained at 11% since 2012.
- **Halogen** saturation has hovered around 6% since 2009.[3]

[3] Note that halogen bulbs are very similar in appearance and are in actuality a subtype of incandescent bulbs. Technicians are thoroughly trained to distinguish halogen bulbs but it is still likely that some halogen bulbs are misidentified as standard incandescent bulbs. For this reason, we also look at combined inefficient bulbs.

- **Combined CFL and LED** saturation in 2015 is significantly higher compared to 2009 and 2012. In 2009, combined CFL and LED saturation accounted for about one-quarter (24%) of all installed bulbs in Connecticut, and in 2015 accounted for just over two-fifths (45%) of all installed bulbs.
- **Combined efficient (CFL, LED, and fluorescent)** bulb saturation in 2015 is significantly higher compared to 2009 and 2012. In 2009, combined efficient bulb saturation accounted for just under one-third (31%) of all sockets in Connecticut, while in 2015 it accounted for more than one-half (56%) of all sockets.
- **Combined inefficient (incandescent and halogen)** bulb saturation in 2015 is significantly different from all three prior studies, dropping 13 percentage points since the 2013 study alone.

Table 2: Comparison of Saturation Rates, 2009-2015[4]

Sockets Containing	2009	2010	2011	2012	2013	2014	2015
Sample Size	*95*	*Interp.*	*Interp.*	*100*	*90*	*Interp.*	*81*
Total Sockets[a]	**4,528**	*Interp.*	*Interp.*	**6,099**	**5,132**	*Interp.*	**4,990**
Avg # of Sockets	48	-	-	61	57	-	62
Incandescent	63%	59%	54%	50%	48%	41%	33%[β†δ]
CFLs	24%	25%	25%	26%	32%	34%	35%[β]
Fluorescent	7%	8%	10%	11%	11%	11%	11%
Halogen	6%	7%	8%	9%	4%	5%	6%
LED	<1%	1%	1%	2%	2%	6%	10%[β†δ]
Other[b]	0%	1%	2%	3%	3%	4%	4%[β]
CFLs + LEDs	24%	26%	27%	28%	34%	39%	45%[β†]
CFLs, LEDs + Fluorescents	31%	34%	36%	39%	45%	50%	56%[β†]
Incandescent + Halogen	69%	66%	62%	59%	52%	46%	39%[β†δ]

[a] The increase in the total number of sockets after 2009 may be exaggerated due to variations in data collection, treatment of empty sockets, and quality control procedures implemented for the 2012, 2013, and 2015 studies.
[b] Other includes cold cathode bulbs, xenon bulbs, bulbs whose type could not be identified, and empty sockets. Empty sockets were not recorded in the 2009 study.
[β] Significantly different from 2009 at the 90% confidence level.
[†] Significantly different from 2012 at the 90% confidence level.
[δ] Significantly different from 2013 at the 90% confidence level.

2.2 COMPARISON AREAS

Figure 9 provides LED saturation estimates over time from Connecticut and eight comparisons areas for which recent lighting inventory studies have been completed, including Massachusetts, portions of California served by the investor-owned electric utilities, upstate and downstate New York, Maine, Rhode Island, Georgia, and Kansas.

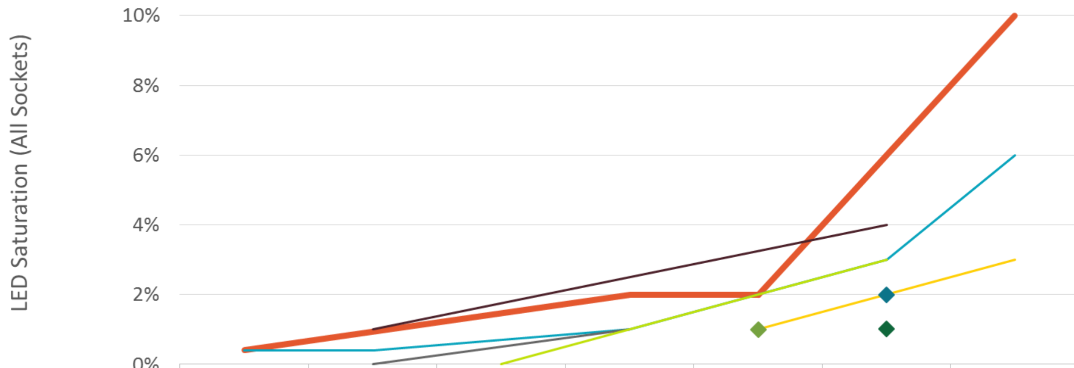
[4] We believe the lower number of sockets in 2009 compared to later years is a direct result of changes to protocols, training, and quality assurance introduced in the 2012 study and a change in the data collection firm.

The results show that efficient-bulb saturation rates have increased overall in all the areas for which we have multiple data points. While LED saturation is increasing across the board, the table makes clear that LED saturation in Connecticut has risen faster than in all other comparison areas shown. While Connecticut LED saturation figures are the highest, they are also the most recent—the 2015 lighting inventory data for Massachusetts and Upstate New York were collected about six months prior to the 2015 Connecticut data. The data from Massachusetts and New York in particular offer insights due to a unique natural experiment. Massachusetts offers similar lighting programs as Connecticut, although Connecticut more aggressively shifted resources from CFLs to LEDs earlier than Massachusetts; moreover, New York ceased supporting LEDs (and specialty CFLs) in 2014 (and standard CFLs in 2012). Note that the Massachusetts and New York data will be updated in early 2016, after the finalization of this report. Some of the highlights of this comparison include the following:

- Connecticut LED saturation quintupled from 2% to 10% between 2013 and 2015.
- Massachusetts exhibited the next largest percentage point increase, tripling from 2% to 6% over a time period that was six months shorter.
- New York also saw its rate triple, but the increase was 1% to 3%.
- Maine's LED saturation rate went from virtually zero in 2014 to 3% in 2014.
- Kansas's 4% LED rate in 2014 is also notable given that it has never had a lighting program.

Figure 9: LED Saturation, 2009-2015[5]

(Base: All sockets in each state and year [some exclude empty sockets])



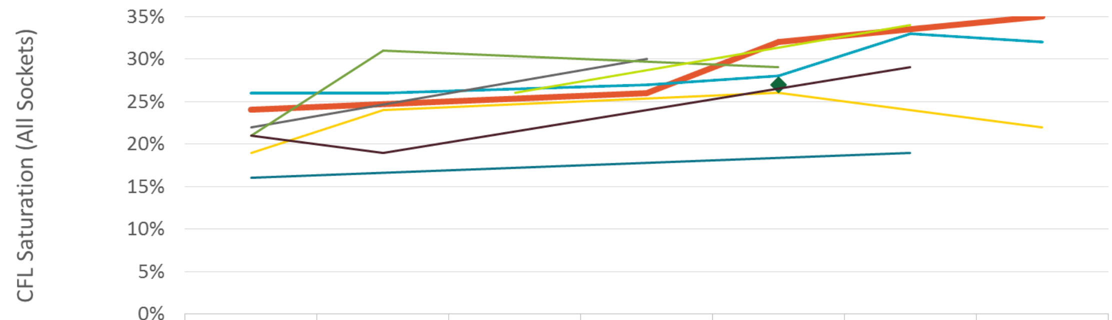
	2009	2010	2011	2012	2013	2014	2015
CT	0.4%			2%	2%		10%
MA	0.4%	0.4%		1%	2%	3%	6%
CA - IOUs		0%		1%			
Upstate NY					1%		3%
Downstate NY					1%		
ME			0%			3%	
RI						1%	
GA						2%	
KS		1%				4%	

Figure 10 shows the same information as the previous table, but for CFLs.

- CFL saturation in Massachusetts, a very active program state, shows a very similar pattern to Connecticut.
- CFL saturation in New York shows signs of backsliding, with a decrease between 2013 and 2015. The timing of this decrease coincides with the state abandoning all residential lighting activity by mid-2014.

[5] Figure 9 and Figure 10 assume consistent, linear changes between estimates, which may not be accurate. For example, Georgia had a saturation rate of 16% in 2009 and 19% in 2014, and the graph shows this change as linear when, in reality, the increase in saturation may have occurred only between 2013 and 2014.

Figure 10: CFL Saturation, 2009-2015
(Base: All sockets in each state and year [some exclude empty sockets])



	2009	2010	2011	2012	2013	2014	2015
CT	24%			26%	32%		35%
MA	26%	26%		27%	28%	33%	32%
CA - IOUs	22%			30%			
Upstate NY	19%	24%			26%		22%
Downstate NY	21%	31%			29%		
ME			26%			34%	
RI					27%		
GA	16%					19%	
KS	21%	19%				29%	

2.3 ROOM-BY-ROOM ANALYSIS

As **Error! Reference source not found.** shows, specialty sockets comprise nearly three-quarters of all sockets in dining rooms (71%), the highest of any room type. Exteriors (57%), kitchens (53%), and foyers (53%) are the only other room types with greater than 50% specialty bulb saturation.

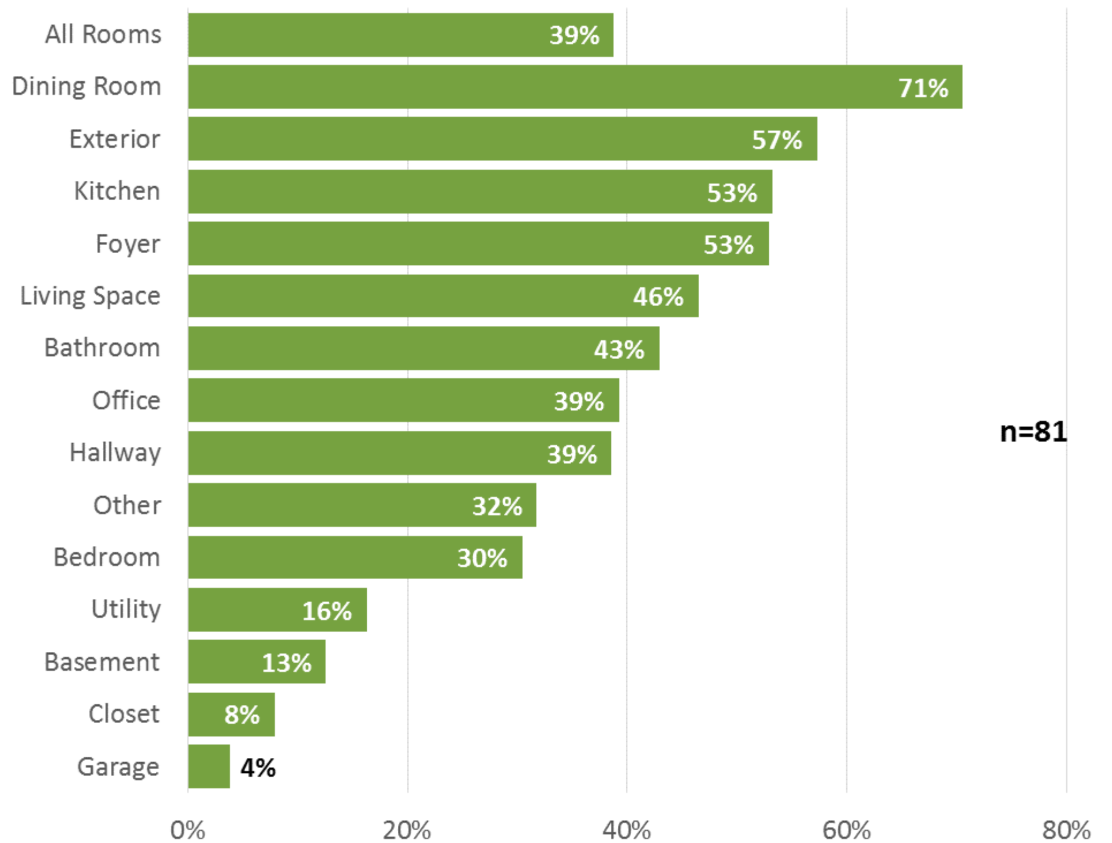
Figure 12 provides an overview of CFL, LED, Linear Fluorescent, and All Energy-Efficient (CFL, LED, and Linear Fluorescent) Bulb saturation by room type over time between 2009 and 2015; 2010, 2011, and 2014 estimates are based on straight-line interpolation. When looking at saturation over time by room type, only three room types continue to have less than 50% energy-efficient bulb saturation: dining rooms (22%), foyers (39%), and exteriors (46%). Both basements and garages made big gains in energy-efficient bulb saturation since the 2013 study, though this is driven more by linear fluorescents than by CFLs and LEDs.[6]

LED saturation was highest in kitchens (21%), offices (15%), living spaces (14%), exteriors (12%), bedrooms (10%), bathrooms (10%), and hallways (9%). Dining rooms lag behind in this category, which is likely due to their special lighting needs (including aesthetic expectations) and the higher relative price of specialty shaped LEDs. Importantly, sockets in exteriors (5.8 hours/day), kitchens (4.2 hours/day), and living spaces (3.5 hours/day)

[6] Fluorescents include all types of linear fluorescent tubes including T-12s. While T-12s are not as efficient as T-8s or T-5s--which can offer a 35% reduction in energy usage compared to T-12s—at around 80 lumens per watt, T-12s are more efficient than incandescent and halogen bulbs as well as many CFLs.

have the average highest hours of use (HOU) of all room types and were among the rooms that had the biggest increase in LED socket saturation since the 2013 study.[7]

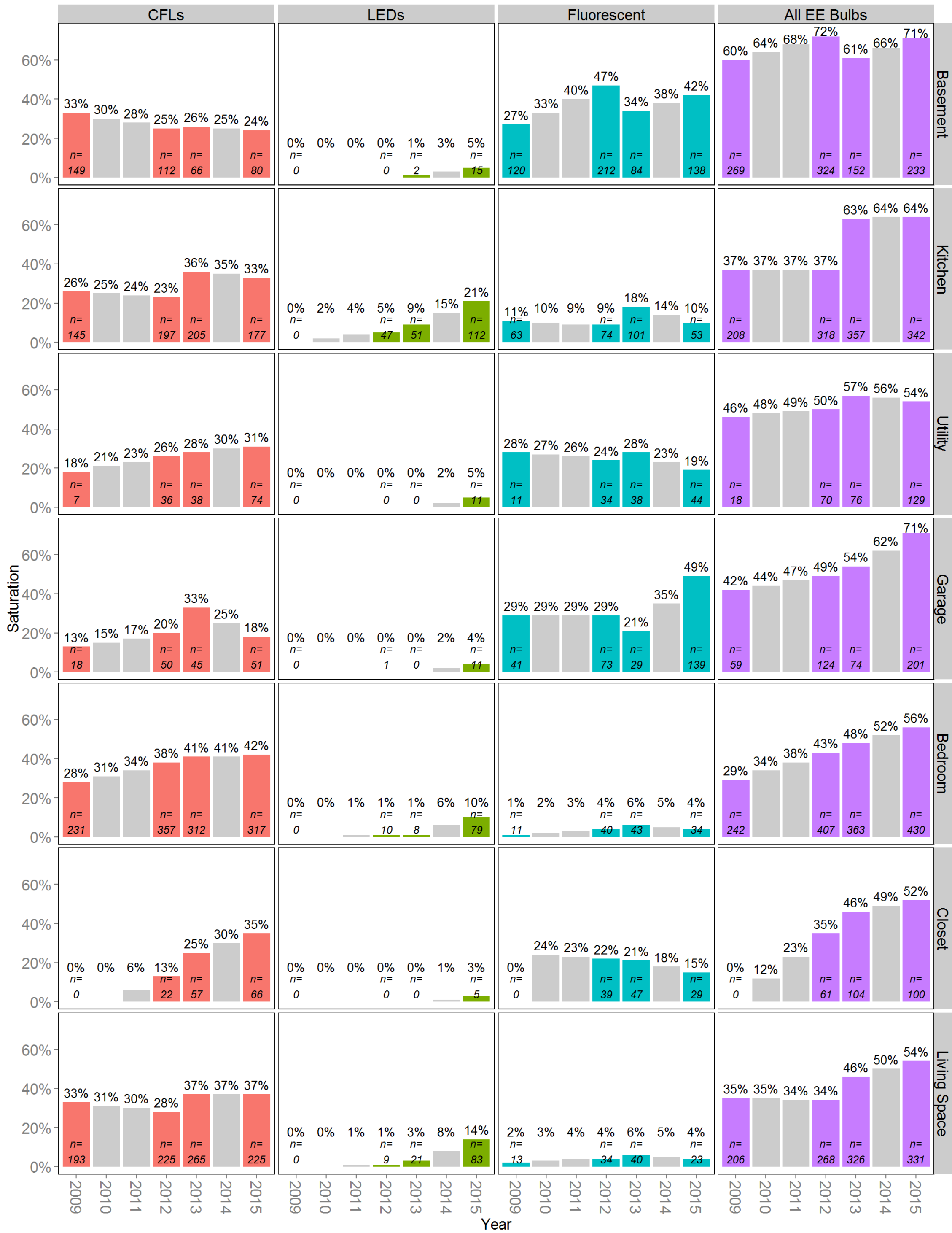
Figure 11: Specialty Bulb Saturation by Room Type, 2015*

