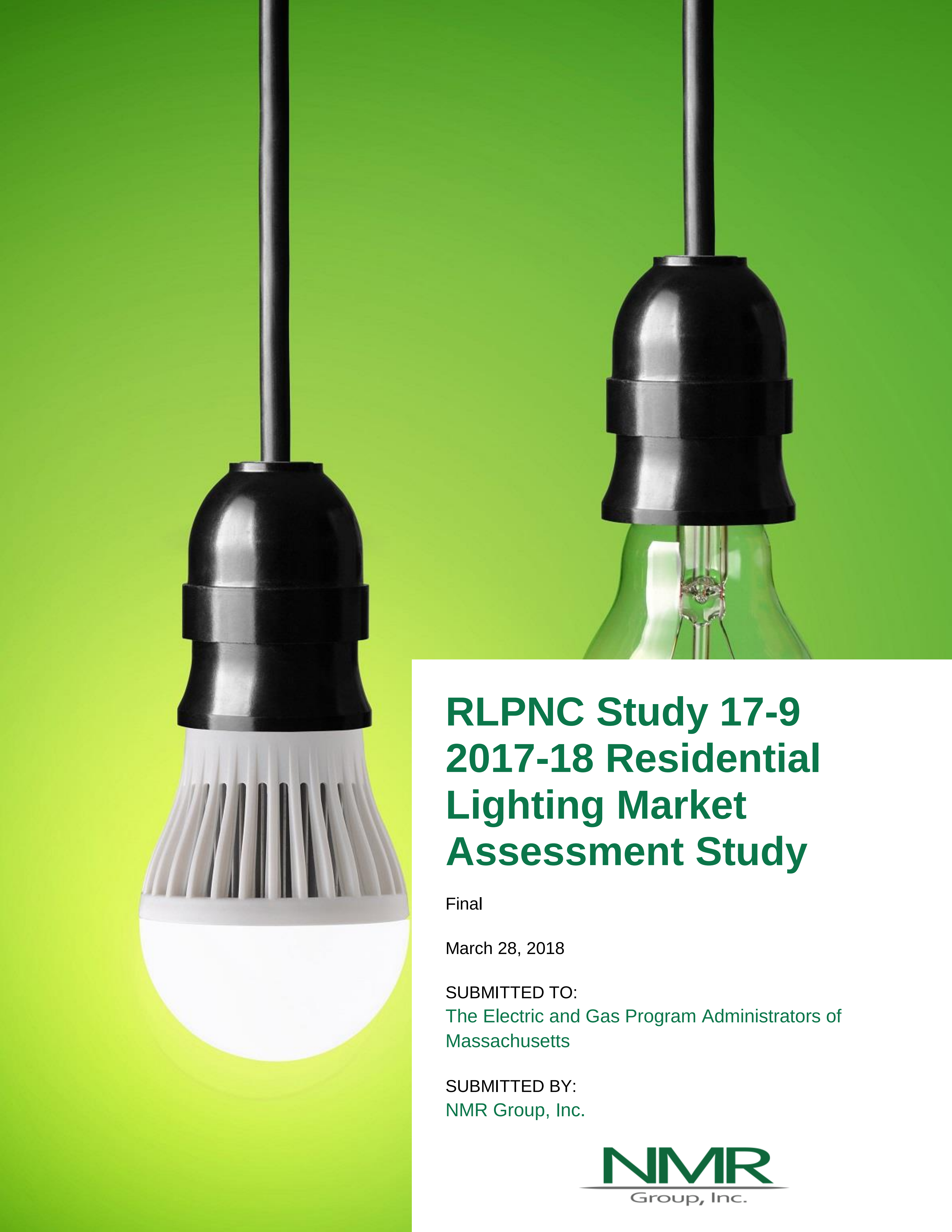


RLPNC Study 17-9 2017-18 Residential Lighting Market Assessment Study

Final

March 28, 2018

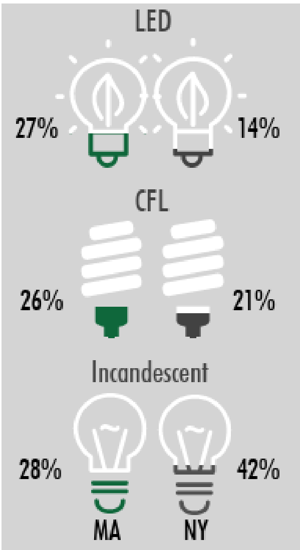
SUBMITTED TO:
The Electric and Gas Program Administrators of Massachusetts

SUBMITTED BY:
NMR Group, Inc.

Massachusetts Residential Lighting Market Assessment

As the results of this study show, the Massachusetts programs have had a strong impact on the saturation and penetration of LED bulbs. LED saturation and penetration rates in the comparison area (New York) continue to lag behind the rates measured in Massachusetts. In addition, ENERGY STAR LEDs (the only LEDs supported by the programs) account for the majority of the difference in LED saturation between the two states - with more than three times as many ENERGY STAR LEDs found in use in Massachusetts compared to New York.

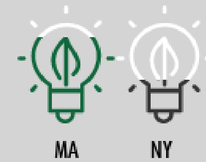
2018 Saturation Rates



In 2018, LED saturation (the percentage of sockets filled with these bulbs) was significantly higher in Massachusetts than in New York.

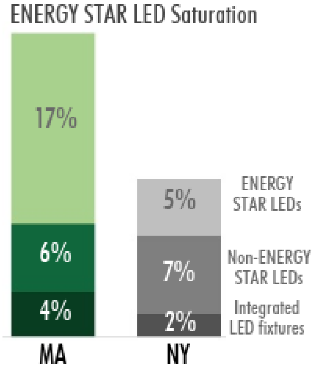
Incandescent saturation was significantly lower in Massachusetts.

In Massachusetts, 74% of LEDs obtained in the previous year were ENERGY STAR, compared to 37% in New York.



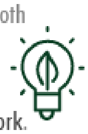
Saturation of ENERGY STAR LEDs in Massachusetts (17%) was more than three times the rate observed in New York (5%).

This is strong evidence that the Massachusetts programs (which exclusively support ENERGY STAR products - including LEDs) are driving increased adoption of LEDs.

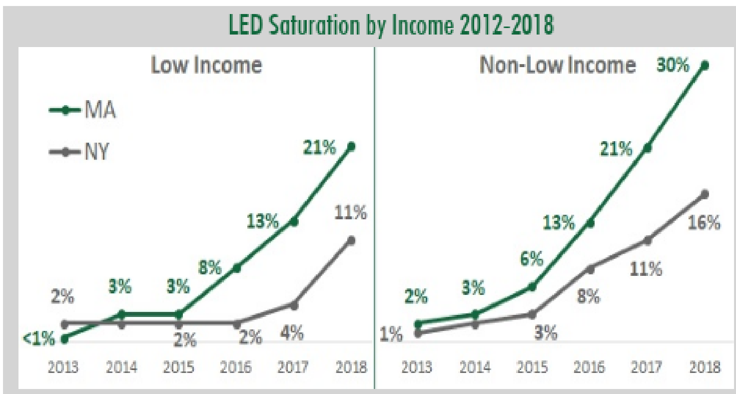


LED Saturation by Demographics

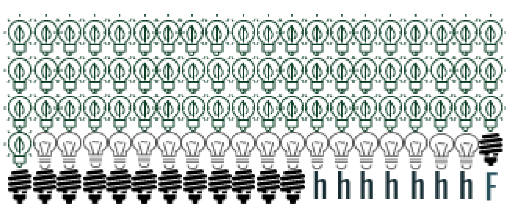
In 2018, LED saturation among both non-low-income and low-income households in Massachusetts was significantly higher compared to counterpart households in New York.



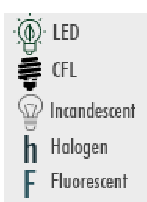
LED saturation was also significantly higher in Massachusetts in multifamily households, single-family households, owned homes, and homes where the highest level of education was "some college, Associate's degree" or "Bachelor's degree or higher."

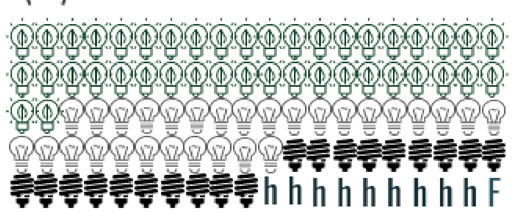


Newly Installed Replacement Bulbs (%) 2017-2018



LED bulbs (61%) were the most common replacement bulb installed in Massachusetts households, followed by incandescent bulbs (28%), CFLs (13%), halogen bulbs (7%), and linear fluorescents (1%); empty sockets exluded.





LED bulbs (42%) were also the most common replacement bulb installed in New York households, followed by incandescents (29%), CFLs (19%), halogen bulbs (9%), and linear fluorescents (1%); empty sockets exluded.

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Executive Summary

This report presents the results of the 2017-18 Massachusetts Residential Lighting Market Assessment Study conducted by NMR Group, Inc. The study was designed to update estimates of lighting saturation and other critical market indicators in Massachusetts. The data for this study came from on-site lighting inventories of homes in Massachusetts and a comparison area (portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse, as well as all of Westchester County – referred to as *New York* in this report) completed between October and December of 2017. Portions of New York were chosen as a comparison area because they present a unique opportunity to understand how the residential lighting market has responded to the cessation of standard spiral CFL incentives in 2012 and essentially all upstream incentives in 2014.[1] New York is also a good comparison area because, the demographic profile of the combined New York comparison area offers a close approximation to Massachusetts.

It is important to note that, unlike previous waves of the study, the 2017-18 Market Assessment relied entirely on visits to panel households, some of which first took part in on-site saturation studies in 2013. In the past, we have also visited newly identified households to replace panelists who drop out, increase the sample size, and test for possible Hawthorne (reactive) effects among panelists. Over four waves of panel visits, we did not detect any significant differences in bulb saturation or other critical market indicators between new and panel visits.[2] This provides strong evidence that the panelists are not exhibiting the Hawthorne effect. Therefore, we visited only panelists this year to reduce costs and shorten the timeline of the study.

Throughout the report we refer to the saturation and penetration of various lighting technologies (LEDs, CFLs, halogens, and incandescent bulbs). **Saturation** is the percentage of sockets filled with a specific bulb type. **Penetration** is the percentage of homes with one or more of a specific lighting technology.

Previous waves of site visits in Massachusetts and New York have typically taken place in the fall and winter (crossing two calendar years). Given this, we chose to label them as representing the beginning of a year. The 2015-16 visits are labeled 2016, the 2016-17 visits are labeled 2017, and the most recent visits are labeled 2018, though the visits took place between October and December 2017. Additional details on visiting time are provided in Appendix A.

This executive summary begins with an overall assessment followed by key findings. The remaining body of the report presents more detailed findings from these efforts. Each section of the report is accompanied by a corresponding appendix with greater levels of details.

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[1] Note: the comparison are does not include Long Island or New York City.

[2] Note: Differences between panel and new visits were detected as part of the 2015-16 study but were determined to be due to timing of visits. In that year, NMR completed all of the panel visits before the new visits - this error in timing was corrected as part of the 2016-17 visits and no differences were detected in that year.

Overall Assessment

Evidence from this study suggests that the Massachusetts programs continued to have a strong impact on saturation and penetration of LEDs. While consumers in the New York comparison area were also adopting LEDs, LED saturation (percent of sockets) and penetration (percent of homes with at least one LED) rates continued to lag the rates measured in Massachusetts. ***LED saturation was 27% in Massachusetts compared to only 14% in New York. LED penetration was 86% in Massachusetts compared to 72% in New York.***

Not only did LED saturation in Massachusetts continue to outpace that in the New York comparison area, but ***the gap in saturation between the two areas widened in each of the last three years*** – indicating that LED sales growth has yet to reach a plateau in Massachusetts.

Further, ***ENERGY STAR® LEDs (the only type of LEDs supported by Massachusetts program efforts) accounted for nearly the entire difference in LED saturation between the two areas***, providing strong evidence that the Massachusetts programs are continuing to have a profound impact on the market.

Impact Factors

As part of this study, NMR prepared updated estimates of residential lighting hours of use based on the results of the 2014 Northeast Residential Lighting Hours-of-Use Study[3] and changes in saturation over time. This study also provided updated discounted lifetime in-service rates for LEDs. These impact factors are provided in Table 1. Details on the methods used to update HOU can be found in Section 2.3. Details on the methods used to update ISR can be found in Section 6.3.

Table 1: Updated Impact Factors

Factor	Prior Value	Updated Value
LED Daily HOU	2.9	**3.0**
LED Discounted Lifetime ISR		
A-line ISR[1]	98%	**93%**
Reflector ISR[2]	98%	**94%**
Specialty ISR[2]	98%	**94%**

[1] Assumes a sunset year of 2022

[2] Assumes a sunset year of 2023

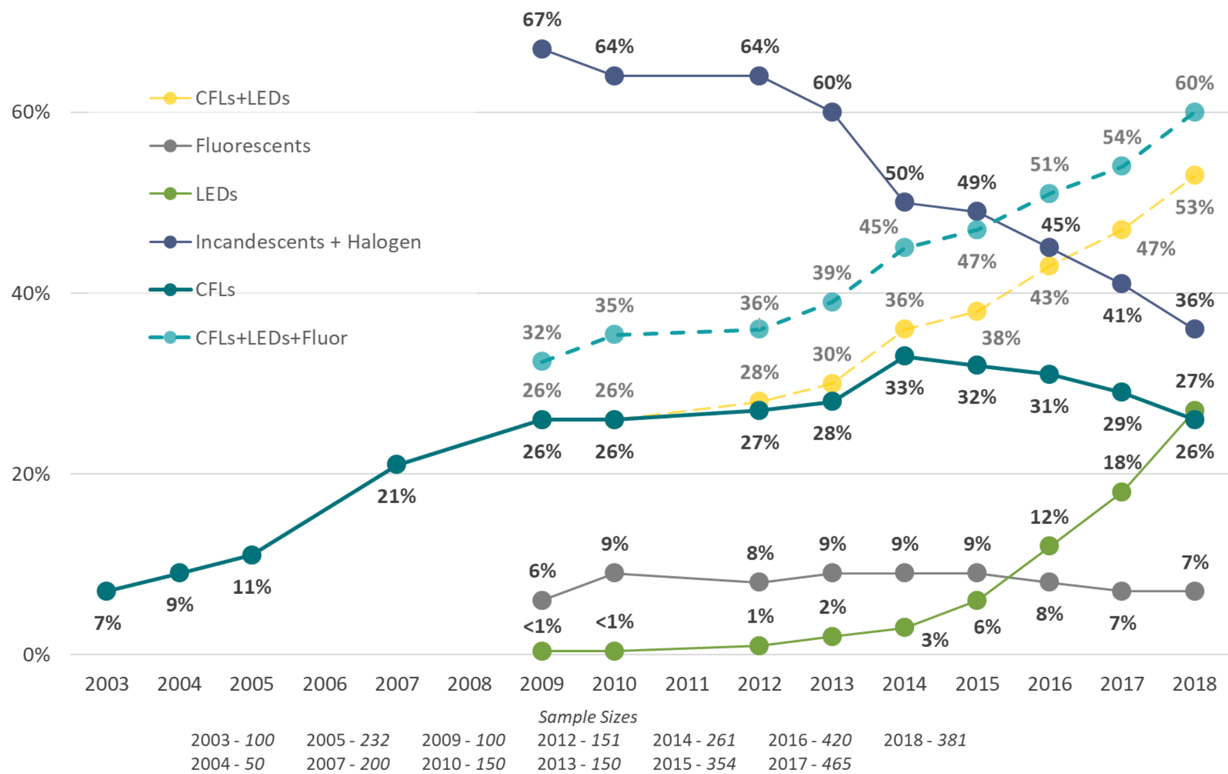
[3] NMR, Northeast Residential Lighting Hours-of-Use Study, 2014. http://tinyurl.com/TimelessHOU

Key Findings

Socket Saturation Trends

Between 2009 and 2018, Massachusetts experienced a steady increase in efficient bulb saturation and a corresponding decrease in incandescent bulb saturation. As Figure 1 shows, ***LED saturation has grown rapidly since 2014, increasing eight-fold from 2014 to 2018, outpacing CFL saturation this year for the first time since we began collecting data.*** CFL saturation has declined steadily (although not statistically) over the past four years. Despite this, saturation of efficient bulbs (CFLs and LEDs) was over 50%, while saturation of inefficient bulbs (incandescent and halogen) declined to 36%. When fluorescent saturation is added to CFL and LED saturation, nearly two-thirds (60%) of all sockets in Massachusetts were filled with an efficient bulb type in 2018. Additional analysis related to saturation trends over time, including by room type, can be found in Section 2.

Figure 1: Saturation in Massachusetts Over Time



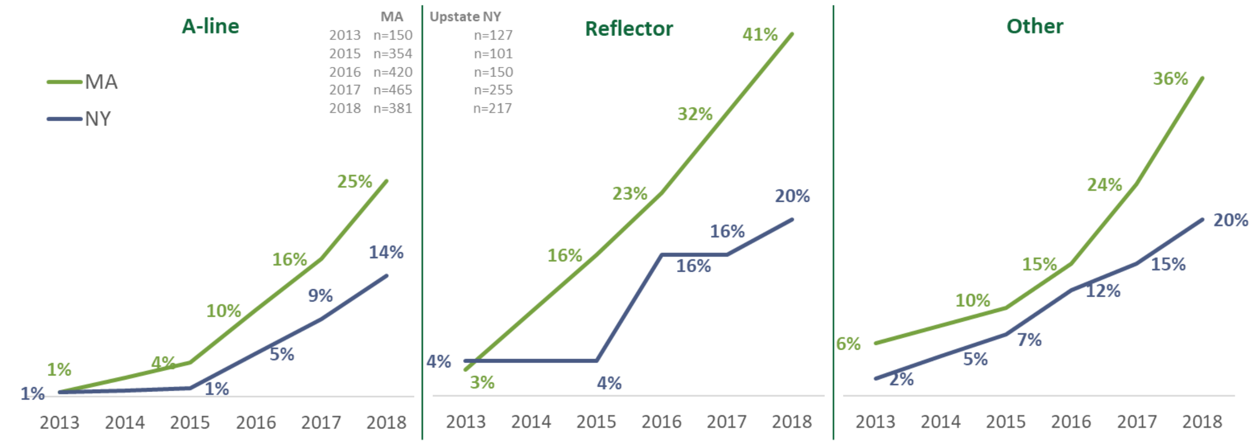
Comparison Area Trends

The use of a comparison area design allowed us to compare trends in Massachusetts, a state that continues to support LED bulbs, to those in portions of Upstate New York, an area that largely phased out its support of energy-efficient bulbs between 2012 and 2014. As Figure 4 shows, ***while New York has also experienced growth in LED saturation, the pace of LED adoption has been slower than that observed in Massachusetts; in fact, the gap***

in LED saturation between the two areas has widened in each of the last three years – indicating that program-induced LED sales growth has yet to level off.

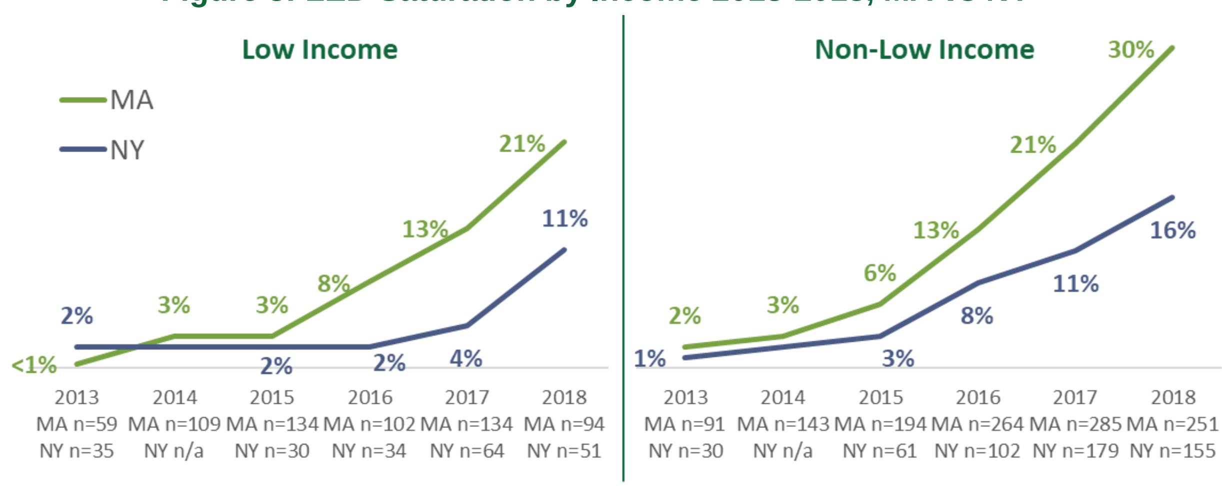
Based on the most recent market assessment, one out of four (25%) A-line bulbs were LED, two out of five (41%) reflector bulbs were LEDs, and over one-third (36%) of other bulbs were LEDs; in New York, only 14% of A-line bulbs were LED, only one out of every five reflector bulbs (20%) was an LED, and one out of every five other bulbs (20%) was an LED.

Figure 2: LED Saturation by Bulb Shape 2013-2018, MA vs NY



In 2018, LED saturation among both non-low-income and low-income households in Massachusetts was significantly higher compared to counterpart households in New York (30% vs. 16%, non-low-income; 21% vs. 11%, low-income).

Figure 3: LED Saturation by Income 2013-2018, MA vs NY

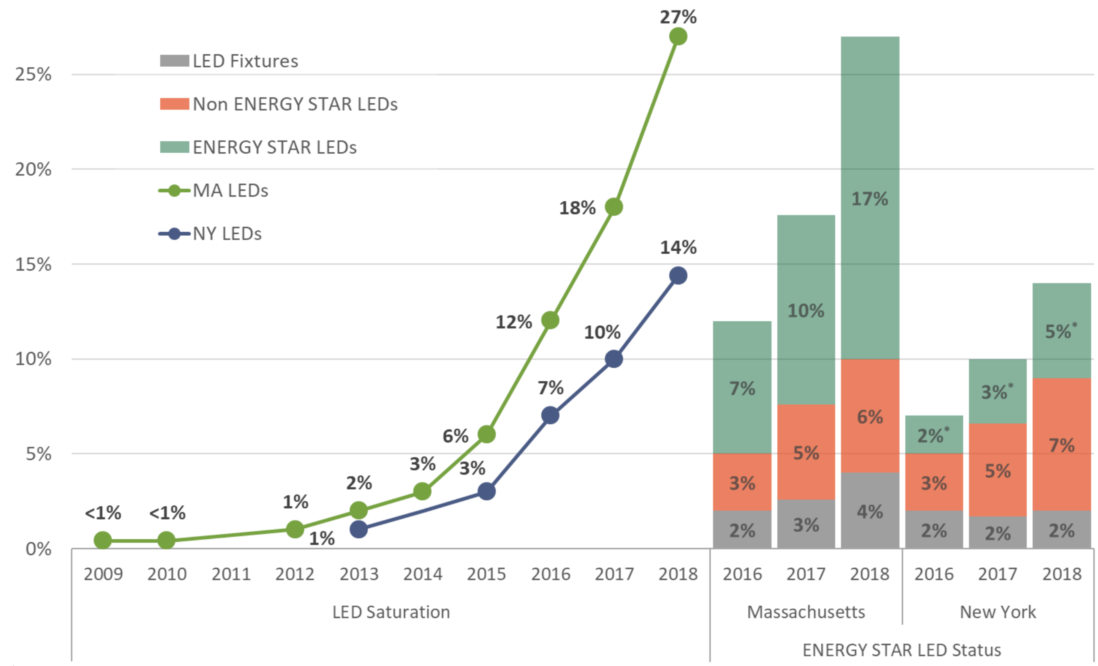


ENERGY STAR® LEDs

Figure 4 also shows the saturation of ENERGY STAR® LEDs in both areas starting in 2016. ***Not only was saturation of ENERGY STAR LEDs more than three times higher in Massachusetts than in New York (17% vs. 5%, a statistically significant difference), but the increased saturation of ENERGY STAR LEDs accounted for almost the entire difference in LED saturation between the two areas.*** This is strong evidence that program support in Massachusetts (exclusively for ENERGY STAR products, including LEDs) is driving increased adoption of LEDs in the state.

At the same time, increases in non-ENERGY STAR LED saturation in both areas and increases in ENERGY STAR LED saturation in the New York comparison area offer evidence of naturally occurring market adoption of LEDs. Additional analysis of ENERGY STAR LEDs can be found in Section 2.1.1 and Section 5.2.

Figure 4: LED Bulb Saturation 2009-2018 with ENERGY STAR LEDs in 2016-2018



* Significantly different from Energy Star LEDs in corresponding year in MA at the 90% confidence level
Note: Percentages are rounded.

Penetration

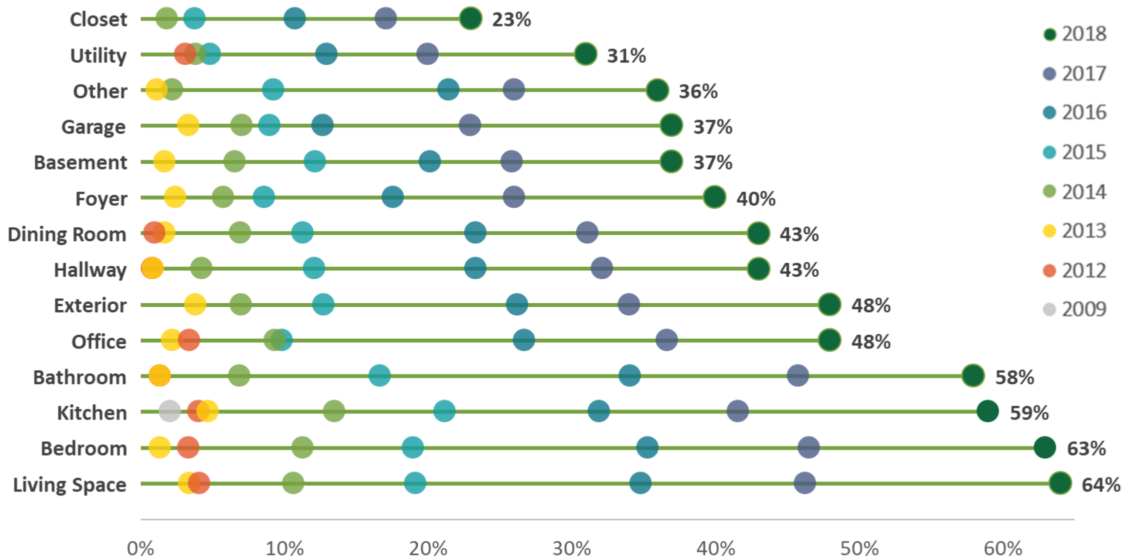
In addition to saturation, penetration is an important early gauge of LED program success. As more households try LEDs[4] and penetration rates rise, saturation rates should follow suit as households expand LED installation to more sockets. ***LED penetration has skyrocketed in Massachusetts, from only 12% of homes in 2013 to nearly nine out of ten homes (86%) in 2018. We also observed a dramatic increase in penetration in the comparison area from 2013 to 2018 (up from 17% to 72%).***

As Figure 5 shows, in Massachusetts, LED penetration has tripled since the 2015 study in nearly all room types (aside from kitchens). Living spaces had the highest LED penetration (64%), followed closely by bedrooms (63%), kitchens (59%), and bathrooms (58%). Importantly, kitchens and living spaces are among the three room-types with the highest hours of use according to the Northeast Residential Lighting Hours-of-Use study. Additional

[4] This assumption is partially based on high levels of LED satisfaction among survey participants, as discussed in Section 7 of this report.

details on penetration, including penetration for other lighting technologies, can be found in Section 3 and Appendix C.

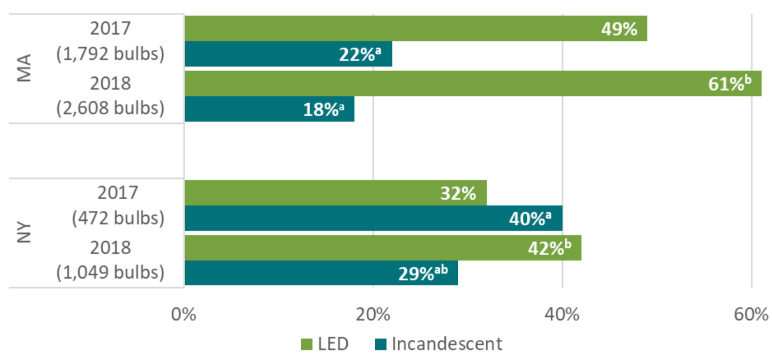
Figure 5: MA LED Penetration by Room Type, 2009-2018



Panel Visits – Changes in Bulb Types over Time

During the panel visits, technicians compared the bulb in each socket found during the most recent lighting inventories (2018) to data listed for the previous lighting inventories (2017), directly observing bulb replacement behavior. As Figure 6 shows, in 2017, LEDs were the most common replacement bulb type (49%) in Massachusetts and the second most common replacement bulb type in New York (32%) (incandescents were the most common in 2017 in NY). ***In 2018, 61% of replacement bulbs installed in Massachusetts were LEDs, and for the first time, LEDs (42%) made up a larger share of replacement bulbs in New York than incandescent bulbs (29%).***

Figure 6: Replacement Bulbs, 2017-2018



[a] Significantly different from MA at the 90% confidence level.
[b] Significantly different from 2017 at the 90% confidence level.

While LEDs were a popular replacement choice, we observed some panelists replacing LEDs with inefficient alternatives. While this behavior was observed in both areas, it was less common in Massachusetts than in the New York comparison area. In Massachusetts, 13% of LEDs were replaced with halogens or incandescent bulbs, compared to 23% in the New York comparison area. Despite some level of backsliding, LED saturation continues to rise in both areas (as discussed above). Additional details on bulb replacement behavior, including types of bulbs replaced, can be found in Section 4.

Storage Behavior

A majority of homes (85%) in the on-site study had at least one bulb in storage. ***Incandescent bulbs were still the most commonly stored bulb type in both Massachusetts and New York, (51% and 58%, respectively).*** About one out of every ten incandescents that were in storage at the beginning of 2017 had been installed by the beginning of 2018 in both areas (10% in Massachusetts and 11% in the comparison area). In Massachusetts, an additional 12% of incandescent bulbs that had been in storage in 2017 were thrown out/recycled between the 2017 visit and the 2018 visits, while only 8% were thrown out/recycled in New York.

Considerations, and Guidance

In this section, NMR offers recommendations, considerations, and guidance for future study planning based on the findings discussed in this report. For each recommendation, consideration, or point of guidance, we offer a rationale based on the findings from evaluation activities conducted as part of this study.

Considerations

Consideration 1: The PAs should continue with plans to include integrated LED fixtures as part of the next program cycle (2019 – 2021).

> *Rationale: Integrated LED fixture saturation has slowly increased since 2016, growing by one percentage point each year (from 2% in 2016 to 4% in 2018). Additionally, over the same period, integrated LED fixture saturation has remained steady (at 2%) in the comparison area. While the difference between the two areas is not statistically significant, the relative growth in Massachusetts does offer some evidence of program effects.*

Consideration 2: The PAs should continue to carefully consider what program efforts can be made to encourage customers to replace inefficient bulbs before failure. The PAs may want to consider a bulb buyback program to persuade people to change out inefficient bulbs before they burn out, fill sockets with LEDs, and remove inefficient bulbs from storage.

> *Rationale: Depending on the outcome of the DOE's examination of the EISA Phase II rulemakings, the window for capturing savings from the residential lighting market may be closing. The high rate of incandescent-to-LED and incandescent-to-CFL conversions found in the study indicates that consumers are already inclined to replace incandescents with CFLs or LEDs. Still, the majority of bulbs are replaced upon failure and the most common reason householders provided for not using energy-efficient bulbs in particular rooms was that the bulbs had not yet burned out.*

In addition, incandescent bulbs made up the majority (51%) of stored bulbs in Massachusetts homes in 2018, with more than twice as many incandescent bulbs in storage as the next closest bulb type (CFLs). Notably, eight out of ten (80%) panelists said that they had plans to use stored incandescents. If these bulbs are not removed from storage, it is highly likely that they will eventually be installed.

Guidance for Future Study Planning

Guidance 1: The PAs should continue to carefully monitor developments related to EISA Phase II, as well as the lighting market more generally, to help inform decisions regarding the future of the residential lighting programs. Possible sources of information include supplier interviews, interviews with DOE staff, and literature reviews.

Rationale: Given the uncertainty surrounding Phase II of EISA, it will be important for the PAs to stay informed about any developments that could have a dramatic impact on the future of the residential lighting programs. Given the current lack of communication from the DOE, it is difficult to assess what the full impact of EISA Phase II will be. However, if implemented as outlined in the January 2017 rules, it is likely that very few bulbs will remain exempt.

Guidance 2: The PAs should continue to carefully monitor the residential lighting market for signs of naturally occurring market adoption to help identify signs that the programs effects are starting to plateau. The on-site study with the inclusion of the comparison area research offers a unique insight into market changes and the effect of the program.

Rationale: Evidence from this study clearly shows that the programs have had a strong impact on the residential lighting market. While program efforts have expanded the gap in saturation between Massachusetts and the comparison area thus far, there are clear signs of naturally occurring market adoption in the non-program comparison area. If program effects begin to wane, it may signal that it is time to adjust program efforts or begin to implement plans to exit the residential lighting market.

Guidance 3: While this study did not include any new visits, if the PAs choose to pursue this study again in the future, evaluators should consider if new visits are needed to help supplement existing sample and provide a check on Hawthorne effects. If new visits are added, evaluators should ensure that any new visits are fielded concurrently with panel visits to help eliminate possible differences in saturation levels between panelists and new visits based on visit timing.

Rationale: While retention rates for panelists have historically been high (70-80%) over time if the panel is not replenished sample sizes will diminish. For the 2016 on-site visits, NMR completed nearly all of the panel visits before beginning the new visits, which made it difficult to determine whether observed differences in LED saturation were due to Hawthorne effects or were a byproduct of visit timing. For the 2017 on-site visits, NMR completed the new and panel visits concurrently, which appears to have obviated issues detected in 2016.

1 Section 1 Introduction

This report presents the results of the 2017-18 Massachusetts Residential Lighting Market Assessment conducted by NMR Group, Inc. The data for this study came from on-site lighting inventories of homes in Massachusetts and a comparison area (portions of Upstate New York)[5] that were completed from October through December 2017. Throughout this report, this study is referred to as ***2018*** so as to differentiate from the ***2017*** study, which took place between October 2016 and February 2017.

1.1 Study Objectives

The goals of this study are to update estimates of lighting saturation in Massachusetts and portions of Upstate New York. The specific objectives include the continued tracking of some prior critical market indicators, as well as the examining of emerging issues related to changes in the lighting market, such as the advent of new technologies and increased efficiency standards. These objectives are as follows:

- Examine socket saturation by bulb type, including the presence of linear fluorescents.
- Identify installations of ENERGY STAR® qualified versus non-qualified LEDs.
- Examine socket saturation by EISA categories: covered, exempt, directional, and linear fluorescent.
- Determine (via the panel visits) what types of bulbs consumers use to replace those that burn out or are removed.
- Examine bulb storage trends, including installations from storage that lead to increases in ISR after the first year.
- Estimate first year and multi-year in-service rates (ISRs) for LEDs, including examining new bulbs to storage and bulbs taken from storage to be used.
- Provide information on delta watts and early replacement.
- Assess bulbs obtained by customers, including purchase and bulbs obtained through direct install programs.
- Compare the trends in consumer purchases and saturation between Massachusetts and New York to see if evidence of program impact continues.
- Examine whether the lack of NYSERDA incentives still appears to contribute to divergences in efficient bulb socket saturation and household penetration between New York and Massachusetts.

[5] Namely, a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse, as well as all of Westchester County, referred to in this report as *New York. Note: the comparison area does not include Long Island or New York City.*

- Examine whether LED installation patterns necessitate a change in assumed upstream LED Hours-of-Use (HOU).[6]

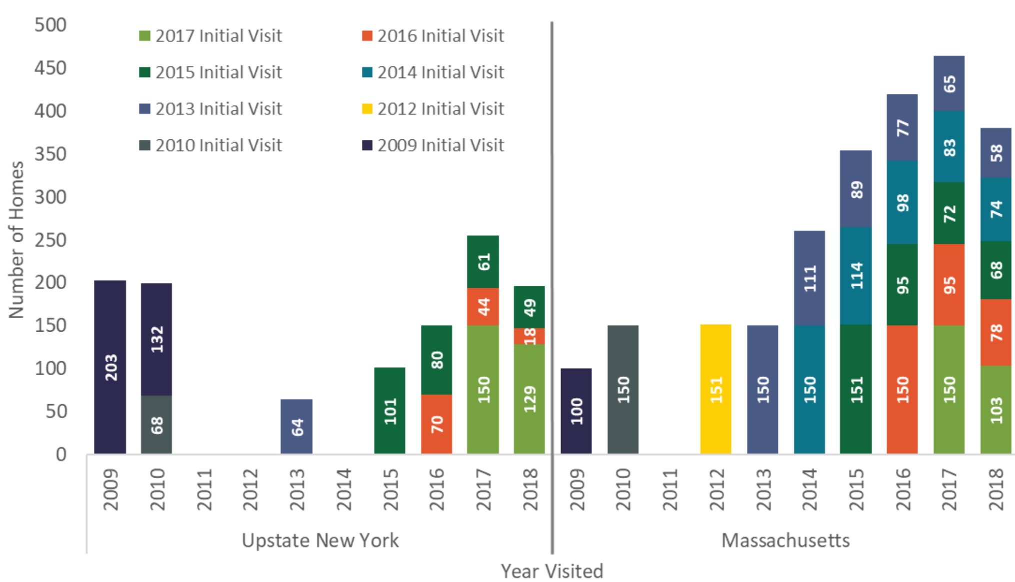
1.2 Methodology

The data for this study came from on-site lighting inventories of homes in Massachusetts and a comparison area (portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse, as well as all of Westchester County, referred to as *New York* in this report) completed between October and December of 2017. New York was chosen as a comparison area because it presents a unique opportunity to understand how the residential lighting market has responded to the cessation of standard spiral CFL incentives in 2012 and essentially all upstream incentives in 2014. New York is also a good comparison area because of its proximity to Massachusetts and the demographic alignment for the comparison area to Massachusetts.

The 2018 Market Assessment represents the most recent efforts in a long-term series of on-site data collection; all of the households in both Massachusetts and New York had taken part in prior on-site visits (panel visits). To date, five waves of panel visits have been completed in Massachusetts and three waves of panel visits have been completed in New York (Figure 7).

The on-site survey data from both Massachusetts and the New York comparison area were weighted to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on the Public Use Microdata Sample (PUMS) from the American Community Survey (ACS) 5-Year Estimates. Additional methodological details can be found in Appendix A.

Figure 7: On-site Visits over Time



6 As updated in 2016: http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Lighting-Hours-of-Use-Update.pdf

2 Section 2 Changes in Socket Saturation Over Time

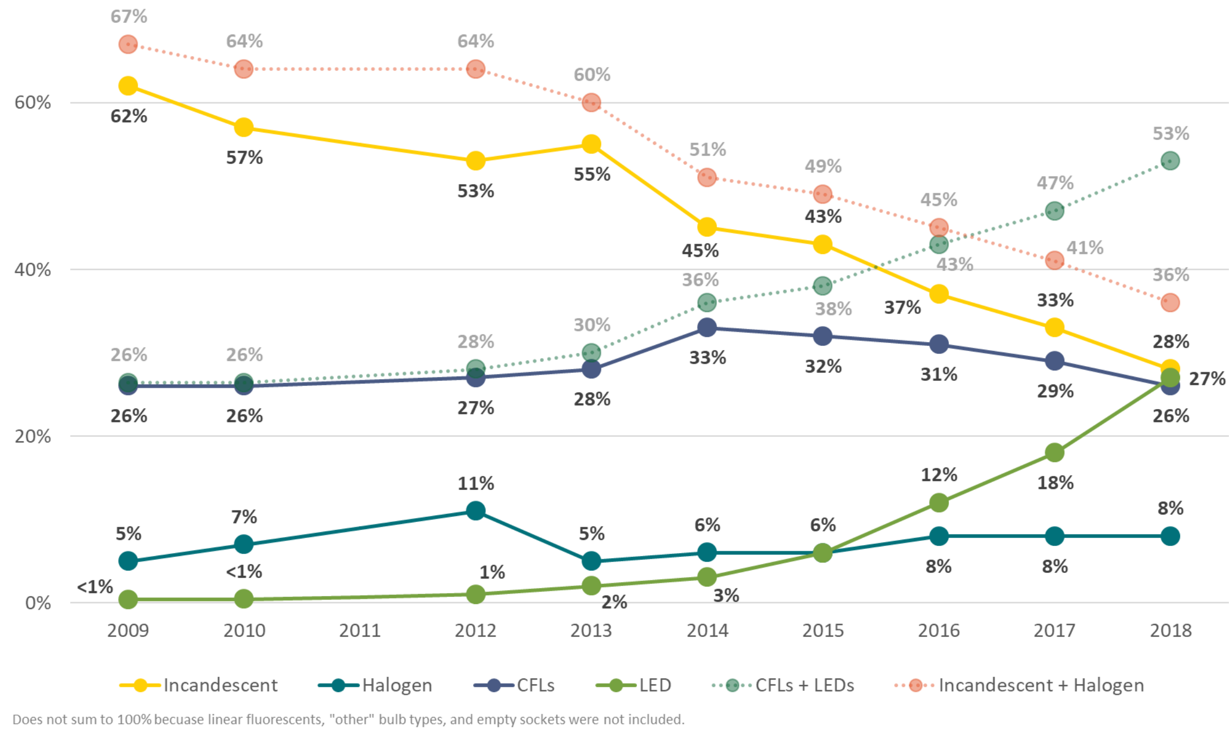
The Massachusetts PAs have been tracking socket saturation (the percentage of sockets filled with a specific bulb type) for CFLs since 2003, and for all bulb types since 2009. In this section, we explore trends in socket saturation in Massachusetts and the comparison area of New York. This includes overall saturation, the saturation of ENERGY STAR-qualified LEDs, and room-by-room saturation.

- ***LED saturation has increased nine-fold since 2014; in 2018, more than one in four sockets (27%) were filled with an LED. At the same time, CFL saturation has been declining steadily since 2014 – down from a high of 33% in 2014 to 26% in 2018.***
- ***Unlike Massachusetts, inefficient bulb saturation in the New York comparison area (51%) remains higher than efficient bulb saturation (43%).***
- ***While the New York comparison area has also experienced growth in LED saturation, in the absence of program support, the pace of LED adoption has been slower than that observed in Massachusetts. In fact, the saturation gap between the two areas has widened in each of the last three years – indicating that LED sales growth in Massachusetts has yet to level off.***
- ***Massachusetts households had significantly higher saturation of ENERGY STAR® LEDs compared to New York households (17% vs. 5%), representing nearly the entire difference in LED saturation between the two areas (27% and 14%, respectively). This is compelling evidence that the Massachusetts programs (which support only ENERGY STAR products) are driving increased adoption of LEDs in Massachusetts compared to New York.***
- ***Examining LED saturation by key demographics provided additional evidence that the Massachusetts programs are impacting a wide variety of customers. Importantly, both low-income households and multifamily households in Massachusetts had higher LED saturation compared to their New York counterparts.***
- ***In 2017, saturation of efficient (CFL and LED) bulbs surpassed that of inefficient (incandescent and halogen) bulbs for the first time in Massachusetts. In 2018, that trend is even more pronounced, with efficient bulb saturation exceeding inefficient bulb saturation 53% to 36%. When fluorescents are included, efficient bulb saturation rises to 60%.***

2.1 Saturation by Household

Figure 8 shows saturation for all bulb types from 2009 through 2018. To aid in understanding trends, we have interpolated data to represent 2011, a year when a study was not completed. The figure clearly shows that Massachusetts has experienced a steady increase in efficient bulb saturation (dotted green line) and a corresponding decrease in inefficient bulb saturation (dotted orange line). In 2018, saturation of efficient (CFL and LED) bulbs (53%) continued to exceed that of inefficient (incandescent and halogen)[7] bulbs (36%). LED adoption continued to drive the increase in efficient bulb saturation, as, over the same timeframe, CFL saturation has been on a slow but study decline since 2014, from 33% in 2014 to 26% in 2018.[8] Notably, LED saturation has increased significantly each year since 2014.

Figure 8: Saturation Rates 2009-2018 (Massachusetts)



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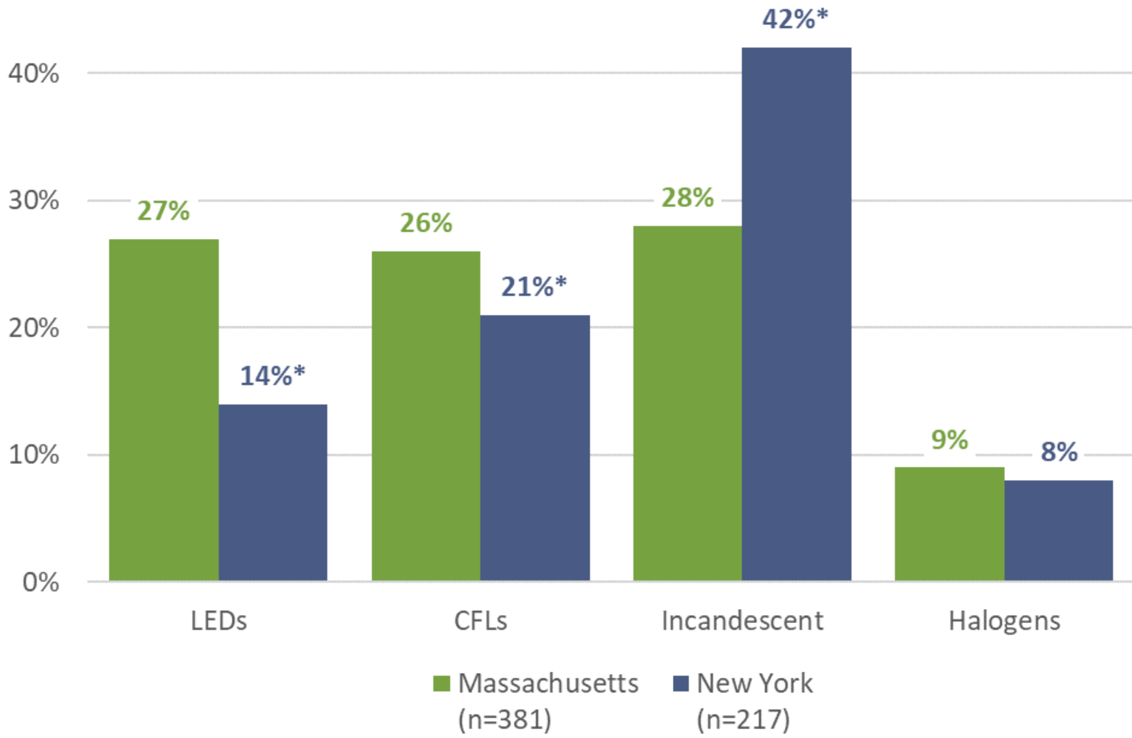
[7] Given the difficulty in distinguishing halogen bulbs from regular incandescent bulbs, we provide estimates for each separately and combined throughout this report.
[8] As discussed in detail in Section 4, in Massachusetts, 13% of removed CFLs were replaced by either an incandescent or halogen. (Figure 18).

Narrowing our focus to just 2018 (Figure 9), we observed significantly higher LED saturation in Massachusetts compared to New York (27% vs. 14%). Not surprisingly, incandescent saturation in Massachusetts was significantly lower compared to New York (28% vs. 42%).

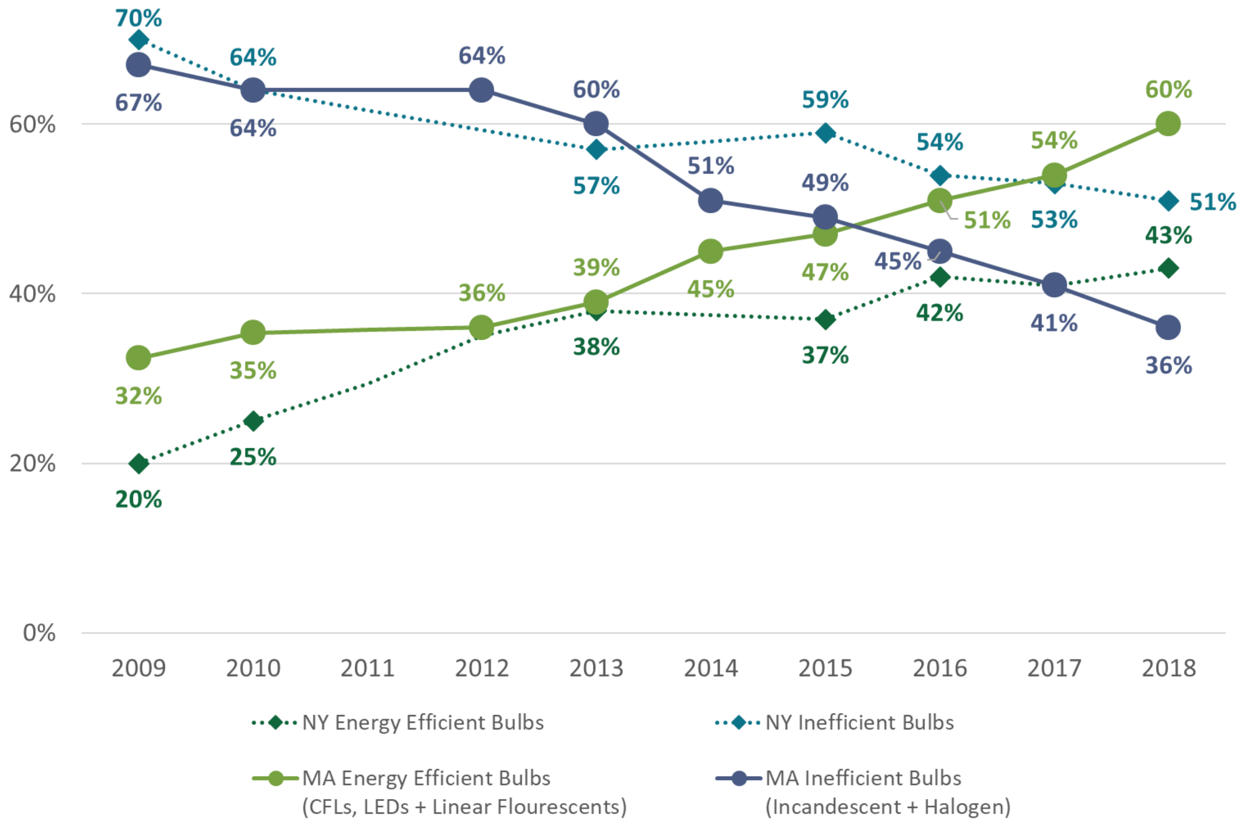
Figure 9: Saturation 2018 (MA & NY)



* Significantly different at the 90% confidence level.

Figure 10 isolates Massachusetts inefficient bulb and efficient bulb saturation trends from 2009 to 2018. In this figure, efficient includes linear fluorescents. When those are added to CFLs and LEDs, 2016 was the first year that efficient bulbs filled more sockets (51%) than inefficient bulbs (46%). In 2018, this trend has continued with efficient bulbs filling three out of every five sockets (60%), while inefficient bulbs filled just over one-third of all sockets (36%). The figure also shows New York's inefficient bulb and efficient bulb saturation trends since 2013. In contrast to Massachusetts, inefficient bulbs still occupy more than one-half of sockets (51%) in New York, while efficient bulbs occupy just 43%. Furthermore, efficient bulb saturation in New York lagged efficient bulb saturation by seventeen percentage points. Additional year-by-year saturation estimates can be found in Appendix B.

Figure 10: Efficient vs. Inefficient Bulb Saturation Rates 2009-2018



Note: Does not sum to 100% because "other" bulb types and empty sockets were not included.

2.1.1 ENERGY STAR® LED Saturation

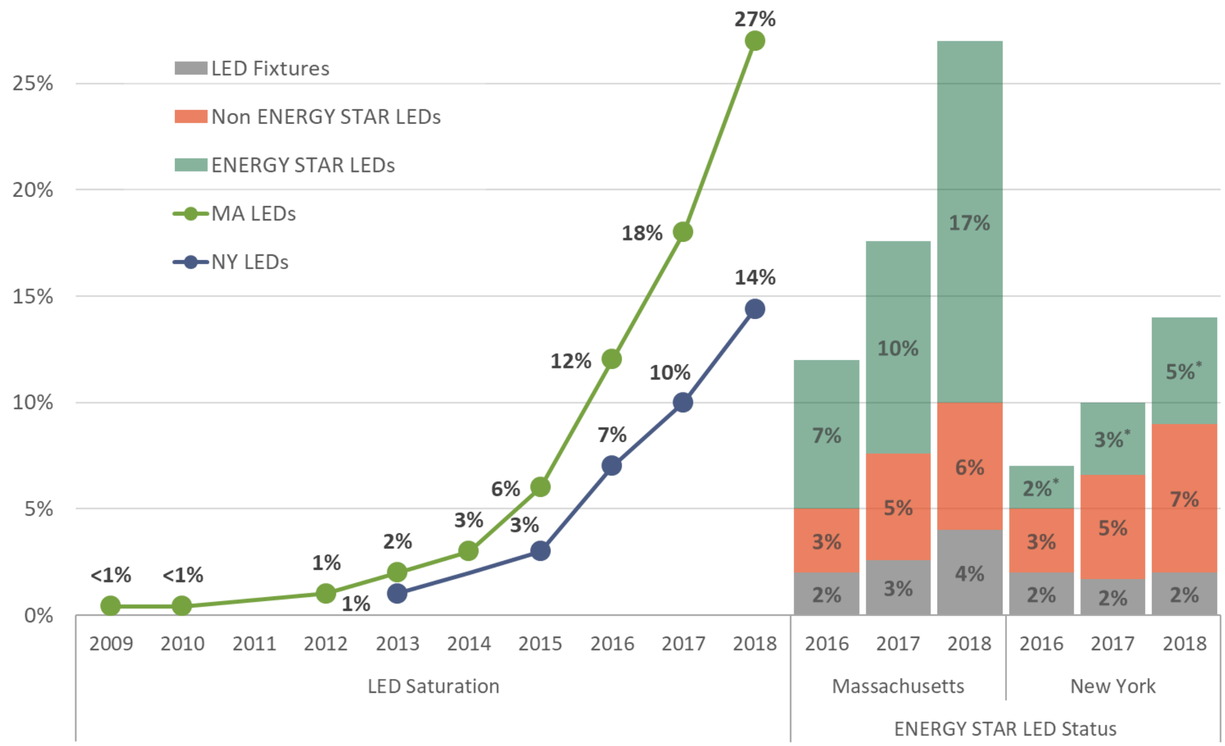
Starting with the 2016 Market Assessment, while on site, technicians collected model numbers for all screw-base LED bulbs (we did not collect model numbers for integrated LED fixtures). Using these model numbers and the list of ENERGY STAR®-qualified LED bulbs, we determined ENERGY STAR status for each LED bulb. Figure 11 provides the results of this analysis for Massachusetts and New York, as well as LED saturation figures for 2009 to 2018 to help provide context. We separated LED saturation into three distinct categories:

- ENERGY STAR qualified
- Non-ENERGY STAR qualified
- Integrated LED fixtures

As the data show, in 2018, ENERGY STAR LED saturation continued to be significantly higher among Massachusetts households than New York households (18% vs. 5%). Interestingly, for the third year in a row, the two states had nearly the same saturation levels for non-ENERGY STAR LEDs (6% in Massachusetts and 7% in New York) and integrated LED fixtures (4% in Massachusetts and 2% in New York). Since the Massachusetts PAs' programs only provide incentives for ENERGY STAR LEDs, this is compelling evidence that the Massachusetts programs are directly leading to increased adoption of ENERGY STAR LEDs. In addition to providing incentives for screw-based ENERGY STAR LEDs, the

Massachusetts program supports ENERGY STAR integrated LED fixtures. While saturation of integrated fixtures is relatively similar in both areas, it may be worth closely monitoring changes in saturation in this area moving forward.

Figure 11: MA & NY LED Bulb Saturation 2009-2018 with ENERGY STAR LEDs 2016-2018

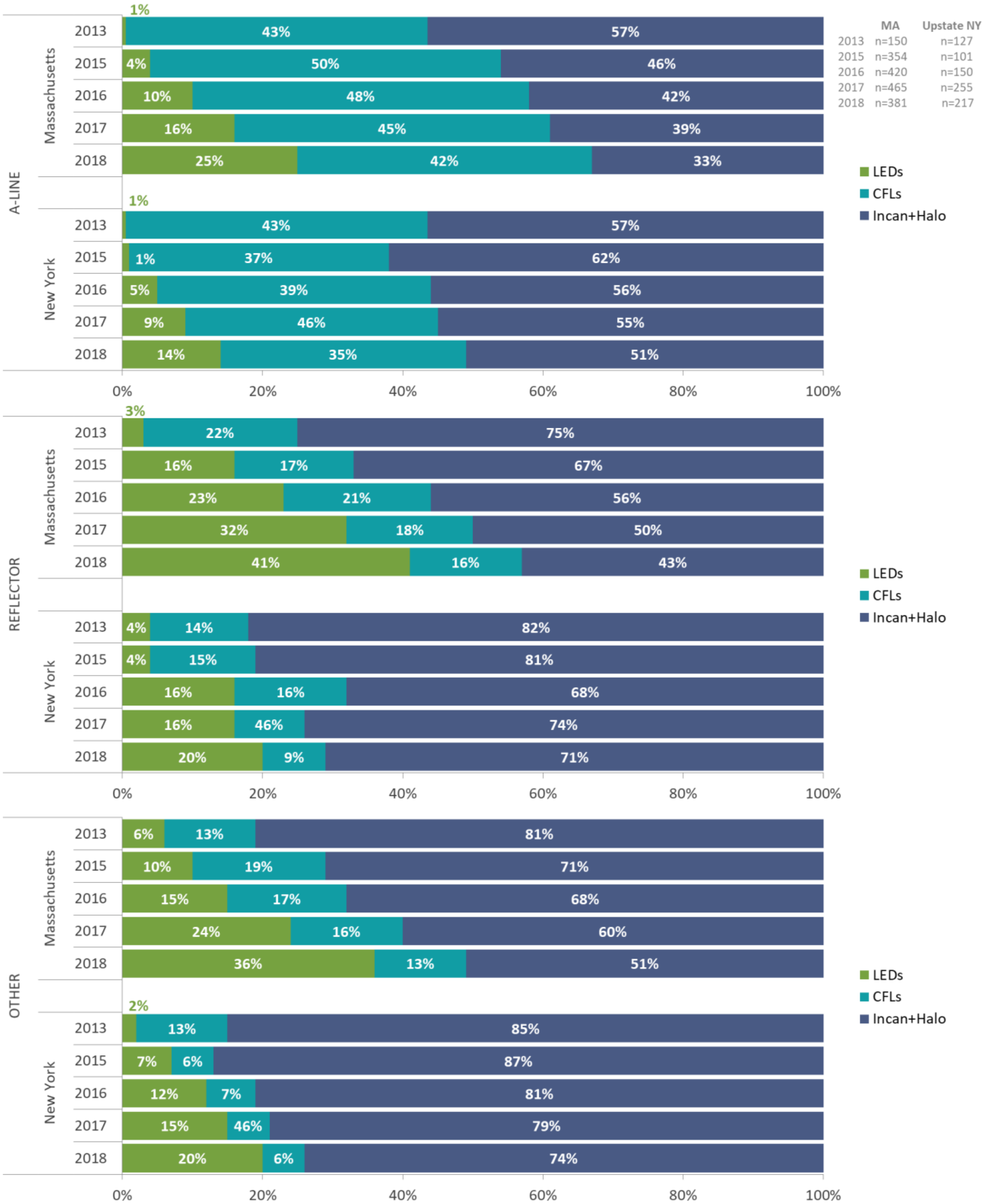


* Significantly different from Energy Star LEDs in corresponding year in MA at the 90% confidence level
Note: Percentages are rounded.

2.1.2 Saturation by Bulb Shape

Figure 12 shows saturation for LEDs, CFLs, and combined incandescent and halogen bulbs by A-line, reflector, and other bulb shape over time. In Massachusetts, one out of four (25%) A-line bulbs were LED, two out of five (41%) reflector bulbs were LEDs, and over one-third (36%) of other shaped bulbs were LEDs; in New York, only 14% of A-line bulbs were LED, only one out of every five installed reflector bulbs was an LED, and one out of every five installed other shaped bulb was an LED.

Figure 12: MA & NY Saturation by Bulb Shape and Bulb Type, 2013-2018

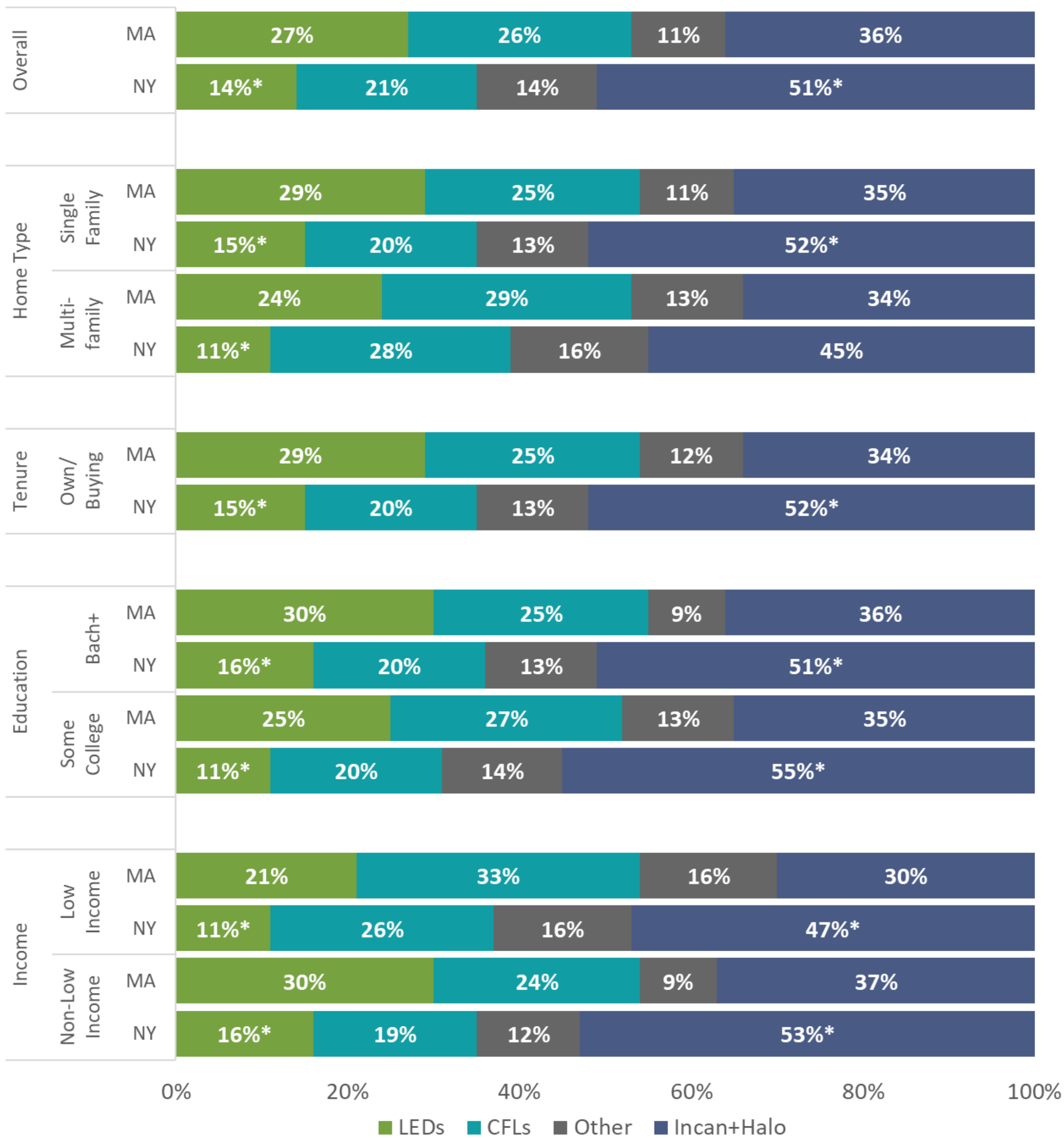


2.1.3 Saturation by Demographics

Figure 13 examines saturation across demographics for CFLs, LEDs, and combined incandescent and halogen bulbs, focusing only on those where LED saturation had a statistically significant difference between Massachusetts and New York. For more detailed findings on saturation across select demographic variables, see Appendix B.

- **Home Type** – LED saturation was significantly higher in Massachusetts than in New York in both ***multifamily*** (five units or more) and ***single-family*** (one to four units) households (24% vs. 11%, multifamily; 29% vs. 15%, single-family). Correspondingly, combined incandescent and halogen saturation was significantly higher among New York single-family households (52% vs. 35%).
- **Tenure** – When compared to Massachusetts, LED saturation was significantly lower in New York among ***own/buying*** households (29% vs. 15% for LEDs). Similarly, combined incandescent and halogen saturation was significantly higher among New York own/buying households (52% vs. 34%).
- **Education** – Massachusetts LED saturation was significantly higher and combined incandescent and halogen saturation was significantly lower among **some *college, Associate's degree*** level of education and the ***Bachelor's degree or higher*** level of education (25% vs. 11% for LEDs; 35% vs. 55% for combined incandescent and halogens) than their counterpart groups in New York (30% vs. 16% for LEDs; 36% vs. 51% for combined incandescent and halogens).
- **Income** – LED saturation among both ***non-low-income*** and ***low-income*** households in Massachusetts was significantly higher than in the counterpart households in New York (30% vs. 16%, non-low-income; 21% vs. 11%, low-income).