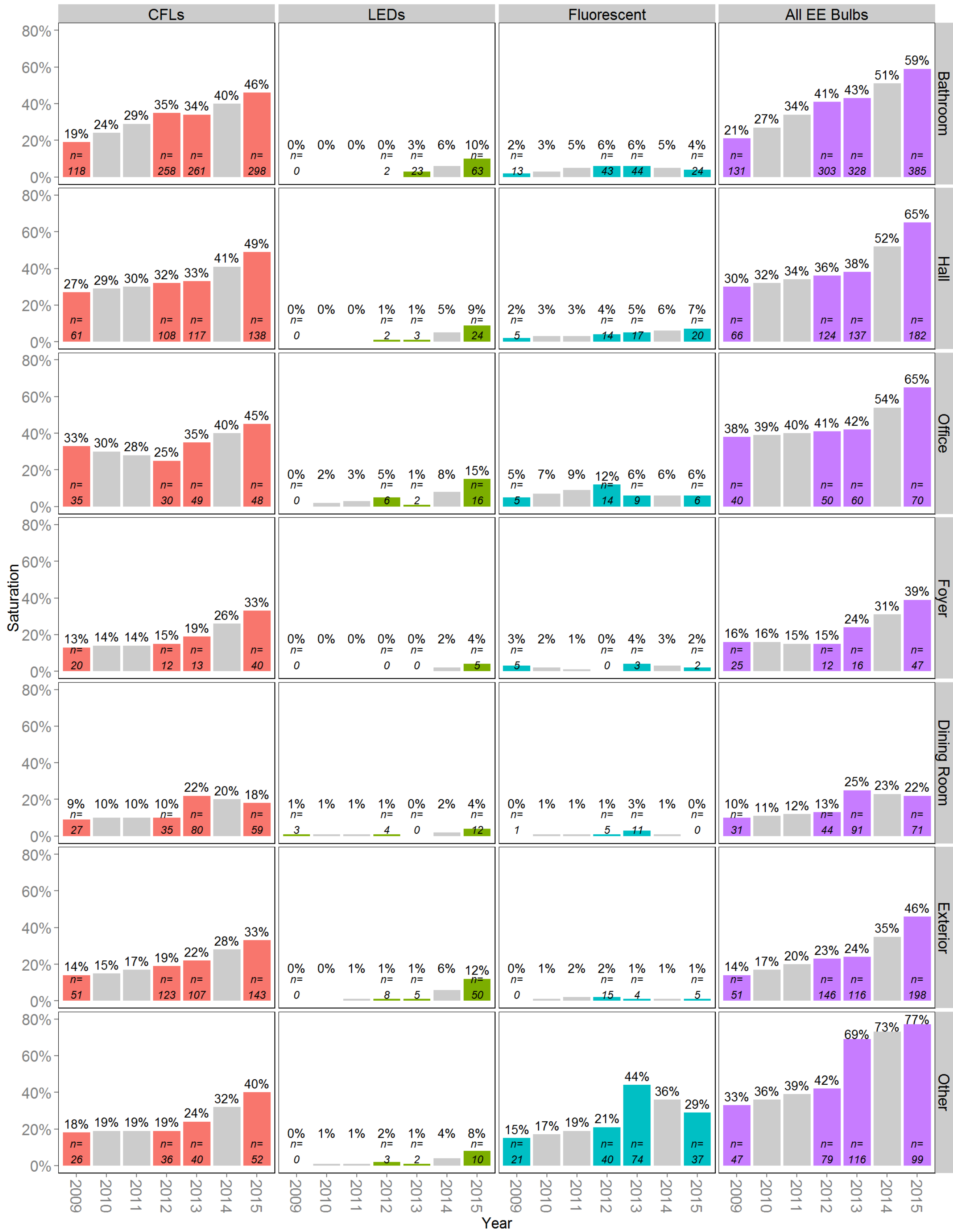


*Specialty bulbs include dimmable and three-way bulbs of any kind; circline fluorescents; flood/spot and tube halogens; all non-spiral CFLs; and bug, candelabra, flood/spot, globe, and bullet/torpedo incandescent bulbs.

[7] NMR, Northeast Residential Lighting Hours-of-Use Study, 2014. http://tinyurl.com/TimelessHOU

Figure 12: Energy-Efficient Bulb Saturation by Room Type, 2009-2015





2.4 COMPARING SATURATION BY INCOME

We also explored saturation by income to look for any key differences between low-income and non-low-income households. Table 3 provides key saturation statistics for the entire population, low-income households, and non-low-income households. Interestingly, low-income households do have significantly fewer sockets compared to non-low-income households at the 90% confidence level. No significant differences exist between the two groups in terms of saturation at the 90% confidence level. However, when we checked for differences at the 80% confidence level, we found that low-income households have significantly lower incandescent bulb saturation levels. Combined inefficient saturation among low-income households is also statistically lower—mostly due to incandescent saturation. This may be due in part to the fact that some of the low-income households participated in utility sponsored direct-install programs. As detailed in Section 4.1.1, 38% of all CFLs and LEDs obtained by low-income households were reportedly obtained through direct-install programs. All other differences in the table are statistically similar. This is not surprising given the relatively low sample sizes involved.

Table 3: Comparison of Saturation Rates by Income

Sockets Containing	All	Low Income	Non-Low Income
Sample Size	*81*	*24*	*54*
Total Sockets[a]	**4,990**	**710**	*4,040*
Avg # of Sockets	62	*30*[β†]	75
Incandescent	33%	19%[†]	35%
CFLs	35%	46%	33%
Fluorescent	11%	14%	11%
Halogen	6%	3%	6%
LED	10%	9%	10%
Other[b]	4%	8%	4%
CFLs + LEDs	45%	55%	43%
CFLs, LEDs + Fluorescents	56%	69%	55%
Incandescent + Halogen	39%	23%[†]	42%

[β] Significantly different from Non-Low Income at the 90% confidence level.

[†] Significantly different from Non-Low Income 80% confidence level.

3 Section 3: Penetration, Familiarity, and Satisfaction

In this section, we explore trends in penetration (i.e., the percentage of homes using at least one of a particular bulb type) for various bulb types, including a room-by-room penetration analysis over time, as well as familiarity and satisfaction with LEDs and CFLs. When examining the market for LEDs, it is important to remember that at this stage of market adoption, penetration is likely a better gauge of LED program success than is total saturation. Penetration shows that the program is getting people to try LEDs, but as more households purchase LEDs and expand the number and diversity of sockets in which LEDs are installed, higher saturation rates will follow suit. Similarly, awareness of and satisfaction with LEDs are important market indicators for LED programs.

- ***In 2015, all signs point to strong growth in LED penetration and awareness and continued high levels of satisfaction with LED bulbs.***
- ***Almost all Connecticut households use at least one CFL, suggesting full market penetration. Any additional gains in the CFL market will come through expanded socket saturation—if the market expands at all, given the rapid adoption of LEDs and competition from lower-priced halogens.***
- ***Incandescent penetration continues a decline first observed in 2013.***
- ***LED penetration jumped for all room types from 2013 to 2015; many room types had no LEDs installed as recently as 2013, while LEDs were present in all room types by 2015.***
- ***CFL penetration has also increased steadily in most room types since 2009, while incandescent penetration has decreased across the board.***

3.1 BULB PENETRATION

As Table 4 shows, both CFL and LED penetration have increased significantly since 2009. However, while CFLs were nearly ubiquitous in Connecticut homes in 2009 (88%), LEDs were just being introduced to the market. Over the last five years, LED penetration has skyrocketed. In the 2009 study, screw-base general service LED bulbs[8] were present in only one home, while in the 2015 study they were present in 34 of 81 homes (42%). CFL penetration, which hovered around 90% to 95% between 2009 and 2013, increased to 99% in 2015, which is essentially full market penetration. In contrast, incandescent penetration dropped to 93%, down from 96% in 2013 and essentially 100% prior to then. Given the difficulty in distinguishing some halogen bulbs from standard incandescent bulbs, we also looked at the combined penetration of incandescent and halogen bulbs. This reveals steady penetration near 100% in each year with relative but not significant declines in 2013 and 2015.

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[8] Specifically, the 2009 study included one home with three medium screw-base flood light LEDs.

Table 4: Penetration, 2009-2015

	2009	2010	2011	2012	2013	2014	2015
Sample Size	*95*	*Interpolated*	*Interpolated*	*100*	*90*	*Interpolated*	*81*
CFLs	88%	91%	94%	96%	91%	95%	99% $^{\beta\delta}$
LED	1%	7%	13%	19%	23%	33%	42% $^{\beta\dagger\delta}$
Incandescent	98%	99%	99%	100%	96%	94%	93%†
Halogens	46%	53%	59%	66%	38%	45%	52%$^{\dagger\delta}$
CFL or LED	88%	91%	94%	96%	91%	95%	99%
Incandescent or Halogen	99%	100%	100%	100%	96%	100%	97%

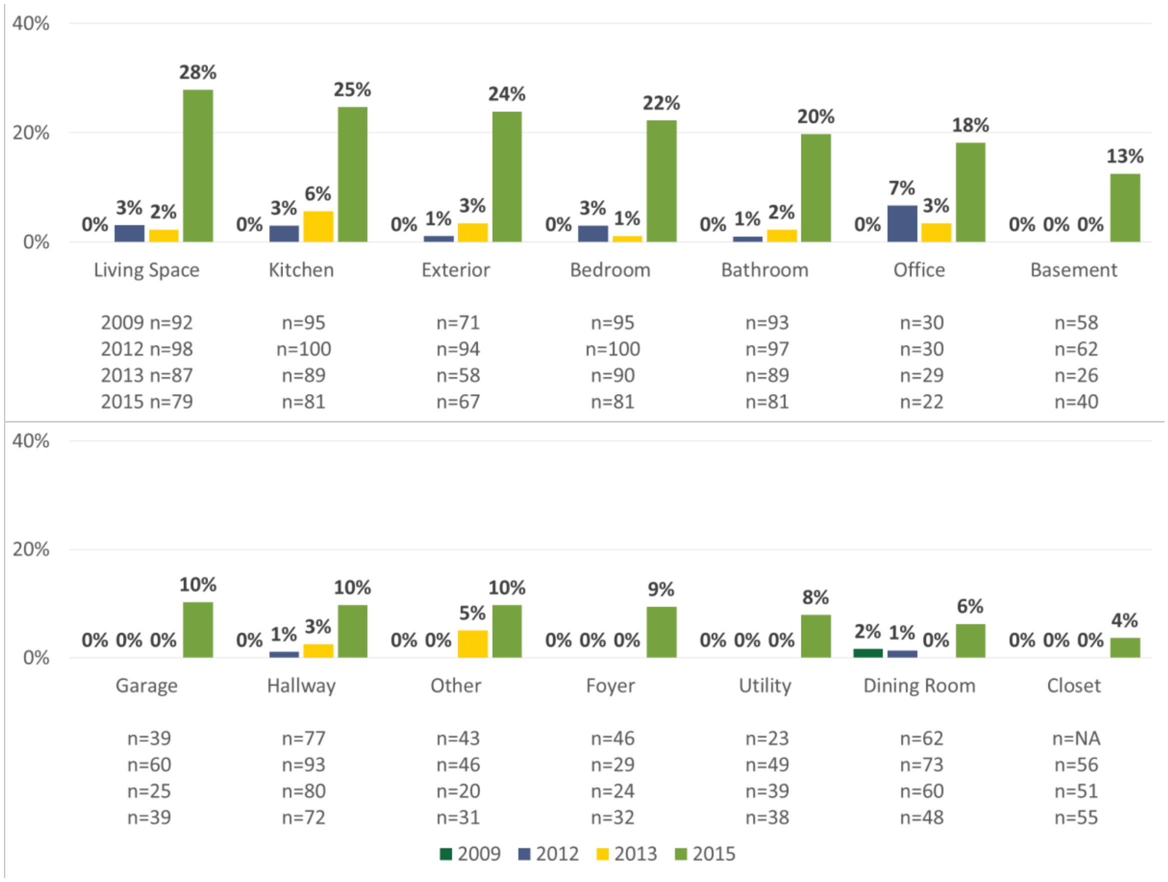
$^{\beta}$ Significantly different from 2009 at the 90% confidence level.

† Significantly different from 2012 at the 90% confidence level.

$^{\delta}$ Significantly different from 2013 at the 90% confidence level.

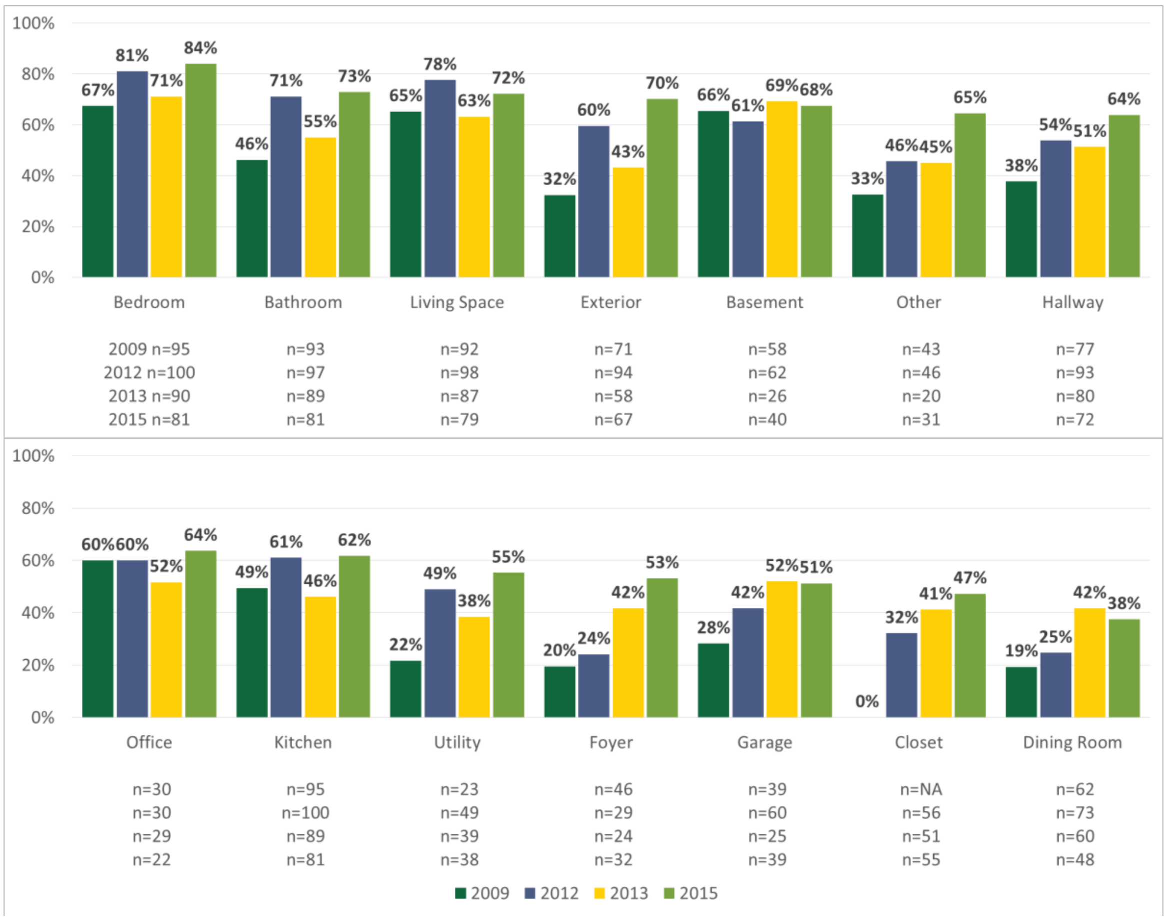
In addition to household-level penetration, we examined LED, CFL, incandescent, and halogen penetration by room type from 2009 to 2015. When calculating penetration by room type, we included only homes that had rooms of that type. For example, in 2015, 79 homes had living spaces and 22 of those homes had at least one LED installed in living spaces, which calculates to a 28% penetration rate. As Figure 13 shows, LED penetration has increased for all room types from 2013 to 2015. Living spaces served as the most common place to install at least one LED (28%), followed by kitchens (25%) and exterior spaces (24%). Many room types had no LEDs installed as recently as 2013, while LEDs were present in all room types by 2015.