Figure 13. Demographics with Statistically Significant Differences in LED Saturation



* Significantly different from MA at the 90% confidence level.
'Other' bulb types includes fluorescent, high pressure sodium, mercury vapor, neon, quartz, acandescent, xenon, unknown, and empty sockets.

2.2 RATE OF LED ADOPTION

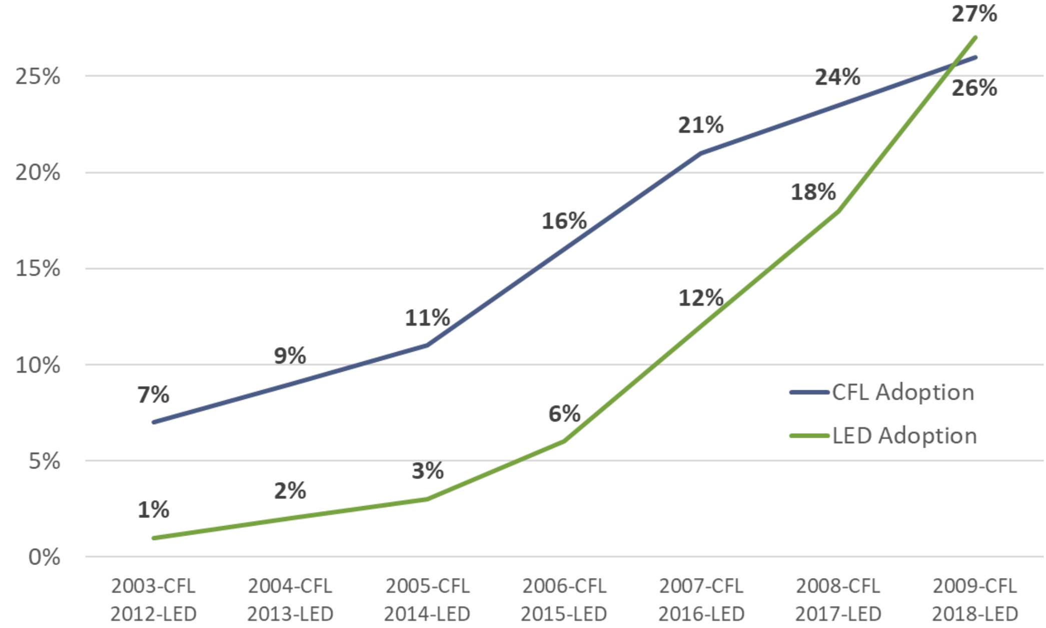
While CFLs first became available in the mid-1980s, they did not rise to prominence until energy-efficiency programs began to market them heavily in the early 2000s. In contrast, the first residential LED screw-base light bulb became available in 2008 but 60-watt equivalent omni-directional LEDs did not become readily available until about three years later (2011). In just seven years, LEDs have captured 27% of the sockets in Massachusetts. In the absence of a strong upstream residential lighting program, households in the New York comparison area have only reached 14% LED saturation.

Given the rapid increase in LED saturation, casual observers may assume that the market has or may soon reach a point of transformation. However, it is important to remember that this is not the first time evaluators have observed rapid adoption of a new lighting technology. The Massachusetts PAs have been carefully studying the residential lighting market for over a decade, which gives us the ability to look back at a snapshot of the market at a time when CFLs were being adopted at a similar pace to how LEDs are being adopted now. The time series data go back to 2003. While this is not quite the start of CFL adoption, it is a period of rapid CFL adoption – similar to what we are observing with LEDs now.

Figure 14 compares CFL adoption from 2003 through 2009 to LED adoption from 2012 through 2018. As the data show, over the first five years, CFLs and LEDs grew at relatively similar paces, with identical overall growth (17 percentage points) through 2008 for CFLs and 2017 for LEDs. However, after 2007, CFL saturation growth slowed and eventually flattened. In contrast, so far, the LED saturation growth has shown no signs of slowing; in fact, between 2017 and 2018, the rate of adoption increased again.

Given the advantages of LEDs over CFLs, customers' stated preference for LEDs over CFLs (see 2016-17 Market Assessment), the increases in federal efficiency standards for lighting – as well as changes to the ENERGY STAR specifications, which effectively preclude CFL qualification and the abandonment of CFLs by some manufacturers – neither the rapid adoption rate of LEDs nor the fact that LEDs surpassed CFLs in terms of saturation was surprising. When examining the market, we think the history of the CFL's rapid adoption followed by a leveling off suggests some caution in jumping to the conclusion that the market is transformed. CFL saturation reached a high of 33% in Massachusetts in 2014 and has been steadily declining as LEDs capture additional sockets.

Figure 14: Comparing CFL and LED Adoption



2.3 Hours of Use Update

The 2014 Northeast Residential Lighting Hours-of-Use (HOU) Study[9] was designed to allow sponsors in the Northeast to update HOU estimates based on room-by-room saturation collected as part of regular saturation studies. In this section, we explore socket saturation as it relates to HOU to prepare updated HOU estimates for the upstream lighting program. This update is not applicable to the direct-install programs, which operate using a somewhat different HOU estimate.

2.3.1 HOU Update – 2018 Saturation Method

To estimate updated HOU, we calculated the proportion of bulbs in each room by bulb type using the 2018 saturation figures.

Formula:

*Proportion of bulbs per room = [(Room Saturation in 2018) * (2018 Socket Count)]*

(Total LED Socket Count)

As an example, we provide the calculations for LEDs for bathrooms here – note that 6,260 represents the average number of LEDs across all room types. The calculations for other bulb categories were carried out similarly. As the calculations show, LEDs in bathrooms account for 14% of all LEDs installed by 2018. To calculate a household HOU estimate, we simply multiplied the snapback-adjusted HOU for each room by the proportion of bulb gains

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

and summed the results. This provides us with a weighted average HOU for installed bulbs (snapback-adjusted).

Bathroom: *28% * 3,047 (LED saturation times socket count in bathrooms) = 853 (LED count in bathrooms)*

853 / 6,260 (LED count in bathrooms divided by LED count in all room types) = 14% (proportion of all LEDs that are in bathrooms)

*= 14% (proportion of all LEDs in bathrooms) * snapback-adjusted HOU in bathrooms of 2.0 = bathroom HOU contribution of 0.28*

Table 2 provides the results of these calculations for LEDs for each room type, as well as the snapback-adjusted HOU by room and the resulting 2018 household snapback-adjusted HOU estimate.

Table 2: Proportion of Bulbs by Room and Type

Room Type	2018 Socket Count	2018 LED Saturation	2018 LED Count	2018 Proportion of LEDs	HOU – Snapback Adjusted*	HOU Times Proportion of LEDs
Bathroom	3,047	28%	853	13.6%	2.0	0.27
Bedroom	3,569	26%	928	14.8%	2.3	0.34
Dining Room	1,483	31%	460	7.3%	3.0	0.22
Exterior	2,083	26%	542	8.7%	5.8	0.50
Kitchen	2,710	37%	1,003	16.0%	4.2	0.67
Living Space	3,056	32%	978	15.6%	3.5	0.55
Other	7,126	21%	1,496	23.9%	1.9	0.45
Household	23,074	**27%**	**6,260**	**100%**	**2.9**	**3.0**

*Snapback Adjusted Efficient HOU based on Northeast HOU Study

We compared the calculated household HOU estimates to the snapback adjusted efficient HOU provided in the Northeast HOU Study. In the HOU study, the household snapback-adjusted HOU provided for energy-efficient bulbs was 2.9 hours per day with a 90% confidence interval of 2.8 to 3.0.

Based on the calculations in this memo, we estimate that HOU for 2018 is 3.0 hours per day.

If we assume the confidence interval from the HOU study still applies, we would assume the 90% confidence interval (CI) for LEDs would be plus and minus 0.1 hours for a confidence interval of 2.9 to 3.1 hours per day.

3 Section 3 Penetration

In this section, we explore trends in penetration (i.e., the percentage of homes using at least one of a particular bulb type). The analysis here examines penetration rates for LED and halogen bulbs, including a room-by-room LED penetration analysis over time. Penetration is an extremely important indicator of LED program success early on in the market adoption process. Penetration shows that the market is advancing and that the program is getting people to try LEDs. 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.

- ***LED penetration in Massachusetts increased significantly since 2017 – from 61% to 86%; New York LED penetration still lags behind Massachusetts, but we observed an impressive increase from 48% penetration in 2017 to 72% penetration in 2018.***
- ***LED penetration in Massachusetts is above 40% in nine room types: living spaces (64%), bedrooms (63%), kitchens (59%), bathrooms (58%), offices (48%), exteriors (48%), dining rooms (43%), hallways (43%), and foyers (40%). Even closets, the room with the lowest LED penetration (23%), saw a 5% increase in penetration over the past year.***
- ***Exteriors, kitchens, and living spaces, the three room types that have the highest hours of use based on the Northeast Residential Lighting Hours-of-Use study, were among the room types with the highest LED penetration in 2018; in particular, living spaces had the highest penetration (64%).***

3.1 Bulb Penetration

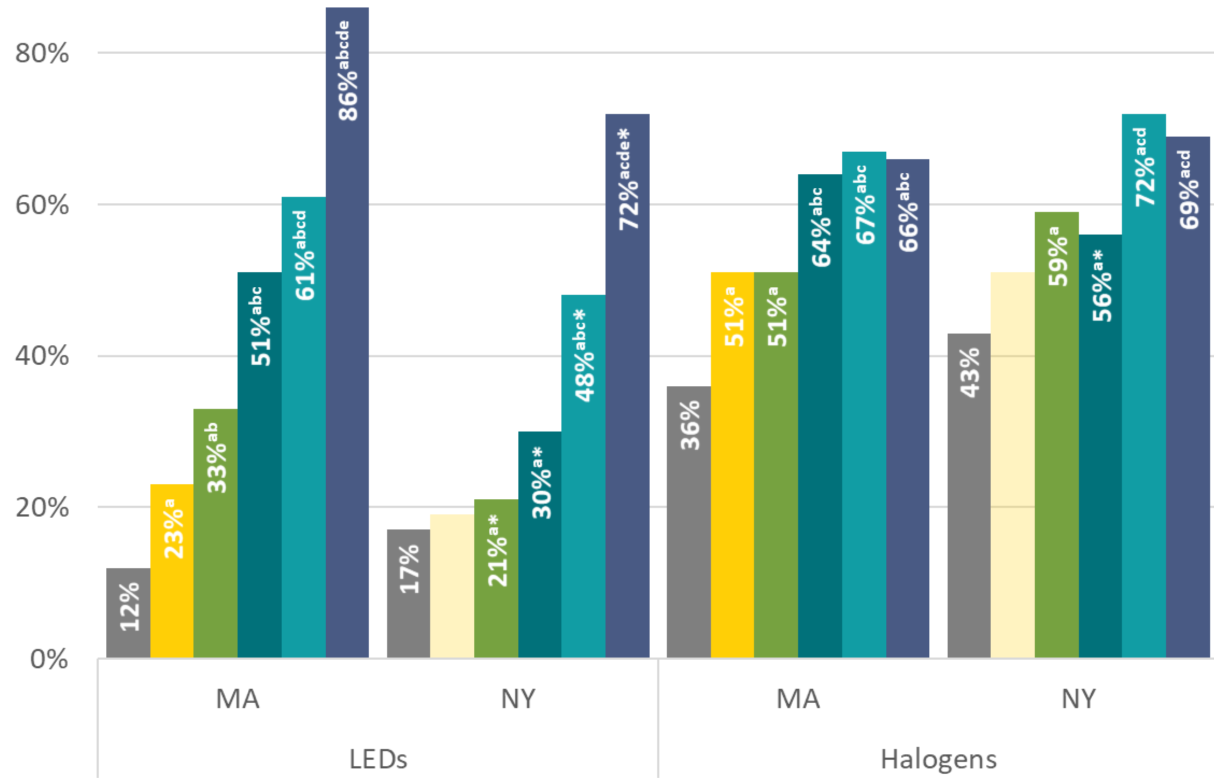
Figure 15 shows penetration for LED and halogen bulbs from 2013 to 2018; as there was no New York study in 2014, penetration for that year is estimated using straight-line interpolation and is shown as faded.

- **LED** penetration, not surprisingly, has increased the most out of all bulb types since 2013 in both areas. In Massachusetts, LED penetration has increased significantly each year, with at least one LED present in nearly nine out of ten homes (86%), up from 61% in 2017. LED penetration in New York also increased in 2018 (from 48% to 72%), but was still significantly lower than in Massachusetts.
- **Halogens** were found in two-thirds (66%) of all homes in Massachusetts in 2018. In New York, halogens were found in more than two-thirds (69%) of all homes in 2018.[10]

For details on incandescent and CFL penetration, see Appendix C.

[10] In 2016, we increased our efforts to differentiate halogen bulbs from incandescent bulbs, including some post-data collection screening processes.

Figure 15: LED and Halogen Bulb Penetration - MA and NY



a Significantly different from 2013 at the 90% confidence level.
b Significantly different from 2014 at the 90% confidence level.
c Significantly different from 2015 at the 90% confidence level.
d Significantly different from 2016 at the 90% confidence level.
e Significantly different from 2017 at the 90% confidence level.
* Significantly different from corresponding year in MA at the 90% confidence level.

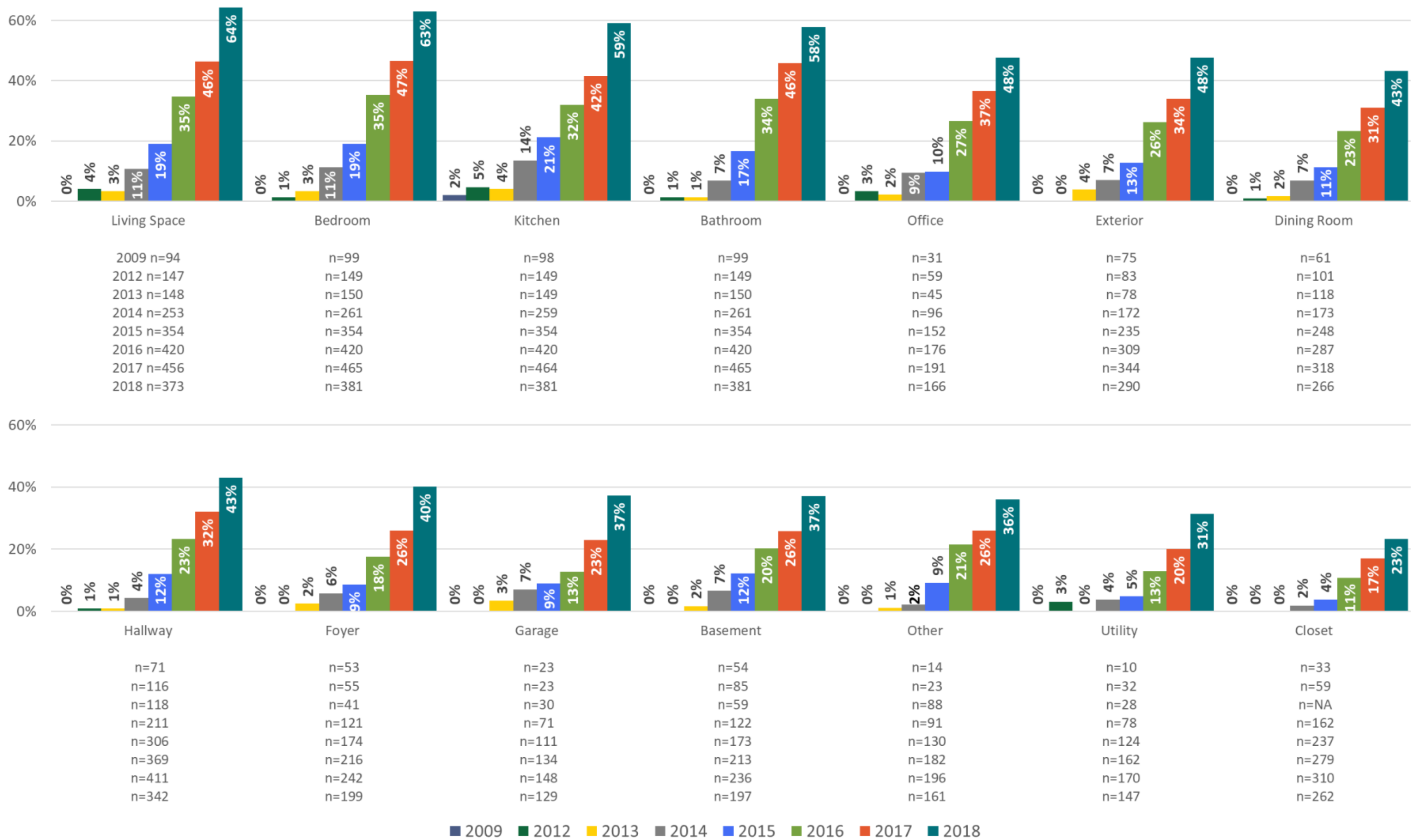
3.2 Room-by-Room Analysis

This section presents LED penetration over time by room type. When calculating penetration by room type, we included only homes that had rooms of that type. For example, in 2018, 129 homes had garages, and 48 of those homes had at least one LED installed in garages, which calculates to a 37% penetration rate.

As Figure 16 shows, LED penetration has increased in all room types since 2009; notably, penetration in all room types has at least doubled since the 2015 study. Living spaces were the most common place to install at least one LED (64%), followed closely by bedrooms (63%), kitchens (59%), and bathrooms (58%). Importantly, exteriors, kitchens, and living spaces – the three room types that have the highest hours of use – were among the four room types with LED penetration over 40% in Massachusetts in 2017. As mentioned above, it is likely that these rooms types also have the highest rate of burnout.[11]

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

Figure 16: LED Penetration by Room Type, 2009-2018 (Massachusetts)



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4 Section 4 Panel Visits – Changes in Bulb Types Over Time

In this section, we explore bulb replacement behavior based on panel visits (repeat visits to the same homes over a period of time). To date, five waves of panel visits have been completed in Massachusetts and three waves of panel visits have been completed in New York. During the panel visits, technicians compared the bulb in each socket found during the 2018 lighting inventories to the bulb recorded for the 2017 lighting inventories. Based on the markings inscribed on the bulbs during the previous years' visits, the technician designated each bulb as *New* (for bulbs that had been installed since the last on-site visit) or *Same* (for bulbs that were included in the 2017 on-site data and were the same in 2018). The technician also designated fixtures in the same manner.

- ***In Massachusetts, LEDs remained the most common replacement bulb type (56%), followed by incandescent bulbs (16%). For the first time since we began studying the New York comparison area, LEDs were the most common replacement bulb type (38%), followed by incandescent bulbs (27%).***
- ***In Massachusetts, LEDs were the most common bulb chosen to replace any removed bulb (incandescent, halogen, LED, or CFL). Even though LEDs were the most common replacement bulb in New York overall, incandescent bulbs were installed to replace incandescents (35%) at a similar rate as LEDs (34%). Massachusetts households replaced significantly more incandescent bulbs with LEDs (55%) than New York households (35%).***
- ***We observed some backsliding (efficient bulbs being replaced with inefficient) in households in both areas, but backsliding was less common than in 2017. In Massachusetts, 13% of LEDs were replaced with a halogen or incandescent bulb, compared to 21% in 2017. Householders who replaced efficient bulbs with inefficient bulbs were most likely to attribute dissatisfaction with function, light quality, appearance, or the ready availability of incandescent bulbs in storage.***
- ***In both areas, bulb failure is the most commonly cited reason for replacing bulbs, followed by a desire to install a more energy-efficient bulb.***

4.1 Bulb Changes 2017-2018

Sockets where the customer had replaced the bulb (or had installed a bulb in an empty socket) since the previous visit were of special interest in the panel visits. This interest stemmed largely from the desire to understand customer replacement behavior over time, especially to understand what types of bulbs LEDs are being used to replace.

As Table 3 shows, the 381 Massachusetts panelists included in Wave 5 replaced 3,093 bulbs, or 13% of total observed sockets (23,079). In 2018, New York panelists replaced 5.8 bulbs per household (Table 4), less than Massachusetts Wave 5 panelists (8.1 bulbs per household), but more than previous years (4.7 bulbs per household in 2017), which was likely driven by increased LED adoption.

Table 3: Massachusetts Panel Replacement Bulb Summary (Unweighted)

Panel Year	MA 2014 (Wave 1)	MA 2015 (Wave 2)	MA 2016 (Wave 3)	MA 2017 (Wave 4)	MA 2018 (Wave 5)
Homes	*111*	*203*	*270*	*315*	*381*
Baseline	May 2014 – June 2014	Dec. – Jan. 2015	Dec. 2015 – Feb. 2016	Oct. 2016 – Jan 2017	Oct. 2017 – Dec. 2017
Months	13	5	12	12	12
Sockets Replaced	834	941	2,003	2,375	3,057
Sockets/Home	7.5	4.6	7.4	7.3	8.1
Sockets/Month	0.6	0.9[12]	0.6	0.6	0.7
Homes Replacing	103 (93%)[b]	169 (83%)[a]	245 (90%)[b]	285 (90%)[b]	349 (92%)[b]

[a] Significantly different from MA Wave 1 at the 90% confidence level.
[b] Significantly different from MA Wave 2 at the 90% confidence level.

Table 4: New York Panel Replacement Bulb Summary (Unweighted)

Panel Year	NY 2016 (Wave 1)	NY 2017 (Wave 2)	NY 2018 (Wave 3)
Homes	*80*	*105*	*217*
Baseline	Jan. – Feb. 2015	Oct. 2016 – Jan. 2017	Oct. 2017 – Dec. 2017
Months	12	12	12
Sockets Replaced	434	439	1,262
Sockets/Home	5.4	4.7	5.8
Sockets/Month	0.45	0.4	0.5
Homes Replacing	65 (81%)[a]	79 (75%)[a]	181 (83%)[a]

[a] Significantly different from same year in MA at the 90% confidence level.
[b] Significantly different from MA Wave 2 at the 90% confidence level.

4.1.1 Bulb Replacement Behavior

Table 5 provides an overview of saturation among only the sockets where bulbs were replaced between 2017 and 2018, highlighting saturation of these sockets before and after bulbs were replaced, as well as the net change in saturation. As the table shows, while LED bulbs had the highest net gains in both areas, the net gain in Massachusetts (52%) was significantly higher than in New York (35%). Net gains for CFLs, incandescent, and halogen bulbs were negative in both areas, while net changes for linear fluorescents were negligible.

[12] Between the 2014 and 2015 visits, panelists replaced roughly 0.9 bulbs per home per month, compared to 0.6 to 0.7 bulbs per home per month in the following years. The difference in bulbs replaced per month may be due in part to the fact that Wave 2 covered only five months, whereas Wave 1 covered slightly more than a full year. Dividing the replacements from the fall over a short period likely accounts for the difference.

Table 5: Bulb Replacement Saturation (Massachusetts & New York)
(Base: Replacement bulbs 2017-2018)

Bulb Type	Massachusetts			New York		
Sample Size	*2,834*			*1,159*		
	Before (Replaced)	**After (Replacement)**	**Net Change**	**Before (Replaced)[b]**	**After (Replacement)**	**Net Change**
LED or CFL	**35%**	**68%**	**+33%**	**26%[a]**	**55%[a]**	**+29%**
LED	*5%*	*56%*	*+52%*	*3%*	*38%[a]*	*+35%*
CFL	*30%*	*12%*	*-18%*	*23%[a]*	*17%[a]*	*-6%*
Incandescent or Halogen	**56%**	**23%**	**-33%**	**62%**	**36%[a]**	**-27%**
Incandescent	*47%*	*16%*	*-30%*	*50%*	*27%[a]*	*-23%*
Halogen	*10%*	*7%*	*-3%*	*12%*	*9%*	*-3%*
Linear Fluorescent	3%	1%	*-2%*	2%	1%	0%
Empty Socket	5%	8%	**+3%**	10%[a]	9%	*-1%*

[a] Significantly different from Massachusetts at the 90% confidence level.
[b] Less than 1% of replaced bulbs were "don't know" or "other".

Figure 17 shows overall bulb replacement behavior for Massachusetts and New York. Replaced bulbs (*before*) are bulbs that were recorded in the 2017 visit but were removed from the sockets when techs returned for the 2018 visit. Replacement bulbs (*after*) are those bulbs installed in sockets in 2018 from which the "replaced bulbs" were removed. We highlight replacement trends for LED, CFL, and incandescent bulbs below. Halogen replacement behavior was similar between areas, and was similar to patterns observed in past years.

For each bulb a panelist replaced, we asked them why they replaced that bulb. Overall, the most common reason panelists gave for replacing bulbs in both areas was that the bulb had failed (burned out or broken). After excluding self-reported energy-efficiency program participation, we observed that unlike in 2017, a similar proportion of bulbs were removed in both areas because the householder wanted to replace it with a more efficient bulb (16% in Massachusetts, 14% in New York).

Trends by Technology

LED

- *Replaced LEDs:* Similar to 2017, LED bulbs represented only a small proportion of bulbs replaced in both Massachusetts (5%) and New York (3%). Nearly one-third (30%) of replaced LEDs in Massachusetts were removed from their sockets due to failure, while 46% were removed because the householder did not like the function, appearance, or light quality of the bulb. Three percent of LEDs were removed to make way for a "smart" LED.
- *Replacement LEDs:* In Massachusetts, LED bulbs were the mostly commonly chosen replacement bulb (56%), significantly different than their use as a replacement bulb

in New York (38%). For the first time since we began studying New York in 2015, LEDs were the most common replacement bulb in New York.

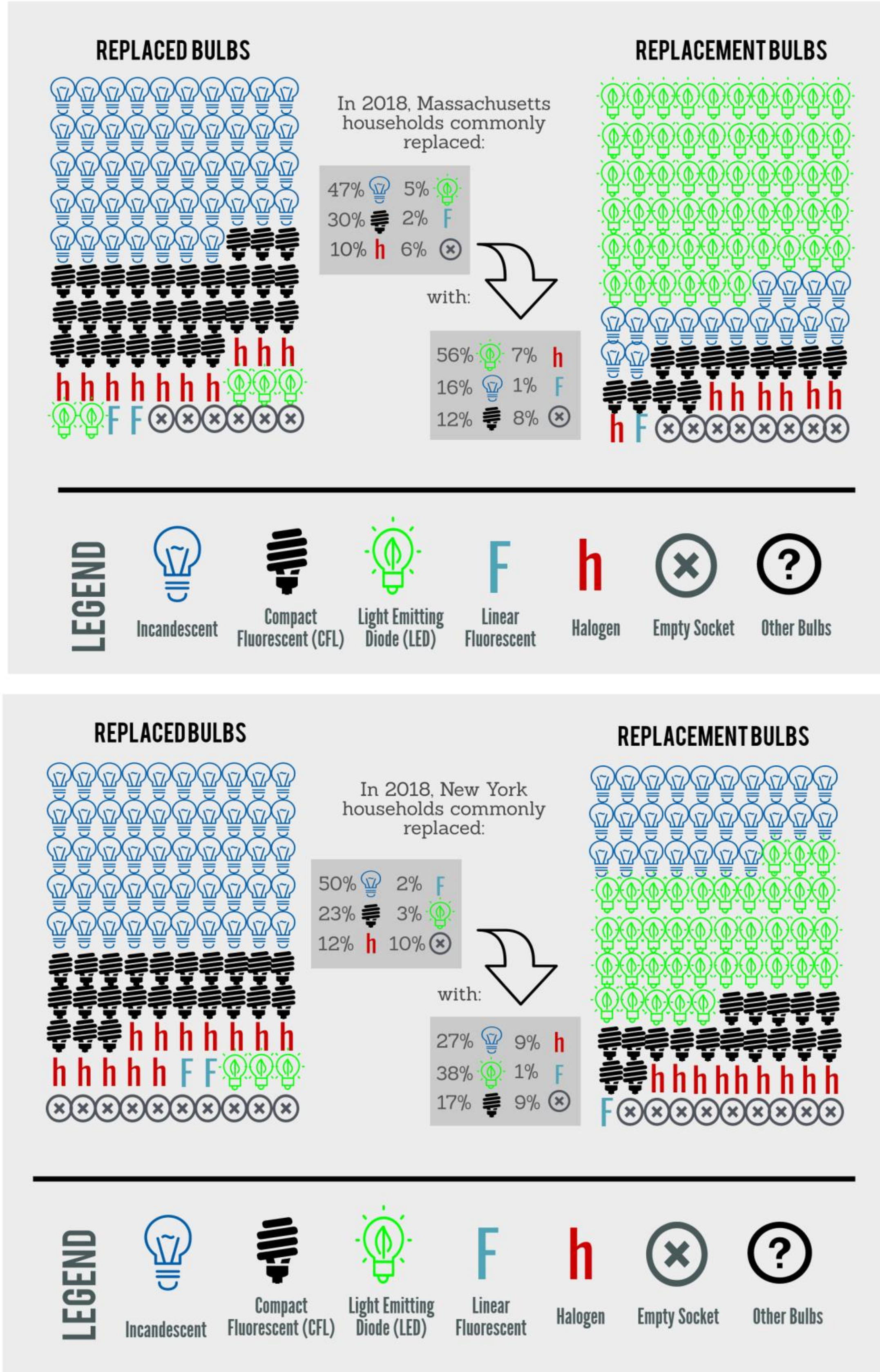
CFL

- *Replaced CFLs:* CFLs were the second most common bulb type replaced in both Massachusetts (30%) and New York (23%).
- *Replacement CFLs:* CFLs continued to decline in popularity. As in 2017, CFLs were the third most common replacement bulb in both Massachusetts (12%) and New York (18%). This indicates that CFLs are possibly leaving the lighting market.

Incandescent

- *Replaced incandescent bulbs:* In both Massachusetts and New York, incandescents, were the most commonly replaced bulb (47% and 50%, respectively).
- *Replacement incandescent bulbs:* Incandescent bulbs were the second most commonly chosen replacement bulb in both Massachusetts (16%) and New York (27%). This represents a change from last year, when we observed incandescent bulbs to be the most popular replacement bulb in New York (34%).

Figure 17: Overall Bulb Replacements (Massachusetts & New York)



In Figure 18, we break down the replacement behavior by proportion of bulbs replaced for each bulb type. While the figure shows some evidence of backsliding (when households replace efficient bulbs with inefficient halogen or incandescent bulbs), it is less pronounced than our findings from 2017 (not pictured). In 2017, less than one-quarter of LEDs replaced since 2016 in Massachusetts (21%) were replaced by a halogen or an incandescent; in 2018, only 13% of LEDs in Massachusetts were replaced by a halogen or incandescent. However, New York households replaced LEDs with an incandescent or halogen at similar rates in both 2017 (25%) and 2018 (23%). The team observed a similar rate of backsliding in both areas for CFLs; in 2018, 13% of CFLs in Massachusetts and 16% of CFLs in New York were replaced with inefficient bulbs.

Trends by Technology

LED

- *What replaced LEDs:* Looking at the few LEDs that had been replaced since the 2017 visit, LEDs were overwhelmingly replaced by LEDs in Massachusetts (75%). While LEDs were the most common replacement (43%) for removed LEDs in New York, they were followed closely by incandescent (20%) and CFL bulbs (17%).
    - *Backsliding:* Thirteen percent of LEDs in Massachusetts, and 23% of LEDs in New York, were replaced by a halogen or an incandescent bulb. This is an important indication that households are willing to switch back to less efficient alternatives. The most common reason cited for replacing an LED with an inefficient bulb was dissatisfaction with the LED bulb's light quality, appearance, or function in that particular socket, followed by the availability of the inefficient bulb in storage.
- *What LEDs replaced:* In Massachusetts, LEDs were the most common replacement bulb for removed CFLs (57%), halogens (57%), incandescents (55%), and even empty sockets (46%). In New York, LEDs replaced one-half of removed CFLs (52%) and one-third of removed CFLs (32%); however, incandescent bulbs are the most common choice for incandescent replacement (35%), slightly ahead of LEDs (34%).

CFL

- *What replaced CFLs:* In Massachusetts, CFLs were primarily replaced by LEDs (57%), mirroring a trend that we first noticed in 2017. In New York, 52% of removed CFLs were replaced with LEDs and 26% with another CFL.
    - *Backsliding:* In Massachusetts, 13% of CFLs were replaced by either a halogen or an incandescent. In New York, backsliding was more pronounced, as 16% of CFLs were replaced by a halogen or an incandescent. This is an important indication that households are willing to switch back to less efficient alternatives.
- *What CFLs replaced:* In Massachusetts, another CFL was installed to replace one in five removed CFLs (20%), and approximately one in ten removed incandescent bulbs (8%), but their popularity is waning, especially in comparison to LEDs. This is not

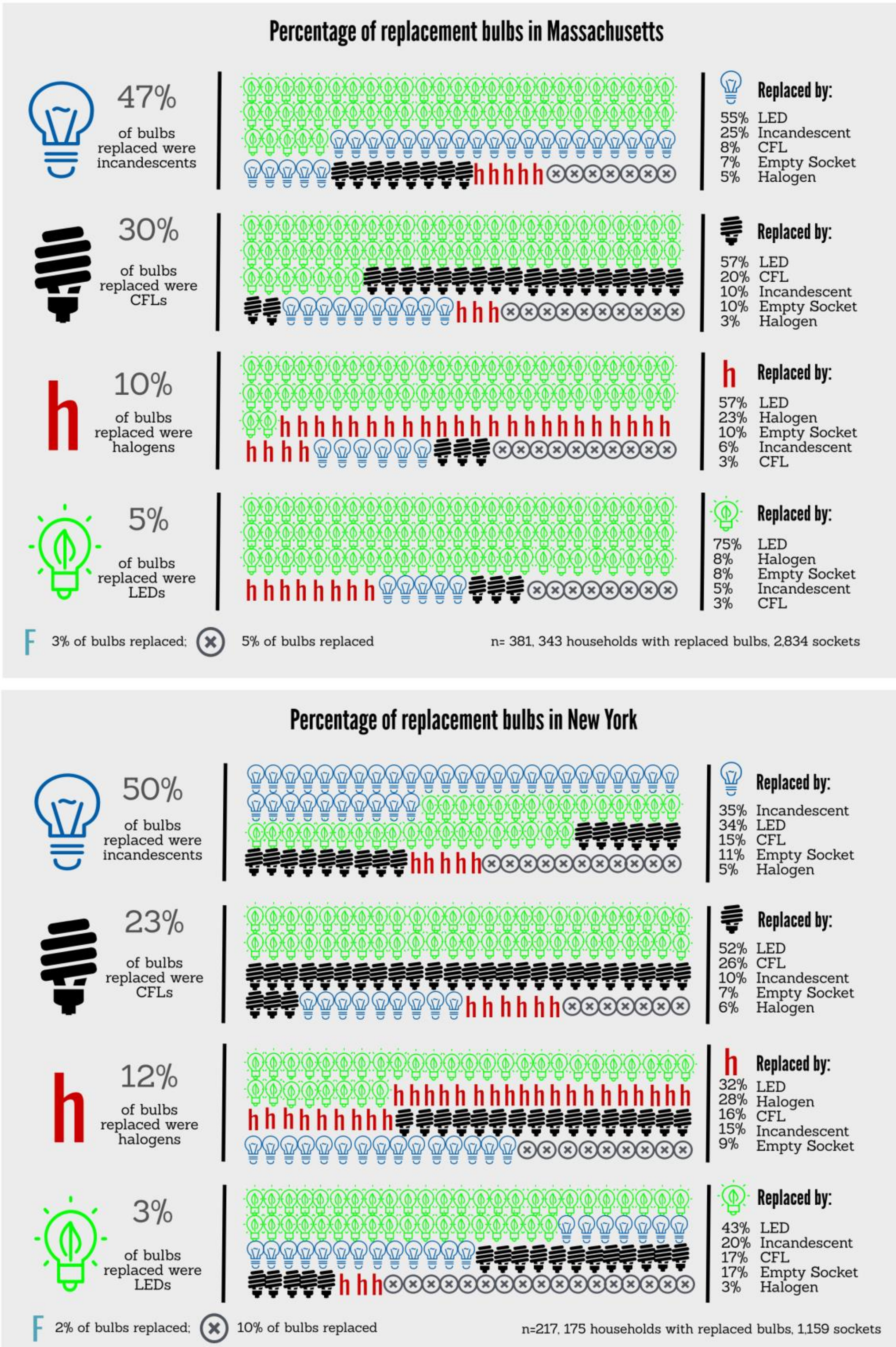
surprising considering fewer suppliers are providing the market with CFLs. In New York, CFLs replaced one in four removed CFLs (26%) and were the third most common bulb replacement choice for incandescents (15%), halogens (16%), and LEDs (17%).

Incandescent

- *What replaced incandescents:* In Massachusetts, approximately two-thirds (63%) of removed incandescent bulbs were replaced by efficient bulb types (CFLs and LEDs), compared to 40% in New York.
- *What incandescents replaced:* Incandescent bulbs replaced 25% of removed incandescents in Massachusetts and 35% in New York. In Massachusetts, incandescents replaced only a fraction of removed LEDs (5%), halogens (6%) and CFLs (10%). In New York, 42% of previously empty sockets were replaced by incandescent bulbs. One in four removed LEDs (20%) and more than one in ten CFLs (16%) were replaced by incandescent bulbs.

For additional information about bulb replacement trends, newly-installed bulbs, and bulb replacement behavior by demographics, see Appendix D.

Figure 18: What Replaced What



If a bulb was replaced by a bulb of a different technology type, we asked panelists about their decision. In Table 6, we look at the reasons panelists gave for replacing inefficient bulbs (incandescent or halogen) with LEDs or CFLs, and efficient bulbs (LED or CFL) with incandescent or halogen bulbs.[13] In both areas, nearly three in four replacement LEDs were installed because the householder wanted to use a more energy-efficient bulb. In 5% of cases where an LED was installed to replace an inefficient bulb, Massachusetts householders cited the cost as a reason they chose the LED while in-store; this was not a factor cited in New York. While we may be able to attribute this to the availability of in-store rebates, it is important to note that low prices were also cited as a reason for changing bulb types in 13% of cases where a halogen was installed to replace an efficient bulb. Massachusetts householders who replaced efficient bulbs (LED or CFL) with incandescents were most likely to attribute dissatisfaction with function, light quality, or appearance (32%), or the ready availability of incandescent bulbs in storage (28%).

[13] Totals do not sum to 100% because more than one response was permitted per bulb.

Table 6: Reasons for Bulb Type Change

(Base: Replacement bulbs in homes that were a different type than the bulb they replaced; excluded bulbs self-reported as DI program)

Massachusetts				
Reasons why…	*Inefficient bulbs replaced with:*		*Efficient bulbs replaced with:*	
Reasons for replacing	LED	CFL	Incandescent	Halogen
Households (n)	*113*	*65*	*58*	*25*
Replaced bulb count	*445*	*111*	*95*	*39*
Wanted to use a more energy-efficient bulb	71%	47%[a]	0%	6%
Did not like function and/or appearance of previous bulb	6%[a]	14%[a]	32%[a]	37%
Good sale/cost of bulbs	5%[a]	4%[a]	0%	13%
I wanted to try a different type of bulb	5%[a]	8%	6%[a]	15%
Available in storage	1%[a]	26%[a]	28%	12%
Don't know/Other	18%	17%[a]	40%[a]	24%
New York				
Reasons why…	*Inefficient bulbs replaced with:*		*Efficient bulbs replaced with:*	
Reasons for replacing	LED	CFL	Incandescent	Halogen
Households (n)	*65*	*44*	*20*	*9*
Replaced bulb count	*245*	*110*	*3427*	*16*
Wanted to use a more energy-efficient bulb	74%	69%	0%	0
Did not like function and/or appearance of previous bulb	2%	6%	41%	2
Good sale/cost of bulbs	0%	0%	0%	0
I wanted to try a different type of bulb	9%	10%	27%	4
Available in storage	5%	14%	25%	7
Don't know/Other	17%	10%	26%	3

[a] Significantly different from New York at the 90% confidence level.

5 Section 5 Recent Purchases

This section provides an analysis of recent bulb purchases based on findings from the on-site. While on site, technicians asked respondents to recall when and from where specific bulbs had been purchased. It is important to keep the self-reported nature of purchase source in mind when reviewing these results. Non-self-reported purchase data provided by other studies in Massachusetts may provide better sources of information – these studies include the RLPNC 16-5 Sales Data and the RLPNC 17-12 Decision Making Studies.

Key findings from this section include the following:

- ***Home improvement stores were the most commonly reported sources of LEDs in both areas for bulbs obtained in 2017, similar to past years.***
- ***Online purchases as a share of new LED bulbs declined in both areas since the previous study.***
- ***In New York, mass merchandise stores commanded a larger share of LED purchases than in the previous study, but we did not observe a change in Massachusetts.***
- ***The percentage of ENERGY STAR LEDs obtained in the past year in Massachusetts (74%) is nearly double the percentage of ENERGY STAR LEDs obtained in New York (37%).***

5.1 Sources of Newly Acquired LEDs

NMR technicians not only asked respondents when they purchased or obtained any new LED found in their homes but also asked them to recall where they had purchased or obtained the bulbs. This section looks at recent purchases by channel. Note that while the number of newly acquired bulbs is based on observation by technicians, the source of bulbs is based entirely on self-reported data. Since the on-site visits take place about 12 months apart and occur in the fall, the period in which newly obtained bulbs were acquired closely corresponds to the calendar year prior to the visits.

Table 7 refers to all bulbs purchased or obtained in the past year. Obtained bulbs include all purchased bulbs, as well as bulbs installed by a landlord or received through energy-efficiency programs. This year, we verified households' participation in direct-install programs for both 2016 and 2017;[14] results are shown in Table 7. In the previous study, one in five bulbs obtained in 2016 reported to be from MassSave were verified to be in a household that participated in a direct-install program; these bulbs comprised 5% of new LEDs. By comparison, 1% of total obtained LEDs obtained in 2017 were verified to be direct install, representing 3% of all bulbs self-reported to be from MassSave.

In both areas, home improvement stores (e.g., Home Depot or Lowe's) were the most common source of obtained LEDs, followed by mass merchandise retailers (e.g., Walmart or

[14] We were unable to verify program participation for 2016 at the time of writing for the 2017 report.

Target). The proportion of LED purchases from mass merchandise retailers doubled in New York – from 10% in 2017 to 22% in 2018 – while purchases from hardware and discount stores declined. This trend mirrors a finding from the RLPNC 17-12 Decision Making Report, in which we observed that New York consumers were buying value-brand LEDs at mass merchandise stores (e.g., Walmart) at a much higher rate than consumers in Massachusetts. In Massachusetts, LEDs obtained in 2017 from discount, hardware, and grocery stores increased, which may reflect the efforts by the PAs to diversify retailers where customers can find program-supported LEDs. The proportion of LEDs purchased online declined by 5% in both Massachusetts and New York from 2017 to 2018. For further analysis of LED bulbs obtained last year, see Appendix E.

Table 7: LED Bulbs Obtained

Bulb Source	MA		NY	
	Obtained in 2016	Obtained in 2017	Obtained in 2016	Obtained in 2017
Sample Size	*315*	*381*	*105*	*217*
Homes with new LEDs	*152*	*186*	*66*	*85*
Bulbs Obtained	**1,606**	**1,654**	**491**	**503**
Avg. # Obtained	**11.8**	**9.5**	**8.5**	**6.6**
Home Improvement	36%	31%	57%[a]	54%[c]
MassSave (DI Verified)	5%	1%[a]	--	--
Mass Merchandise	7%	7%	10%	22%[bc]
Discount	1%	6%[a]	1%	<1%[c]
Hardware	3%	6%[a]	9%[a]	2%[bc]
Online	8%	3%[a]	10%	5%
Grocery	1%	3%[a]	1%	1%[c]
Lighting & Electronics	4%	3%	<1%[a]	0%[c]
Membership Club	4%	2%	4%	2%
Electrician	<1%	2%	0%[a]	1%
EE Fair/Pop-up[15]	<1%	2%	--	--
Other	5%	1%[a]	2%	3%
Don't know*	25%	33%[a]	6%	9%
Legend		Most common source		2nd most common source

[a] Significantly different from Massachusetts 2017 at the 90% confidence level.
[b] Significantly different from New York 2017 at the 90% confidence level.
[c] Significantly different from Massachusetts 2018 at the 90% confidence level.
* "Don't know" includes bulbs reported as have been installed by MassSave at households that were unconfirmed program participants.

[15] Householders reported purchasing bulbs at MassSave kiosks at community events and /or "pop-up" stores.

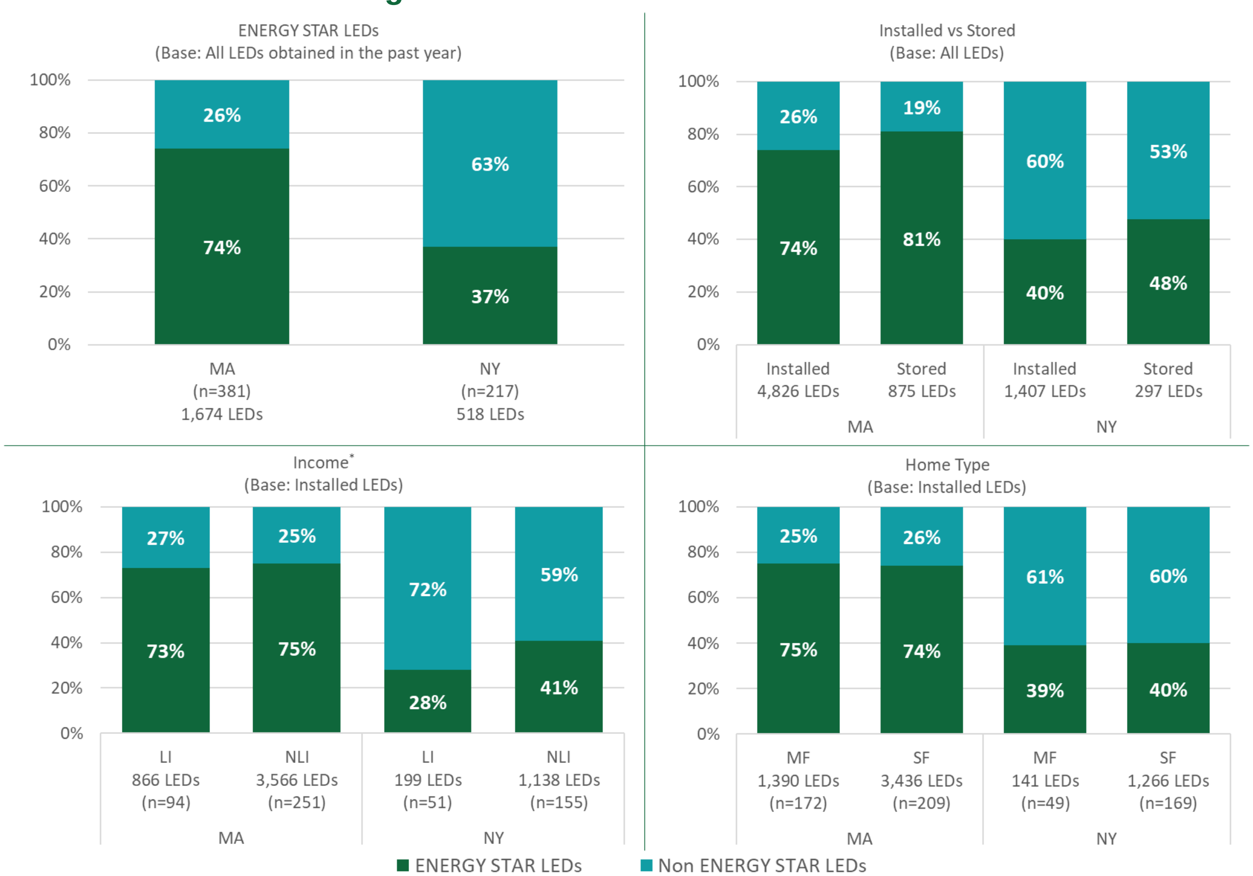
5.2 Purchases by ENERGY STAR Status

We first looked only at LEDs purchased within the past year, shown in the top left chart in Figure 19. In Massachusetts, 75% of all LEDs purchased within the past year were ENERGY STAR LEDs. This is higher than the percentage (37%) of all LEDs obtained within the past year that were ENERGY STAR LEDs in New York.

We also examined ENERGY STAR LEDs in other ways, as shown in the remaining three charts in Figure 19. Out of all LEDs found in the home (not just those purchased within the past year), nearly three-quarters (74%) of installed LEDs and eight of out ten (81%) stored LEDs in Massachusetts were ENERGY STAR. In New York, two out of five (40%) installed LEDs were ENERGY STAR and just under one-half (48%) of all stored LEDs were ENERGY STAR in 2018.

The bottom two charts show the percentage of installed LEDs that were ENERGY STAR by income and home type. In Massachusetts, approximately three out of four LEDs were ENERGY STAR in both low-income (73%) and non-low-income (75%), as well as in both multifamily (75%) and single-family (74%) households. In New York, two out of five LEDs installed in non-low-income homes (41%), multifamily homes (39%) and single-family homes (40%) were ENERGY STAR.

Figure 19: ENERGY STAR LEDs



*Not Included in income: 36 MA and 20 NY homes where Income = Don't know

6 Section 6 Storage Behavior

As in years past, most households stored bulbs; 324 of the 381 Massachusetts households (85%) and 184 of the 217 New York households (85%) visited for the 2018 study had at least one bulb in storage. In this section, we present analysis related to storage, including in-service rates for CFLs and LEDs, and a complete analysis of bulbs found in storage in on-site participant households.

- ***Incandescent bulbs remained the most common type found in storage in both Massachusetts and New York (51% and 58%, respectively), with more than twice as many incandescent bulbs in storage as the next closest bulb type (CFLs).***
- ***On average, households in both areas had enough bulbs in storage to fill about one-quarter of sockets. In addition, according to self-reported intentions, the majority of these bulbs were being stored for future use.***
- ***In Massachusetts, 10% of LEDs that were in storage in 2017 were installed in 2018; in New York, 11% were installed by the 2018 visit.***
- ***More than one out of every ten (12%) incandescent bulbs that had been in storage in 2017 in Massachusetts were thrown out/recycled between the 2017 visit and the 2018 visits, while only 8% were thrown out/recycled in New York.***
- ***The first-year in-service rate for LEDs was 80% based on the weighted average of LEDs obtained in the year ahead of the 2016, 2017, and 2018 Studies.***
- ***In addition to first-year ISR, we were able to observe second year ISR for LEDs purchased in 2015 and 2016 and third-year ISR for LEDs purchased in 2015. Using these values, we calculated multi-year ISR for 2017 – 2025. ISR increases from 80% in year one to 97% by year nine. We recommend the following discounted lifetime ISRs by LED type: A-line 93%, reflector 94%, and EISA Exempt 94%.***[16]

6.1 Stored Bulbs

As in past studies, incandescent bulbs made up the majority (51%) of stored bulbs in Massachusetts homes in 2018. Notably, according to panelists, eight out of ten (80%) stored incandescents were being stored for future use – indicating that these bulbs may eventually be used. CFLs accounted for nearly one out of four (22%) stored bulbs, while LED storage increased to 16%, nearly all of which (97%) were being stored for future use.

Massachusetts households stored an average of 14.5 bulbs in 2018 – enough bulbs to fill over one-quarter of the sockets in an average home. In comparison, New York households stored an average of 12.1 bulbs in 2018 – enough bulbs to fill just under one-quarter of

[16] The ISR sunset year was determined through calculations by the PAs from the output from evaluation study 17-6: Market Adoption Model (MAM) to determine the EUL, expert evaluator views of the state of the market for the three bulb categories and discussion between the PAs and EEAC evaluation members with assistance from NMR (the evaluation contractor).

sockets in an average home. There were two households in New York with more than 100 bulbs in storage, the majority of which were incandescents being stored for future use.

Table 8: Stored Bulbs by Bulb Type Over Time

(Base: All on-site respondents)

	Massachusetts							New York				
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2013[δ]**	**2015**	**2016**	**2017**	**2018**
Sample Size	*151*	*150*	*261*	*354*	*420*	*465*	*381*	*127*	*101*	*150*	*255*	*217*
Avg # of Stored Bulbs/Home[*]	**6.7**	**7.1**	**15.8**	**15.6**	**17.5**	**17.8**	**14.5**	**11.6**	**18.3**	**14.5**	**16.2**	**12.1**
Incandescent	66%	66%	68%	64%	59%	56%	51%	67%	70%	57%	59%	58%
CFLs	24%	31%	25%	27%	26%	24%	22%	24%	17%	17%	21%	19%
Halogen	8%	3%	4%	5%	7%	9%	9%	4%	6%	17%	11%	8%
Fluorescent	1%	1%	2%	1%	2%	2%	2%	4%	5%	6%	3%	3%
LEDs	<1%	<1%	2%	2%	5%	9%	16%	1%	2%	3%	6%	12%
Other[**]	0%	0%	0%	<1%	<1%	<1%	<1%	1%	<1%	<1%	0%	0%

[*] In 2014, technicians found more bulbs in storage than had been found in previous years due to new quality control and data collection protocols.

[**] Other includes xenon, high pressure sodium bulbs, and mercury vapor bulbs.

[δ] One outlier in 2013 with 354 bulbs in storage was removed for this analysis.

6.2 Stored Bulb Status

NMR was able to track stored bulb status from the 2017 visit to the 2018 visit. There was a total of 4,452 bulbs still in storage in Massachusetts in 2018; 1,842 of the bulbs that had been in storage in 2017 were no longer in storage in 2018. New York panel sites had 2,030 bulbs in storage in 2018 and 991 that had been in storage in 2017 that were no longer in storage in 2018. Most bulbs that had been in storage in 2017 were still in storage in 2018 (71% in Massachusetts; 67% in New York). Notably,

- More than one out of every ten (12%) incandescent bulbs that had been in storage in 2017 in Massachusetts were thrown out/recycled between the 2017 visit and the 2018 visits, while only 8% were thrown out/recycled in New York.
- In Massachusetts, 10% of LEDs that were in storage in 2017 were installed in 2018; in New York, 11% were installed by the 2018 visit. In both areas, one out of four stored LEDs were newly purchased (41% in both areas).

Table 9: Stored Bulbs Status

Bulb Status 2018	Massachusetts					
	LED	CFL	Incandescent	Halogen	Fluorescent	All
# of Bulbs	***1,054***	***1,667***	***3,827***	***644***	***163***	***7,354***
Same	42%	61%	62%	63%	53%	29%
New	41%	9%	11%	11%	6%	14%
Thrown Out/Recycled	3%	11%	12%	7%	22%	10%
Installed in Fixture	10%	10%	6%	10%	4%	8%
Previously Installed	2%	3%	1%	1%	9%	2%
Don’t Know/Other	3%	6%	8%	8%	6%	7%
Bulb Status 2018	**New York**					
	LED	**CFL**	**Incandescent**	**Halogen**	**Fluorescent**	**All**
# of Bulbs	***377***	***762***	***2,037***	***337***	***91***	***3,605***
Same	39%	49%	62%	45%	78%	56%
New	41%	14%	13%	20%	1%	16%
Thrown Out/Recycled	<1%	6%	8%	7%	0%	7%
Installed in Fixture	11%	8%	4%	5%	3%	6%
Previously Installed	<1%	3%	<1%	<1%	0%	1%
Don’t Know/Other	10%	19%	14%	22%	17%	15%

6.3 In-Service Rate

Panelists visited as part of this study were the fifth wave of panel visits. Of the 381 panelists – 58 were first visited in 2013, 74 were first visited in 2014, 68 were first visited in 2015, 78 were first visited in 2016, and 103 were first visited in 2017. More details on the panel visits can be found in Appendix A.[17]

6.3.1 First-Year vs. Lifetime ISR Defined

In-service rate (ISR) represents the percent of program bulbs that program participants have obtained and installed in a given period of time. Typically, ISRs for residential lighting programs are presented for first-year and lifetime.

First-year ISR is a measure of how many LEDs are installed within the first year after acquisition. It is common for first-year ISRs for upstream lighting programs to be well below 100%. Per the Uniform Methods Project Residential Lighting Protocol (UMP),[18] three factors lead to lower first-year ISRs:

1. Deeply discounted price
2. Inclusion of multipacks in the program
3. Consumers waiting until a bulb burns out before replacing it

First-year ISR for any given year is relatively easy to calculate from the panel data collected in Massachusetts. For this report, we simply identified all the new LEDs observed (installed or in storage) at panel households. That is, any LEDs that had not been present at the household at the time of our last visit (October 2016 – February 2017). We then divided the number of new LEDs found installed by the total number of new LEDs observed. We excluded any bulbs identified as having been obtained through a direct-install program.

The **lifetime ISR** represents the percent of program bulbs expected to be installed eventually (i.e., the proportion of LEDs purchased that are to be used in sockets). In the case of ISR, lifetime does not refer to the rated number of hours or expected useful life of a bulb, but instead the time horizon for which we can reasonably expect LED energy savings to continue to be installed from storage. In the case of LED bulbs, the lifetime ISR represents how many LEDs may eventually be installed versus given away, thrown away, returned, lost, or terminally left in storage.

While the UMP includes guidance and advice from other studies on calculating CFL lifetime ISR, very little primary research has been conducted on lifetime LED ISR. This is due in part to the fact that until recently, LED saturation was too low to offer large enough sample sizes in on-site visits. Fortunately, the RLPNC 17-9 study offers an opportunity to observe multi-year ISR among panelists. Specifically, we have calculated a second-year ISR based on the 109 homes we visited in both 2016 and 2017 that had stored and/or installed LEDs purchased

[17] http://ma-eeac.org/wordpress/wp-content/uploads/Lighting-Market-Assessment-Consumer-Survey-and-On-Site-Saturation-Study.pdf
[18] https://www.nrel.gov/docs/fy17osti/68562.pdf

in the period between the 2015 and 2016 visits. Again, we excluded any bulbs identified as having been obtained through a direct-install program.

6.3.2 LED Observed First-Year ISR

Based on conversations between the Energy Efficiency Advisory Council (EEAC) Consultants and the Massachusetts Electric PAs, Massachusetts has decided to use a weighted average approach for calculating first-year ISR for LEDs.

To calculate the first-year ISR, we averaged first-year ISR observed among sites visited as part of the 2016, 2017, and 2018 Market Assessments. We excluded the 2014-2015 Market Assessment because the panel visits that year took place only five months after the 2014 visits – the relatively short time between visits does not allow us to accurately observe first-year ISR.

We weighted the first-year ISRs for 2016, 2017, and 2018 by the number of LEDs observed each year to calculate the weighted first-year ISR. Note that the data presented in this table include all LEDs. While we did examine first-year ISR for LEDs by ENERGY STAR status, we had an insufficient sample to present second-year ISR by ENERGY STAR status. Therefore, to retain comparability, we suggest using all LEDs for ISR as well. In the future, if sufficient data exist to examine multi-year ISR by ENERGY STAR status, the PAs and EEAC may wish to use a first-year ISR derived based on only ENERGY STAR LEDs since the program only supports ENERGY STAR products.

Table 10: LED First-Year Observed ISR

Study Year	# of Sites (unweighted)	# of LEDs (unweighted)	First-Year ISR (weighted)
2016	126	762	84%
2017	157	1,412	79%
2018	196	1,846	79%
Weighted Average	**479**	**4,020**	**80%**

6.3.3 LED Observed Second-Year ISR

In addition to allowing us to calculate first-year in-service rates based on observations of bulbs obtained in the past year, the panel visits provide an opportunity to understand multi-year in-service rates (an area with little primary research). Based on the 2016-17 Market Assessment, NMR calculated two-year in-service rates.[19] Building upon that work, NMR has leveraged the data collected as part of the 2018 Market Assessment to calculate two- and three-year in-service rates. We present the data in two separate tables, which walk through the number of LEDs installed by the year they were purchased.

[19] RLPNC 16-7: LED In-Service Rate Calculations (memo)

Table 11 shows in-service rate over a three-year period for LEDs that were first purchased in 2015.[20] Table 12 shows in-service rate over a two-year period for LEDs that were first purchased in 2016. All data are presented unweighted.

2015 Purchases. As part of the 2016 Market Assessment, with these 109 homes, we observed a total of 1,316 new LEDs that customers had purchased in 2015. In total, 1,187 (90%)[21] of these LEDs had been **installed** and 129 were being **stored** for future use.

- When we returned to these same 109 homes as part of the 2017 Market Assessment, an additional 53 of the 2015 purchased bulbs (or 41% of those left in storage) had been installed.
- Finally, when we returned to these 109 homes as part of the 2018 Market Assessment, an additional 14 bulbs (or 18% of those left in storage) had been installed.
- In total, 95% of all bulbs purchased in 2015 were installed over a three-year period.

Table 11: LED Multi-Year ISR – Bulbs Purchased in 2015

	# of Sites	Stored (weighted)	Installed (weighted)	Incremental Install from Storage	Installed Total (ISR)
Year 1 (2015)	109	129	1,187	n/a	90%
Year 2 (2016)	109	76	1,240	53 (41%)	94%
Year 3 (2017)	109	62	1,254	14 (18%)	95%

2016 Purchases. As part of the 2017 Market Assessment, we visited 146 homes that had purchased 1,804 LEDs in 2016. In total, 1,436 (80%)[22] of these LEDs had been **installed** and 368 were being **stored** for future use.

- When we returned to these same 146 homes as part of the 2018 Market Assessment, an additional 104 bulbs (or 28% of those left in storage) had been installed.
- In total, 85% of all bulbs purchased in 2016 were installed over a two-year period.

Table 12: LED Multi-Year ISR – Bulbs Purchased in 2016

	# of Sites	Stored	Installed	Incremental Install from Storage	Installed Total (ISR)
Year 1 (2016)	146	368	1,436	n/a	80%
Year 2 (2017)	146	264	1,540	104 (28%)	85%

[20] Given the relatively low levels of LED penetration and saturation, as well as the short time between 2014 and 2015 panel visits (just five months), we were unable to generate reliable estimates for bulbs purchased in 2014.
[21] Note: the first-year ISR presented here differs from that presented in Table 10 because the sample is the subset of sites visited in 2015, 2016 and 2017.
[22] Note: the first-year ISR presented here differs from that presented in Table 10 because the sample is the subset of sites visited in 2016 and 2017.

To calculate the weighted average multi-year ISR for bulbs purchased in 2015 and 2016, we simply added the stored bulbs and installed bulbs (separately) from 2015 and 2016 for Years one and two. The results of this addition are shown in Table 12. Based on these combined counts, we calculated the average incremental install from storage for year two as 32%.

Table 13: Weighted Average Multi-Year ISR

	Stored	Installed	Incremental Install from Storage	Installed Total (ISR)
Year 1	129 + 368 = 497	1,187 + 1,436 = 2,623	n/a	84%
Year 2	76+ 264 = 340	1,240 + 1,540 = 2,780	157 (32%)	89%

6.3.4 Estimated Lifetime ISR

While we observed first-, second-, and third-year ISR as part of the panel visits, three years is likely far short of the time frame during which customers will install LED bulbs that they have stored. Therefore, we must extrapolate based on the data at hand.

For the first-year ISR, we used the weighted average of 80% as shown in Table 10 above. We then assumed that customers would install LEDs from storage at a rate of 32% of stored bulbs for the second year and 18% for each year thereafter (based on observed second- and third-year installation patterns shown in Table 11 and Table 13). We used this measured incremental installation from storage data to estimate ISR by year.

For example, for 2017, we have a weighted average ISR of 80% - meaning 20% of LEDs are in storage. We assume the 32% of the LEDs being stored will be installed in 2018 (32% * 20% = 6%), bringing the 2018 ISR to 86% and reducing the share in storage to 14%. For 2019, we assume that 18% of the remaining 14% in storage will be installed (18% * 14% = 3%), bringing the 2019 ISR to 89%. Using this approach, each year, the number of LEDs in storage declines and the total ISR increases – approaching, but not reaching, 100% when we extrapolate out nine years to 2025 (Table 14).

Table 14: In-Service Rate Extrapolation

Year	Incremental Install from Storage	Storage	ISR
1 – 2017	n/a	20%	80%
2 – 2018	32%	14%	86%
3 – 2019	18%	11%	89%
4 – 2020	18%	9%	91%
5 – 2021	18%	7%	93%
6 – 2022	18%	6%	94%
7 – 2023	18%	5%	95%
8 – 2024	18%	4%	96%
9 – 2025	18%	3%	97%

Determining how many years out to extrapolate ISR to achieve a lifetime estimate requires looking at the broader market for LEDs. Based on the work incorporated into the 17-6 Market Adoption Model, which included consensus market-share estimates arrived at based on input from the PAs, the EEAC, and NMR, the PAs have established estimated useful lives (EUL) for three main categories of LED bulbs: A-line, reflector,[23] and specialty.[24] EULs vary by bulb category based on the assumption that the market for some categories will transform more slowly. The EULs the PA's calculated yielded 7 years for all three bulb types (with that for A-lines rounded up from 6.5 years).

Based on these EULs, input for lighting experts on the state of the market for each bulb category, and discussions between the PAs and EEAC evaluation consultants (with assistance from NMR), the PAs and EEAC established sunset years for each bulb type. Sunset years are defined as points in time past which the Massachusetts PAs will no longer claim energy savings for a bulb–determined by the date which consumers are unlikely to find non-LED bulbs available for purchase.

Using these three sunset years, we have established lifetime ISR by bulb type as included in Table 15.[25] As the table shows, we assume that the PAs will stop claiming savings after 2022 for A-line LEDs, after 2023 for reflectors, and after 2023 for other specialty LEDs. Since the years used are based on market occurrences, the ISR rate is based on an actual stop-year rather than the number of years after purchase. For example, A-Line ISR will stop at 2022 for each year going forward.