Figure 13: LED Penetration by Room Type, 2009-2015



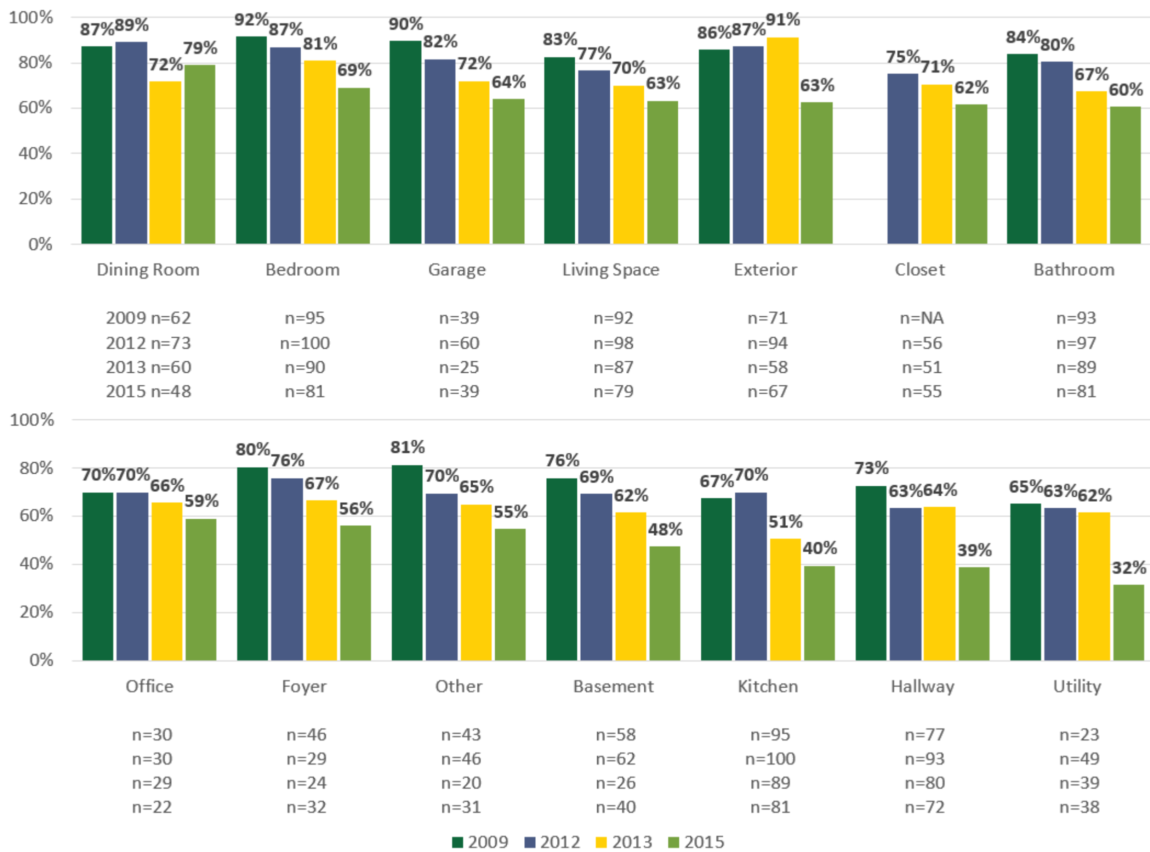
CFL penetration has increased steadily in most room types since 2009, with some variation (Figure 14). In 2015, more than four out of five (84%) homes had at least one CFL installed in bedrooms, up from 67% in 2009. The room types with the biggest jump in penetration from 2009 to 2015 were exteriors (32% to 70%), utility rooms (22% to 55%) and foyers (20% to 53%). As with saturation, dining rooms remain the least common place even to find a CFL.

Figure 14: CFL Penetration by Room Type, 2009-2015



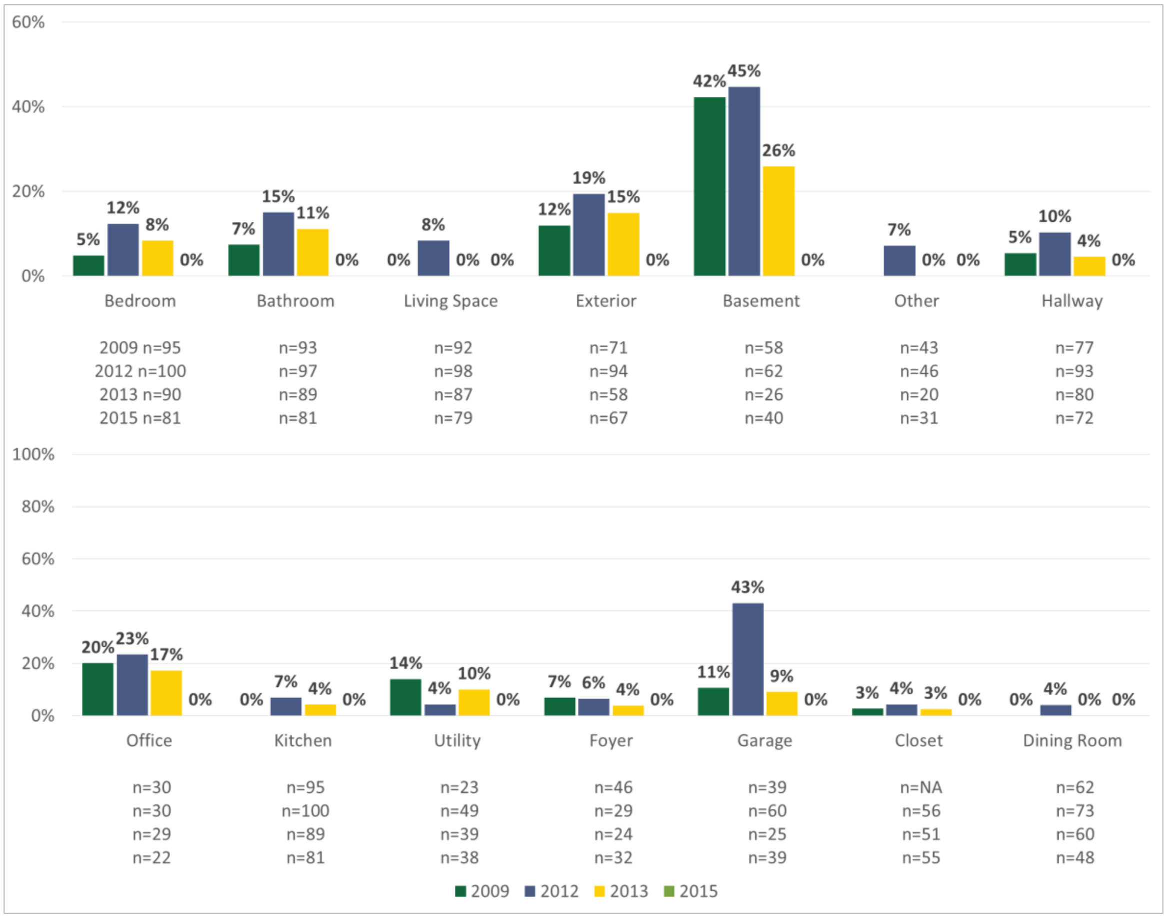
Incandescent penetration has shown a decrease in all room types over the past few years, which is in line with the decrease in incandescent socket saturation. The biggest drop in incandescent penetration since 2009 has been in hallways (65% to 32%) and utility rooms (73% to 39%). Exteriors saw the biggest drop in incandescent penetration between 2013 and 2015, with it reaching a high of 91% in 2013 and then dropping to 63% (29 percentage points) in 2015. Notably, only four out of ten homes (40%) had at least one incandescent bulb installed in kitchens in 2015.

Figure 15: Incandescent Penetration by Room Type, 2009-2015



Halogen penetration by room type is somewhat erratic, which is not surprising given the relatively low levels of halogen saturation in Connecticut and the difficulty of identifying halogen bulbs. Despite this, the room types where we find halogen bulbs appear to be relatively consistent; basements, offices, and exteriors appear to have the highest halogen penetration, followed by bathrooms, bedrooms, and garages.

Figure 16: Halogen Penetration by Room Type, 2009-2015



3.2 FAMILIARITY AND SATISFACTION WITH BULB TYPES

To provide a larger sample than just on-site alone, questions about familiarity and satisfaction with bulb types were asked during the consumer survey. Each respondent was asked about his or her level of familiarity with CFLs, LEDs, and halogen bulbs (Table 5).

LEDs: Two-thirds of 2015 respondents were either somewhat or very familiar with LEDs (66%), up from just 35% in 2012 when LEDs were the bulb type consumer survey respondents were least familiar with.

CFLs: Nine out of ten 2015 respondents were somewhat or very familiar with CFLs (89%), up from 75% in 2012.

Halogens: Respondents in 2015 were least familiar with halogen bulbs, with three out of five (57%) reporting that they were somewhat or very familiar with this type of bulb. This is similar to the 54% who said the same in 2012.

Table 5: Familiarity with CFLs, LEDs, and Halogens

(Base: Telephone survey respondents)

Level of Familiarity*	CFLs		LEDs		Halogens	
	2012	2015	2012	2015	2012	2015
Sample Size	*551*	*151*	*551*	*151*	*551*	*151*
Very familiar	34%	67%	14%	42%	23%	35%
Somewhat familiar	41%	22%	21%	24%	31%	22%
Not too familiar	11%	6%	20%	12%	19%	18%
Not at all familiar	14%	4%	44%	21%	27%	24%
Don't know	1%	0%	<1%	0%	<1%	1%

*We also examined familiarity and satisfaction for the subset of on-site participants; their patterns mirrored those of all telephone respondents.

As Table 6 shows, those who self-reported having CFLs or LEDs installed were also asked to rate their level of satisfaction with each bulb type. While approximately three-quarters of respondents who had CFLs installed said they were very or somewhat satisfied with CFLs, 84% of respondents who had LEDs installed were very or somewhat satisfied with them, with more than one-half reporting they were very satisfied with LEDs. Of the four respondents who said they were somewhat dissatisfied with LEDs, two indicated dissatisfaction with price of LEDs, two said they were dissatisfied with the brightness of LEDs, and one said they were dissatisfied with the dimmability of LEDs.

Table 6: Satisfaction with CFLs and LEDs

(Base: Respondents who reported having CFLs/LEDs installed)

Level of Satisfaction	CFLs	LEDs
Sample Size	*114*	*58*
Very satisfied	33%	52%
Somewhat satisfied	39%	32%
Neither satisfied nor dissatisfied	14%	10%
Somewhat dissatisfied	10%	7%
Very dissatisfied	3%	0%

Of those who reported having both CFLs and LEDs installed, approximately six out of ten (59%) preferred LEDs over CFLs. Notably, however, one-quarter of respondents said that it depends on the situation (Table 7).

Table 7: Prefer CFLs or LEDs

(Base: Respondents who reported having both CFLs and LEDs installed)

Preference	Consumer Survey	On-Sites Only
Sample Size	*50*	*26*
Prefer CFLs over LEDs	4%	4%
Prefer LEDs over CFLs	59%	63%
Depends on the situation	26%	24%
Not yet sure	11%	9%

Brightness or light output was the most common reason cited for preferring LEDs over CFLs, followed closely by energy use/energy efficiency. Other reasons mentioned were color appearance, bulb life, and the fact that they turn on instantly. Those who said that their preference depended on the situation also cited brightness or light output as the main reason, followed by color appearance (Table 8).

Table 8: Reason Prefer CFLs or LEDs

(Base: Respondents who reported having both CFLs and LEDs installed; multiple response)

Reason	Prefer CFLs over LEDs	Prefer LEDs over CFLs	Depends on the situation	Not yet sure
Sample Size	*2*	*30*	*13*	*5*
Brightness or Light Output	0	13	8	2
Energy Use/Energy Efficiency	1	12	0	0
Color Appearance	0	7	5	0
Bulb Life	0	6	0	0
Turn on Instantly	0	5	1	0
Price	2	4	4	1
Lumens	0	1	0	0
Dimming	0	1	1	0
Other	0	4	1	1
Don’t know	0	0	0	3

4

Section 4: Recent Purchases

Not only did NMR technicians ask respondents when they had bought the LEDs and CFLs found in their homes, we also asked them to recall where they had obtained the bulbs they had acquired within the past year. This section looks at recent purchases by channel and also includes an assessment of bulbs obtained through direct-install programs as well as an analysis of self-reported purchasing behavior.

- ***A large number of bulbs (about 14%) were obtained through direct-install programs.***
- ***Among purchased bulbs, consumers bought about three-fifths of LEDs and CFLs from home improvement stores.***
- ***While consumers recalled buying CFLs at many other retail channels, the only other large source for LEDs was club stores. This is consistent with the program, which has historically focused on big box and home improvement stores.***
- ***The majority (81%) of newly installed CFLs replaced incandescents; the majority of newly installed LED bulbs also replaced incandescents (45%), though this was followed closely by CFLs (38%).***
- ***Approximately one-half of participants reported purchasing incandescent bulbs within the past six months, which indicates that EISA has not completely eroded the market for incandescent bulbs; purchasing CFLs and LEDs was also very common.***

4.1 SOURCES OF NEWLY ACQUIRED BULBS

Figure 17 looks at all bulbs obtained within the past year. The most common place homeowners went to get both LEDs and CFLs was home improvement stores (e.g., Home Depot or Lowe's), which accounted for over two-fifths of the LEDs (45%) and CFLs (44%) on-site respondents had obtained in the past year. This is not surprising because, historically, the Connecticut program has relied heavily on home improvement stores as the main conduit to consumers. In a 2015 study, NMR found that about one-half (49%) of LED sales and 61% of standard CFL sales came through home improvement stores.[9] Club stores were the second most common source of LEDs (23%) and the third most common source of CFLs (6%). Unfortunately, because the data were self-reported, homeowners were unable to recall where one-quarter (23%) of all newly installed CFLs and LEDs had been obtained. Of note, 11 homes self-reported that they had obtained LEDs or CFLs from a direct-install program within the past year. However, when we examined program records, only five of these homes appear to have participated in the Connecticut Home Energy Services (HES) program or HES Income Eligible (HES-IE) programs in 2014 or 2015. In

[9] NMR, R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall Report, 2015. http://tinyurl.com/R86-Study

Figure 17, we have coded the source of self-reported direct-install bulbs for the other six (unconfirmed) homes as *Don't know*.[10]

Figure 17: Where Bulbs Obtained

(Base: All bulbs obtained within the past year)

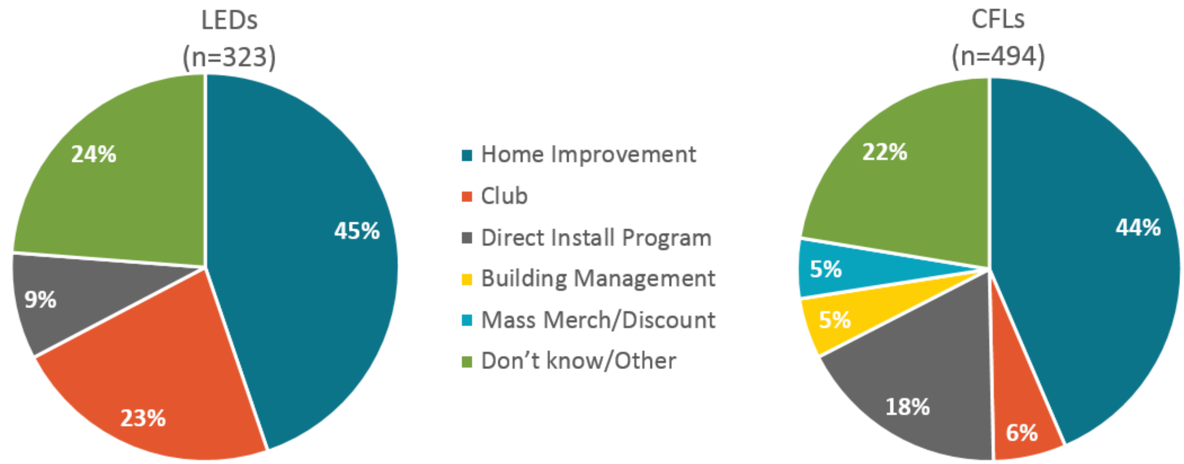
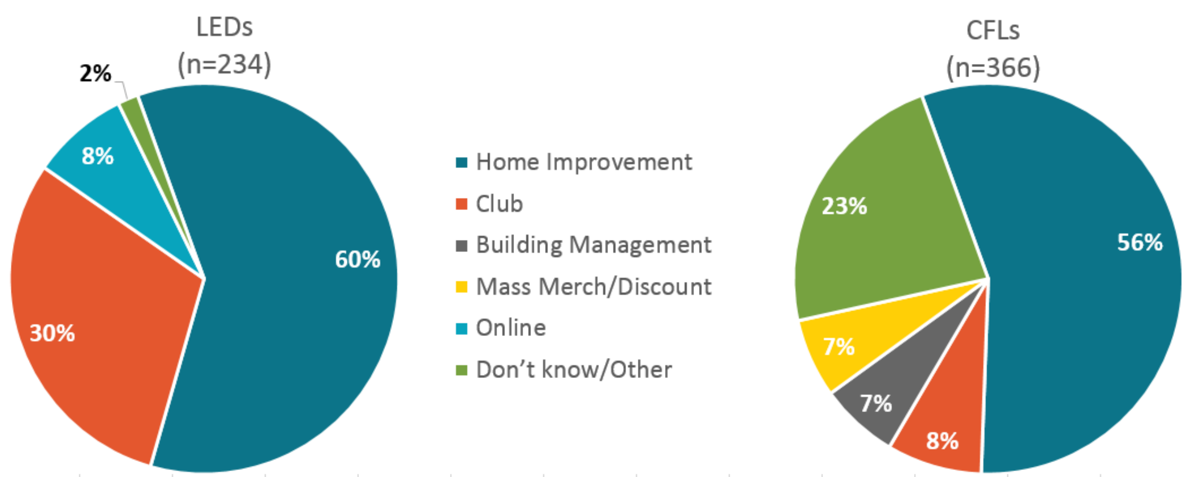


Figure 18 looks solely at bulbs *purchased* from retail stores; for more details on bulbs obtained through direct-install programs, see Table 11. Home improvement stores (e.g., Home Depot or Lowe's) accounted for about three out of every five LEDs (60%) and CFLs (56%) purchased within the past year. Nearly one-third (30%) of LED bulbs were purchased at club stores (e.g., Costco or Sam's Club), while only 8% of CFLs were purchased in this type of store.

Figure 18: Where Bulbs Purchased

(Base: All bulbs purchased within the past year; excludes self-reported direct-install bulbs)



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[10] If we include the bulbs identified as direct-install bulbs from the six unconfirmed participants, direct install bulbs account for 24% of all bulbs obtained in the past year—25% of LEDs and 22% of CFLs.

4.1.1 Sources of Bulbs by Income

To determine whether or not low-income households were more likely to shop at different store types than the general population, we explored purchase behavior by income (low income or non-low income). As Table 9 shows, there exist many significant differences between low-income households and non-low-income households at the 90% confidence level. A large portion (38%) of the CFLs and LEDs obtained by low-income households were from direct-install programs. In addition, low-income households appear unlikely to obtain bulbs from home improvement stores (the most common store for non-low-income households). Still, low-income households were unable to recall the source of two-fifths of all bulbs purchased within the past 12 months.

Table 9: Purchase Source by Income

Sockets Containing	All	Low Income	Non-Low Income
Sample Size	*81*	*24*	*54*
Bulbs Purchased	**787**	***116***	**650**
Avg # Purchased	***10***	**5**	**12**
Home Improvement	44%	9% $^{\beta}$	52%
Warehouse/Club	13%	2% $^{\beta}$	15%
Direct Install Program	14%	38% $^{\beta}$	11%
Building Management	3%	--	4%
Mass Merch/Discount	3%	10%	2%
Bargain	1%	5%	--
Don't know/Other	22%	36% $^{\beta}$	16%

$^{\beta}$ Significantly different from Non-Low Income at the 90% confidence level.

4.1.2 Influence of Direct-Install Program Activity

In order to understand the influence of direct-install program participants on the on-site sample, we compared key statistics from the on-site sample to the population of HES program participants and the upstream lighting program (Table 11). Based on this analysis, we conclude that the proportion of on-site participants in our sample (6%) is double that of the population (3%); however, the confidence interval around the proportion of on-site participants who participated in direct-install programs (2-10%) encompasses the population estimate (3%). In other words, the evidence is only indicative—not conclusive—of greater on-site household participation in other programs. In addition, the percentage of bulbs obtained through direct-install programs by the on-site sample is nearly the same as the proportion of direct-install program-supported bulbs. Finally, when we calculated saturation estimates including and excluding the direct-install participants, we produced the same saturation estimates for CFLs and LEDs—and found only very slight differences between incandescent, fluorescent, and halogen saturation estimates.

Proportion of Direct-Install Participants

Among R154 on-site participants, 11 households (14%) self-reported participation in the PAs' direct-install programs. However, when we tried to confirm program participation using HES and HES-IE program records, we were only able to confirm participation for five on-site participants (6%). In comparison, in 2014, according to HES and HES-IE program data,[11] the HES and HES-IE programs reported serving 34,714 households, roughly 3% of all households in Connecticut. While the proportion of on-site participants who participated in direct-install programs is higher than the population, the confidence interval around the proportion of on-site participants who participated in direct-install programs encompasses the population estimate (2%-10%). This means that while the evidence is indicative of greater on-site household participation in direct-install programs, it is not conclusive.

Effect of Direct-Install Participants on Saturation Estimates

To assess the effect direct-install participants had on overall saturation estimates, NMR calculated overall saturation by bulb type with and without the five confirmed direct-install participants. When rounded to the nearest full percent, removing the direct-install participants does not impact the key saturation estimates for CFLs or LEDs. In fact, even when looking at tenths of a percent, there is only a difference of 0.4% between the two estimates for CFLs. Altogether, differences in saturation estimates sum to 2.9% across all bulb types, driven primarily by differences in incandescent (1.2%) and linear fluorescent (1%) saturation.

Table 10: Comparison of Saturation Rates

Sockets Containing	2015 (excluding DI)	2015 (including DI	Difference
Sample Size	*76*	*81*	*N/A*
Total Sockets	***4,683.***	**4,990**	**N/A**
Avg # of Sockets	*62*	62	--
Incandescent	34.6%	33.4%	1.2%
CFLs	35.0%	35.4%	0.4%
Fluorescent	10.1%	11.1%	1%
Halogen	5.6%	5.6%	--
LED	9.9%	9.9%	--
Other	4.9%	4.6%	0.3%

Bulbs Obtained Through Direct-Install Programs

The bulbs reported as obtained through a direct-install program by the five confirmed HES program participants accounted for 14% of all bulbs obtained in the past year across the sample of on-site participants.[12] On average, these five on-site participants reported 23 direct-install bulbs. In comparison, on average in 2014, the HES program installed 24 bulbs

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[11] http://www.ctenergydashboard.com/Public/PublicHESActivity.aspx

[12] If we include the unconfirmed participants the percent of self-reported direct-install bulbs is 24%.

per home. Unconfirmed self-reported direct-install participants reported far fewer bulbs installed by direct-install programs, on average—additional evidence supporting the assessment that these customers did not actually participate in the HES programs.

Direct-Install Bulbs as a Percent of Lighting Program Activity

Between January and October 2015, the Energize CT Retail Lighting Program reported combined CFL and LED sales of 2,341,703. During the same period, the HES and HES-IE programs reported installing approximately 347,623 bulbs. Excluding non-program retail sales, direct-install bulbs account for 13% of total supported bulbs. In comparison, in the on-site sample, confirmed participants accounted for 14% of all bulbs reported obtained in the past year. Importantly, the denominator for on-site participants includes upstream bulbs, direct-install bulbs, and non-program-supported bulbs.

Table 11: Direct-Install Program Participation

Group	Households	Avg. Bulbs	Total Bulbs
On-site Participants	81	10	787
Confirmed Self-Reported DI Participants	5 (6%)	23	113 (14%)
Unconfirmed Self-Reported DI Participants	6 (7%)	12	73 (9%)
Total Self-Reported DI Program Participants	11 (14%)	17	186 (24%)
2014 HES Program Participation			
Households in Connecticut	1,355,973	N/A	N/A
2014 HES Program Participants	16,712 (1.2%)	24	401,088
2014 HES-IE Program Participants	18,002 (1.3%)	10	171,803
2014 HES + HES-IE Participants	34,714 (2.6%)	17	572,891
2015 Year to Date HES and Lighting Program Statistics			
2015 HES Program Participants (Jan – Sept '15)	9,495	22	208,890 (8%)
2015 HES-IE Program Participants (Jan – Sept '15)	11,516	12	138,733 (5%)
2015 HES + HES-IE Participants (Jan – Sept '15)	21,011	17	347,623 (13%)
Upstream Program Sales (Jan – Sept '15)	N/A	N/A	2,341,703 (87%)

4.1.3 Purchases by Manufacturer

Table 12 lists the number of standard CFLs, specialty CFLs, and LEDs purchased for each manufacturer based on the top ten manufacturers found in the 2015 on-site inventory. We report the unweighted number of bulbs purchased because of the relatively small sample sizes of purchases for each manufacturer. The Home Depot store brand, Ecosmart, accounted for the largest number of both standard (131) and specialty (36) CFLs that respondents reported purchasing in the year prior to the 2015 study. When reviewing purchases of LEDs in 2015, Feit Electric was the leading manufacturer (72 LEDs), followed closely by Cree (68 LEDs).

Table 12: Total Purchases by Manufacturer

(Base: All CFLs and LEDs purchased within the past year; data are unweighted)

Manufacturer	Standard CFLs	Specialty CFLs	LEDs	Total
Total	*382*	*112*	*323*	*817*
Home Depot (Ecosmart)	131	36	5	172
Feit Electric	31	4	72	107
Lumacoil	27	3	0	30
GE	23	2	1	26
Utilitech	18	0	2	20
Philips	11	9	50	70
Cree	9	11	68	88
Maxlite	9	22	0	31
TCP	2	0	24	26
Simply Conserve	85	22	63	170
Don't know	36	3	38	77

4.2 BULB REPLACEMENTS

During the on-site visits, for installed CFLs or LEDs identified as having been purchased within the past year, homeowners were asked what bulb type the newly purchased bulb had replaced. As a point of comparison, we provide data from a panel study conducted in Massachusetts in 2015. [13] In Connecticut, the data are self-reported, whereas the Massachusetts panel study relied on bulb changes observed by trained technicians who visited each home multiple times over the course of two to three years. During each visit, technicians recorded new bulbs and matched them to the previous year's data to determine what bulbs had been replaced. To aid in the study, all bulbs were marked when first observed, so technicians knew unmarked bulbs were new to the home.[14]

In Connecticut, the majority (81%) of newly installed CFLs replaced incandescents, followed by 13% filling sockets in new fixtures, and 6% replacing other CFLs. In Massachusetts, the most common bulb type replaced was still incandescents, though at a significantly lower percentage than what was self-reported in Connecticut. Another significant difference is that one-third of newly installed CFLs in Massachusetts replaced other CFLs.

When looking at newly installed LEDs, the most common bulb type replaced was, again, incandescents (45%), though this was followed closely by CFLs (38%). The Massachusetts data showed similar results, with 54% of LEDs replacing incandescents and 22% replacing

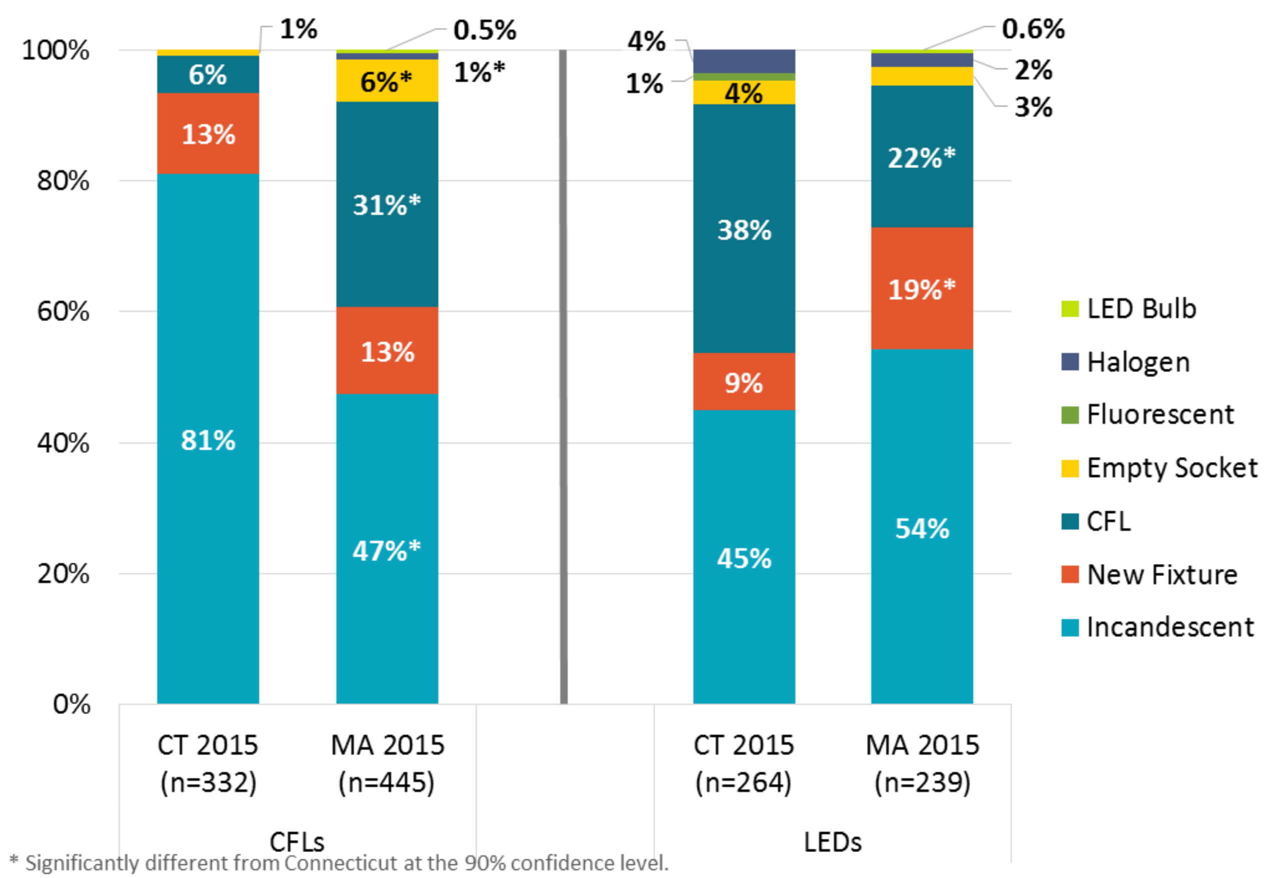
[13] http://www.nmrgroupinc.com/wp-content/uploads/2015/07/Barclay_et_al_We_Know_What_You_Did_Last_Summer.pdf

[14] The Massachusetts residential lighting panel study is an ongoing effort. As of January 2016, the study is undertaking its third wave of panel visits—visiting a total of 270 panel homes. Some homes have been taking part annually since 2013 with four or more visits.

CFLs. This is not surprising considering the strong preference for LEDs over CFLs shown in Table 7.

Figure 19: Replaced Bulbs 2015, CT and MA

(Base: CFLs and LEDs that replaced installed bulbs; excluding self-reported direct-install bulbs, new fixtures, and empty sockets)



New CFLs or LEDs were installed in a combined total of 596 sockets during the year prior to the study. Based on self-reported responses for what bulb type and wattage had been replaced by CFLs or LEDs purchased within the past year, we calculated the estimated delta watts for newly installed CFLs to be 41, and the average delta wattage of LEDs was 27.

Looking closely at the type of bulb the CFLs and LEDs replaced, it is clear that most of the drop in wattage came from replacing incandescent bulbs with CFLs or LEDs. The average delta wattage of newly installed LEDs is lower than that of newly installed CFLs primarily due to the fact that two out of five (43%) new LEDs replaced CFLs.

These calculations, however, rely solely on self-reported data; participants were not only asked to recall whether a CFL or LED had been purchased within the past year, they were also asked to recall the bulb type and wattage it had replaced. When compared to the Massachusetts panel study, where actual observed bulb changes from 2014 to 2015 were recorded, these average changes in wattages were very different: for CFLs, 41 delta watts in Connecticut vs. 28 delta watts in Massachusetts; for LEDs, 27 delta watts in Connecticut vs. 38 delta watts in Massachusetts (Table 13). Given the nature of self-reported data, we place greater faith in the Massachusetts findings. In addition, we note that even actual observed delta watts offer only a snapshot of history and do not factor in changes in market conditions.

Table 13: Delta Watts by Bulb Type for Past Year

(Base: CFLs and LEDs that replaced installed bulbs; excluding self-reported direct-install bulbs, new fixtures, and empty sockets)

	Newly Installed Bulbs					
	CFLs			LEDs		
Bulb Type Replaced	**n**	**New CFLs**	**Avg Delta Watts**	**n**	**New LEDs**	**Avg Delta Watts**
Total Replaced Bulbs	*332*		*41*	*264*		*27*
Incandescent	*309*	93%	44	*135*	51%	48
Fluorescent	*1*	<1%	26	*3*	1%	3
Halogen	*0*	-	0	*11*	4%	32
CFLs	*22*	7%	0	*114*	43%	3
LED Bulb	*0*	N/A	N/A	*1*	<1%	0

4.3 CONSUMER SURVEY SELF-REPORTED PURCHASE BEHAVIOR

We also asked customers about general purchasing habits in the consumer survey. To aid with recall, we limited questions to the past six months.[15] More than two-thirds (67%) of consumer survey respondents recalled purchasing bulbs within six months prior to the study. More than one-half (55%) had purchased screw-base CFLs, and nearly two-fifths (37%) had purchased screw-base LEDs. Approximately one-half (48%) reported purchasing incandescent bulbs, which adds to the growing body of evidence suggesting that the implementation of EISA has not completely eroded the market for incandescent bulbs (Table 14). However, these percentages rely solely on self-reported data and should be treated with some caution—especially considering that most consumers are likely unable to distinguish between halogen and incandescent bulbs.

Table 14: Bulbs Purchased in the Past Six Months[16]

(Base: Respondents who reported having purchased bulbs in the past six months; multiple response)

Bulb Type	Consumer Survey
Sample Size	*100*
CFLs (screw-base)	55%
Incandescents	48%
LEDs (screw-base)	37%
Fluorescents	21%
Halogens	19%
CFLs (pin-base)	8%
LEDs (pin-base)	8%
Other	1%

[15] During the on-site visits, we asked customers about purchasing behavior during the past six months, the past year, and the period before the past year.

[16] We have found over multiple studies across several states that self-reported responses are not accurate when compared to what is found installed in the home. For example, comparing Table 14 responses to responses from CFL and LED purchases reported during on-site visits, only 35% had purchased at least one screw-base CFL within the past six months, and only 26% had purchased at least one LED.

4.4 CONSUMER UNDERSTANDING OF LIGHTING INFORMATION

When asked what information they looked for on bulb packaging to help them decide which bulb to purchase, only 5% of all respondents mentioned looking for the Lighting Facts or energy facts label without being prompted. However, when those who had not mentioned it were asked directly if they refer to the lighting facts/energy facts label when deciding which bulb to purchase, one-half reported that they did (Table 15).