Table 15: Estimated Lifetime LED In-Service Rate

Year	A-Line	Reflector	Specialty
1 – 2017	80%	80%	80%
2 – 2018	86%	86%	86%
3 – 2019	89%	89%	89%
4 – 2020	91%	91%	91%
5 – 2021	93%	93%	93%
6 – 2022	**94%**	94%	94%
7 – 2023		**95%**	**95%**

6.3.5 Discounting Future Savings for Benefit-Cost Tests

In Massachusetts, the PAs are required to examine benefits and costs associated with energy-efficiency programs in present value terms. Since we know that consumers do not immediately install all bulbs during the year in which they are purchased, the PAs must have a process in place to account for savings that occur after the year in which that incentive was

[23] Reflectors include PAR, MR, BR, ER, and other reflector shapes.
[24] Specialties include globes, candelabras, and other non-reflector specialty shaped lamps.
[25] Note: We assume the same incremental install rate for each type of LED as our sample is not sufficiently large to allow us to calculate incremental installations by specific LED categories.

paid. The UMP suggests two methods to account for bulbs that are installed after the first year:

1. *Stagger the timing of savings claims. In this method, all the program expenses are claimed during the program year, but the savings (and, therefore, the accompanying avoided-cost benefits) are claimed in the years during which the program measures are estimated to be installed. This approach more accurately captures the anticipated timing and quantity for the realized savings.*

2. *Discount future savings. In this method, all the costs and benefits are claimed during the program year, but the savings (in terms of avoided costs, kilowatt-hours, or kilowatts) from the expected future installation of stored program bulbs are discounted back to the program year using a societal or utility discount rate.[26] This method offers the simplicity of claiming all costs and benefits during the program year, and thus not having to track and claim future installations.*

For Massachusetts, the PAs have chosen the second method and this study's ISR is currently using a discount rate of 2.54%. The discount rate is set based on a twelve-month average of the historic yields from the ten-year United States Treasury note, using the previous year to determine the twelve-month average. The order governing this can be found here: http://170.63.40.34/DPU/FileRoomAPI/api/Attachments/Get/?path=11-120%2f13113dpuord.pdf

To establish the discounted in-service rate for each of the three bulb types, we calculated the net present value based on the first-year ISR and the incremental ISR for each year through 2023. Table 16 provides the discounted ISR for each year from 2017 through 2023. To apply the discounted ISR, the PAs need only choose the discounted ISR that corresponds to the last year of claimed savings for a specific lamp type.

- A-line = 93%
- Reflector = 94%
- Specialty = 94%

Table 16: Estimated vs. Discounted ISR

Year	A-Line	Reflector	Specialty	Discounted ISR
1 – 2017	80%	80%	80%	80%
2 – 2018	86%	86%	86%	86%
3 – 2019	89%	89%	89%	89%
4 – 2020	91%	91%	91%	91%
5 – 2021	93%	93%	93%	92%
6 – 2022	94%	94%	94%	**93%**
7 – 2023		95%	95%	**94%**

[26] Energy or demand savings are not normally discounted; however, this approach provides simplicity for calculating program benefit/cost ratios and the actual net present value of avoided costs, which often are used for cost recovery. For programs that want to bid into capacity markets (for example, PJM), the staggered approach is recommended because it more accurately captures the actual timing and cumulatively increasing nature of the demand savings.

7 Section 7 LED Satisfaction

In all households that had at least one LED installed, participants indicated their level of satisfaction with each model currently installed in their homes. Results by ENERGY STAR® Status are detailed in Table 17, and results by bulb shape are described in Table 18. Respondents in both areas reported high levels of satisfaction with their LED bulbs: Householders in Massachusetts reported that they were "very satisfied" or "somewhat satisfied" with 97% of their LEDs, slightly higher than New York householders (96%). Only "very satisfied" and "somewhat satisfied" responses are reflected in the tables below; see Table 49 and Table 50 in Appendix E for information on additional response categories.

- ***Overall, among households that had LEDs installed, LED satisfaction was high, and satisfaction with ENERGY STAR LEDs was not significantly different from that of non-ENERGY STAR labeled bulbs.***
- ***Although satisfaction with ENERGY STAR LEDs was similar to non-ENERGY STAR LEDs in Massachusetts, their popularity was demonstrated by the fact that we found over three times as many ENERGY STAR LEDs installed than non-ENERGY STAR LEDs, which is likely a result of the program.***

In Massachusetts, satisfaction with ENERGY STAR and non-ENERGY STAR bulbs was statistically similar, with respondents reporting that they are "very satisfied" with 89% of their ENERGY STAR bulbs. Similarly, we observed no difference in bulb satisfaction between ENERGY STAR and non-ENERGY STAR bulbs in New York.

Table 17: LED Satisfaction

(Base: Respondents with at least one LED installed in the home)

Level of Satisfaction	Massachusetts				New York			
	ENERGY STAR LEDS	Non-ENERGY STAR LEDS	Don't know	All LEDs	ENERGY STAR LEDS	Non-ENERGY STAR LEDS	Don't know	All LEDs
Households	*247*	*135*	*128*	*291*	*76*	*96*	*84*	*142*
Number of Bulbs	*2,636*	*785*	*829*	*4,249*	*312*	*492*	*308*	*1,111*
Very Satisfied	89%[a]	92%[a]	83%[a]	89%	83%	87%	88%	86%
Somewhat Satisfied	8%	5%[a]	11%	8%	12%	9%	11%	10%

[a] Significantly different from New York at the 90% confidence level.

A-line bulbs were the most common LEDs found in both Massachusetts and New York, followed by reflectors (Table 18). LED satisfaction for A-line bulbs was high in both areas (96%), although more respondents in Massachusetts reported they were "very satisfied" with their bulbs than in New York. Furthermore, 89% of respondents in Massachusetts reported being "very satisfied" with their reflector bulbs, compared to 83% in New York.

Table 18: LED Satisfaction by Bulb Shape

(Base: Respondents with at least one LED installed in the home)

Level of Satisfaction	Massachusetts						
	A-Line	Reflector	Candle	Globe	Slim-style	Bullet/ Torpedo	Other
Households	*268*	*183*	*85*	*54*	*20*	*10*	*17*
Number of Bulbs	*2,374*	*1,022*	*489*	*184*	*67*	*36*	*78*
Very Satisfied	89%[a]	89%[a]	86%[a]	87%[a]	97%	45%[a]	86%
Somewhat Satisfied	7%[a]	9%	11%[a]	11%[a]	2%	55%[a]	9%
	New York						
Households	*128*	*52*	*21*	*7*	*2*	*8*	*10*
Number of Bulbs	*768*	*138*	*82*	*24*	*4*	*29*	*19*
Very Satisfied	84%	83%	95%	93%	2	100%	18
Somewhat Satisfied	12%	10%	4%	7%	2	0%	1

[a] Significantly different from New York at the 90% confidence level.

To further assess consumers' experiences with LEDs, the team asked respondents who were "somewhat dissatisfied" or "very dissatisfied" to explain their responses (see Appendix D for additional information). Although the subset of respondents was small, with responses regarding 26 bulbs in Massachusetts and four bulbs in New York, the most common reason was dissatisfaction with the bulb's appearance or light quality, followed by complaints over bulbs burning out or breaking, or not working well with a dimmer.

8 Section 8 EISA Coverage, Exemptions and Exclusions

This section examines the potential impact of EISA Phase I and Phase II (sometimes referred to as the EISA backstop) on installed bulbs in Massachusetts and New York by categorizing each bulb as covered by EISA, directional (covered by a separate rulemaking), linear fluorescent, or not covered by EISA. Here, we provide a summary of the EISA status of bulbs observed installed during on-site visits.

- ***The future of Phase II of EISA is currently uncertain. After DOE issued two rulemakings in January 2017, the National Electrical Manufacturers Association (NEMA) filed a petition to review the DOE rulemakings and ultimately reached a settlement agreement with DOE. In exchange for NEMA agreeing to withdraw its petition, the DOE agreed to re-open and complete the GSL rulemaking. Initially, reports were that the DOE would issue revised rules in September of 2017, but as of February 2018, the DOE has not indicated if and how it will complete the rulemakings.***
- ***As currently drafted, EISA Phase II will prohibit the manufacture, import, and sale of non-compliant bulbs. This may mean that, unlike Phase I, where the effects of EISA lagged implementation, Phase II effects may precede implementation (planned for January 1, 2020). While the DOE has left Phase II enforcement specifics somewhat vague, preliminary indications are that a sell-through period is likely, and DOE specifically said that they may delay enforcement for some bulb categories.***
- ***About six out of every ten installed bulbs in Massachusetts (58%) and New York (64%) in 2017 were directly covered by EISA Phase I; the remaining installed bulbs were exempt from EISA Phase I (14% and 12%), directional (19% and 15%), or linear fluorescent (8%, and 9%).***
- ***Of installed bulbs in Massachusetts that are covered by EISA Phase I, 65% meet or exceed EISA Phase I requirements – 61% are efficient bulbs (CFLs or LEDs) and 4% are EISA-compliant halogen bulbs.***

Figure 20: EISA Phase I Categories

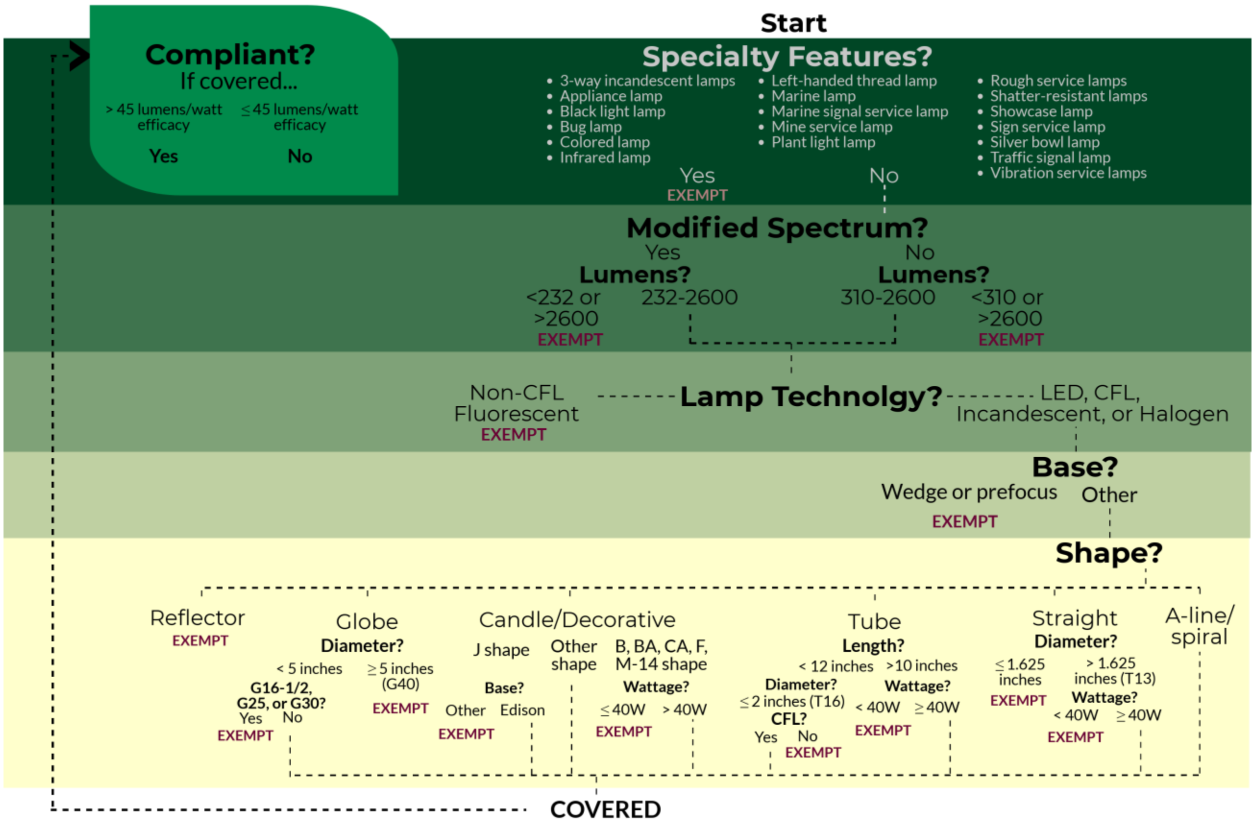
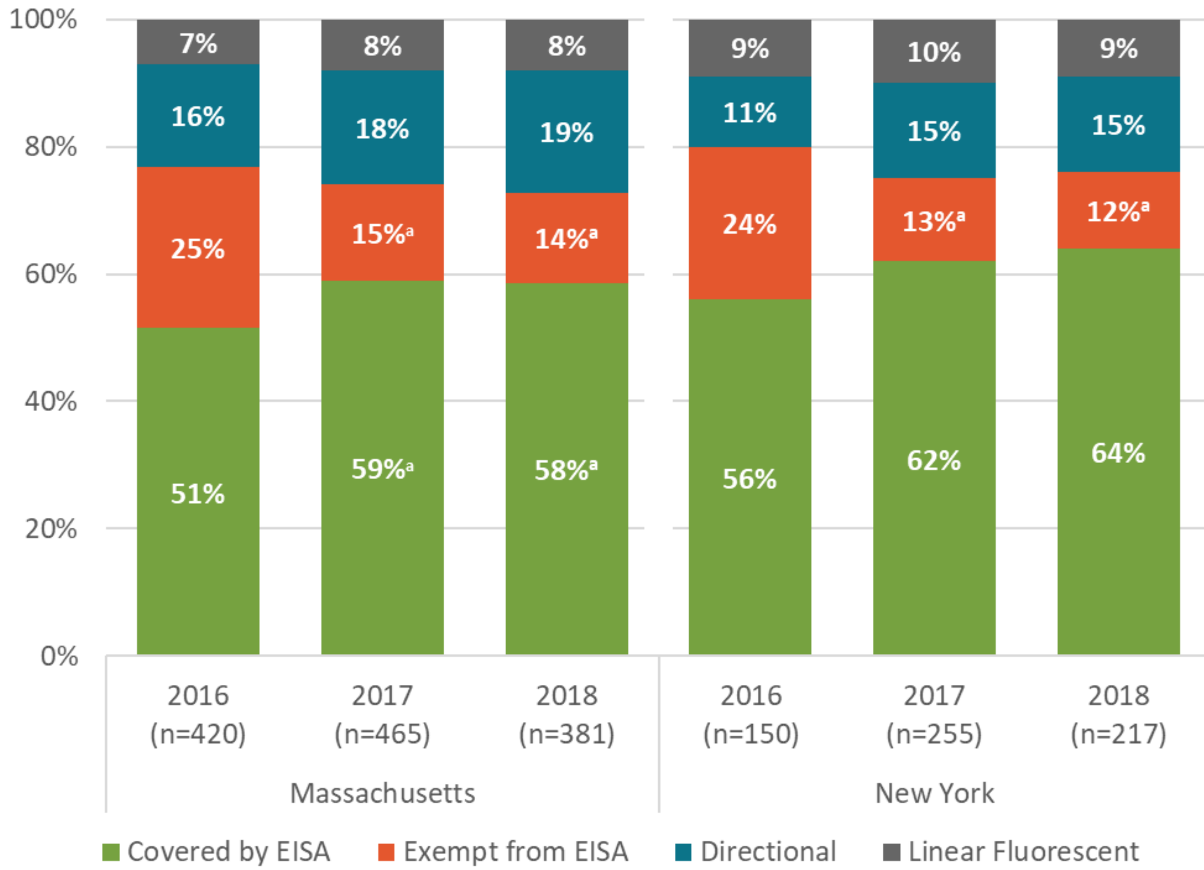


Figure 21 shows installed bulbs in Massachusetts and New York homes in 2016, 2017, and 2018, grouped into four categories: covered by EISA, directional, linear fluorescent, and exempt from EISA.

As in 2017, both Massachusetts and New York on-site data in 2018 showed that approximately six out of every ten currently installed bulbs were covered by EISA (58% in Massachusetts and 64% in New York). EISA-exempt bulb saturation was also similar to 2017 saturation in both areas.[27]

[27] 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.

Figure 21: Bulbs by EISA Phase I Category



[a] Significantly different from 2016 at the 90% confidence level.

To help in understanding the current state of sockets covered by EISA, we present the breakdown of bulbs by type that are categorized as General Service covered by EISA. As Table 19 shows, three out of five (61%) of EISA-covered bulbs found installed in Massachusetts were efficient (CFLs or LEDs), and just under one-half (46%) were inefficient. In New York, more than two-fifths (43%) of installed General Service bulbs were efficient and three-fifths (57%) were inefficient. Among all Covered General Service bulbs, 65% of all bulbs in Massachusetts were already EISA compliant in 2018 compared to 49% of bulbs in the New York comparison area.

Table 19: General Service Covered by EISA Phase I Saturation

Sockets Containing	Massachusetts			New York		
	2016	2017	2018	2016	2017	2018
Sample Size	*420*	*465*	*381*	*150*	*255*	*217*
Total Bulbs	**17,346**	**16,710**	**12,038**	**7,372**	**9,817**	**7,293**
CFL	47%	38%	35%	37%	30%	29%
Incandescent	40%	42%	35%	55%	55%	51%
Halogen	3%	4%	4%	3%	6%	6%
LED	10%	16%	26%	5%	9%	14%
Other	--	<1%	<1%	<1%	<1%	0%
Total Efficient	*57%*	*54%*	*61%*	*42%*	*39%*	*43%*
Total Inefficient	*43%*	*46%*	*39%*	*58%*	*62%*	*57%*
Already EISA Compliant	*60%*	*58%*	*65%*	*45%*	*45%*	*49%*

8.1 Phase I EISA Coverage

In 2015, the Northeast Energy Efficiency Partnerships (NEEP) issued a paper that looked at the residential lighting market in the Northeast in the context of EISA.[28] The purpose of the NEEP 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 five categories in order to increase understanding of the proportion of bulbs covered by the EISA rulemaking.

As the coverage of EISA is important in determining the future of residential lighting, we set out to examine on-site saturation data for installed bulbs in Massachusetts in a similar context. In order to group the on-site data collected into categories, we used the flow chart presented in Figure 20.[29] Ultimately, we elected to categorize bulbs into four distinct categories, combining two of the NEEP categories (exempt from EISA Phase I and decorative):

NEEP Categories

1. General Service (covered by EISA)
2. Directional
3. Linear Fluorescent
4. General Service (exempt from EISA)
5. Decorative

NMR Categories

1. Covered by EISA
2. Directional
3. Linear Fluorescent
4. Exempt from EISA

Any bulbs that were not covered in this flow chart were categorized as non-general service bulbs. Any bulbs with incandescent equivalent wattages below 29 watts or above 100 watts

[28] 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

[29] Note that this flowchart outlines EISA categorization based on the original EISA 2007 legislation and does not take into account differences in exempted bulbs outlined in the DOE's notice of proposed rulemaking, which applies only to CFLs and LEDs.

(outside the EISA lumen or wattage categories) were also categorized as not covered by EISA Phase I. Because lumen information is not included on light bulbs, we relied on wattage recorded on site to determine equivalent incandescent wattage for LED, CFL, and halogen bulbs. We used the ratios provided in Table 20, which were derived from manufacturer-recommended wattage equivalency tables. We recognize that adopting a single wattage ratio is a simplified approach because wattage ratios vary depending on desired lumen output. To convert observed wattages to incandescent-equivalent wattages, we simply multiplied observed wattages by the ratio and rounded to the nearest whole watt. For example, an LED with a wattage of 11 would be assumed to have an incandescent equivalent wattage of 73 [11 * 6.66 = 73].

Table 20: Wattage Ratios

Bulb Type	LED Ratio	Incandescent Ratio
LED	1.0	6.66
CFL	0.59	3.70
Incandescent	0.15	1.0
Halogen	0.22	1.39

8.2 EISA Phase I Coverage – Replacement Bulbs

To help increase our understanding of the EISA status of bulbs being installed by customers, we examined the source and EISA status of replacement bulbs installed in Massachusetts panel households in 2017.[30] As stated above, these EISA categories are based on the original EISA 2007 coverages and do not factor in proposed changes that expand covered bulbs, which would not go into effect until after January 1, 2020. For this analysis, we excluded linear fluorescents. As a point of comparison, the proportions of all bulbs divided into the three remaining EISA categories are as follows:

- Covered by EISA: 68%
- Exempt: 17%
- Directional: 16%

As Table 21 shows, in Massachusetts, nearly seven out of ten replacement bulbs were General Service bulbs covered by EISA (68%), 17% were categorized as exempt, and 16% were directional.

Covered by EISA Phase I

CFLs (92%) were the most likely to be covered by EISA, followed by halogens (78%), LEDs (66%), and incandescents (54%).

[30] Given the relatively small sample sizes in New York, we have limited this analysis to Massachusetts.

Exempt from Phase I

Incandescents (37%) were the most likely to be categorized as exempt, followed by LEDs (14%), halogens (4%), and CFLs (4%).

Directional

LEDs (20%) were the most likely to be categorized as directional, followed by halogens (18%), incandescents (9%), and CFLs (4%).

Table 21: Replacement Bulbs by EISA Phase I Category (Massachusetts)

Bulb Type	# of Bulbs	Covered by EISA	General Service (Exempt from EISA)	Directional
Total Bulbs	***2,721***	***1,845***	***450***	***427***
		68%	***17%***	***16%***
LED	*1,613*	66%	14%	20%
CFL	*378*	92%	4%	4%
Incandescent	*532*	54%	37%	9%
Halogen	*199*	78%	4%	18%

When we examined the bulb source for bulbs that were covered by EISA, we found that nearly one-half of incandescents (46%) covered by EISA were new, indicating that customers were still able to find non-compliant bulbs from sources other than storage. Further, the vast majority of halogens (66%) were new (Table 21).

Table 22: Replacement Bulbs covered by EISA Phase I by Source (Massachusetts)

Bulb Type	# of bulbs	Bulbs Covered by EISA – Source		
		New bulb	From storage	From another fixture
Total Bulbs	***1,845***	***1,338***	***434***	***73***
		73%	**24%**	**4%**
LED	1,056	90%	8%	2%
CFL	346	44%	44%	12%
Incandescent	287	46%	50%	4%
Halogen	156	66%	32%	2%

A Appendix A Methodology

This appendix provides a detailed summary of the methodological approaches used for this study.

A.1 Weighting Scheme

The on-site survey data were weighted to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on Public Use Microdata Sample (PUMS) from the American Community Survey (ACS) 5-Year Estimates. The guiding principles behind the schemes are as follows:

- To maintain comparability with previous schemes dating back to 2008; this is very important for tracking changes in saturation, use, purchase, and storage behavior
- To reflect the population of Massachusetts, including by weighing the data for the New York comparison area to the demographic characteristics of Massachusetts
- To make certain that the panel data are treated properly (i.e., that the panel data correctly represent the population and what we want to compare over time)

Table 23: On-Site Visit Weight Scheme

Year	Tenure and Home Type	Households	Sample Size	Proportionate Weight
2018 Panel Visits Massachusetts	*Total*	2,588,743	381	
	Owner-Occupied		285	
	Some College or Less	796,710	85	1.40
	Bachelor's Degree or Higher*	792,033	200	0.59
	Renter-Occupied		96	
	Some College or Less	653,851	39	2.50
	Bachelor's Degree or Higher**	316,295	57	0.83
*Includes 1 tenure = occupied without payment or rent and 1 tenure = occupied without payment or rent and education = prefer not to answer. **Includes 2 education = prefer not to answer.				
2018 Panel Visits New York	*Total (MA households to represent)*	2,588,743	217	
	Owner-Occupied			
	Some College or Less	796,710	44	1.53
	Bachelor's Degree or Higher*	792,033	120	0.56
	Renter-Occupied			
	Some College or Less	653,851	32	1.73
	Bachelor's Degree or Higher	316,295	21	1.28
*Includes 2 education = prefer not to answer				

Table 24 provides the weighted estimates of total saturation by area as well as the mean and median saturation at the household level. The greater the difference between the mean and median per household, the greater the discrepancy between households with a lot of that bulb type installed versus those with few. This difference was largest for LEDs, likely demonstrating that there are some households "completely sold" on LEDs while others are not, indicated that there are still households that could be influenced by a lighting program.

Table 24: **Saturation by Socket and Mean and Median Saturation by Household, 2018**

Bulb Type	Massachusetts (n=381)			New York (n=217)		
	Saturation	Mean	Median	Saturation	Mean	Median
Incandescent	28%	27%	23%	42%	39%	40%
CFLs	26%	29%	28%	21%	24%	20%
LEDs	27%	24%	17%	14%	13%	7%
Halogen	8%	7%	5%	9%	9%	6%
Fluorescent	7%	8%	5%	8%	8%	5%

A.2 On-Site Lighting Inventories – Panel Visits

NMR visited 598 homes – 381 in Massachusetts and 217 in New York – to collect data on their lighting use, storage, and purchase behavior. These visits represent the most recent efforts in a long-term series of on-site data collection; all of the households in both Massachusetts and New York had taken part in prior on-site visits (panel visits). Importantly, visits conducted in Massachusetts and New York have been coordinated since 2009.[31] Figure 22 provides an overview of on-site visits conducted during this period, and Figure 23 provides a summary of visit timing. Visits for the 2018 Market Assessment were conducted at the end of 2017.

The PAs, Energy Efficiency Advisory Council (EEAC) Consultants, and evaluators chose New York as a comparison area because it presents a unique opportunity to understand how the residential lighting market has responded to the cessation of standard spiral CFL incentives in 2012 and essentially all upstream incentives in 2014. The New York State Energy Research and Development Authority (NYSERDA) continued limited support for specialty CFLs and LEDs through mid-2014, but the volume of incentivized bulbs was very small compared to those supported in Massachusetts. On-site lighting saturation surveys in New York serve as a proxy to help understand what may have happened in Massachusetts had the Massachusetts PAs similarly eliminated standard spiral CFL incentives during the same period. New York is also a good comparison area because of its proximity to Massachusetts and the demographic alignment for the comparison area to Massachusetts.

[31] Coordination between 2009 and 2013 reflected participation in joint studies (Multistate Modeling Efforts and the Regional Hours of Use Study). Massachusetts, however, funded data collection in New York in 2015, 2016, 2017, and 2018 for reasons discussed in the body of the report.

To date, five waves of panel visits have been completed in Massachusetts, and three waves of panel visits have been completed in New York. The panel in Massachusetts was first established in 2013, with 150 new on-site visits.

- **Massachusetts Panel Wave One:** In 2014, we returned to 111 of the homes first visited in 2013 as part of the Regional Hours-of-Use Study and visited an additional 150 homes for the first time.
- **Massachusetts Panel Wave Two:** In 2015, we returned to 203 homes – 89 that were first visited in 2013 and 114 that were first visited in 2014 – and visited an additional 151 homes for the first time.
- **Massachusetts Panel Wave Three:** In 2016, we returned to 270 homes – 77 that were first visited in 2013, 98 that were first visited in 2014, and 95 that were first visited in 2015 – and visited an additional 150 homes for the first time.
- **Massachusetts Panel Wave Four:** In 2017, we returned to 315 homes – 65 that were first visited in 2013, 83 that were first visited in 2014, 72 that were first visited in 2015, and 95 that were first visited in 2016 – and visited an additional 150 homes for the first time.
- **Massachusetts Panel Wave Five:** For the 2018 Market Assessment, we returned to 381 homes – 58 that were first visited in 2013, 74 that were first visited in 2014, 68 that were first visited in 2015, 78 that were first visited in 2016, and 103 that were first visited in 2017. No homes were visited for the first time in this wave.

In 2015, NMR oversaw the establishment of a panel in New York as a comparison area for Massachusetts. In 2015, we visited a total of 101 homes for the first time.

- **New York Panel Wave One:** In 2016, we returned to 80 of the homes first visited in 2015 and visited an additional 70 homes for the first time.
- **New York Panel Wave Two:** In 2017, we returned to 105 homes – 61 that were first visited in 2015 and 44 that were first visited in 2016 – and visited an additional 150 homes for the first time.
- **New York Panel Wave Three:** In 2018, we returned to 217 homes – 49 that were first visited in 2015, 18 that were first visited in 2016, and 129 that were first visited in 2017. No homes were visited for the first time in this wave.

One potential drawback of a panel study is the possibility that study participants may change their behavior because of study participation – a phenomenon known as the Hawthorne Effect.[32] In past years, the Team has compared panelists to new visits to test for this and other possible differences between the panel and new visit households, but found that the panel and new visits showed very similar or identical levels of penetration, saturation, and purchase behavior. Based on past evidence, and in an effort to reduce evaluation costs and

[32] The Hawthorne effect, also called reactive effects or observation bias, occurs when subjects of an experiment alter behavior due to observation.

expedite the evaluation schedule, the PAs and EEAC elected to forgo new visits as part of the 2018 Market Assessment.

Figure 22: On-site Visits over Time

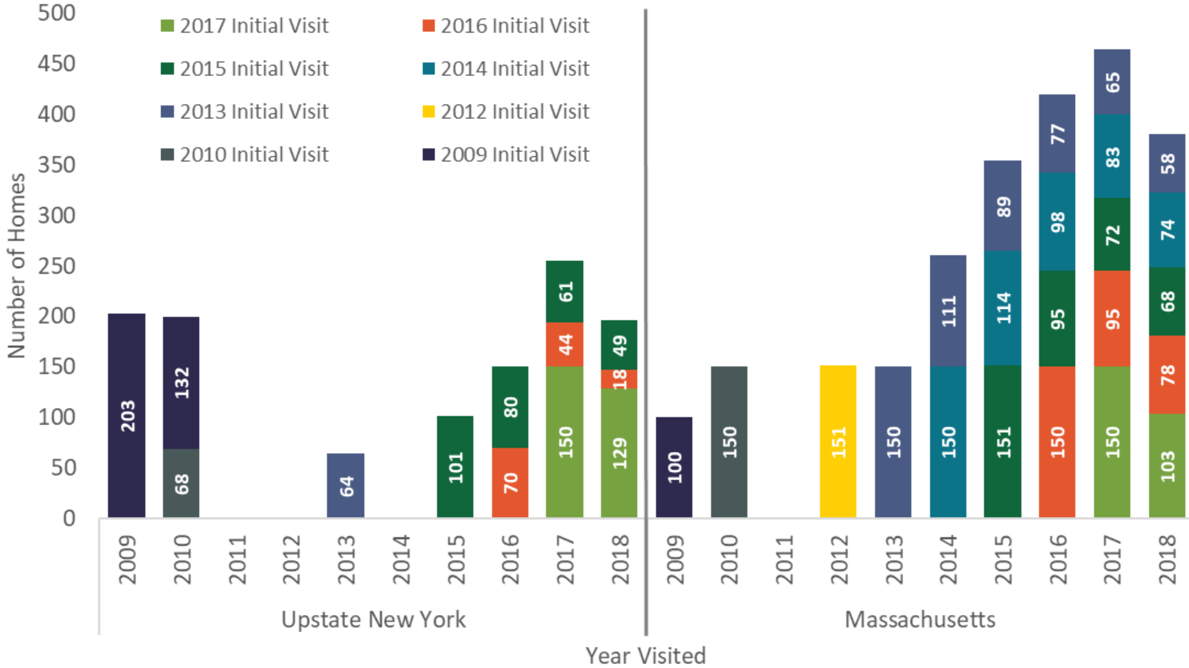
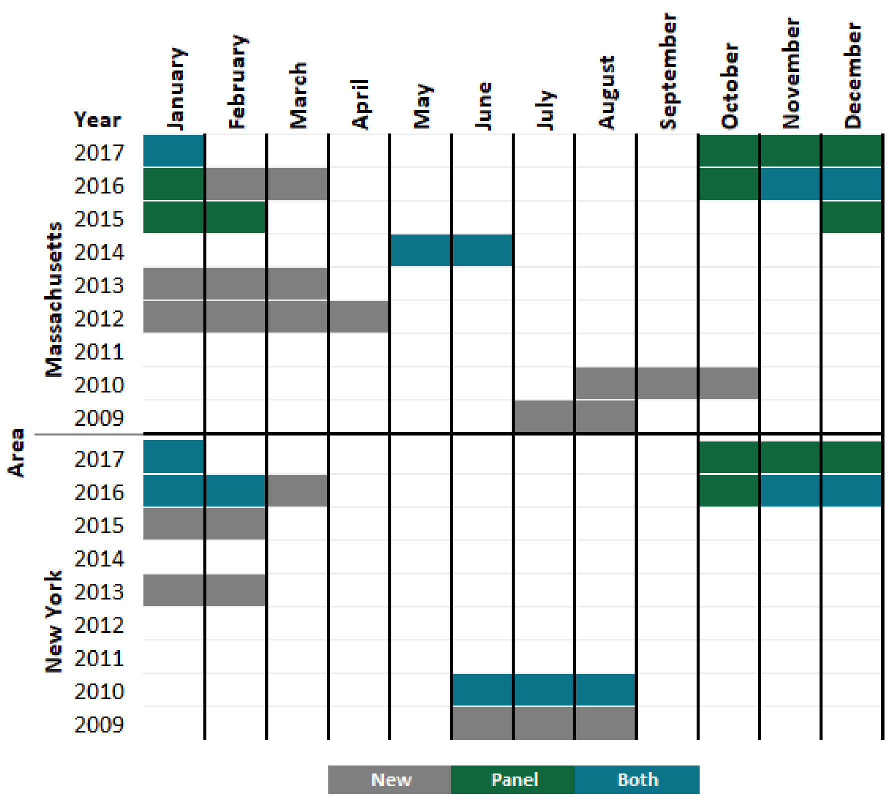


Figure 23: Timing of On-site Visits



A.3 DIRECT INSTALL

Table 25 provides an overview of direct-install program participation by year of program participation. Based on an examination of participant records for the Home Energy Services Electric, Low-Income-Single Family Electric, Low-Income Single-Family Retrofit, Residential Home Energy Services, Residential Lighting, and Residential Multifamily Retrofit programs, we estimate that about 3% of the households in PA service areas participated in at least one program each year from 2012 through 2017, and that an additional 5% participated in 2010 or 2011. Given this, we would expect our sample to include about 25% of households that had previously participated in a direct-install program. On-site technicians asked households whether they had ever participated in a program where someone came to their homes to install energy-efficient bulbs and, if so, when.

To control for possible response bias, we worked with the PAs to verify participation for new visit and panelist households from 2014, 2015, 2016, and 2017 against the program records for direct-install programs and low-income and multifamily direct-install programs.[33] Looking at verified participation in direct-install programs, we find that the combined sample includes 22% confirmed direct-install participants and that individual years of participation are generally in line with expectations. Still, this is an area that future studies should continue to carefully monitor and investigate.

Table 25: Direct-Install Program Participation by Year (Unweighted)

Year of Program Participation	Panelists [Self-Report]	Panelists [Verified]
All Years	**41%**	**22%**
2017	4%	1%
2016	8%	2%
2015	6%	6%
2014	8%	3%
2013	4%	3%
2012	4%	2%
2011	2%	<1%
Before 2011	4%	5%
Unknown year	1%	--
Non-participant	59%	79%

[33] Analysis was limited to households with first visits in either 2014, 2015, 2016 or 2017 because NMR does not have account numbers for households first visited in 2013.

A.3.1 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 82 confirmed direct-install participants. When rounded to the nearest full percent, removing the direct-install participants has a negligible impact on the key saturation estimates for CFLs or LEDs.

Table 26: Comparison of Saturation Rates (Unweighted)

Sockets Containing	2018 (excluding DI)	2018 (including DI)	Difference	2018 (DI Only)
Sample Size	*299*	*381*	*N/A*	*82*
Total Sockets	*16,307*	*23,074*	*N/A*	*6,767*
Avg. # of Sockets	*55*	*61*	--	*83*
Incandescent	30%	28%	2%	21%
CFLs	25%	26%	1%	27%
LED	25%	27%	2%	29%
Fluorescent	7%	7%	--	7%
Halogen	8%	8%	--	7%
Other/Don’t know	<1%	<1%	--	<1%
Empty Sockets	5%	4%	1%	3%

B Appendix B Saturation – Additional Detailed Analysis

In this appendix, we expand on findings presented in Section 2. We show saturation in Massachusetts and New York compared over time (2009-2018), by room type, by bulb shape, and across demographic groups. We also look at saturation of linear fluorescent bulbs and bulb saturation in specialty bulb sockets.

B.1 Saturation by Household

Table 27 provides the same data shown in Figure 8, as well as combined saturation figures for efficient and inefficient bulb types, the proportion of sockets occupied by specialty bulbs,[34] and notations for significant differences between years and areas. It also presents data for New York. Some of the additional highlights regarding saturation by area are summarized below.

Massachusetts

- **LED** saturation has increased sharply since 2014, increasing nine-fold from 2014 to 2018 (3% to 27%).
- **CFL** saturation increased steadily from 2009 to 2014; after peaking in 2014 at 33%, saturation has steadily declined each year (relatively but not significantly), down to 26% in 2018.
- **Incandescent** saturation has decreased 34 percentage points (62% to 28%) between 2009 and 2018. The percent of sockets filled with incandescent bulbs decreased relatively from 2017 to 2018, with an average annual decline of approximately four percentage points.
- **Linear fluorescent** saturation has declined by one percentage point each year since 2015.
- **Halogen** saturation remained at 8% in 2018. (Note that halogen and incandescent bulbs are very similar in appearance. We make every effort to train technicians to identify halogen bulbs, but recognize that some bulbs labeled as incandescent are likely halogen, and vice versa. Therefore, we present all incandescent and halogen data separately and combined.)
- **Combined CFL and LED** saturation in 2018 is significantly higher (53%) than in 2017 (47%). In 2009, combined efficient bulb saturation accounted for more than one-quarter (26%) of all sockets in Massachusetts; in 2017, it accounted for more than one-half (53%) of all sockets.

[34] Specialty bulbs include: three-way bulbs of any kind, dimmable CFLs and fluorescents, circline fluorescents, non-A-line LED, incandescent and halogen bulbs, and non-twist/spiral CFLs.

- **Combined efficient (CFL, LED, and linear fluorescent)** bulbs accounted for three out of five (60%) sockets in 2018.
- **Combined inefficient (incandescent and halogen)** bulbs filled just over one-third (36%) of all sockets in Massachusetts in 2018, down 31 percentage points since 2009.
- The proportion of sockets occupied by a **specialty bulb** of any technology has hovered around 40% since 2009. The proportion of sockets occupied by a **specialty CFL** (any CFL that is not twist/spiral) increased significantly, from 4% in 2009 to 11% in 2014, and has remained steady since. If we exclude A-line CFLs from specialty, the proportion of sockets occupied by a specialty bulb has remained steady, at around 8%.
- The proportion of sockets occupied by a **specialty LED** (LEDs that are not A-line shaped) has increased significantly, from 5% in 2016 to 8% in 2017 and 11% in 2018. In 2018, more than four out of ten (43%) specialty LEDs were reflectors and one-quarter (26%) were candle shaped.

New York

- **LED** saturation in New York has increased steadily since 2013, though at a much slower rate than in Massachusetts (1% to 14% in New York vs. 2% to 27% in Massachusetts during the same period). Additionally, LEDs filled significantly fewer sockets in New York in 2017 than they did in Massachusetts (14% vs 27%).
- **CFL** saturation has diverged between New York and Massachusetts since 2013. CFL saturation has remained largely stable in New York since 2013 and, at 21%, was relatively lower than CFL saturation in Massachusetts (26%) in 2018. The decrease in New York CFL saturation is concurrent with the phase-out of CFL incentives in the comparison area.
- **Incandescent** saturation in 2018 was significantly higher in New York (42%) than in Massachusetts (28%).
- **Combined CFL and LED** saturation in 2018 was significantly lower in New York (35%) than in Massachusetts (47%); likewise, **combined efficient (CFL, LED, and linear fluorescent)** saturation in 2018 was significantly lower in New York (43%) than in Massachusetts (60%).
- **Combined inefficient (incandescent and halogen)** saturation was significantly higher in New York (51%) than in Massachusetts (36%).

Table 27: Comparison of Saturation Rates, 2009‑2018

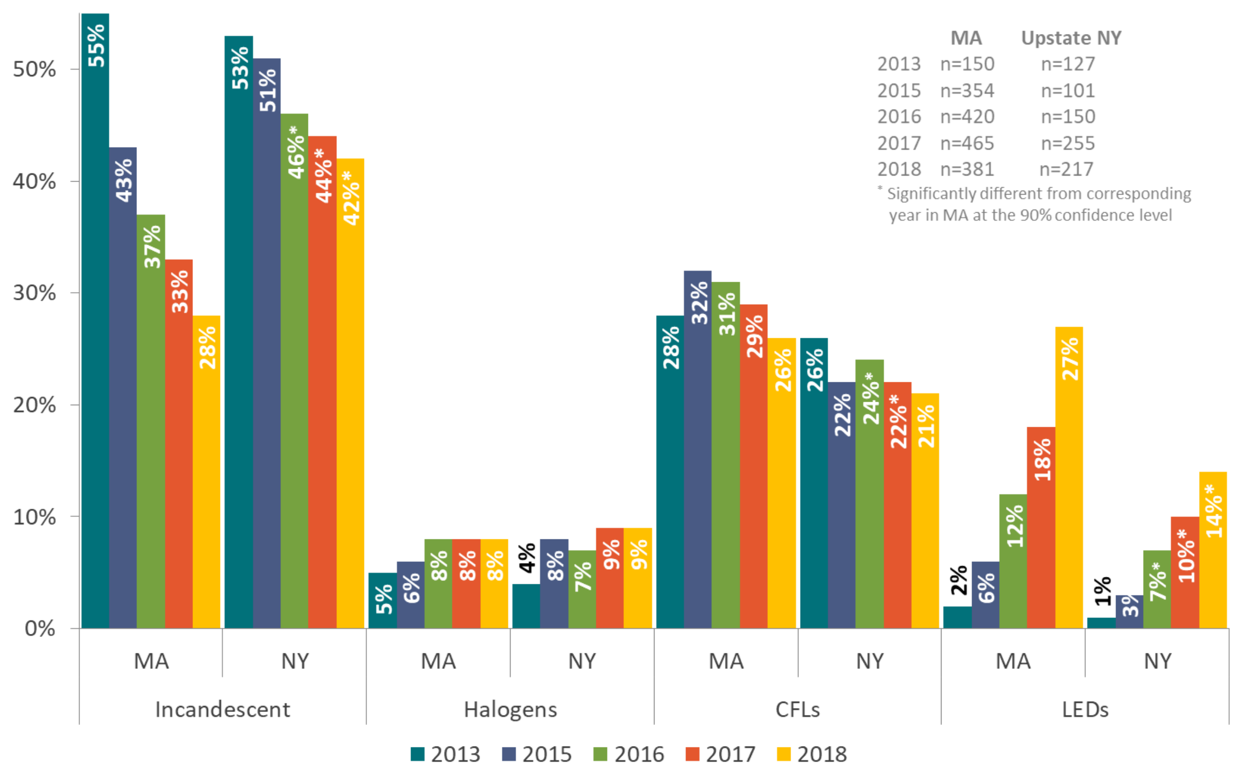
Sockets Containing	Massachusetts									New York				
	2009	**2010**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2013**	**2015***	**2016**	**2017**	**2018**
Sample Size	*100*	*150*	*151*	*150*	*261*	*354*	*420*	*465*	*381*	*127*	*101*	*150*	*255*	*217*
Total Sockets	**3,709**	**6,741**	**6,565**	**6,341**	**13,550**	**18,398**	**24,219**	**27,148**	**20,449**	**6,181**	**6,171**	**9,854**	**15,792**	**11293**
Avg. Sockets per Household	**46**	**45**	**44**	**42**	**49**	**52**	**54**	**58**	**54**	**49**	**62**	**56**	**62**	**52**
Incandescent	62%	57%	53%	55%	45%[abd]	43%[abcd]	37%[abcdef]	33%[abcdef]	28%[abcdefg]	53%[ghi]	51%[ghi]	46%[ghi]	44%[hi]	42%[i]
CFLs	26%	26%	27%	28%	33%	32%	31%	29%	26%[ef]	26%	22%[fg]	24%[g]	22%[h]	21%
Fluorescent	6%	9%	8%	9%	9%	9%	8%	7%	7%	11%	12%	12%[hi]	9%	8%
Halogen	5%	7%	11%[a]	5%[c]	6%[c]	6%[c]	8%	8%	8%	4%[ghi]	8%	8%	9%	9%
LEDs**	<1%	<1%	1%	2%[ab]	3%[ab]	6%[abcde]	12%[abcdef]	18%[abcdefg]	27%[abcdefgh]	1%[ghi]	3%[ghi]	7%[ghi]	10%[hi]	14%[i]
Other***	<1%	1%	-	2%[ac]	4%[abc]	4%[abc]	4%[b]	4%[ab]	4%[abh]	5%	5%	5%	6%i	5%
CFLs + LEDs	26%	26%	28%	30%	36%[ab]	38%[abcd]	43%[abcde]	47%[abcdef]	53%[abcdefgh]	27%[ghi]	25%[fghi]	30%[ghi]	32%[hi]	35%[i]
CFLs + LEDs + Fluorescents	32%	35%	36%	39%	45%[ab]	47%[abcd]	51%[abcd]	54%[abcdef]	60%[abcdefgh]	38%[ghi]	37%[fghi]	42%[ghi]	41%[hi]	43%[i]
Incandescents + Halogen	67%	64%	64%	60%	51%	49%	45%[abcd]	41%[abcdef]	36%[abcdefg]	57%[ghi]	59%[ghi]	54%[ghi]	53%[hi]	51%[i]
Any Specialty Bulb	30%	31%	48%[ab]	38%	40%[ab]	42%[ab]	42%[ab]	44%[ab]	43%[ab]	38%	37%	33%[ghi]	39%	38%
Any Specialty CFL	4%	7%	8%	8%	11%[a]	10%[a]	11%[ab]	10%[a]	9%[a]	6%[g]	5%[fgh]	5%[ghi]	4%[hi]	4%[i]
Any Specialty CFL (Not Including A-line CFLs)	-	-	7%	6%	9%	8%	8%	8%	7%	5%	4%[gh]	4%[gh]	3%[hi]	3%[i]
Any Specialty LED	<1%	-	1%	2%	2%	4%	5%	8%[acdefg]	11%[acdefg]	1%[hi]	2%[hi]	3%[hi]	3%[hi]	4%[i]

[*] One household in NY with 62 bulbs installed was removed from the analysis.
[**] The LED category includes both LED bulbs and integrated LED fixtures.
[***] Other includes xenon bulbs, metal halide, sodium, empty sockets, and unknown bulb types.
[a] Significantly different from MA 2009 at the 90% confidence level.
[b] Significantly different from MA 2010 at the 90% confidence level.
[c] Significantly different from MA 2012 at the 90% confidence level.
[d] Significantly different from MA 2013 at the 90% confidence level.
[e] Significantly different form MA 2014 at the 90% confidence level.
[f] Significantly different from MA 2015 at the 90% confidence level.
[g] Significantly different from MA 2016 at the 90% confidence level.
[h] Significantly different from MA 2017 at the 90% confidence level.
[i] Significantly different from MA 2018 at the 90% confidence level.

B.2 Comparison Area

Figure 24 shows Massachusetts and New York bulb saturation for 2013. The figure also shows saturation of incandescents, halogens, CFLs, and LEDs for 2015 through 2018. When looking at efficient bulbs, CFL saturation has slowly decreased in both areas since 2013, while LEDs have increased significantly in both, albeit at a faster pace in Massachusetts. LED saturation was significantly higher in Massachusetts than in New York in 2018. Both areas showed a decline in incandescent saturation since 2013, though 2018 incandescent saturation in New York was significantly higher than in Massachusetts. Halogen saturation remained steady in both areas in 2018.

Figure 24: MA & NY Bulb Saturation, 2013-2018



B.3 Saturation by Demographics

This section looks at saturation across select demographics for CFLs, LEDs, and combined incandescent and halogen bulbs in Massachusetts (Table 28) and New York (Table 30). Note that saturation percentages do not add up to 100% because fluorescent, other bulb types, and empty sockets are not shown in the table, but were included in the saturation calculations.

Massachusetts

- **Income** – LED saturation was significantly higher in non-low-income households (30% vs. 21%).[35] CFL saturation was relatively higher in low-income households (33% vs. 24%), while combined incandescent and halogen saturation was relatively higher in non-low-income households (37% vs. 30%).
- **Education** – Saturation was similar across all levels of education.
- **Tenure** – LED saturation in own/buying households was significantly higher than in rent/lease households (29% vs. 18%).
- **Home Type** – Saturation was similar across home types.

New York

- **Income** – Saturation is similar across income types. However, LED saturation among both low-income and non-low-income households in New York was significantly lower than in Massachusetts (11% vs. 21% LI; 16% vs. 30% NLI). Combined incandescent and halogen saturation in both low-income and non-low-income households was significantly higher than in Massachusetts (47% vs. 30% LI; 53% vs. 37% NLI).[36]
- **Education** – Saturation was similar across all levels of education. However, New York LED saturation was significantly lower and combined incandescent and halogen saturation was significantly higher among both the **Some College, Associates degree** level of education and the **Bachelor's Degree or Higher** level of education (11% vs. 25% for LEDs; 55% vs. 35% for combined incandescent and halogens) than their counterpart groups in Massachusetts (16% vs. 30% for LEDs; 51% vs. 36% for combined incandescent and halogens).
- **Tenure** – Saturation was similar across tenure. When compared to Massachusetts, LED saturation was significantly lower in New York among own/buying households (15% vs. 29% for LEDs); similarly, combined incandescent and halogen saturation was significantly higher among New York own/buying households (52% vs. 34%).
- **Home Type** – Saturation was similar across home types. When compared to Massachusetts households, LED saturation was significantly lower in both multifamily (11% vs. 24%) and single-family households (15% vs. 29%). Additionally, in single-family households, combined incandescent and halogen saturation was significantly higher (52% vs. 35%) in New York.

[35] Note that nine low-income households and 64 non-low-income, nine prefer-not-to-answer-income households in Massachusetts were confirmed to have participated in a lighting direct-install program.
[36] Note that 14 low-income households, 26 non-low-income, and five prefer-not-to-answer-income households in New York reported participating in a lighting direct-install program.

Table 28: Saturation by Demographics (Massachusetts)

Income	Sample Size	# of Bulbs	# of Bulbs Statewide	Avg # of Sockets per HH	CFLs	LEDs	Incan+Halo
Non-Low-Income	251	13,804	92,712,040	65	24%	30%*	37%
Low-Income	94	4,805	32,271,568	36	33%	21%	30%
DK/Refused	36	1,838	12,345,704	51	26%	25%	38%
*Significantly different from Low-income at the 90% confidence level.							
Education							
High School or Less	40	3,250	21,827,633	43	28%	24%	34%
Some College, Associate's Degree	84	7,001	47,023,019	50	27%	25%	35%
Bachelor's Degree or Higher	254	10,091	67,775,053	62	25%	30%	36%
DK/Refused	3	105	703,609	53	13%	69%	9%
Tenure							
Own/Buying	283	16,181	108,681,463	69	25%	29%*	34%
Rent/Lease	96	4,191	28,148,869	29	29%	18%	38%
Occupied without Payment or Rent	2	74	498,981	74	3%	69%	17%
*Significantly different from Rent/Lease at the 90% confidence level.							
Home Type							
Multifamily	172	6,890	46,276,789	36	29%	24%	35%
Single-Family	209	13,557	91,052,524	71	25%	29%	35%

Table 29: Statewide Socket Counts by Room Type (Massachusetts)

HOU Room Type	All Households		Multifamily		Single-Family	
	# of Sockets Statewide	Avg # of Sockets per HH	# of Sockets Statewide	Avg # of Sockets per HH	# of Sockets Statewide	Avg # of Sockets per HH
Bedroom	18,943,121	8.5	3,472,725	6.9	15,470,396	10.2
Bathroom	17,477,213	7.2	3,245,955	5.5	14,231,258	8.9
Living Space	16,655,610	7.0	2,626,800	5.5	14,028,810	8.6
Kitchen	14,317,301	6.6	2,674,945	5.2	11,642,356	8.1
Dining Room	8,746,487	3.5	1,157,844	2.7	7,588,643	4.2
Other	45,993,257	16.1	4,011,035	8.8	41,982,222	23.4
Exterior	11,039,676	4.7	768,893	1.6	10,270,783	7.7
Indoor	76,139,732	49.0	13,178,269	34.6	62,961,463	63.4

Table 30: Saturation by Demographics (New York)

Income	Sample Size	# of Bulbs	# of Bulbs (Population)	Avg # of Sockets per HH	CFLs	LEDs	Incan+Halo
Non-Low-Income	155	8,375	98,757,512	62	19%	16%	53%
Low-Income	51	2,100	24,766,102	37	26%	11%	47%
DK/Refused	20	818	9,649,054	36	25%	10%	47%
Education							
High School or Less	17	1,028	12,121,117	37	28%	17%	37%
Some College, Associate’s Degree	59	4,249	50,100,920	45	20%	11%	55%
Bachelor’s Degree or Higher	139	5,944	70,099,195	64	20%	16%	51%
DK/Refused	2	72	851,435	72	16%	3%	75%
Tenure							
Own/Buying	164	9,360	110,376,888	69	20%	15%	52%
Rent/Lease	53	1,933	22,795,779	24	24%	11%	47%
Home Type							
Multifamily	49	1,523	17,958,199	22	28%	11%	45%
Single-Family	169	9,770	115,214,469	66	20%	15%	52%

B.4 Linear Fluorescent Saturation

To better understand opportunities for increased efficiency among linear fluorescent bulbs, technicians categorized linear fluorescent bulbs as T4, T5, T8, or T12 based on a simple measurement of bulb diameter. As detailed earlier, linear fluorescents accounted for about 7% of all bulbs in residential homes in Massachusetts and 8% in New York homes. As Table 31 shows, the majority of linear fluorescents in both areas were T12s in 2018.

Still, there appears to be some opportunity to improve efficiency by encouraging households to replace T12 lighting with higher efficiency alternatives. However, the extent of this opportunity is small in comparison to the overall residential lighting market (58% of 7% in Massachusetts – or about 4% of the market). Finally, linear fluorescent 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, for which an electrician must assist.

Table 31: Installed Linear Fluorescents

Size	Massachusetts			New York		
	2016	2017	2018	2016	2017	2018
Sample Size	*420*	*465*	*381*	*150*	*255*	*217*
# of Bulbs	1,593	1,639	1,336	914	1,130	889
T4	--	--	--	<1%	<1%	<1%
T5	7%	8%	8%	3%[a]	4%[a]	5%
T8	29%	29%	28%	26%	33%	34%[b]
T12	62%	57%	58%	67%	59%	58%[b]
Don't Know	2%	6%[b]	6%	4%	4%	3%[a]

[a] Significantly different from corresponding year in MA at the 90% confidence level.
[b] Significantly different from 2016 at the 90% confidence level.

B.5 Saturation of Specialty Sockets

Table 32 shows saturation by lamp shape and specialty features. As the data show, LED saturation in Massachusetts was highest among reflector (38%) and dimmable (34%) specialty applications. LED saturation for candle (26%), bullet (23%), and globe (21%) shaped bulbs was lower. This may be a byproduct of greater availability of traditional halogen and incandescent alternatives in these categories. CFL saturation only remained higher than LED saturation among 3-way bulbs.

In comparison, LED saturation in New York lagged behind Massachusetts in all specialty categories. This is not surprising given the lower overall saturation of LEDs in New York.

Table 32: Saturation of Specialty Sockets by Bulb Type

Feature	Massachusetts				
	# of Bulbs	LEDs	CFLs	Halogens	Incandescents
Reflector/Flood	3,053	38%	17%	21%	24%
Candle	2,187	26%	6%	2%	67%
Bullet/Torpedo	346	23%	0%	77%	0%
Globe	913	21%	21%	1%	56%
Dimmable	1,782	34%	9%	14%	43%
3-way	585	26%	33%	4%	36%
Feature	New York				
	# of Bulbs	LEDs	CFLs	Halogens	Incandescents
Reflector/Flood	1,312	13%	10%	28%	48%
Candle	1,089	10%	2%	1%	88%
Bullet/Torpedo	193	17%	0%	83%	0%
Globe	539	5%	5%	1%	88%
Dimmable	390	11%	11%	11%	67%
3-way	182	11%	19%	7%	63%

B.6 Room-by-Room Saturation Analysis

In this section, we explore the proportion of sockets occupied by a specialty bulb by room category and bulb type, and focus on the proportion of sockets occupied by a specialty LED. An important consideration when examining saturation by room type is the proportion of specialty sockets present in each room type. This is important because CFL and LED specialty bulbs are generally significantly more expensive, and the selection of efficient specialty bulbs can be somewhat limited.

As Figure 25 shows, specialty sockets – including three-way bulbs of any kind; dimmable CFLs and fluorescents; circline fluorescents; non-A-line LED, incandescent, and halogen bulbs; and non-twist/spiral CFLs – comprised just over two-fifths (43%) of all bulbs in Massachusetts households in 2018. In 2018, specialty sockets comprised about three-fifths of all sockets in dining rooms (61%), kitchens (56%), and exteriors (56%) – the highest among all room types. Living spaces (51%) were the only other room type with greater than 50% specialty bulb saturation. Closets (15%), garages (19%), basements (22%), and utility rooms (23%) had the lowest saturation of specialty bulbs in 2018.

The proportion of sockets occupied by a specialty LED was similar across room types, hovering around 16%. However, when compared to the proportion of sockets occupied by a specialty bulb overall, dining rooms had nearly the lowest proportion of sockets occupied by specialty LED bulbs (13%) but the highest overall proportion of sockets occupied by a specialty bulb. This indicates that there is a lot of potential for energy-efficient bulbs remaining in dining room specialty sockets. Dining rooms also had the lowest proportion of sockets occupied by energy-efficient bulbs, as shown in Figure 26 and discussed below.

Figure 25: Specialty Bulb Saturation and Specialty LED Saturation by Room Type, 2018 (Massachusetts)

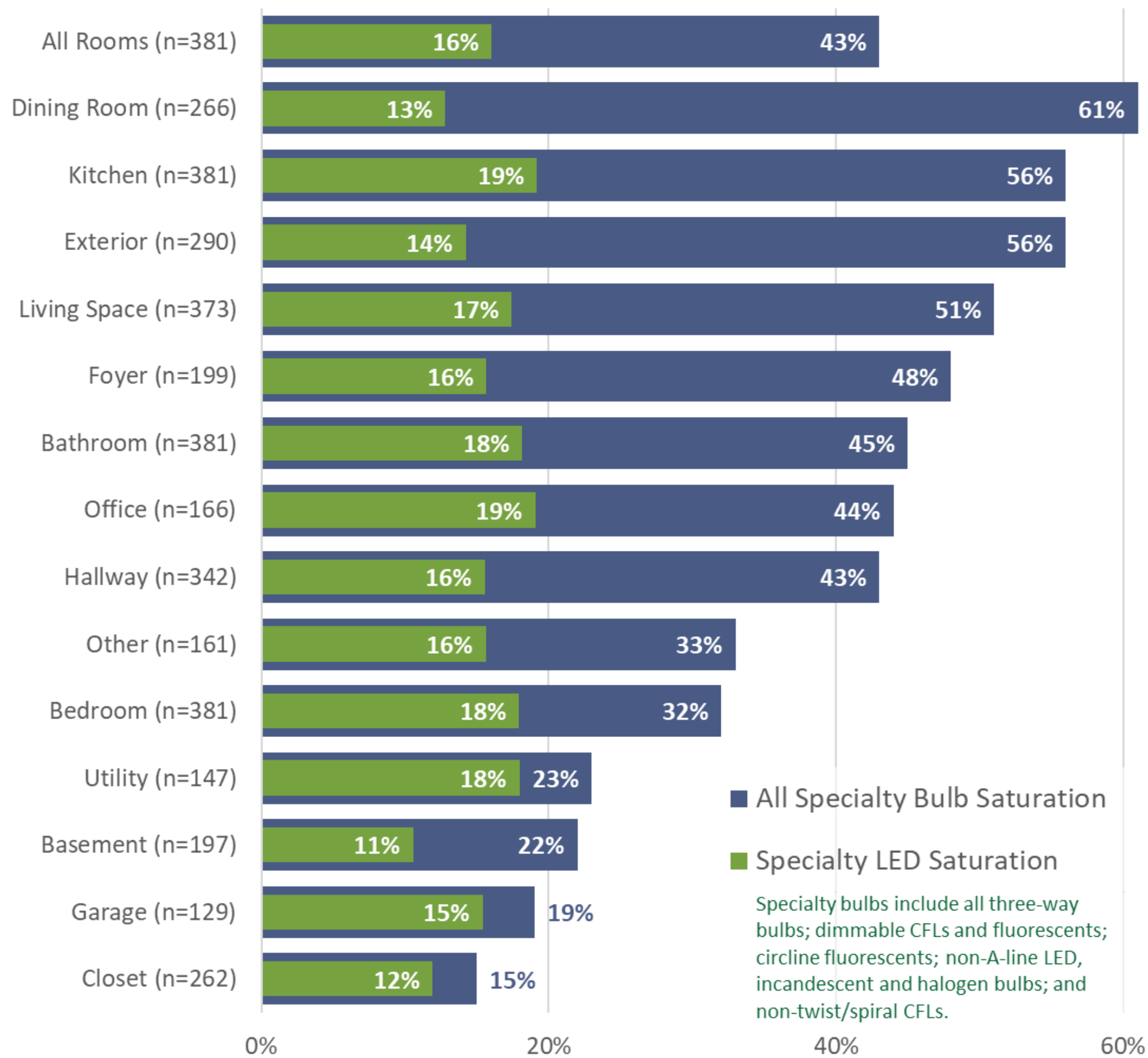


Figure 26 provides an overview of CFL, LED, and combined energy-efficient (CFL, LED, and linear fluorescent[37]) bulb saturation by room type from 2009 to 2018 for Massachusetts and 2013 to 2018 for New York. For years with missing data (2010 and 2011 in Massachusetts and 2014 in New York), estimates were based on straight-line interpolation.[38]

In Massachusetts, similar to trends at the household level, energy-efficient bulb saturation has steadily increased in most room types since 2009. In particular, energy-efficient bulb saturation has doubled – or more – in garages (60%), bedrooms (53%), living spaces (54%), offices (61%), dining rooms (39%), hallways (55%), and exteriors (43%), and has nearly

[37] Linear fluorescent saturation not included in figure.

[38] Note: socket counts by room type are available in **Error! Reference source not found.**, which can be found in Appendix C.