Table 15: Use of Lighting/Energy Facts Label

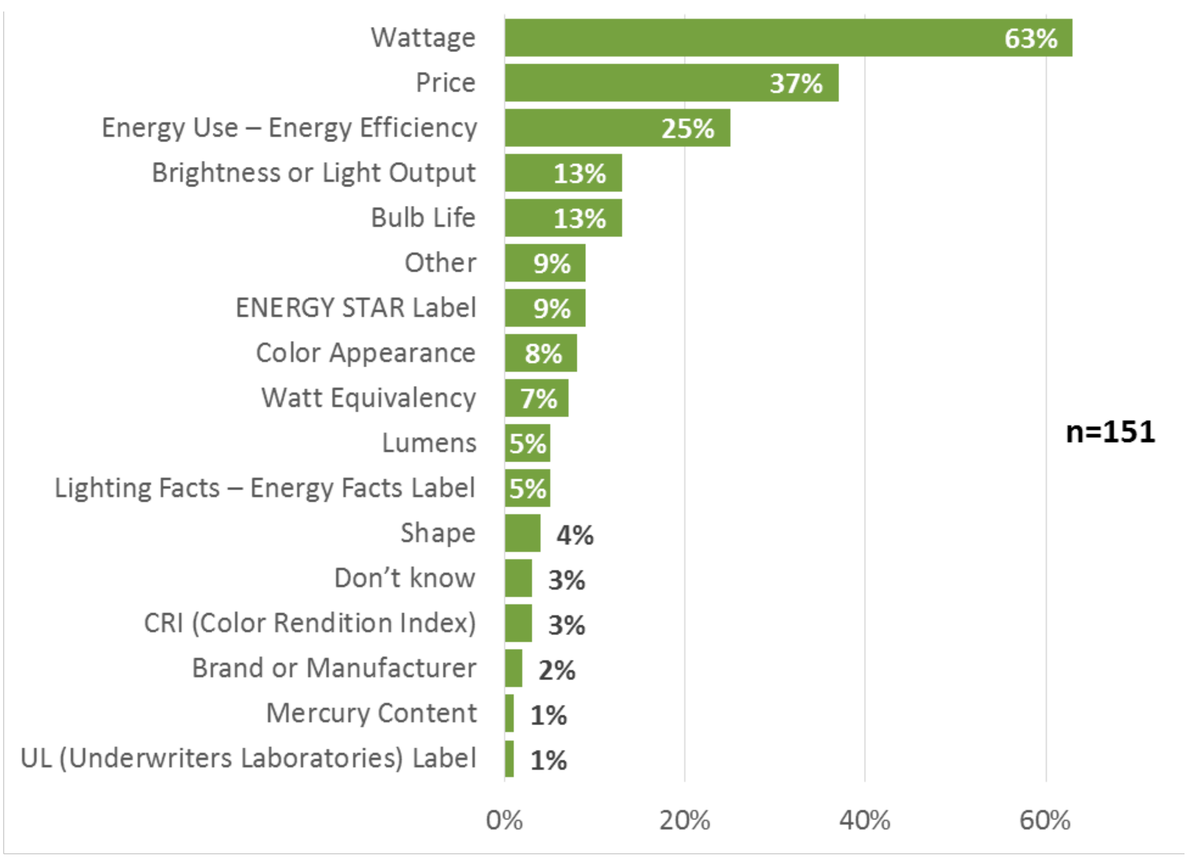
(Base: Respondents who did not self-report using the Energy Facts Label)

	Consumer Survey
Sample Size	*144*
Yes	49%
No	51%
Don't know	1%

All respondents were asked to list what information they look for on bulb packaging when making bulb purchasing decisions. Overall, consumers were still referring to wattage (63%) and price (37%) above all when considering which bulb to purchase. Markedly, one in four (25%) reported considering bulb energy use/energy efficiency (Figure 20).

Figure 20: Information Looked for on Bulb Packaging

(Base: All Respondents; Multiple Response)



In an effort to assess respondents' knowledge of the market, all were asked to define both *lumens* and *cool white and warm white*. Just over one-half (54%) of all consumer survey respondents had heard the term *lumens* in relation to lighting. When asked what the term meant, four out of five (80%) said that lumens refers to light output or brightness. The second most common answer, "Don't know," was given by nearly one out of five (17%) respondents (Table 16).

Table 16: Lumens

(Base: Respondents who had heard of lumens; multiple response)

Definition of lumens	Consumer Survey
Sample Size	*82*
Light Output or Brightness	80%
Same as Watts	6%
Other	4%
Light Color	2%
Don't know	17%

Seventy percent of respondents had heard the terms *warm white* and *cool white* in reference to lighting. As shown in Table 17, most respondents were able to assign meaning to each term, while some were more vague and general in their responses. The most common response was to associate each term with the color the bulb emits, with just under one-third (31%) assigning a white/blue color to *cool white* and a yellow/orange/red color to *warm white*. One-fifth thought that *cool white* was brighter, while *warm white* was more comfortable or "soft."

Table 17: Understanding of Warm White/Cool White

(Base: Respondents who had heard of warm white/cool white; multiple response)

Definition of cool white/warm white	Consumer Survey
Sample Size	*98*
Cool white is white/blue color; warm with is yellow/red/orange color	31%
Cool white is brighter; warm white is comfortable/soft	20%
Related to bulb brightness/intensity	16%
Related to bulb temperature/heat coming from bulb	10%
Warm white is brighter and more natural	9%
Cool white is a lighter white; warm white is a darker white	7%
Related to color or mood	7%
Other	5%
Don't know	3%

5

Section 5: Storage Behavior

Sixty-five of the 81 homes (80%) visited for the 2015 on-site study had bulbs in storage. In this section, we explore trends in storage behavior across time in Connecticut as well as in-service rates—i.e., the percentage of CFLs and LEDs bulbs that were newly purchased and installed within the past year.

- ***While incandescent bulbs were still the most commonly stored bulb type, they have begun to show signs of losing ground to CFLs, which have increased.***
- ***While the average number of bulbs in storage was similar in 2013 and 2015, the median doubled in the same period.***
- ***Most bulbs were being stored for future use, though 15% of incandescent bulbs were reportedly earmarked for disposal.***
- ***Newly purchased LEDs were installed at a much quicker rate than newly purchased CFLs.***

While more than one-half (52%) of visited homes had incandescent bulbs in storage, this percentage has decreased by eleven points since 2012. Conversely, the percentage of energy-efficient bulbs in storage has increased by nine points, from 34% in 2012 to 43% in 2015 (Table 18). When looking at the reason for storing bulbs, more than nine out of ten (92%) energy-efficient bulbs were in storage for future use, while just over eight out of ten (84%) inefficient bulbs were in storage for future use; homeowners planned to throw out or recycle, did not plan to use, or did not have plans for 15% of the inefficient bulbs.

For select incandescent bulbs in storage that are no longer being manufactured—40-, 60-, 75-, and 100-watt A-lamp bulbs—homeowners were asked if they had purchased and stored these bulbs *because* they were no longer being manufactured (stockpiling). Fourteen on-site participants (17%) said they were stockpiling incandescent bulbs because they are no longer being manufactured, accounting for 40% of stored 40-, 60-, 75-, and 100-watt incandescents. This is a high proportion of homes reporting stockpiling bulbs and is somewhat inconsistent with findings in other areas. In fact, over the past two years across four states, NMR has only identified a total of 13 self-identified stockpilers among hundreds of on-site visits. This may be the beginning of a new trend, as EISA has had more time to take effect, or an anomaly in the sample.

- In 2015 in Massachusetts and New York, none of the new on-site participants was identified as a stockpiler.
- In 2014,
  - 4% of Massachusetts on-site participants (10 homes) were identified as stockpilers.
  - 3% of Georgia on-site participants (2 homes) were identified as stockpilers.
  - 2% of Kansas on-site participants (1 home) were identified as stockpilers.

Saturation among stockpilers in Connecticut in 2015 is slightly different from that of the overall sample, with 53% non-energy-efficient bulb saturation (vs. 44% overall), and 48% efficient bulb saturation (vs. 56% overall). One home was labeled as an outlier, accounting for more than one-half (54%) of stockpiled bulbs and 17% of all stored bulbs. This outlier was removed for the analysis in Table 18.[17]

Table 18: Stored Bulbs by Bulb Type over Time

	2012	2013	2015*
Sample Size	*100*	*90*	*80*
Total Stored Bulbs	**1,995**	**1,169**	**1,214**
Avg. # of Stored Bulbs	**5**	**13**	**15**
Median	**4**	**4**	**8**
Incandescent	63%	61%	52%
CFLs	30%	27%	35%
Fluorescent	4%	3%	4%
Halogen	4%	9%	5%
LED	<1%	1%	4%
Other	0%	0%	<1%

*One outlier was removed for this analysis.

Not surprisingly, self-identified stockpilers had a higher average number of bulbs in storage compared to non-stockpilers. In total, excluding the outlier, the 13 self-identified stockpilers accounted for 36% of all bulbs in storage (434 total bulbs, 33 on average). In total, homes that did not report stockpiling accounted for 64% of all bulbs in storage (780 total bulbs, 12 on average). Stockpiled bulbs account for 19% (82 total bulbs, 6 on average) of stored bulbs among stockpilers. Of note, stockpilers also have a larger number of non-stockpiled stored bulbs in storage compared to non-stockpilers—more than twice as many (27 vs. 12). This may indicate that stockpilers are more likely to store bulbs in general—not just stockpile bulbs that are no longer being manufactured. (Table 19)

Table 19: Comparing Storage Habits

	Stockpilers	Non-Stockpilers
Sample Size	*13*	*67*
Total Stored Bulbs	434	780
Avg. # of Stored Bulbs	33	12
Total stockpiled bulbs	82	N/A
Avg. # of stockpiled bulbs	6	N/A
Total non-stockpiled bulbs	352	780
Avg. # of non-stockpiled bulbs	27	12

*One outlier was removed for this analysis.

[17] The outlier had a total of 248 bulbs in storage, 94 of which were being stockpiled because they were no longer manufactured.

5.1 STORAGE BY INCOME

Not surprisingly, given the lower number of total sockets, low-income households have fewer bulbs in storage compared to non-low-income households. However, as Table 20 shows, income does not appear to have any impact on the types and proportions of bulbs that are found in storage.

Table 20: Stored Bulbs by Bulb by Income

	All	Low Income	Non-Low Income
Sample Size	*80*	*24*	*53*
Total Stored Bulbs	**1,214**	**133**	**1,005**
Avg. # of Stored Bulbs	**15**	**6** β	**19**
Median	**8**	**2**	**11**
Incandescent	52%	44%	53%
CFLs	35%	49%	33%
Fluorescent	4%	1%	4%
Halogen	5%	2%	6%
LED	4%	3%	4%
Other	<1%	2%	--

*One outlier was removed for this analysis.

β Significantly different from Non-Low Income at the 90% confidence level.

5.2 FIRST YEAR IN-SERVICE RATES

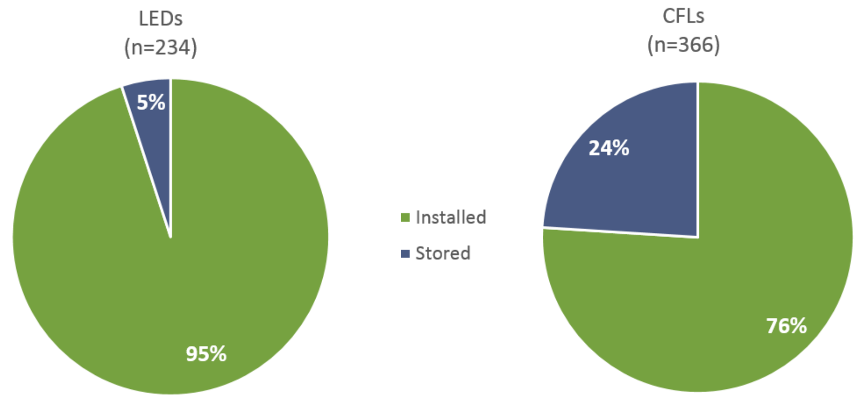
Newly purchased CFLs and LEDs have a combined self-reported first-year in-service rate of 84%. When looking at the first-year in-service rate by bulb type, Figure 21 shows that newly purchased LEDs are being installed at a faster rate than CFLs. More than eight out of ten (76%) CFLs purchased within the past year were installed, while nearly all (95%) newly purchased LEDs were installed.

For reference, the average first-year in-service rate reported in the Unified Methods Project (UMP)[18] is 79%; while the CFL installation rate is nearly identical to this (76%), the in-service rate for LEDs found in the Connecticut 2015 on-site study is significantly higher (95%). This offers evidence that consumers are more likely to install LEDs within the first year compared to CFLs, possibly due to higher levels of satisfaction with LEDs (Table 6), higher prices, and smaller pack sizes.

[18] http://www.nrel.gov/extranet/ump/pdfs/20140514_ump_res_lighting_draft.pdf

Figure 21: First Year In-Service Rate for Newly Purchased CFLs and LEDs

(Base: All bulbs purchased within the past year; excludes self-reported direct-install bulbs)



5.3 LIFETIME IN-SERVICE RATES

According to the UMP, while first-year in-service rates from upstream programs are less than 100%, studies have shown that, over time, consumers plan to install the remaining incented bulbs. Measuring in-service rates for two- or three-year periods can be difficult, though, as consumer recall fades over time.

To calculate in-service rates after year one, the UMP recommends using findings from a 2013 study conducted by Navigant Consulting and Apex Analytics.[19] This study included actual on-site verifications conducted three times over the course of the study to examine actual bulb installations. The study found that 79% of CFLs were installed within 12 months of purchase, 87.7% within 24 months, and 93.6% within 36 months. Using this trajectory applied to the first-year in-service rate found in this study, NMR calculated the second and third year in-service rates presented in Table 21 for both CFLs and LEDs. For the four-year in-service rate, we followed the UMP's guidance to assume that up to 97% of bulbs in storage are installed within four years of purchase.

Table 21: Three Year In-Service Rates

	CFLs	LEDs
First Year ISR	76%	95%
Second Year ISR	86%	97%
Third Year ISR	93%	98%
Fourth Year ISR	97%	100%

[19] Navigant Consulting and Apex Analytics, LLC (November 7, 2013). Storage Log Study of CFL Installation Rate Trajectory. Prepared for Duke Energy Progress.

6 Section 6: EISA Coverage, Exemptions, and Exclusions

This section looks at installed bulbs in the context of EISA. By categorizing each bulb as covered by EISA, exempt from EISA, or excluded from the EISA scope, NMR was able to assess EISA's impact on current bulb installation.

- ***Just over one-half (56%) of installed Connecticut bulbs were covered by EISA; the remaining 44% were either non-general service bulbs or exempt from EISA.***
- ***NEEP's review of shelf stocking studies showed that just over one-third (36%) of bulbs currently being sold are covered by EISA.***
- ***Among installed bulbs covered by EISA, 62% meet or exceed EISA requirements—60% are efficient bulbs (CFLs or LEDs) and 2% are EISA-compliant halogen bulbs.***

The Northeast Energy Efficiency Partnerships (NEEP) recently issued a report looking at the residential lighting market in the Northeast in the context of EISA.[20] The purpose of the report was to determine if the residential lighting market has been transformed, where the market is heading, and if there is a role for residential lighting programs in the future. As part of the NEEP assessment, residential lighting was grouped into the following categories in order to increase understanding of the proportion of bulbs covered by the EISA rulemaking:

- General Service covered by EISA
- General Service exempt from EISA
- Non-General Service Lighting (excluded from EISA scope)[21]

NMR wanted to look at installed bulbs in Connecticut in this context as well in order to specifically assess the proportion of bulbs currently installed that are covered by EISA. In order to group the on-site data collected into categories, we used the flow chart in Figure 22 prepared by Apex Analytics. Any bulbs that were not covered in this flow chart were categorized as Non-General Service Bulbs. Any bulbs that fell outside the EISA lumen or wattage categories were categorized as exempt or excluded by EISA.

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[20] NEEP, The State of Our Sockets: A Regional Analysis of the Residential Lighting Market, 2015. http://www.neep.org/sites/default/files/resources/StateOfOurSocketsFinal_0.pdf

[21] The R154 study excluded appliance lights and non-permanent holiday lights.