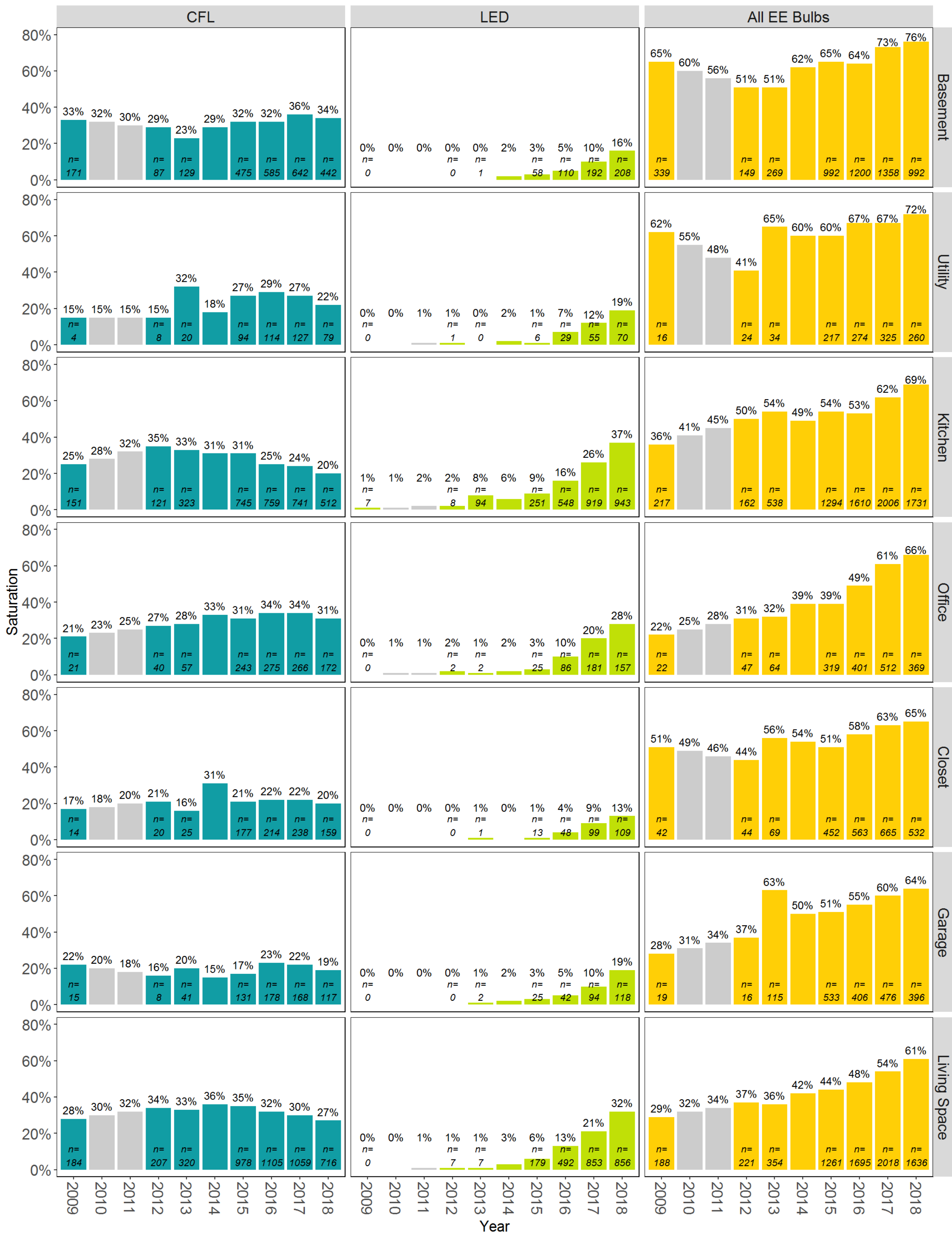
quadrupled in bathrooms (54%). In 2016, nine of ten rooms with the highest proportion of sockets occupied by a specialty bulb overall (Figure 25) had not yet reached 50% efficient bulb saturation, aside from kitchens. As of 2017, all but four of these rooms (exterior [43%], dining room [39%], foyer [47%], and other [49%]) had crossed the 50% threshold due to significant increases in LED saturation in these rooms (Figure 26). Prior to 2013, increases in overall energy-efficient bulb saturation were led primarily by CFLs. Starting in 2013 and continuing through 2017, the uptick in overall saturation rates has primarily been due to increases in LED saturation, as CFL saturation rates have remained constant or declined on a room-by-room basis.[39]

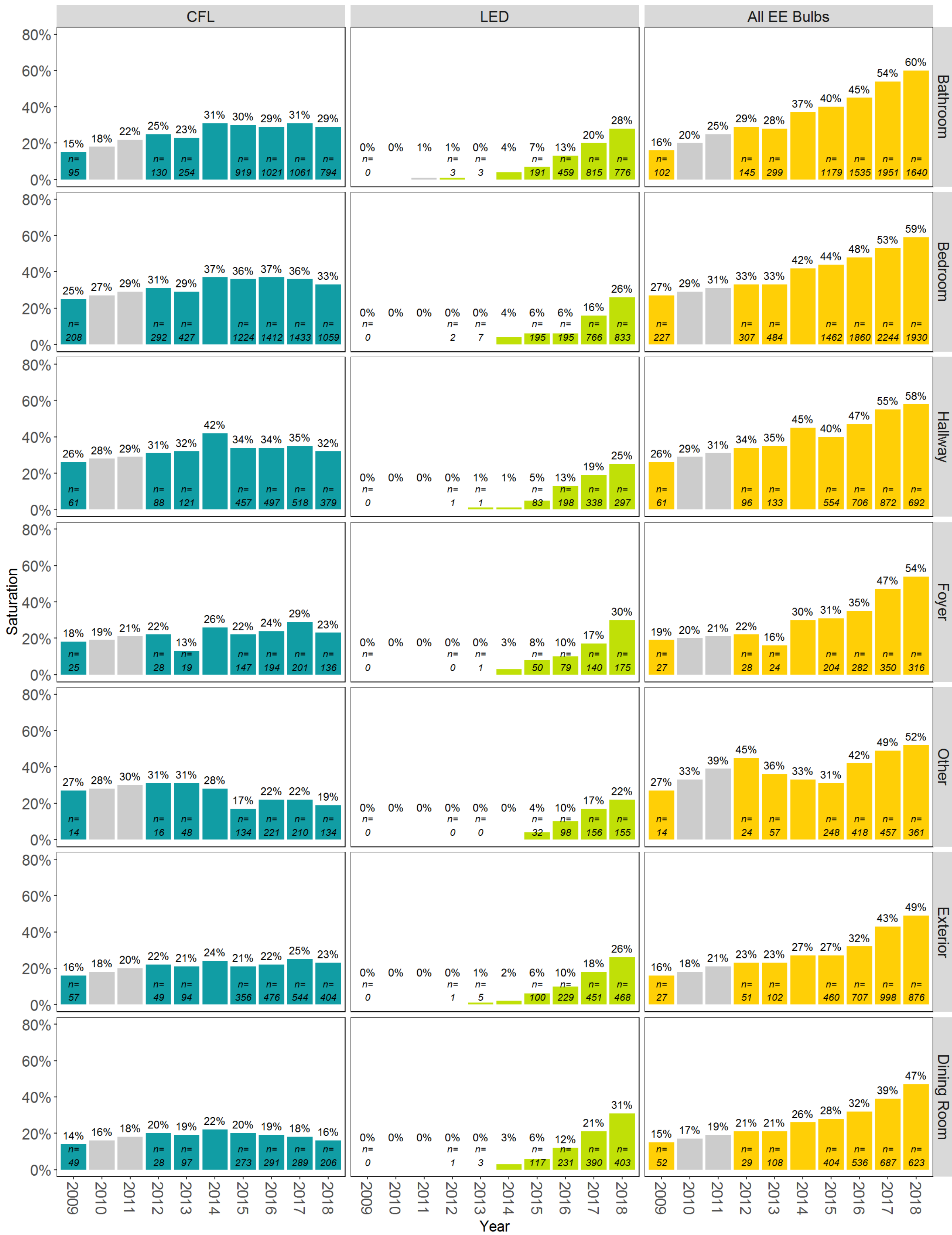
Massachusetts – Trends by Technology

- **LEDs.** Prior to 2014, saturation rates for LEDs in all room types were either very low (1-2%) or nonexistent. In the years since, LED saturation has doubled each year in nearly every room type. As of 2018, LED saturation is above 20% in nearly every room type except closets (13%), basements (16%), utility rooms (19%), and garages (19%). LED saturation was highest in kitchens, dining rooms, and living spaces; notably, these are three of the four room types that have the highest hours of use (for more detail on hours of use, see Section 2.3). Given the higher HOUs, it is likely that these rooms also have the highest rate of burn out.
- **CFLs.** As LED use has sharply increased, CFL saturation has stagnated or declined in recent years. In 2018, LED saturation outpaced CFL saturation in living spaces (32% LED, 27% CFL), exteriors (26% LED, 23% CFL), foyer (30% LED, 23% CFL), and “Other” rooms (22% LED, 19% CFL) – a milestone first reached by dining rooms and kitchens in 2017. Unlike prior years, there were no room types in which CFL saturation increased relative to 2017 saturation rates. A comparison of 2013 saturation rates by room reveals that, for most room types, Massachusetts and New York had very similar energy-efficient bulb saturation rates. Energy-efficient bulb saturation in Massachusetts continued to increase from 2013-2018, outpacing New York energy-efficient bulb saturation in nearly every room type. Overall, energy-efficient bulb saturation is higher for each room type in Massachusetts than in New York. Although CFL saturation is declining more slowly in New York than in Massachusetts, smaller per-year increases in LED saturation rates explain the lower efficient bulb saturation in New York. For more details, see Figure 27.

[39] Inconsistencies in data collection prior to 2014 may partially explain some of the uneven trend lines in Massachusetts.

Figure 26: Energy-Efficient Bulb Saturation by Room Type, 2009-2018 (Massachusetts)

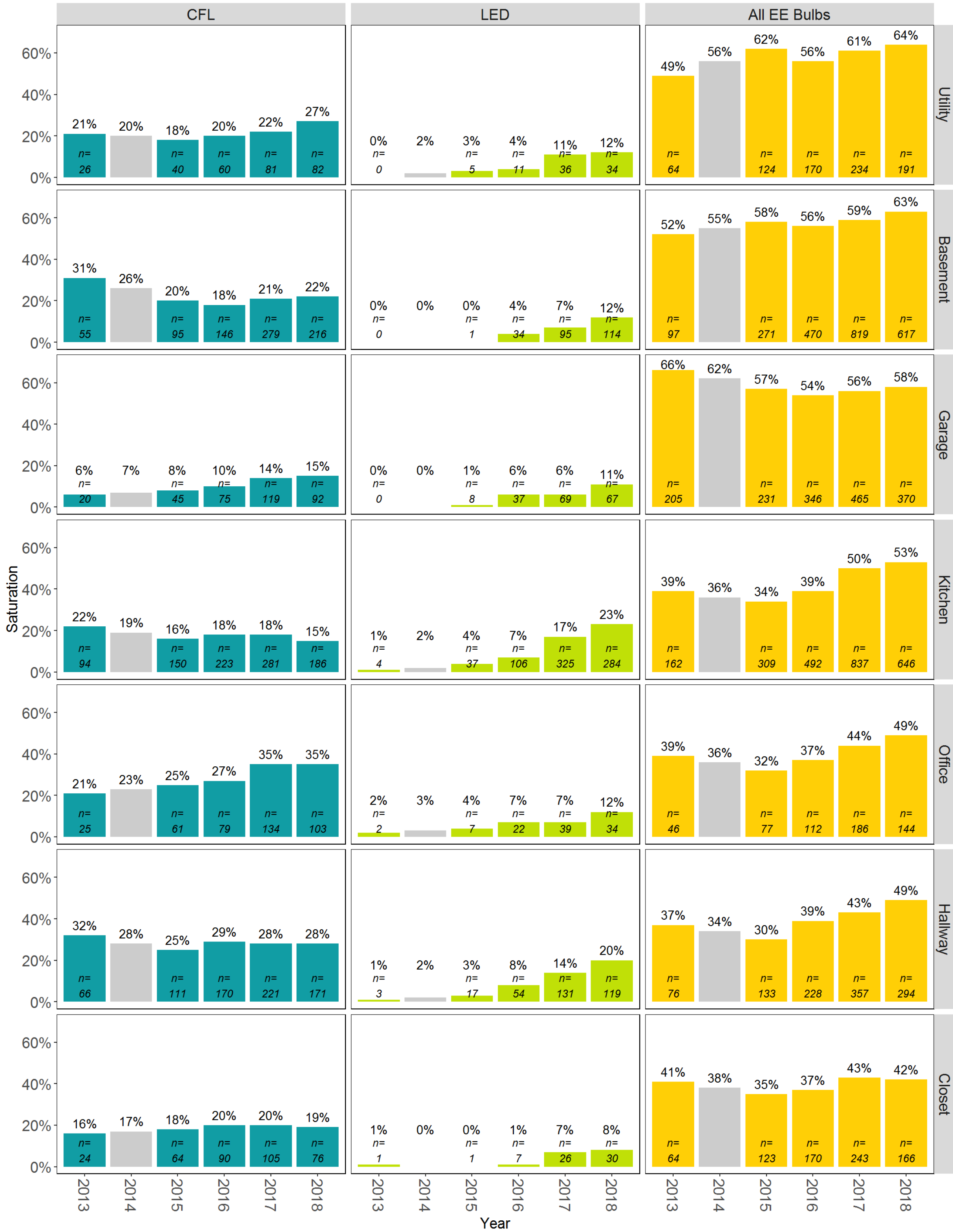


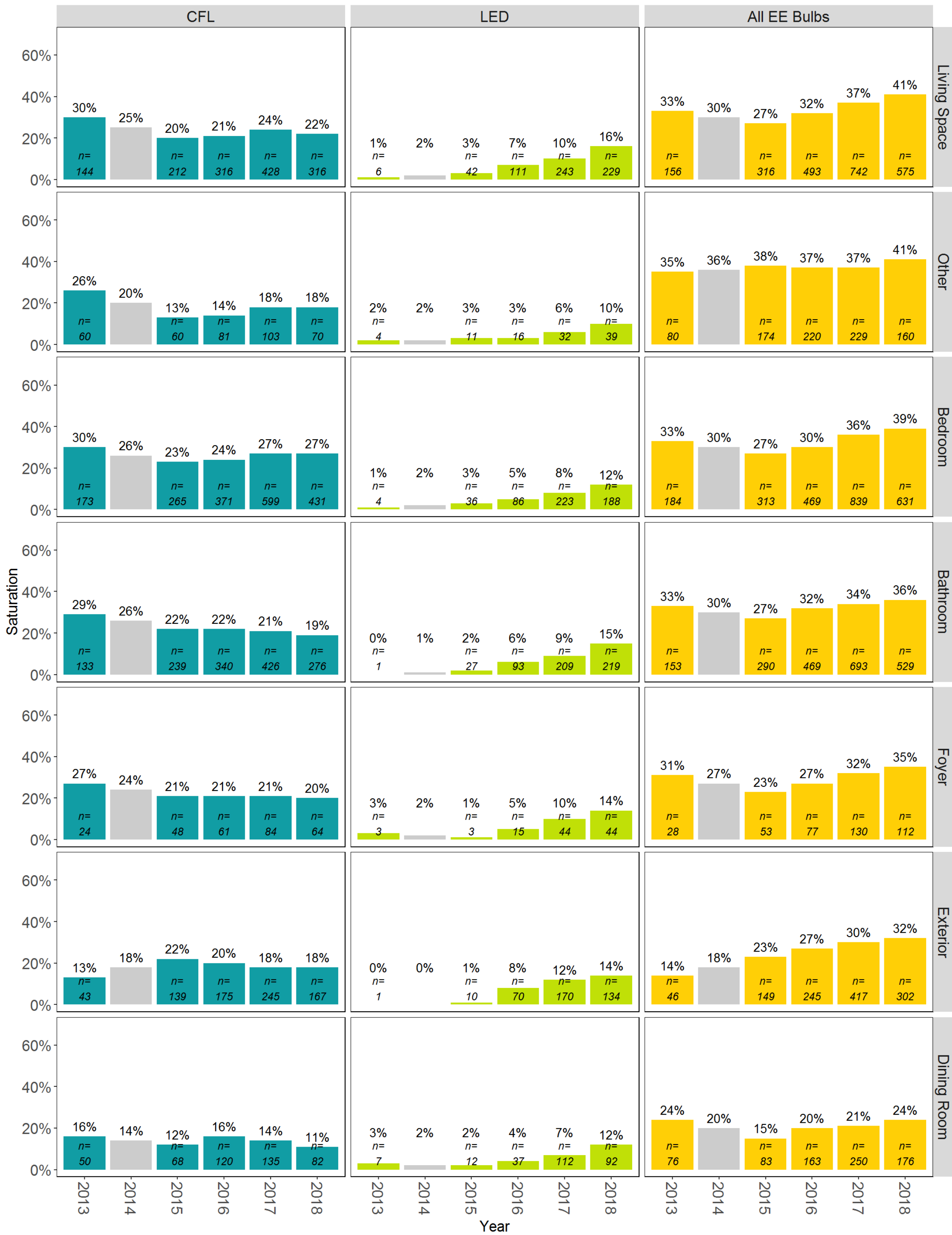

CFL
LED
All EE Bulbs
Bathroom
Bedroom
Hallway
Foyer
Other
Exterior
Dining Room
Saturation
Year
0%
20%
40%
60%
80%
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

New York Trends by Technology

- **LEDs.** 2018 LED saturation rates in New York room types ranged from 8% (closet) to 23% (kitchen), while saturation in Massachusetts ranged from 13% (closet) to 37% (kitchen). In the past year, LED saturation increased by at least 5% in seven out of the fourteen room types: kitchen (23%), hallway (20%), living space (16%), bathroom (15%), office (12%), basement (12%), and garage (11%). Although LED saturation increased from 2017 rates in all room types, two room types had only a 1% increase: utility rooms (12%) and closets (8%). LED saturation rates for all room types were lower in New York than in Massachusetts.
- **CFLs.** In general, CFL saturation across room types increased moderately or declined. As with the overall energy-efficient bulb saturation rates, these percentages fall short of those observed in Massachusetts for each room type, with the exception of offices and utility rooms, which, for the first time since 2013, have higher CFL saturation levels in New York than Massachusetts.

Figure 27: Energy-Efficient Bulb Saturation by Room Type, 2013-2018 (New York)





CFL
LED
All EE Bulbs
Living Space
Other
Bedroom
Bathroom
Foyer
Exterior
Dining Room
Saturation
Year
2013
2014
2015
2016
2017
2018
60%
40%
20%
0%

Appendix C Penetration – Additional Detailed Analysis

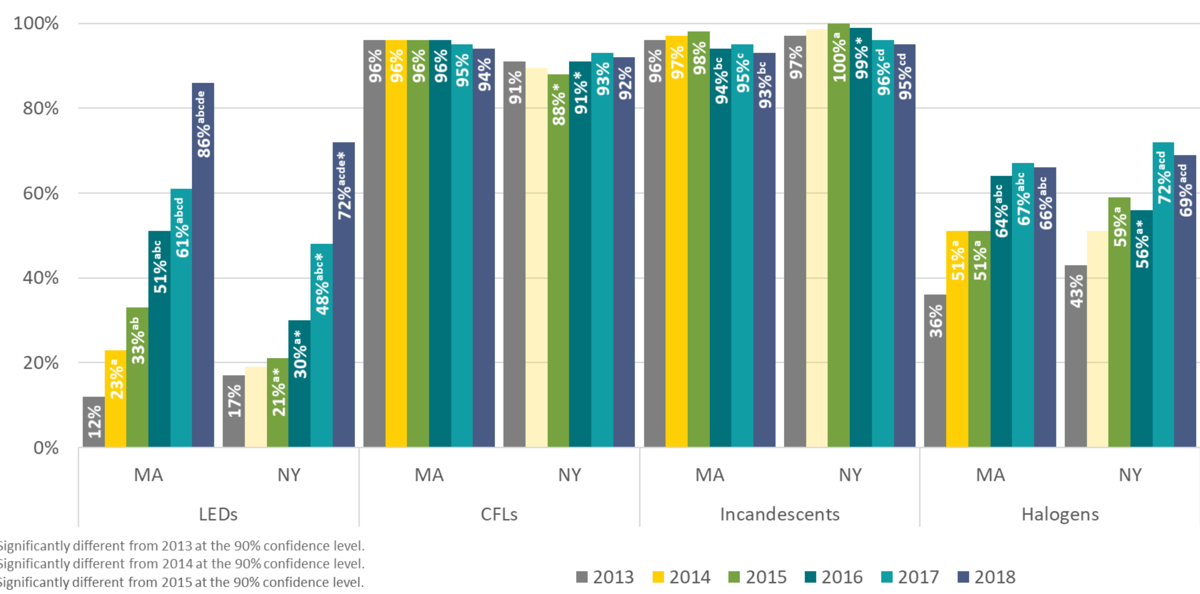
In this appendix, we expand on findings from Section 3. We show penetration in both Massachusetts and New York for all bulb types; present additional room-by-room penetration figures for CFLs, incandescent, and halogen bulbs; and explore reasons why householders do not have efficient bulbs installed in any of the five main room types (living rooms, bedrooms, bathrooms, kitchens, and dining rooms).

C.1 Penetration by Bulb Type

While Figure 15 in Section 3.1 focuses only on LED and halogen penetration, Figure 28 shows penetration for all bulb types from 2013 to 2018.

- **CFL** penetration decreased by one percentage point in Massachusetts in 2018, just as it did in 2017, after having remained steady at 96% since 2013; CFL penetration in New York also decreased by one percentage point to 92% in 2018.
- **Incandescent** penetration remained high in both areas. In Massachusetts, incandescent penetration increased slightly to 95% of households in 2017. Incandescent penetration in New York decreased significantly from 99% in 2016 to 96% in 2017.

Figure 28: Penetration by Bulb Type, 2009-2018



[a] Significantly different from 2013 at the 90% confidence level.
[b] Significantly different from 2014 at the 90% confidence level.
[c] Significantly different from 2015 at the 90% confidence level.
[d] Significantly different from 2016 at the 90% confidence level.
[e] Significantly different from 2017 at the 90% confidence level.
[*] Significantly different from corresponding year in MA at the 90% confidence level.

C.2 Room-by-Room Analysis – Other Bulb Types

CFL Penetration

In 2018, CFL penetration declined in nearly all room types; penetration in basements, living spaces, and bathrooms dropped the most (four percentage points each). CFL penetration was again highest in bedrooms (76%), basements (68%), and living spaces (62%). As with saturation, dining rooms remained the least common place to find a CFL (Figure 29). This drop in penetration is in line with a steady decline in CFL saturation and is expected to continue as CFLs begin to exit the market.

Incandescent + Halogen Penetration

Inefficient bulb (incandescent and halogen) penetration has shown a general decrease over the past few years, which is in line with the decrease in incandescent socket saturation. The biggest drop in inefficient bulb penetration since 2009 has been in offices (81% to 49%), followed by foyers (77% to 47%), and dining rooms (89% to 58%). Garages seem to be an anomaly for inefficient bulb penetration; after a dip in 2013, inefficient bulb penetration in garages increased by seven percentage points between 2009 and 2016 (74% to 81%), but declined to 70% in 2017 and 69% in 2018 (Figure 30).

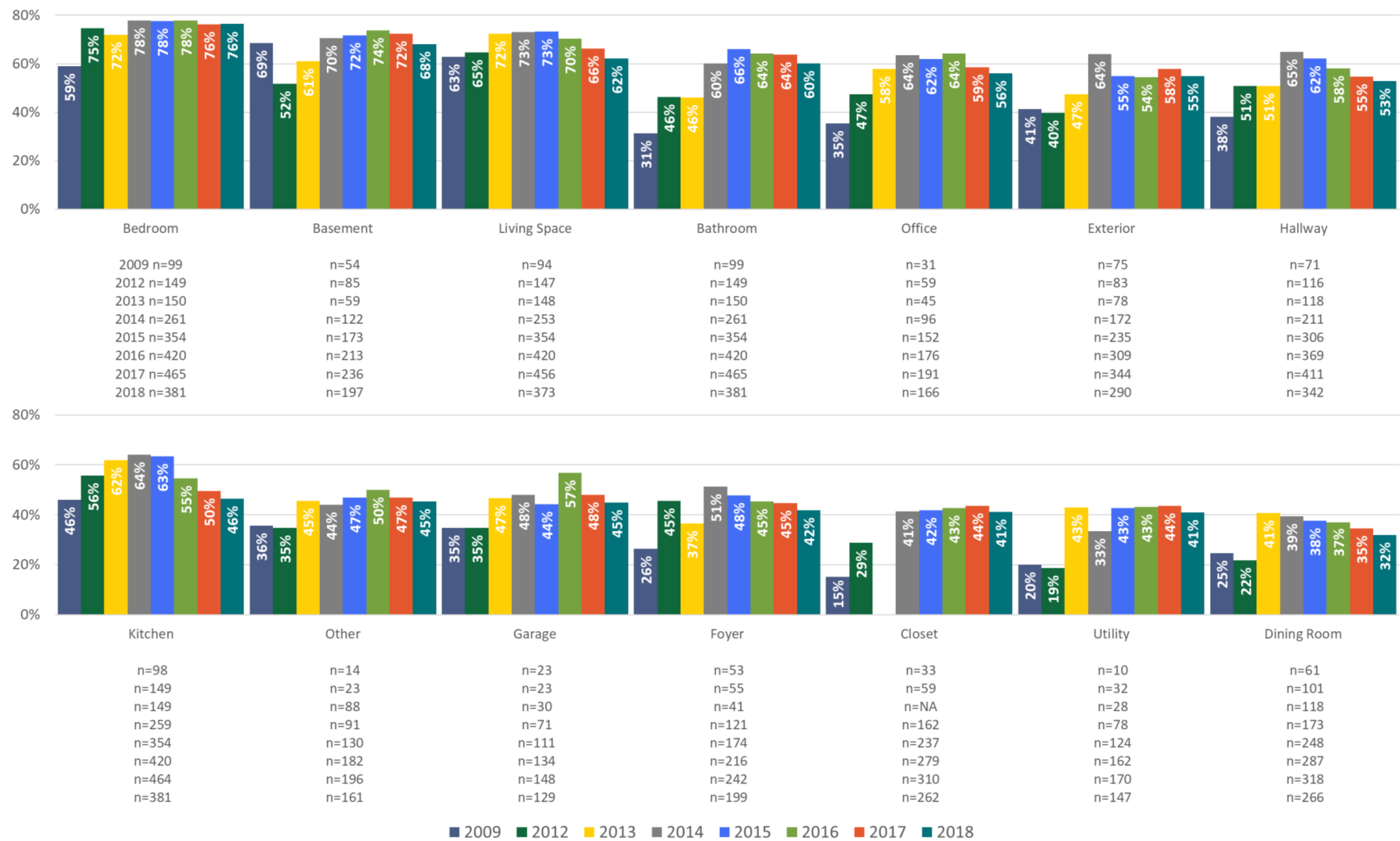
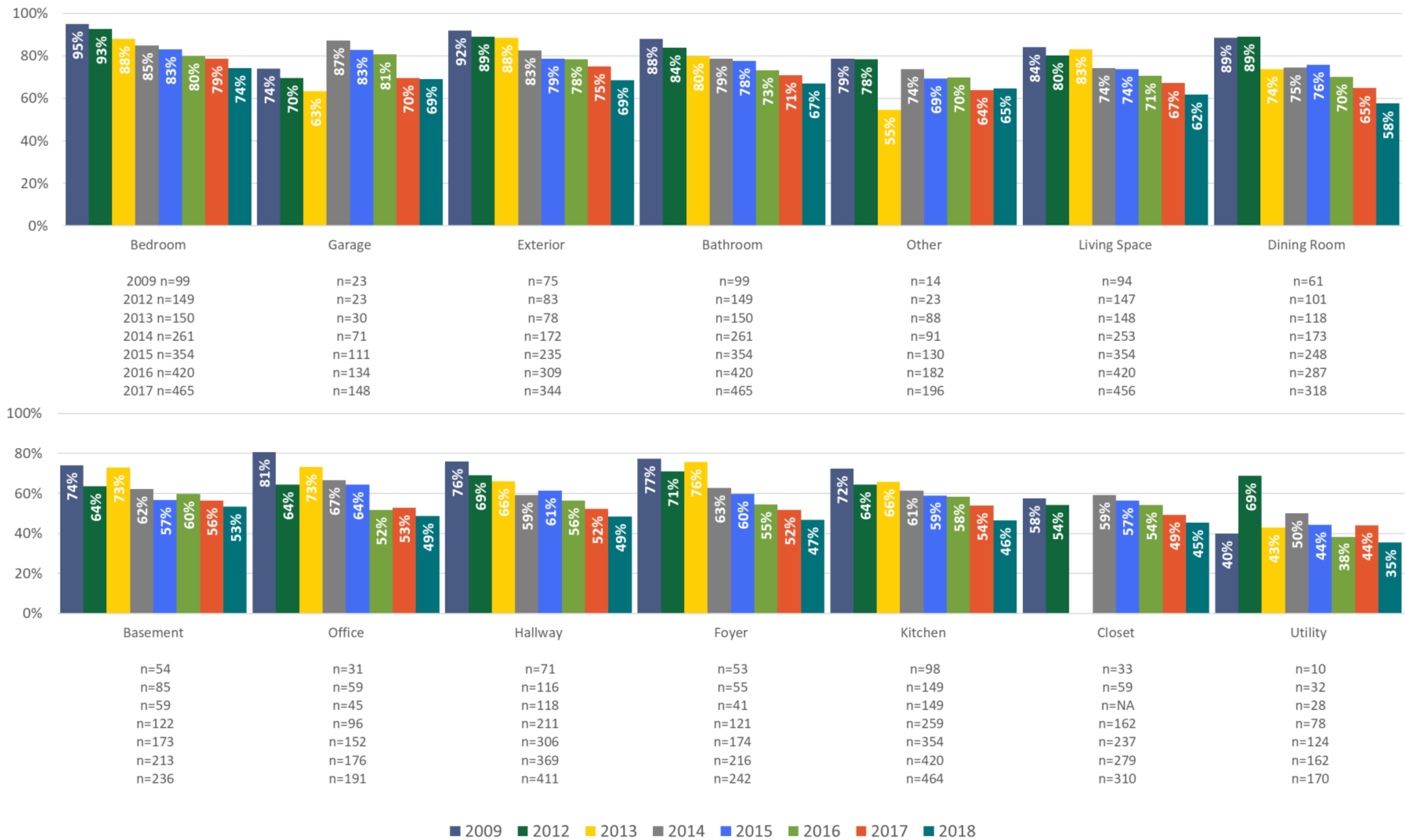


Figure 29: CFL Penetration by Room Type, 2009-2018 (Massachusetts)

Figure 30: Incandescent and Halogen Penetration by Room Type, 2009-2018 (Massachusetts)



C.3 Rooms Without Energy-Efficient Bulbs

While on site, technicians identified if any of the five main room types (kitchens, living spaces, bedrooms, bathrooms, and dining rooms) did not have any LEDs or CFLs installed. In both areas, the dining room was the most common room without an LED or CFL (36% in Massachusetts and 58% in New York).[40] Across all five room types, New York households had significantly lower rates of LED/CFL penetration compared to Massachusetts.

Table 33: Rooms Without Energy-Efficient Bulbs

(Base: Respondents without CFLs/LEDs installed in certain rooms, excluding homes without that specific room type)

Room Type	Massachusetts		New York	
	2017	2018	2017	2018
Sample Size	*465*	*381*	*255*	*217*
Dining Room	47%[a]	36%[ab]	70%	58%[b]
Kitchen	30%[a]	19%[ab]	42%	29%[b]
Bathroom	22%[a]	18%[a]	43%	35%[b]
Living Space	17%[a]	14%[a]	31%	28%
Bedroom	14%[a]	11%[a]	26%	22%

[a] Significantly different from New York at the 90% confidence level.
[b] Significantly different from 2017 at the 90% confidence level.

For rooms where no LEDs or CFLs were installed, technicians asked the householder why they did not have any efficient bulbs installed. Respondents could indicate multiple responses per room type. The reasons provided by Massachusetts households are summarized in Table 34, and New York responses are summarized in Table 35.

The most common response given for not yet having installed CFLs or LEDs was that the current bulbs in a room had not yet burned out.[41] These tables exclude that response in favor of responses that better characterize respondents' bulb preferences and indications of their future practices in terms of likelihood to install efficient lighting types.

In Massachusetts, the most common response given was that the consumer had future plans to install CFLs or LEDs (ranging from 13% to 42% per room type). In kitchens, the most common response was that CFLs/LEDs did not fit in the fixtures (51%);in bedrooms, the most common response was that that they do not have any CFLs/LEDs installed anywhere in the household (41%). Notably, price was noted as a barrier relatively infrequently, with responses ranging from 3% (bathrooms) to 5% (dining rooms).

[40] Since dining rooms were not present at all sites, this figure represents the number of households with no efficient bulbs in their dining room out of households with a dining room.
[41] Percentages by state for "current bulbs have not burned out" -– Massachusetts: Dining Room (39%), Living Space (42%), Bedroom (55%), Bathroom (30%), Kitchen (30%); New York: Dining Room (47%), Living Space (47%), Bedroom (51%), Bathroom (43%), Kitchen (39%)

In New York, as in Massachusetts, the most common response given was that the consumer had future plans to install CFLs or LEDs (ranging from 36% to 55% per room type). Notably, New Yorkers were more likely than Massachusetts residents to indicate plans to install efficient lighting in all room types in 2018.

Table 34: Reasons for Not Installing EE bulbs (Massachusetts)

(Base: Respondents without LEDs/CFLs installed in Certain Rooms; n=128)

Reason	Dining Rooms	Kitchens	Bathrooms	Living Spaces	Bedrooms
Homes with no CFLs/LEDs in Room Type[42]	*70*	*58*	*57*	*34*	*22*
I have not installed CFLs/LEDs but plan to	42%	27%	32%	25%	13%
I do not like CFLs/LEDs	17%	6%	12%	14%	15%
CFLs/LEDs did not fit	14%	51%	25%	11%	15%
I do not have any CFLs/LEDs	12%	8%	16%	19%	41%
LEDs/CFLs too expensive	5%	4%	3%	4%	4%
Management changes bulbs/came with unit	4%	7%	9%	6%	0%
CFLs do not work with dimmer/3-way	2%	1%	0%	14%	13%
Not familiar with LEDs	1%	0%	0%	6%	11%
DK/Other	11%	4%	11%	0%	0%

[42] Sample count, n, excludes respondents who gave “current bulbs have not burned out” as only response.

Table 35: Reasons for Not Installing CFLs/LEDs (New York)

(Base: Respondents without LEDs/CFLs installed in Certain Rooms; n=95)

Reason	Dining Rooms	Kitchens	Bathrooms	Living Spaces	Bedrooms
Homes with no CFLs/LEDs in Room Type[43]	*72*	*47*	*63*	*35*	*27*
I have not installed CFLs/LEDs but plan to	55%	36%	52%	49%	53%
CFLs/LEDs did not fit	12%	21%	17%	11%	6%
I do not like CFLs/LEDs	12%	17%	17%	19%	29%
I do not have any CFLs/LEDs	9%	9%	6%	11%	8%
CFLs do not work with dimmer/3-way	5%	9%	1%	4%	0%
LEDs/CFLs too expensive	2%	4%	3%	5%	6%
Not familiar with LEDs	1%	4%	3%	0%	0%
Management changes bulbs/came with unit	0%	3%	0%	0%	0%
DK/Other	4%	5%	6%	0%	0%

[43] Sample count, n, excludes respondents who gave “current bulbs have not burned out” as only response.

D

Appendix D Bulb Replacement Behavior

In this appendix, we expand on findings from Section 4. We compare average bulb replacement between direct install and non-direct install households, explore replacement choices for empty sockets, examine differences in bulb replacement behavior and all newly-installed bulbs across demographic groups, and report delta watts results from the on-site visits.

D.1 Average Bulb Replacement by household

Table 36 delves further into average bulb replacement by household. Unlike Table 3, the counts in this table are weighted. To ensure that the presence of direct-install participants does not skew the results, we examined data separately for self-reported direct install participants. In total, 25 of the 381 households in Massachusetts said that they participated in a direct-install program in 2017. Of these, we were only able to verify participation by two households – representing 1% of new LEDs obtained during 2017.

Still, to ensure that direct install bulbs do not skew our results, we examined the rate of LED installations between self-reported direct-install participants and all other panelists. As Table 37 shows, households that self-reported participation were more likely to have installed LEDs at a higher rate than other households Excluding self-reported direct-install participants, Massachusetts households installed 1.1 more replacement bulbs on average than New York households, primarily due to higher rates of LED replacement.