Figure 22: EISA Categories[22]

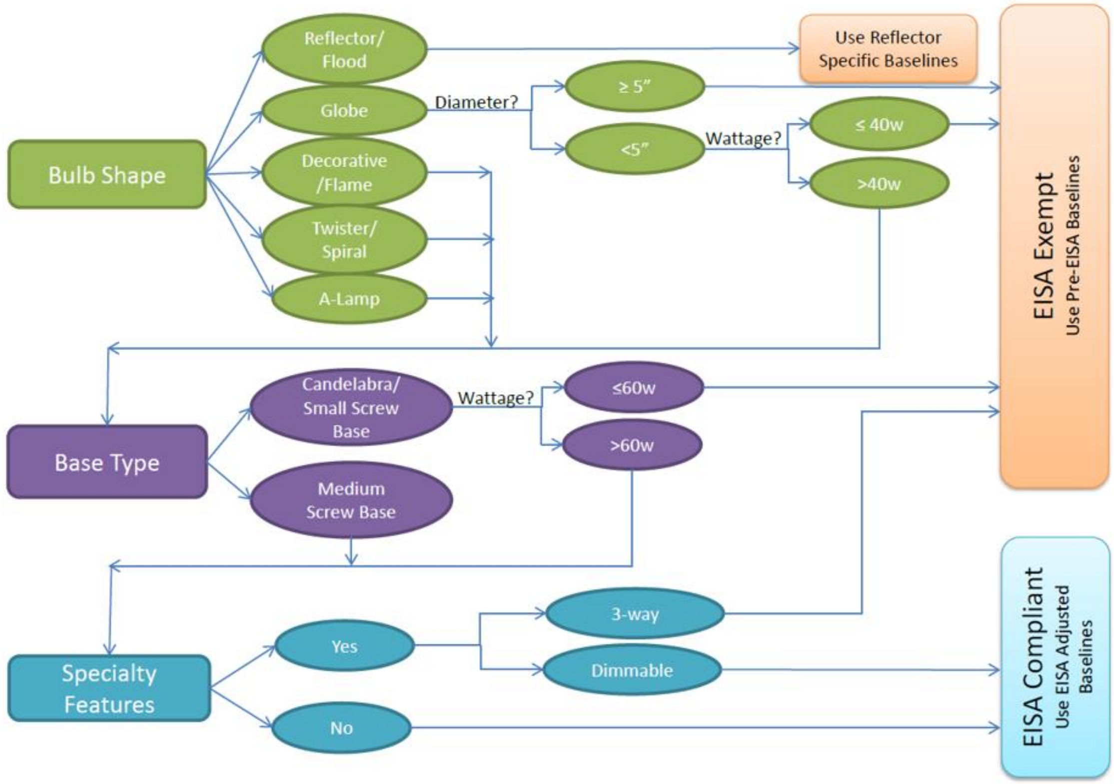


Figure 23 shows installed bulbs in Connecticut homes in 2015 grouped into three categories: covered by EISA, exempt from EISA, or excluded from EISA rulemaking. Over one-half (56%) of installed bulbs were general service covered by EISA bulbs.[23] Figure 24 shows the results of the NEEP analysis as presented in its report. The NEEP analysis found that just over two-thirds (36%) of available bulbs were general service covered by EISA.

The differences in findings between the two studies can be explained by differences in methodology. The analysis for this study (R154) covers currently installed bulbs based on lighting inventory data collected in the field, whereas the NEEP estimates cover bulbs available for purchase (and not sales weighted) based on secondary research from recently completed shelf-stocking surveys and limited regional sales data. Shelf-stocking surveys provide helpful insights in understanding what choices customers will face when purchasing bulbs in the near future, while lighting inventories provide a snapshot of currently installed bulbs. In addition, on-site lighting inventories are not able to fully capture the installation of exempt bulbs in sockets that are nearly indistinguishable from similar EISA covered bulbs, such as rough service lamps, shatter-resistant lamps, and vibration service lamps. Future

[22] This flow chart was created by Apex Analytics.

[23] Examining the breakdown for currently installed inefficient bulbs alone reveals a similar breakdown: 54% covered by EISA, 21% exempt from EISA, and 26% non-general service bulbs.

studies may want to collect data on all recently purchased bulbs; this may offer better insight into whether or not households are purchasing EISA-exempt bulbs.

Figure 23: Connecticut (R154) Installed Bulbs by EISA Category

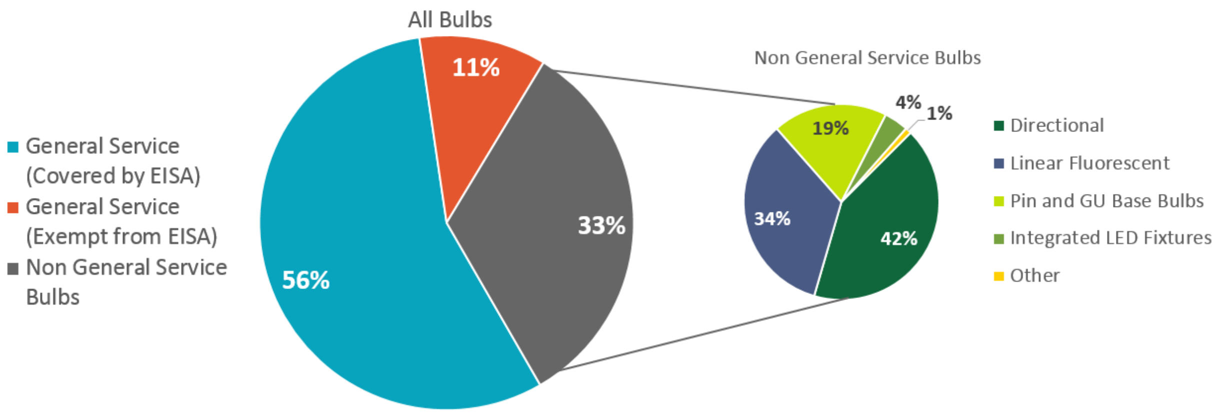


Figure 24: NEEP Residential Lighting Product Breakdown[24]

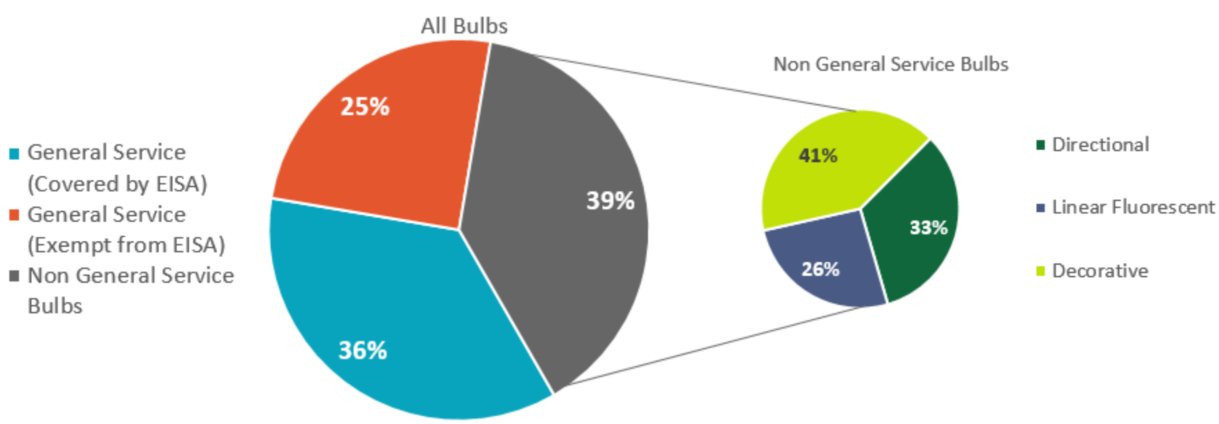


Table 22 provides the data presented in the figures above in tabular format for ease of comparison. As the table shows, there is general agreement between the two studies regarding the proportion of directional and linear fluorescents.

[24] NEEP, The State of our Sockets: A Regional Analysis of the Residential Lighting Market, 2015. http://www.neep.org/sites/default/files/resources/StateOfOurSocketsFinal_0.pdf

Table 22: Bulbs by EISA Category

	R154	NEEP
Covered General Service	56%	36%
Exempt General Service	11%	25%
Non General Service		
Directional	14%	13%
Linear Fluorescent	11%	10%
Pin and GU Base Bulbs	6%	N/A
Integrated LED Fixtures	1%	N/A
Other	<1%	N/A
Decorative	N/A	16%

To help understand the impact of EISA, we also explored the efficiency of bulbs categorized as General Service covered by EISA. Table 23 provides the saturation of all bulbs categorized as General Service covered by EISA. As the data reveals, three-fifths (60%) of EISA-covered bulbs found installed are efficient (CFLs or LEDs), and only two-fifths (40%) are inefficient. Further, of among all Covered General Service bulbs, about three out of five (62%) are already EISA compliant. While none of the currently installed Covered General Service incandescent bulbs meet the EISA requirements, all CFL, all LEDs, and 81% of installed halogens are EISA compliant.

Table 23: General Service Covered by EISA Saturation

Sockets Containing	2015 Saturation	EISA Compliant
Sample Size	*81*	*81*
Total Bulbs	2,691	2,691
CFL	53%	100%
Incandescent	38%	0%
Halogen	2%	81%
LED	7%	100%
Other	<1%	0%
Total Efficient	*60%*	*100%*
Total Inefficient	*40%*	*4%*
All EISA Covered Bulbs	*N/A*	*62%*

7 Section 7: Remaining Potential Energy Savings

One of the goals of this study was to update the residential energy potential for energy-efficient lighting in Connecticut. To do this, NMR combined findings from the recent Northeast Residential Lighting Hours of Use (HOU) study completed in 2014 with the Connecticut data collected in 2015.[25] This section looks at current energy usage in Connecticut homes by room type as well as the potential savings that remain available in residential lighting.

- ***Overall, while inefficient bulb types fill less than one-half of the sockets in Connecticut homes (44%), they are responsible for two-thirds (67%) of the energy used by lighting in these homes.***
- ***Analysis suggests that EISA may result in an additional 150 annual average kWh reduction in Connecticut homes.***
- ***If all inefficient sockets were changed to CFLs, Connecticut homes could potentially save 895 kWh per household, in addition to any savings from EISA.***
- ***If all inefficient sockets were changed to LEDs, Connecticut homes could potentially save 983 kWh per household, in addition to any savings from EISA.***
- ***The remaining potential savings that could be achieved by replacing inefficient sockets with CFLs or LEDs are about 87% of already achieved savings.***
- ***Remaining potential savings are likely lower for low-income households compared to the general population.***

7.1 ENERGY SAVINGS POTENTIAL

NMR calculated potential savings for five scenarios to help illustrate the remaining potential in the Connecticut residential lighting market as a whole.[26]

1. Incandescent-land – annual household energy usage if all screw-base bulbs were incandescent.
2. Current market – energy usage today based on actual current lighting inventories. Note that the current market already includes some effects from EISA.
3. EISA-land – annual household energy usage if all currently installed non-EISA-compliant General Service bulbs covered by EISA were replaced with a minimum EISA-compliant bulb. As the current market has already been affected by EISA, this scenario represents additional EISA-induced savings.

[25] NMR, Northeast Residential Lighting Hours-of-Use Study, 2014. http://tinyurl.com/TimelessHOU

[26] Note that NMR attempted to develop separate savings estimates for low-income and non-low-income households, but the subsamples were too small to provide robust estimates. However, we would expect low-income households to have lower energy-saving potential based on the lower number of total sockets found in low-income households.

4. CFL-land – annual household energy usage if all currently installed inefficient bulbs were replaced with CFLs.
5. LED-land – annual household energy usage if all currently installed inefficient bulbs were replaced with LEDs.

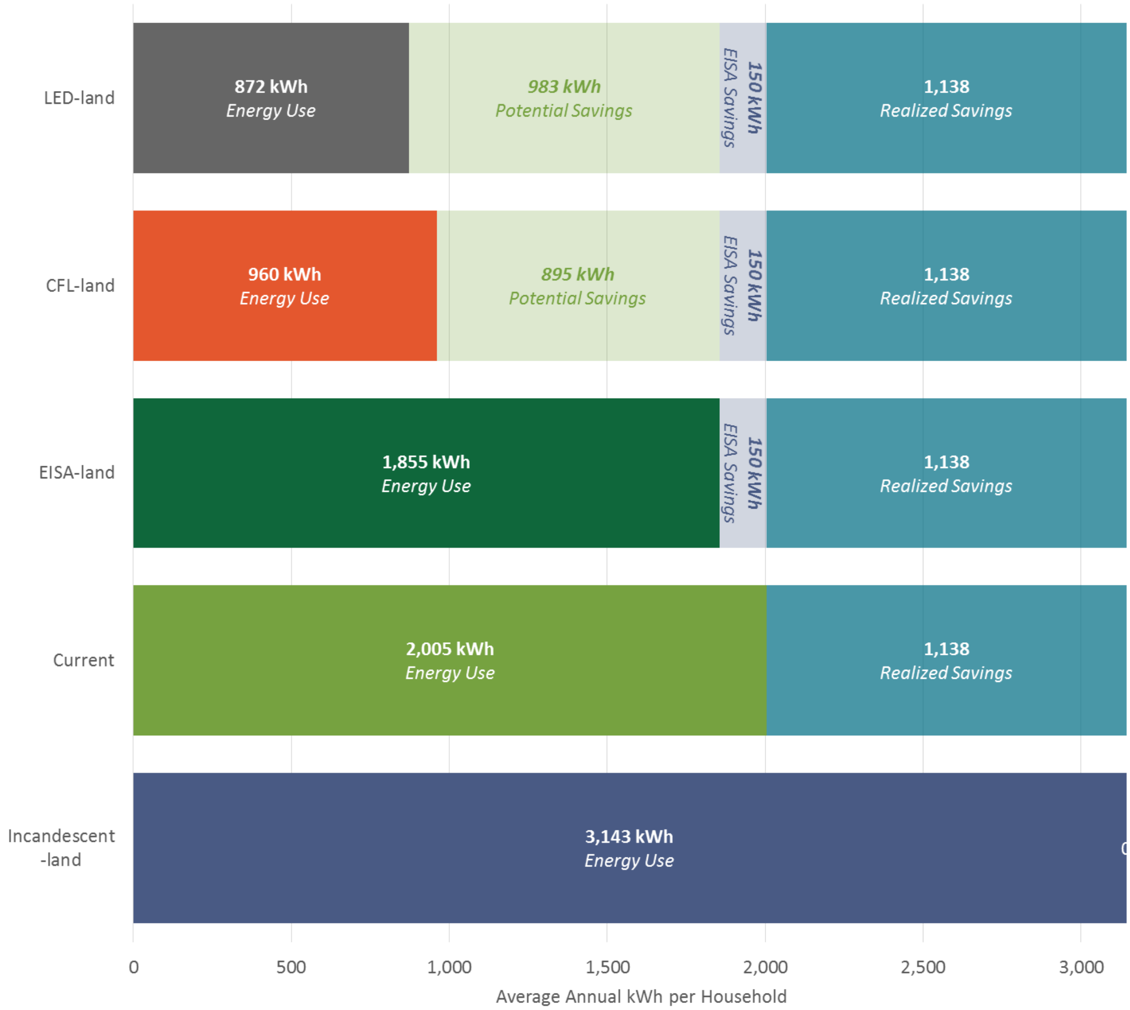
Incandescent-land, was calculated by replacing all screw-base CFLs and LEDs with screw-base incandescents; linear fluorescents and non-screw-base bulbs were not changed. This scenario allowed us to imagine what residential lighting energy usage would be today if efficient bulbs had never been introduced to the market.

For **EISA-land**, we first determined which bulbs were general service and covered by EISA. Then, for each of these bulbs, we estimated their general lumen output based on wattage and bulb type.[27] If they were not complaint with EISA, we replaced each bulb's wattage with the minimum EISA-complaint bulb for the general lumen category (72w, 53w, 43w, or 29w). If the bulbs were already compliant with EISA standards, we kept their original wattage. We did not increase the wattage of bulbs that exceed EISA standards (are already compliant)—therefore, in this scenario, households are actually more efficient than just a minimum EISA standard.[28] Finally, as the current market has already been affected by EISA, this scenario represents additional EISA-induced savings above and beyond the current market.

To create **CFL- and LED-land**, each inefficient bulb's wattage was replaced with the equivalent replacement wattage of a CFL or LED. This allowed us to imagine a situation where all bulbs installed in the home were efficient. Using the all-bulb HOU[29] in Table 15, we could then look at what energy use would be if all bulbs were efficient and estimate the potential savings from reaching 100% efficient socket saturation. In these two scenarios, there is still a large amount of potential savings per household. LED-land shows the largest amount of potential savings (compared to EISA-land) available, with a reduction of 983 kWh per household possible—an amount equal to 86% of all savings realized to date in the current market.

[27] https://www.energystar.gov/ia/partners/manuf_res/LightingfactsheetFinal.pdf
[28] As discussed in Section 6Section 6:, only 56% of all installed bulbs are covered by EISA and 62% of installed bulbs that are covered by EISA already meet or exceed the minimum requirements.
[29] Based on the assumption that efficient HOU will approach the all bulb HOU estimate over time as saturation approaches 100%.

Figure 20: HOU and Energy Savings Potential



7.2 ENERGY USAGE AS A PERCENT OF TOTAL HOUSEHOLD USAGE

In order to help place the estimated electric usage in context, Table 24 provides the estimated electric usage from each scenario as a percent of average annual total household electricity usage. According to data provided by Eversource, households in Connecticut served by Eversource used, on average, 8,395 kWh in 2014. Meaning that current estimated lighting electric usage represents nearly one-quarter (24%) of average annual electric usage. If households were to convert to 100% efficient bulbs (CFL- or LED-land), that percentage could be reduced to 10%-11%, which would, in theory, reduce average annual household electric usage to 7,262 to 7,350 kWh per year—a reduction of about 13%.

Table 24: Estimated Lighting Electric Usage

Scenario	Estimated Electric Usage	Percent of Household Usage
Average annual household electric usage	8,395 kWh	100%
Incandescent-land	3,143 kWh	37%
Current	2,005 kWh	24%
EISA-land	1,855 kWh	22%
CFL-land	960 kWh	11%
LED-land	872 kWh	10%

7.3 CALCULATING POTENTIAL SAVINGS

Table 25 shows the overall HOU estimates broken out by type of bulb (inefficient vs. efficient vs. all bulbs) and by room type. The 2014 study showed that the HOU vary by room type and type of bulb; therefore, NMR chose to use these values for a more accurate estimate.

Table 25: HOU Values for Efficient and Inefficient Bulb Types by Room Type

Room Type	Inefficient	Efficient	All Bulb
Bathroom	1.4	2.1	1.7
Bedroom	1.8	2.4	2.1
Dining Room	2.5	2.9	2.8
Exterior	5.3	5.7	5.6
Kitchen	3.7	4.3	4.1
Living Space	3.0	3.3	3.3
Other	1.4	2.0	1.7

To determine potential energy savings, NMR categorized each installed bulb as efficient (CFL, LED, or Fluorescent) or inefficient. Using these categories, each bulb's wattage was multiplied by the HOU values displayed in Table 25. These values were multiplied by 365 to get HOU per year for each bulb and divided by 1,000 to reach kWh per year by room type and bulb type (inefficient or efficient). These values were then averaged on the household level (divided by n=81).

Table 26 shows the current hours of use by room type in Connecticut. Overall, while inefficient bulb types fill the less than one-half (44%) of the sockets in Connecticut homes, they are responsible for two-thirds (67%) of the energy used by lighting in these homes. When looking at hours of use by room type, dining rooms have the highest rate of inefficient bulb saturation, which account for nearly all (91%) of the energy used in this room type. The only room type where efficient bulbs are responsible for more of the energy used than inefficient bulbs is Other.

Table 26: HOU by Bulb Type and Room Type – Current Market

	Inefficient			
Room Type	**Avg. KwHOU/ HH**	**% HOU**	**% Saturation**	**Avg. Sockets**
Household	**1,351**	**67%**	**44%**	**27**
Dining Room	112	91%	78%	3
Exterior	473	84%	54%	3
Living Space	192	69%	46%	3
Bedroom	137	64%	44%	4
Bathroom	84	62%	41%	3
Kitchen	145	57%	36%	2
Other*	208	47%	37%	8
	Efficient			
Room Type	**Avg. KwHOU/ HH**	**% HOU**	**% Saturation**	**Avg. Sockets**
Household	**655**	**33%**	**59%**	**35**
Dining Room	12	9%	46%	1
Exterior	88	16%	64%	2
Living Space	85	31%	63%	4
Bedroom	78	36%	22%	5
Bathroom	52	38%	56%	5
Kitchen	109	43%	54%	4
Other	231	53%	56%	13

* Other includes basements, closets, foyers, garages, hallways, offices, utility rooms, and other room types.

7.4 CONSIDERATIONS FOR ESTIMATING SAVINGS IN THE FUTURE

It is our understanding that the PAs are interested in discovering methods to help estimate expected savings for lighting direct-install programs based on demographic variables—specifically, square footage of homes. Since lighting energy savings are directly related to number of bulbs retrofitted, it makes intuitive sense that larger homes would have more sockets and thus more opportunities for efficient bulbs. To explore this theory, NMR used a stepwise procedure to select the best predictors from the following available demographic variables:

- Room count
- Square footage
- Home type (single-family or multifamily)
- Tenure (own or rent)
- Income (low income or non-low income)
- Education (some college education or no college education)

In the stepwise procedure, only room count and square footage were determined to be potential predictors of socket count. Table 25 provides the correlation coefficient for each of the demographic variables considered.

Table 27: Stepwise Procedure – Correlation Table

Demographic Variable	Correlation Coefficient
Room Count	0.9129
Square Footage	0.7846
Home Type	0.4591
Tenure	0.5843
Income	-0.4670
Education	0.4391

Next, we ran a simple linear model with *bulb count* as the dependent variable and *room count* and *square footage* as predictors. This model resulted in an R^2 of 0.84—meaning about 84% of the observed variation in the number of sockets can be explained using these two variables.[30] However, when we excluded square footage, despite it being statistically significant, the model (with just room count) performed almost the same with an R^2 of 0.83. A model with only square footage returned a poorer fit with a R^2 of 0.62. Based on this analysis, we would say that number of rooms is a better predictor of number of sockets than is square footage. In addition, in our experience, many customers do not know the size of their home in square feet but are able to provide a somewhat accurate room count. So it may be easier for the PAs to collect information on the number of rooms from customers than on square footage. Note that the data here on square footage and room counts were collected by technicians in the field. For room count, technicians counted all separate rooms in the home—including bathrooms, kitchens, utility rooms, foyers, hallways, unfinished basements, or other unfinished spaces used for storage. The US Census excludes these room types in its room counts. Closets are not treated as separate rooms.

[30] R^2 or the coefficient of determination, is a number that indicates the general fit of a statistical model. An R^2 of 1 would represent a perfect fit, while an R^2 of 0 indicates that the line does not fit the data at all.

Figure 20: Room Count Linear Model

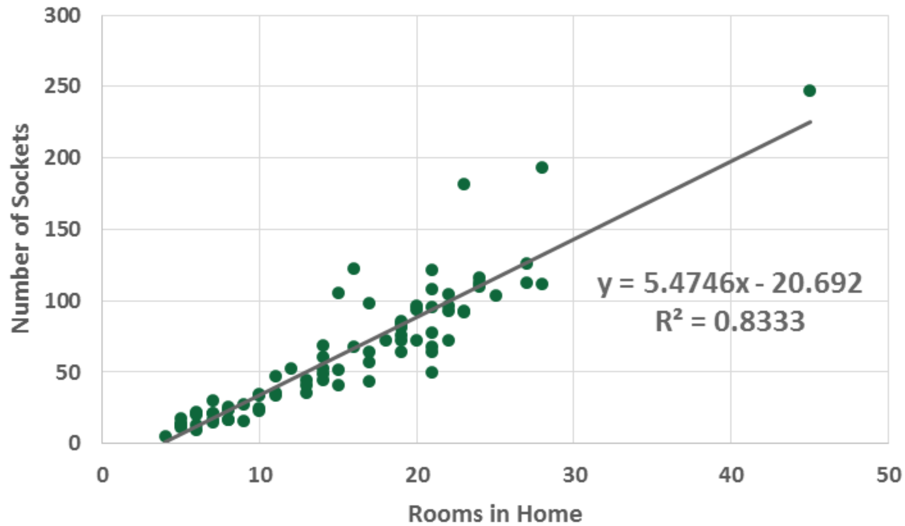
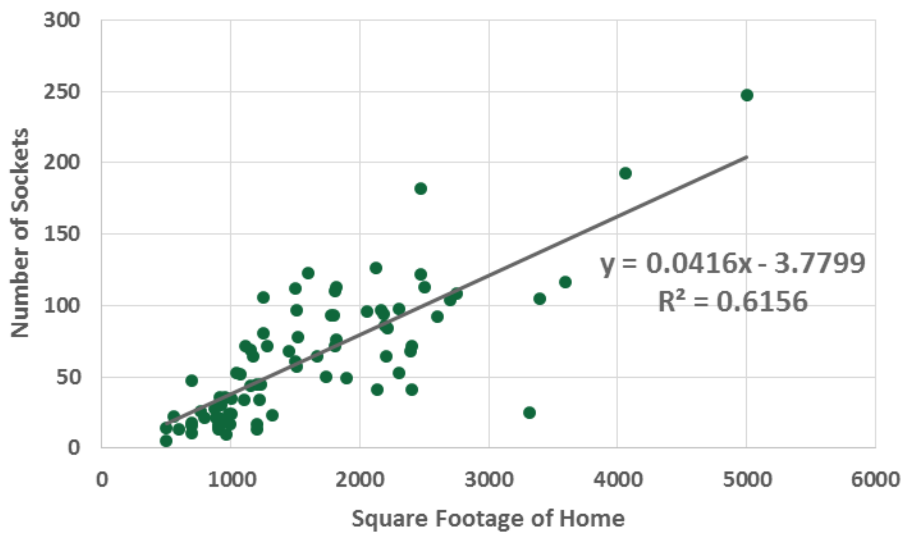


Figure 20: Square Footage Linear Model



7.5 ESTIMATED LIGHTING ELECTRIC USAGE BY INCOME

Here we present some preliminary energy use estimates for low-income and non-low-income households. Note, however, that we present these estimates with some caution. The R154 sample was designed within budget constraints to represent the population of Connecticut, but the sample size does not provide sufficient data to prepare robust estimates for subsamples. So, while the overall sample provides a good estimate for the entire population, estimates for subsamples are subject to greater levels of error.

Still, while low-income status was not a good predictor of socket counts (detailed above), we know that in this sample that low-income households on average have significantly fewer sockets compared to non-low-income households (30 vs. 75). Therefore, it is not surprising that this sample would reveal that low-income households have lower levels of lighting electric usage. Table 28 provides the estimated lighting electric usage by income for each of the five scenarios as well as the potential savings for CFL- and LED-land as compared to EISA-land.

Again, given the small sample sizes, we can only say the estimates for low-income households are relatively lower compared to the general population and non-low-income households.

Table 28: Estimated Lighting Electric Usage by Income

Scenario	Estimated Lighting Electric Usage		
	Low Income	All	Non-Low Income
n	**24**	**81**	**54**
Incandescent-land	1,125 kWh	3,143 kWh	3,944 kWh
Current	597 kWh	2,005 kWh	2,599 kWh
EISA-land	553 kWh	1,855 kWh	2,411 kWh
CFL-land	384 kWh	960 kWh	1,322 kWh
LED-land	359 kWh	872 kWh	1,198 kWh
Potential Savings Compared to EISA-land			
CFL-land	169 kWh	895 kWh	1,089 kWh
LED-land	194 kWh	983 kWh	1,213 kWh

8 Section 8: Demographics

The demographic information was collected over the phone through the consumer survey. Connecticut census data comes from the 2014 American Community Survey (ACS) 1-year Estimates; we provided census data in comparison to the consumer survey and on-site participant sample when it was available.

- ***Overall, the consumer survey and on-site visit participant samples were similar to the Connecticut population.***
- ***While some categories were significantly different (single-family homes, respondents in the 55-65 year age range, etc.), the majority were comparable.***
- ***The on-site participant sample was very similar to the consumer survey, indicating that there was not a lot of shift in demographics between the survey and the actual visits.***

Home Type: More than seven out of ten (71%) on-site participants lived in single-family households, which are defined in this study as residential buildings with one to four units, including single-family detached and single-family attached homes. This is significantly different from the Connecticut 2014 ACS 1-year estimates, which show that more than eight out of ten (82%) of homes in the state are single-family.

Tenure: More than two-thirds (68%) of on-site participants owned their homes, while only one-third (32%) were renters.

Income: The majority (65%) of the on-site sample were not low-income households.

Home Size: Nearly six out of ten (59%) on-site participants reported that their homes were smaller than 2,000 square feet.

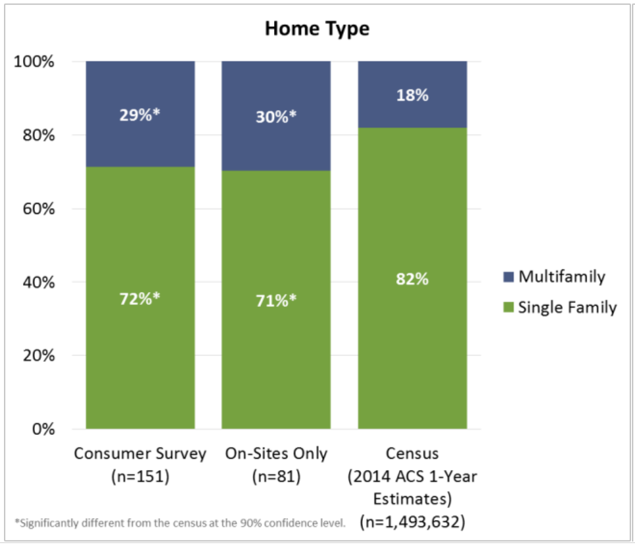
When Built: Almost one-quarter (23%) of the homes that participated in the 2015 on-site study were built in the 1960s, which is significantly different from the 14% statewide built during the same period.

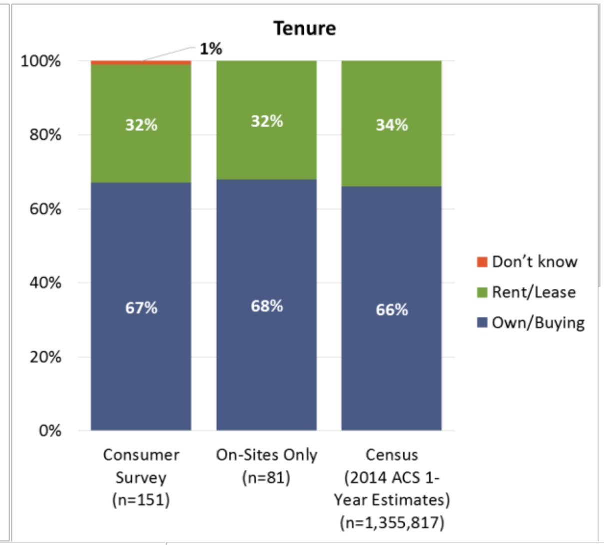
Education: The most common level of education achieved among on-site participants was a bachelor's degree or higher (49%), followed by high school graduate (includes GED; 25%).

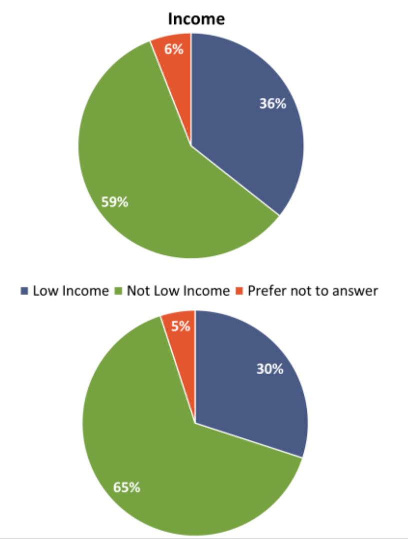
Number of Rooms: The on-site visits were generally a good match to the Census for number of rooms, although the on-site (25%) and consumer survey (24%) samples had significantly fewer homes with six to seven rooms compared to the Census (36%).

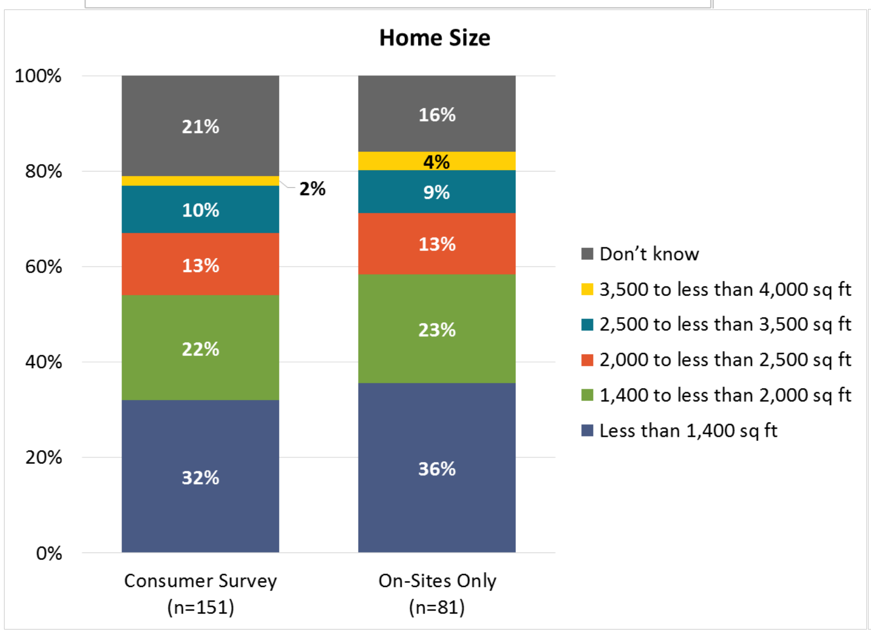
Number of People: More than one-third (37%) of participants were two-person households.

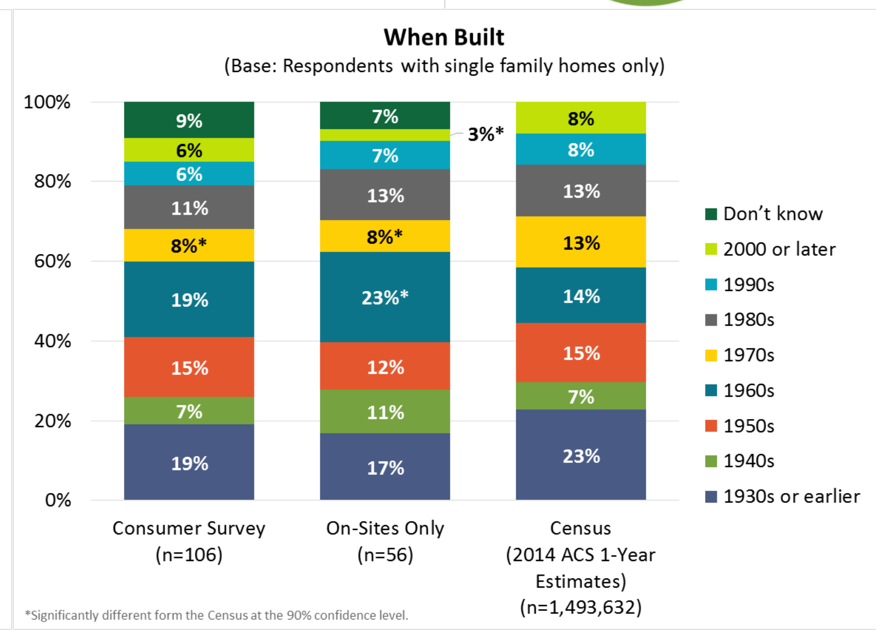
Age: Nearly one out of three participants were between 55 and 64 years old, which is significantly more than the population found statewide in this age group.

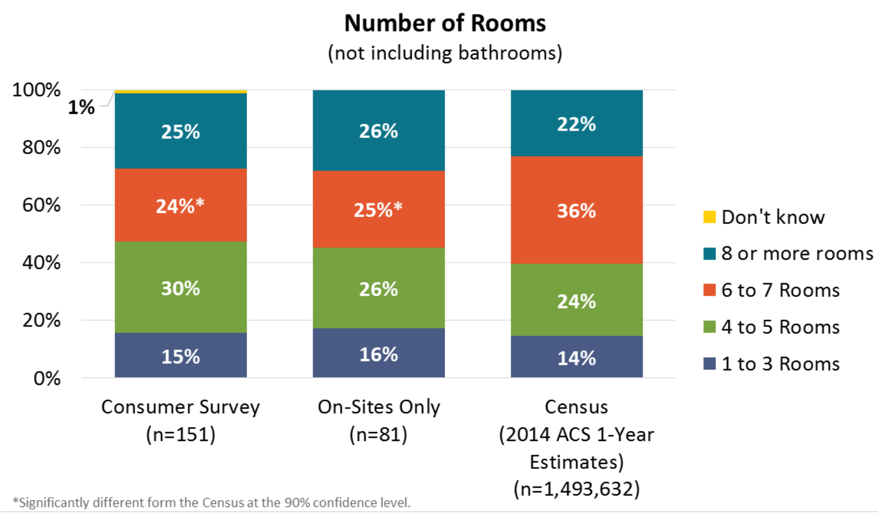

Home Type
100%
80%
60%
40%
20%
0%
29%*
30%*
18%
72%*
71%*
82%
Multifamily
Single Family
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=1,493,632)
*Significantly different from the census at the 90% confidence level.

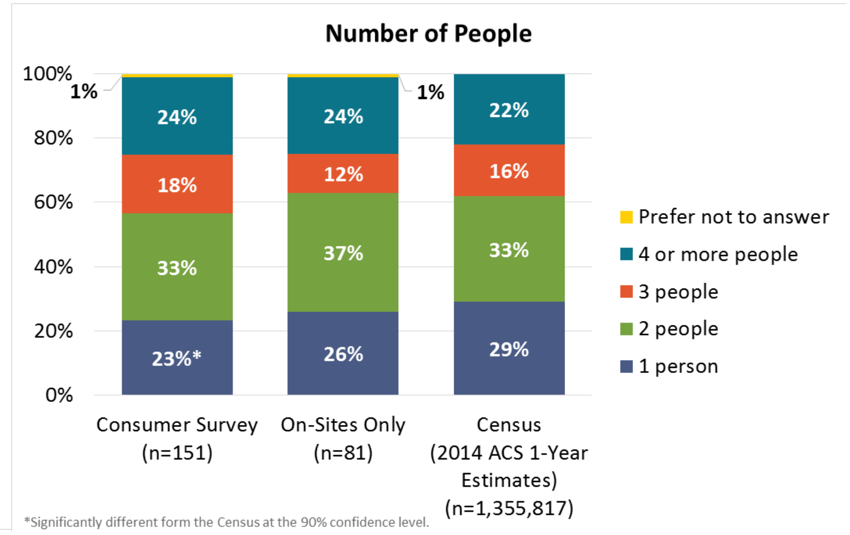

Tenure
100%
80%
60%
40%
20%
0%
1%
32%
32%
34%
67%
68%
66%
Don't know
Rent/Lease
Own/Buying
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=1,355,817)

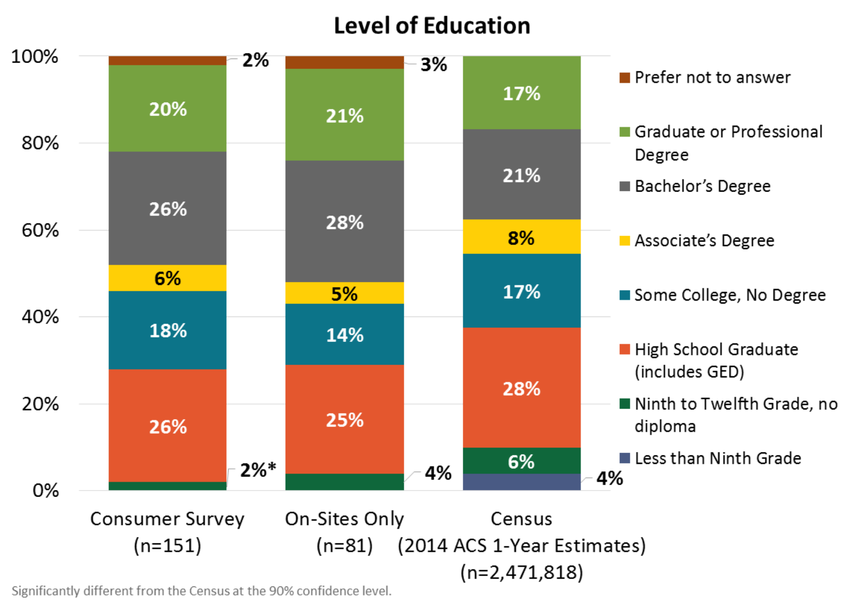

Income
6%
36%
59%
Low Income
Not Low Income
Prefer not to answer
5%
30%
65%

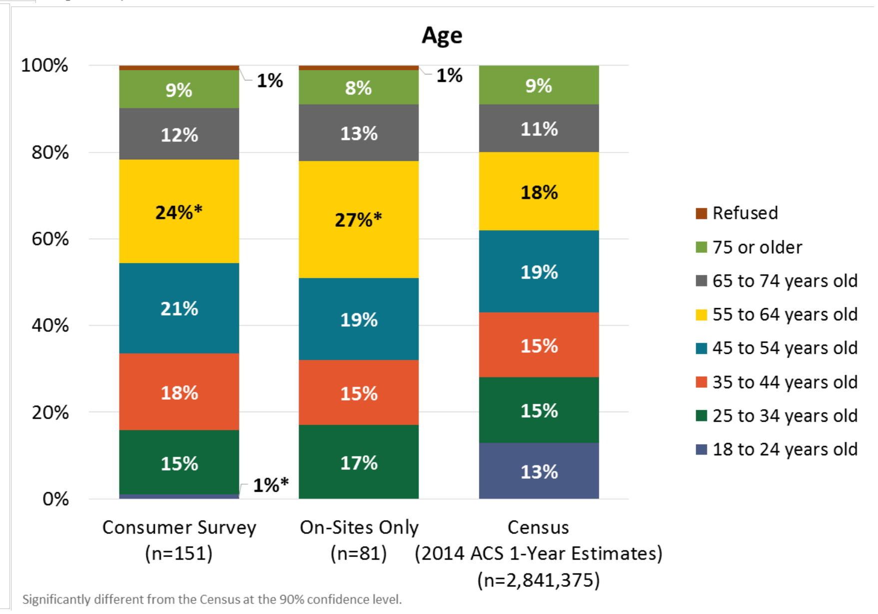

Home Size
100%
80%
60%
40%
20%
0%
21%
2%
10%
13%
22%
32%
16%
4%
9%
13%
23%
36%
Don't know
3,500 to less than 4,000 sq ft
2,500 to less than 3,500 sq ft
2,000 to less than 2,500 sq ft
1,400 to less than 2,000 sq ft
Less than 1,400 sq ft
Consumer Survey (n=151)
On-Sites Only (n=81)


When Built
(Base: Respondents with single family homes only)
100%
80%
60%
40%
20%
0%
9%
6%
6%
11%
8%*
19%
15%
7%
19%
7%
3%*
7%
13%
8%*
23%*
12%
11%
17%
8%
8%
13%
13%
14%
15%
7%
23%
Don't know
2000 or later
1990s
1980s
1970s
1960s
1950s
1940s
1930s or earlier
Consumer Survey (n=106)
On-Sites Only (n=56)
Census (2014 ACS 1-Year Estimates) (n=1,493,632)
*Significantly different form the Census at the 90% confidence level.


Number of Rooms
(not including bathrooms)
100%
80%
60%
40%
20%
0%
1%
25%
24%*
30%
15%
26%
25%*
26%
16%
22%
36%
24%
14%
Don't know
8 or more rooms
6 to 7 Rooms
4 to 5 Rooms
1 to 3 Rooms
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=1,493,632)
*Significantly different form the Census at the 90% confidence level.


Number of People
100%
80%
60%
40%
20%
0%
1%
24%
18%
33%
23%*
1%
24%
12%
37%
26%
22%
16%
33%
29%
Prefer not to answer
4 or more people
3 people
2 people
1 person
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=1,355,817)
*Significantly different form the Census at the 90% confidence level.


Level of Education
100%
80%
60%
40%
20%
0%
2%
20%
26%
6%
18%
26%
2%*
3%
21%
28%
5%
14%
25%
4%
17%
21%
8%
17%
28%
6%
4%
Prefer not to answer
Graduate or Professional Degree
Bachelor's Degree
Associate's Degree
Some College, No Degree
High School Graduate (includes GED)
Ninth to Twelfth Grade, no diploma
Less than Ninth Grade
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=2,471,818)
Significantly different from the Census at the 90% confidence level.


Age
100%
80%
60%
40%
20%
0%
9%
1%
12%
24%*
21%
18%
15%
1%*
8%
1%
13%
27%*
19%
15%
17%
9%
11%
18%
19%
15%
15%
13%
Refused
75 or older
65 to 74 years old
55 to 64 years old
45 to 54 years old
35 to 44 years old
25 to 34 years old
18 to 24 years old
Consumer Survey (n=151)
On-Sites Only (n=81)
Census (2014 ACS 1-Year Estimates) (n=2,841,375)
Significantly different from the Census at the 90% confidence level.

A

Appendix A Methodology

In this appendix, we provide methodological details concerning the R154 study, including the consumer survey, the on-site saturation survey, comparison area data collection, weighting schemes, and interpolation of data for missing data points.

A.1 CONSUMER SURVEY

For the 2015 R154 study, the telephone survey screened respondents by asking them if they would participate in the on-site part of the study. If the respondent agreed, the interview would continue; if he or she did not agree, the call was terminated. This differed from previous evaluations in Connecticut conducted in 2009, 2012, and 2013. In the past, NMR relied on a study design approach in which we first called randomly selected customers of Eversource and UI to conduct a telephone survey that explored various lighting- and EISA-related issues. At the end of the telephone survey, the interviewer offered each respondent an incentive to participate in an on-site visit to his or her home that would be used to gather more information about that household's lighting use. The change in methodology in 2015 was driven by budgetary needs.

In all years, NMR randomly selected households from among all respondents voicing interest in participating and called to set up on-site visits.

A.2 ON-SITE SATURATION SURVEY

For the 2015 R154 study, NMR completed 81 on-site lighting inventory visits. In addition, in this report we have incorporated the results of on-site visits completed in 2009 (95 visits), 2012 (100 visits), and 2013 (90 visits). Sampling methods varied slightly across the studies, with the 2013 sample designed to secure comparable numbers of single-family and multifamily homes.

In each wave of on-sites, NMR or its subcontractor employed and trained technicians to conduct the on-site data collection. A typical on-site visit proceeded as follows: A technician arrived at the home at a pre-scheduled time, introduced him- or herself, and asked for the contact person who had been identified when scheduling the visit. The technician then walked through each room of the home (including the home's exterior and exterior structures), examining all lighting sockets and gathering data on fixture type, bulb type, bulb shape, socket type, wattage, and specialty characteristics for all installed lighting products. The technician also examined bulbs in storage, again noting similar detailed information on each type of bulb, and asked the householder specific questions regarding the house's lighting. In the 2013 study, technicians also installed time-of-use light meters (loggers); additional detail on the loggers is included in the Northeast Residential Lighting Hours-of-Use Study.[31]

[31] NMR, Northeast Residential Lighting Hours-of-Use Study, 2014. http://tinyurl.com/TimelessHOU

Starting in 2012, in addition to closely reviewing the on-site data submitted by the technicians, NMR began to collect data directly instead of through subcontractors. In addition, as an extra level of quality control, NMR began calling 20% of participants to ensure that their experiences with the field technician were satisfactory and revisited approximately 5% of the homes, repeating the data collection process to ensure that the highest quality data was collected.

A.2.1 Comparison Area Data Collection

In addition to examining Connecticut-specific lighting inventory data, this report explores the saturation of energy-efficient residential lighting products in Connecticut over time *in reference* to six comparison areas: Massachusetts, New York, Maine, Rhode Island, Georgia and Kansas. NMR focused on these particular comparison areas for a number of reasons, including the availability of prior saturation estimates that allowed us to look at a time series of data, but also because they display varying levels of lighting program activity. Georgia recently began providing incentives for CFLs and LEDs (earlier it had focused on education and small promotions or bulb giveaways), whereas Kansas is a non-program-activity comparison area not currently or historically providing incentives for efficient lighting. Massachusetts continues to provide incentives for standard CFLs, specialty CFLs, and LEDs; New York, on the other hand, ceased standard spiral CFL incentives in 2012 and gradually removed any remaining specialty and LED incentives by the second half of 2014. In this way, NMR could consider the impact of differing levels of program support on changes in efficient bulb saturation. We compare the prior Connecticut data to those collected from these four states between 2009 and 2015.

While we present data from nine comparison areas, NMR believes that the data from Massachusetts and New York offer the most pertinent comparisons. Massachusetts has the longest uninterrupted time series of lighting data in the nation and continues to offer comparable programs to Connecticut; New York offers a unique natural experiment because of the recent withdrawal of residential lighting programs in that state. California is another good source, but the data are sparse and the last available data are from 2012—which, given the rapid pace of change in the market, might not reflect the current status of lighting in California.

A.3 WEIGHTING SCHEME

NMR weighted the 2015 on-site data to reflect the population proportions for tenure and home type in Connecticut based on the American Community Survey (ACS) 2014 1-year Estimates. The guiding principles behind the scheme are as follows:

- To maintain comparability to previous schemes dating back to 2009
- To reflect the 2015 population of Connecticut

Due to the limited number of multifamily owner-occupied housing units in the sample, the scheme combined owner-occupied housing units into one group, but split renter-occupied units into single-family and multifamily. The consumer survey was weighted in the same manner in order to maintain consistency. The 2015 weights used are shown in Table 29. Weighting schemes from prior Connecticut studies are shown in Table 30 below.

Table 29: 2015 Connecticut On-Site Visits Weighting Scheme

Tenure and Home Type	Households	Sample Size	Proportionate Weight	Sample Error
On-Site Visits Only				
Total	*1,355,973*	*81*	*n/a*	*9.6%*
Owner-Occupied Housing Units	917,074	56	0.97	11.1%
Renter-Occupied Housing Units				
Single Family	87,430	10	0.52	27.4%
Multifamily	351,469	15	1.40	22.0%
Consumer Survey				
Total	*1,355,973*	*151*	*n/a*	*7.1%*
Owner-Occupied Housing Units	917,074	106	0.96	8.0%
Renter-Occupied Housing Units				
Single Family	87,430	20	0.49	18.9%
Multifamily	351,469	25	1.57	16.8%

Table 30: Connecticut Weighting Schemes 2009-2013

Year	Tenure and Home Type	Households	Sample Size	Proportionate Weight	Sample Error
	Total	*1,326,092*	*95*		*9.9%*
	Owner-Occupied	917,097	76	0.86	9.5%
2009	Renter-Occupied***				
	Single Family**	76,331	10	0.55	27.4%
	Multifamily	332,664	9	2.65	29.1%
	Total	*1,355,973*	*100*		*11.5%*
	Owner-Occupied				
	Single Family	821,275	81	0.75	9.2%
2012	Multifamily	95,799	6	1.18	36.8%
	Renter-Occupied				
	Single Family	87,430	7	0.92	33.6%
	Multifamily	351,469	6	4.32	36.8%
	Total	*1,355,973*	*90*		*9.8%*
	Owner-Occupied				
	Single Family	821,275	34	1.60	14.3%
2013	Multifamily	95,799	14	0.45	22.8%
	Renter-Occupied***				
	Single Family	87,430	11	0.53	26.0%
	Multifamily	351,469	31	0.75	15.0%

* Includes one "Occupied without payment or rent."
** Includes one "Don't know."

A.4 INTERPOLATION OF 2010, 2011, AND 2014

Because saturation studies were not conducted in Connecticut in 2010, 2011, or 2014, NMR interpolated saturation for these years based on the 2009, 2012, 2013, and 2015 on-site data. We used straight line interpolation to provide estimates for missing years. This interpolation is provided in order to aid tracking trends over time in Connecticut and across comparison areas for which data collection time periods do not align.