Table 36: 2018 Panel Replacement Bulbs

	Massachusetts			New York
Replacement Bulbs	DI (Self-Reported)	Non-DI	Overall	Overall
Panel Households	*25*	*356*	*381*	*217*
Households replacing bulbs	*25*	*319*	*343*	*175*
Overall	18.9	6.5	7.4	5.3
Incandescent	0.4	1.3	1.2	1.4
CFL	0.7	0.9	0.9	0.9
Fluorescent	0.1	0.1	0.1	0.1
Halogen	0.2	0.5	0.5	0.4
LED	17.3	3.0	4.2	2.0
Empty Socket	0.2	0.6	0.6	0.5

D.2 Empty Sockets

In 2017, NMR reported that significantly more bulbs removed in 2017 were replaced by empty sockets in New York (14%) than in Massachusetts (4%); not surprisingly, that created more empty sockets to be filled by bulbs in 2018. In New York, 10% of total replaced sockets were previously empty, compared to 6% in Massachusetts (Table 37). However, in New York, the most common bulb type to fill an empty socket was an incandescent bulb (43%), whereas LEDs were the most common choice in Massachusetts (46%). The number of empty sockets in 2018 was comparable between areas (8% and 9%, respectively). In order to maintain comparability with past years' analyses, we chose not to exclude empty sockets from the panel replacement bulb analysis.

Table 37: Empty Sockets, 2017-2018

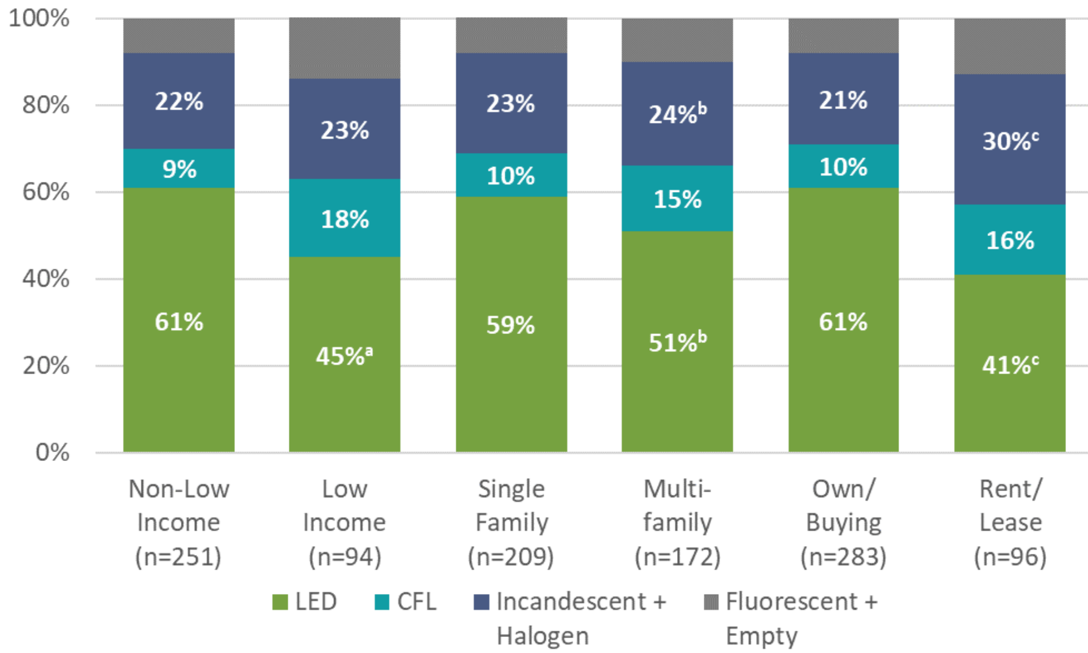
Bulb Type	Massachusetts	New York
Panel Households	*381*	*217*
Bulbs Replaced 2017-2018	*2,861*	*1,159*
Bulbs that replaced empty sockets in 2017:		
Total Empty Sockets 2017	*150*	*110*[b]
% of Total Replaced Bulbs	*5%*	*10%*[a]
Incandescent	15%	43%[a]
CFL	30%	14%[a]
Fluorescent	1%	4%[a]
Halogen	9%	10%
LED	45%	26%[a]
In 2018, empty sockets replaced the following removed bulbs:		
Total Empty Sockets 2018	*224*	*109*[b]
% of Total Replaced Bulbs	*8%*	*9%*
Incandescent	41%	57%[a]
CFL	39%	16%[a]
Fluorescent	2%	6%[a]
Halogen	13%	11%
LED	5%	5%

[a] Significantly different than Massachusetts at the 90% confidence level.
[b] Three sockets remained empty in 2018.

D.3 Bulb Replacement Behavior by Demographic Variables

We explored replacement behavior by education, income, home type, and tenure to determine if replacement behavior varied by demographic characteristics. Highly educated householders, non-low-income householders, homeowners, and householders in single-family dwellings were more likely than others to install replacement LEDs. This pattern held true in both Massachusetts and New York. While Massachusetts is still outpacing New York in LED replacement, the difference in replacement behavior among demographic groups is not as dramatic as observed in 2017. Massachusetts householders in these groups (e.g., low-income households) installed more replacement LEDs than their New York counterparts, indicating that Massachusetts is outpacing New York in efficient bulb replacement no matter how you parse the data.

Figure 31: Replacement Bulbs by Demographic, 2018 (Massachusetts)



a. Significantly different from Non-Low-Income at the 90% confidence level.
b. Significantly different from Single Family at the 90% confidence level.
c. Significantly different from Own/Buying at the 90% confidence level.

We compared bulb replacement behavior across demographic groups in both Massachusetts and New York. While the differences between groups were similar in both areas, Massachusetts households installed significantly more efficient replacement bulbs than New York households, even when accounting for demographic differences. The only exception are low-income households in New York, which installed replacement LEDs at the same rate as non-low-income households (38% and 37%, respectively). Not surprisingly, given the overall higher rate of LED usage in Massachusetts, MA householders who have at least some college education, are non-low-income, own their homes, or live in single-family units are significantly more likely to install efficient replacement bulbs (LEDs or CFLs). This difference appears to be driven by LED usage, as replacement rates for CFLs are declining across most demographic groups in Massachusetts.

In Massachusetts, householders who rent or lease installed LEDs at the same rate as homeowners in New York (41%). Furthermore, Massachusetts householders with a high school education or less installed a statistically similar number of LEDs (43%) to replace removed bulbs as New York householders with a bachelor's degree or higher (46%). Detailed findings for each area are explored below.

In Massachusetts, households replaced 56% of removed bulbs with LEDs and 12% with CFLs, indicating that over two-thirds (68%) of removed bulbs were replaced by an energy-efficient bulb type (Table 5). However, replacement rates fluctuated across demographics within Massachusetts, as described below, with differences particularly apparent in the use of LED bulbs as replacements. The data is presented in Table 38.

- *Replaced bulbs* are bulbs that have been removed from the socket since the last visit (the bulb recorded as installed in the 2017 visit).
- *Replacement bulbs* are those installed in the socket in the 2018 visit.

Replaced bulbs did not vary significantly between demographic groups, so we focus on trends in replacement bulb behavior, as described below.

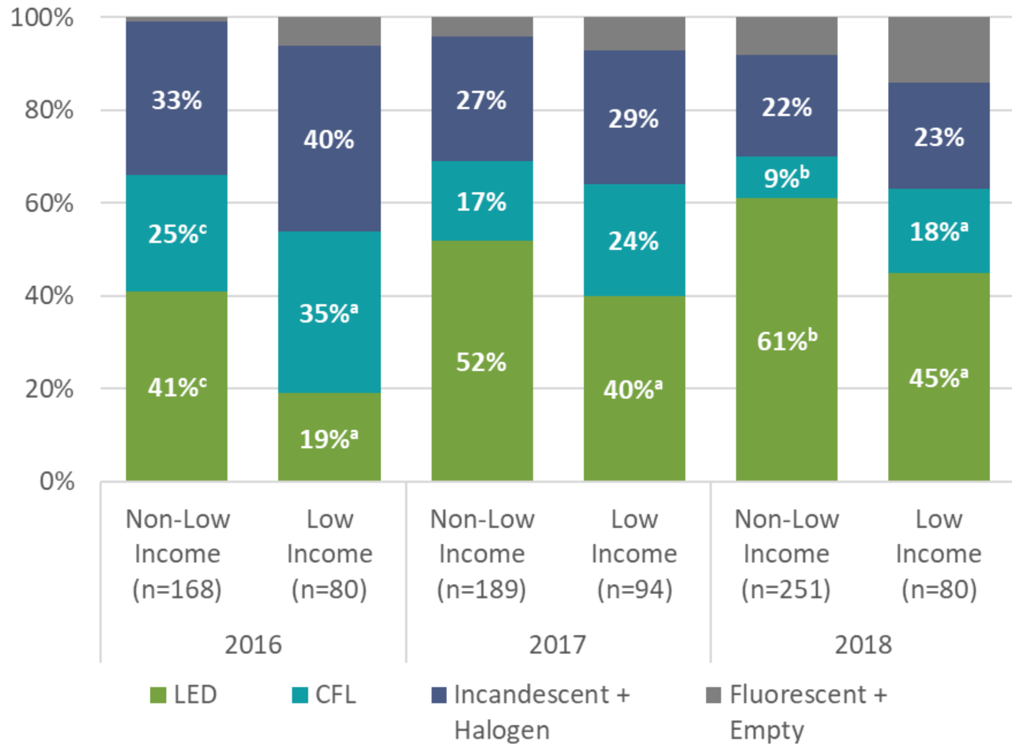
Trends by Demographic

- ***Education**:* Households with a bachelor's degree or higher and households with some college and/or an Associate's degree installed significantly more LEDs (59% and 58%, respectively) than households with some college or an associate's degree (38%) or a high school education or less (43%).
- ***Income**:* Low-income households installed significantly fewer LEDs (45%) than non-low-income households (61%). Low-income households had the highest rate of CFL replacement (19%). As shown in Figure 32, CFL replacement rates in low-income households have declined since we first looked at replacement behavior by demographics in 2016 (35%), and LED replacement rates have increased from 19% in 2016 to 45% in 2018.
- ***Home Type**:* Households in multifamily units installed fewer LEDs (50%) and slightly more CFLs (15%) than single-family households (59% and 10%, respectively). Inefficient bulb replacement behavior was similar between households in each home type.
- ***Tenure**:* Renters installed significantly fewer replacement LEDs (41%) than owners (61%). Unlike past years, when renters installed significantly more inefficient bulbs than homeowners, replacement rates this year were similar and overall differences were driven by higher LED adoption by homeowners.

In New York, differences in bulb replacement behavior among demographic groups (Table 39) was similar to Massachusetts.

- *Replacement bulbs:* Householders with a bachelor's degree or higher, single-family householders, and homeowners were significantly more likely to install replacement LEDs. However, unlike in Massachusetts (and previous trends observed in New York) LED replacement rates were similar between low-income (38%) and non-low-income households (37%).

Figure 32: Replacement Behavior by Income, 2016-2018 (Massachusetts)



a. Significantly different from Non-Low-Income at the 90% confidence level.
b. Significantly different from 2017 at the 90% confidence level.
c. Significantly different from 2016 at the 90% confidence level.

Table 38: Replaced/Replacement Bulbs by Demographic, 2018 (Massachusetts)

Demographic		Replaced Bulbs (Before)						Incandescent + Halogen	CFL + LED
	Bulb Count	Incandescent	CFL	Fluorescent	Halogen	LED	Empty Socket		
Education		%	%	%	%	%	%	%	%
Bachelor's Degree or Higher (n=254)	*1,299**	46%	30%	2%	11%	6%	5%†	55%	31%
Some College/Associate's Degree (n=84)	*1,084*	48%	29%	3%	10%	4%	5%	58%	33%
HS Education or Less (n=40)	*437*	51%	30%	2%	5%	3%	8%	56%	33%
Income									
Non-Low-Income (n=251)	*1,811**	51%	26%	3%	10%	5%†	4%†	61%	31%
Low-Income (n=94)	*718**	37%[c]	41%[c]	1%	10%	3%	8%	47%[c]	43%[c]
Home Type									
Single-Family (n=209)	*1,733*	51%	30%	3%	7%†	5%	4%†	57%	34%†
Multifamily (n=172)	*1,104**	42%[d]	30%	2%	14%[d]	5%	7%	55%	35%
Tenure									
Own/Buying (n=283)	*2,135**	49%	29%	2%	8%	6%	4%†	47%†	35%
Rent/Lease (n=92)	*697*	41%†	32%†	2%	13%	3%	9%	54%†	35%†
Demographic		**Replacement Bulbs (After)**						Incandescent + Halogen	CFL + LED
	Bulb Count	Incandescent	CFL	Fluorescent	Halogen	LED	Empty Socket		
Education		%	%	%	%	%	%	%	%
Bachelor's Degree or Higher (n=254)	*1,299**	14%	11%	1%	8%	59%†	7%	24%†	70%†
Some College/Associate's Degree (n=84)	*1,084*	17%	12%	2%	4%	58%†	7%	21%†	70%†
HS Education or Less (n=40)	*437*	23%	12%	1%	8%	43%[a]	12%	31%	55%[a]
Income		%	%	%	%	%	%	%	%
Non-Low-Income (n=251)	*1,811*	16%†	9%†	2%	6%	61%†	6%	22%†	70%†
Low-Income (n=94)	*718*	14%†	19%[c]	1%	7%	45%[c]	14%[c]	23%	63%
Home Type		%	%	%	%	%	%	%	%
Single-Family (n=209)	*1,733*	17%†	10%†	1%	5%	59%†	8%	23%†	69%†
Multifamily (n=172)	*1,104*	16%†	15%	2%	9%	50%[d]†	8%	24%[d]†	65%†
Tenure									
Own/Buying (n=283)	*2,135*	15%†	10%†	1%	6%	61%†	7%†	21%†	71%†
Rent/Lease (n=96)	*697*	20%	16%	3%	10%	41%[e]†	10%	30%[e]	47%[e]

Significantly different than [demographic category] at the 90% confidence level.

[a] Bachelor's Degree or Higher   [b] Some College/Associate's Degree   [c] Non-Low-Income
[d] Single-Family   [e] Own/Buying   † New York
*1% of bulbs are Don't Know/Other; row may not sum to 100%

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Table 39: Replaced/Replacement Bulbs by Demographic (New York)

(Base: New York Panel Households)

Demographic	Bulb Count	Replaced Bulbs (Before)							
		Incandescent	CFL	Fluorescent	Halogen	LED	Empty Socket	Incandescent + Halogen	CFL + LED
Education		%	%	%	%	%	%	%	%
Bachelor's Degree or Higher (n=139)	*498*	47%	25%	1%	13%	3%	10%†	60%	28%
Some College/Associate's Degree (n=59)	*462*	53%	21%	2%	11%	3%	10%	64%	24%
HS Education or Less (n=16)	*195*	53%	26%	5%	7%	2%	8%	60%	28%
Income									
Non-Low-Income (n=155)	*802*	51%	21%	2%	14%	3%†	9%†	65%	24%
Low-Income (n=41)	*291*	50%	28%	2%	6%[c]	2%	10%	56%	30%
Home Type									
Single-Family (n=169)	*938*	51%	23%	2%	11%†	3%	10%†	62%	26%†
Multifamily (n=48)	*224**	48%	25%	3%	14%	2%	7%	62%	27%
Tenure									
Own/Buying (n=164)	*894*	49%	25%	2%	12%	3%	10%†	61%†	28%
Rent/Lease (n=53)	*267*	56%†	19%†	1%	12%	3%	8%	68%†	22%†
Demographic	**Replacement Bulbs (After)**								
	Bulb Count	Incandescent	CFL	Fluorescent	Halogen	LED	Empty Socket	Incandescent + Halogen	CFL + LED
Education		%	%	%	%	%	%	%	%
Bachelor's Degree or Higher (n=139)	*498**	22%	13%	1%	8%	46%†	10%	35%†	59%†
Some College/ Associate's Degree (n=59)	*462*	34%[a]	16%	2%	11%	29%[a]†	9%	45%†	45%[a]†
HS Education or Less (n=16)	*195*	20%	33%	0%	1%[ab]	37%	9%	21%[b]	70%[b]
Income									
Non-Low-Income (n=155)	*802*	26%†	17%†	1%	10%	37%†	9%	36%†	54%†
Low-Income (n=41)	*291*	28%†	20%	1%	2%[c]	38%	11%	30%	58%
Home Type									
Single-Family (n=169)	*938*	25%†	18%†	1%	7%	41%†	8%	32%†	59%†
Multifamily (n=48)	*224*	32%†	18%	2%	10%	24%[d]†	15%	42%†	42%[d]†
Tenure									
Own/Buying (n=164)	*894*	25%†	18%†	1%	8%	41%†	7%†	33%†	59%†
Rent/Lease (n=53)	*267*	33%	14%	1%	8%	27%[e]†	17%[e]	41%	41%[e]

Significantly different from [demographic category] at the 90% confidence level.

[a] Bachelor's Degree or Higher
[b] Some College/Associate's Degree
[c] Non-Low-Income
[d] Single-Family
[e] Own/Buying
† Massachusetts

*1% of bulbs are Don't Know/Other; row may not sum to 100%

D.4 NEWLY INSTALLED BULBS

Table 40 shows bulbs in 2018 that had been newly installed in Massachusetts panel households since the previous visit in 2017. The *Replacement (no empty)* column shows the bulbs that were newly installed in sockets since the 2017 visit, excluding sockets where a bulb was removed but had not yet been replaced (empty sockets). The *new fixtures* column comprises bulbs in fixtures (and sockets) that are new to panel households in 2018. *Total* examines replacement bulbs and bulbs in new fixtures together.

In 2018, Massachusetts households installed significantly more efficient bulbs (LEDs and CFLs, 74%) than New York (61%). This difference was driven by the higher rate of LED installation in Massachusetts among both replacement bulbs and new fixtures. Six in ten bulbs new to sockets in 2018 were LEDs (60%), compared to 43% in New York. The rate of CFL installation held steady in New York from 2017 to 2018 (20%), while we observed a significant decrease in the proportion of CFLs installed in Massachusetts (from 20% in 2017 to 14% in 2018). This is a change from 2017, when we noticed that while CFL usage was declining in both areas, it was declining more slowly in Massachusetts. We attributed this observation to the persistence of rebates for CFLs in Massachusetts through the end of 2016. Now that CFLs are no longer eligible for rebates, it appears that Massachusetts households are more commonly choosing LEDs over CFLs when choosing replacements for inefficient bulbs. (The proportion of new-to-socket incandescent bulbs in Massachusetts fell from 23% in 2017 to 18% in 2017.)

Trends by Technology

LED

- *Replacement LEDs:* In Massachusetts, LED bulbs were the most commonly chosen replacement bulb (61%); LEDs were chosen significantly more frequently in Massachusetts than they were in New York (42%). A higher proportion of newly-installed LEDs were new to the home in Massachusetts (92%), compared to New York (87%).
- In Massachusetts, more LEDs were installed in fixtures new to the home (57%) than in New York (57%), as well as compared to Massachusetts in 2017 (45%).

CFL

- *Replacement CFLs:* CFL installation is declining in Massachusetts (14% of all new bulbs in 2018, compared to 20% in 2017) and holding steady in New York (18%).
- More newly installed CFLs were new to the home in New York (63%) – rather than installed from storage – than in Massachusetts (43%).

Incandescent and Halogen

- *Replacement bulbs:* In Massachusetts, approximately one in four (25%) newly installed bulbs were incandescent or halogen, compared to 38% in New York. Nearly three-quarters (73%) of replacement incandescents in New York were new to the home, compared to one-half (48%) in Massachusetts.

Table 40: Newly Installed Bulbs

	Massachusetts			New York		
2018						
Bulb Type	Replacement (No Empty)	New Fixtures	Total	Replacement (No Empty)	New Fixtures	Total
Households Replacing Bulbs	*338*	*195*	*361*	*177*	*85*	*185*
Bulb Count	*2,608*	*619*	*3,227*	*1,049*	*245*	*1,294*
LED or CFL	**74%**	**69%**	**74%**	**61%[a]**	**59%[a]**	**61%[a]**
LED	*61%*	*57%*	*60%*	*42%[a]*	*47%[a]*	*43%[a]*
CFL	*13%*	*18%*	*14%*	*19%[a]*	*12%[a]*	*18%*
Incandescent or Halogen	**25%**	**21%**	**25%**	**38%[a]**	**38%[a]**	**38%[a]**
Incandescent	*18%*	*16%*	*18%*	*29%[a]*	*27%[a]*	*29%[a]*
Halogen	*7%*	*5%*	*7%*	*9%*	*11%[a]*	*9%*
Linear Fluorescent	2%	4%	2%	1%	3%	1%
2017						
Bulb Type	Replacement (No Empty)	New Fixtures	Total	Replacement (No Empty)	New Fixtures	Total
Households Replacing Bulbs	*281*	*168*	*294*	*75*	*56*	*88*
Bulb Count	*2,303*	*549*	*2,852*	*385*	*166*	*551*
LED or CFL	**69%**	**64%**	**68%[b]**	**52%[a]**	**38%[ab]**	**48%[ab]**
LED	*49%[b]*	*45%[b]*	*48%[b]*	*32%[a]*	*25%[ab]*	*30%[ab]*
CFL	*20%[b]*	*19%*	*20%[b]*	*20%*	*13%*	*18%*
Incandescent or Halogen	**30%**	**33%[b]**	**30%**	**46%[a]**	**52%[ab]**	**48%[ab]**
Incandescent	*22%*	*25%[b]*	*23%*	*40%[ab]*	*40%[ab]*	*40%[ab]*
Halogen	*7%*	*8%*	*8%*	*6%*	*12%*	*8%*
Linear Fluorescent	1%	3%	2%	2%	10%[b]	4%

[a] Significantly different from Massachusetts at the 90% confidence level.
[b] Significantly different from 2018 at the 90% confidence level.

Table 41 provides an overview of where replacement bulbs came from: new to the home, from storage, or from another fixture. In both Massachusetts and New York, over three-quarters of replacement bulbs were new to the home (76% and 77%, respectively), while one in five replacement bulbs came from storage (21%). As in past years, Massachusetts households are installing fewer replacement inefficient bulbs overall, and an increasing number of these bulbs originate in storage and are not new to the home. Nearly half (49%)

of replacement incandescent bulbs in Massachusetts came from storage, compared to 25% in New York. Four in five replacement halogen bulbs in New York are new to the home (79%); in Massachusetts, less than two-thirds (63%) of halogen bulbs are new to the home, while the rest were installed from storage or moved from another fixture.

Table 41: Replacement Bulbs by Bulb Source

(Base: Bulbs installed in MA (n=381) and NY (n=217) households in 2018, empty sockets excluded)

Bulb Type	Massachusetts				New York			
	2018							
Bulbs	# of bulbs	New	Storage	Another Fixture	# of bulbs	New	Storage	Another Fixture
All replacement bulbs	*2,608*	*76%*	*21%*	*3%*	*1,049*	*77%*	*21%*	*2%*
Incandescent	*468*	48%	49%	3%	*308*	73%[a]	25%[a]	2%
CFL	*330*	43%	47%	10%	*203*	63%[a]	32%[a]	5%[a]
Fluorescent	*40*	79%	21%	0%	*11*	8	4	0
Halogen	*188*	63%	35%	2%	*91*	79%[a]	21%[a]	0%
LED	*1,583*	92%	6%	2%	*436*	87%[a]	12%[a]	2%
	2017							
Bulbs		New	Storage	Another Fixture		New	Storage	Another Fixture
All replacement bulbs	*2,095*	*73%*	*23%*	*4%*	*374*	*82%[a]*	*15%[a]*	*2%*
Incandescent	*449*	50%	47%	3%	*127*	79%[a]	18%[a]	1%
CFL	*402*	53%[b]	36%[b]	11%	*63*	75%[ab]	20%[ab]	4%[a]
Fluorescent	*29*	80%	16%	4%[b]	*7*	6	1	0
Halogen	*147*	67%	31%	2%	*20*	86%[a]	14%[a]	0%
LED	*985*	94%	4%	2%	*104*	88%[a]	8%	3%
	2016							
Bulbs		New	Storage	Another Fixture		New	Storage	Another Fixture
All replacement bulbs	*1,680*	*74%*	*22%*	*4%*	*318*	*82%*	*17%*	*1%*
Incandescent	*459*	57%[c]	40%	3%	*113*	75%[a]	23%[a]	2%
CFL	*473*	57%	34%	9%	*108*	81%[a]	19%[a]	0%[ac]
Fluorescent	*41*	92%[c]	3%[c]	5%	*2*	0	2	0
Halogen	*132*	90%	8%[c]	1%	*8*	81%[a]	19%[a]	0%
LED	*575*	96%	2%	1%	*21*	98%[c]	0%[c]	2%

[a] Significantly different from Massachusetts at the 90% confidence level.
[b] Significantly different from 2018 at the 90% confidence level.
[c] Significantly different from 2017 at the 90% confidence level.

D.5 Newly Installed Replacement Bulbs by Demographics

When 2016, 2017 and 2018 replacement bulb data are placed side by side for each of these groups (Table 42 and Table 43), it is apparent that LED usage is growing proportionally in each demographic category. While overall rates of replacement (the bulb installed in a socket to replace a removed bulb) are lower for LEDs in households without a bachelor's degree, low-income households, rental, or multifamily units, LED replacement is significantly higher in 2018 than 2017 for almost every demographic category compared. The increase is quite dramatic in some cases; for example, householders that rent or lease their home only replaced 22% of all removed bulbs with LEDs in 2017, compared to 41% in 2018. This analysis reveals that while some demographic groups are less likely to install LEDs than others, LED replacement rates are increasing across the board, indicating that efforts to encourage LED use and/or make them more affordable are indeed working and should be continued.

Table 42: Replacement Bulbs by Demographic, 2017-18

Bulb Type	Educational Attainment								
	Bachelor's or Higher			Some College/ Associate's			High School or Less		
Bulb Type	2016	2017	2018	2016	2017	2018	2016	2017	2018
Sample Size	*163*	*214*	*254*	*72*	*69*	*84*	*31*	*32*	*40*
Bulb Count	*962*	*1,079*	*1,299*	*658*	*681*	*1,084*	*207*	*333*	*437*
LED or CFL	**61%[c]**	**70%**	**70%**	**56%**	**62%**	**70%**	**46%**	**63%**	**55%[a]**
LED	*36%[c]*	*55%*	*59%*	*28%*	*38%[b]*	*58%*	*21%*	*39%*	*43%[a]*
CFL	*25%[c]*	*15%*	*11%*	*28%*	*24%[b]*	*12%*	*25%*	*24%*	*12%*
Incandescent or Halogen	**33%**	**27%**	**22%**	**32%**	**31%**	**21%**	**36%**	**30%**	**31%**
Incandescent	*26%*	*20%[b]*	*14%*	*25%*	*22%*	*17%*	*30%*	*24%*	*23%*
Halogen	*7%*	*7%*	*8%*	*7%*	*9%*	*4%*	*6%*	*6%*	*8%*
Linear Fluorescent	0%	1%	1%	5%	2%	2%	2%	1%	1%
Empty Socket	6%[c]	2%[b]	7%	7%	5%	7%	16%	6%	12%

[a] Significantly different from Bachelor's Degree or Higher at the 90% confidence level.
[b] Significantly different from 2018 at the 90% confidence level.
[c] Significantly different from 2017 at the 90% confidence level.

Table 43: Replacement Bulbs by Demographic, 2017-18, cont'd

	Income					
	Non-low-income			Low-income		
Bulb Type	2016	2017	2018	2016	2017	2018
Sample Size	*168*	*189*	*251*	*80*	*94*	*94*
Bulb Count	*1,213*	*1,235*	*1,811*	*509*	*655*	*718*
LED or CFL	**61%**	**69%**	**70%**	**48%[c]**	**64%**	**64%**
LED	*38%[c]*	*52%[b]*	*61%*	*16%[cd]*	*40%[d]*	*45%[d]*
CFL	*23%*	*17%[b]*	*9%*	*32%[d]*	*24%*	*19%[d]*
Incandescent or Halogen	**33%**	**27%**	**22%**	**33%**	**29%**	**21%**
Incandescent	*25%*	*19%*	*16%*	*25%*	*22%*	*14%*
Halogen	*8%*	*8%*	*6%*	*8%*	*7%*	*7%*
Linear Fluorescent	1%	1%	2%	5%	2%	1%
Empty Socket	5%	3%	6%	14%[cd]	6%[b]	14%[d]
	Home Type					
	Single-Family			**Multifamily**		
Bulb Type	2016	2017	2018	2016	2017	2018
Sample Size	*143*	*251*	*209*	*127*	*64*	*172*
Bulb Count	*1,159*	*1,864*	*1,733*	*683*	*232*	*1,104*
LED or CFL	**60%[c]**	**69%**	**69%**	**52%**	**52%[be]**	**65%**
LED	*37%[c]*	*49%[b]*	*59%*	*22%[e]*	*34%[be]*	*50%[e]*
CFL	*23%*	*20%[b]*	*10%*	*30%*	*18%*	*15%*
Incandescent or Halogen	**31%**	**27%**	**22%**	**31%**	**41%[be]**	**24%**
Incandescent	*26%*	*22%*	*17%*	*26%*	*22%*	*15%*
Halogen	*5%*	*5%*	*5%*	*11%[e]*	*21%[be]*	*9%*
Linear Fluorescent	2%	1%	1%	3%	1%	2%
Empty Socket	7%[c]	3%[b]	8%	8%	7%	8%
	Tenure					
	Own/Buying			**Rent/Lease**		
Bulb Type	2016	2017	2018	2016	2017	2018
Sample Size	*188*	*231*	*283*	*79*	*82*	*96*
Bulb Count	*1,433*	*1,622*	*2,135*	*390*	*473*	*697*
LED or CFL	**60%[c]**	**73%**	**71%**	**47%[f]**	**44%[bf]**	**57%[f]**
LED	*37%[c]*	*54%[b]*	*61%*	*11%[cf]*	*22%[bf]*	*41%[f]*
CFL	*23%*	*19%*	*10%*	*36%[cf]*	*22%[f]*	*16%*
Incandescent or Halogen	**32%[c]**	**23%**	**21%**	**37%**	**44%[bf]**	**30%[f]**
Incandescent	*25%[c]*	*18%*	*15%*	*28%*	*33%[bf]*	*20%*
Halogen	*7%*	*5%*	*6%*	*9%*	*14%[f]*	*10%*
Linear Fluorescent	2%	1%	1%	3%	2%	2%
Empty Socket	6%	3%[b]	7%	13%[f]	7%	10%

[a] Significantly different from Non-Low-Income at the 90% confidence level.
[b] Significantly different from Single-Family at the 90% confidence level.
[c] Significantly different from Own/Buying at the 90% confidence level.

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D.6 Delta Watts

New CFLs or LEDs were installed in a combined total of 2,035 sockets in the Massachusetts sample during the year prior to the study. We calculated the estimated delta watts for newly installed CFLs to be 17, and the average delta wattage of newly installed LEDs to be 26. Looking closely at the types of bulbs CFLs and LEDs replaced, it is clear that delta watts are driven by replacing incandescent or halogen bulbs with CFLs or LEDs. Note that the delta watts presented are in no way meant to supplant the delta watts developed through the Market Adoption Model. The estimates presented here do not reflect the entirety of consumer options, but instead simply show what was installed prior to replacement. The Market Adoption Model considers market intelligence data from several studies to develop market share estimates with and without the program.

Table 44: Delta Watts by Bulb Type for Past Year

(Base: CFLs and LEDs that replaced installed bulbs; new fixtures and empty sockets excluded)

Bulb Type Replaced	Newly Installed Bulbs – MA					
	CFLs			LEDs		
	n	New CFLs	Avg. Delta Watts	n	New LEDs	Avg. Delta Watts
Total Replaced Bulbs	*302*		*17*	*1733*		*26*
Incandescent	110	36%	44	819	47%	42
CFL	168	56%	-0.5	458	26%	6
Halogen	9	3%	43	169	10%	37
LED	5	2%	-3.3	134	8%	-0.1

E

Appendix E LED Purchases and Satisfaction

In this appendix, we show purchases by bulb shape and compare LED purchasing behavior in Massachusetts households across select demographic variables, expanding the analysis first reported in Section 5. In addition, we provide the full-length tables (including “neither satisfied or dissatisfied”, “somewhat dissatisfied”, and “very satisfied”) for information presented in Table 17 and Table 18 in Section 7.

E.1 New Purchases by Bulb Shape

This section looks at new purchases by bulb type and by A-line, reflector, and other bulb shape for bulbs purchased in 2016 and bulbs purchased in 2017. These were bulbs that were new to the home since the previous visit, excluding all bulbs that homeowners self-reported were from a direct install program.

As Table 45 and Table 46, LEDs made up the majority of purchases in 2017 in all shape categories in both states, aside from other bulb shapes in New York, where incandescents were the majority.

A-line

- In Massachusetts, more than one-half (56%) of all A-line bulbs purchased in 2017 were LEDs, up from two out of five (41%) A-line bulbs purchased in 2016.
- In New York, only two out of every five (40%) A-line bulbs purchased in 2017 were LEDs, an increase of 16 percentage points from bulbs purchased in 2016.

Reflector

- Nearly four out of every five (78%) reflector bulbs purchased in 2017 in Massachusetts was an LED, up from just over three out of every five (63%) bulbs purchased in 2016.
- In New York, one-half of all reflector bulbs purchased in 2017 was an LED, up from just two out of every five (41%) bulbs purchased in 2016.

Other Bulb Shapes

- Nearly one half of other bulb shapes purchased in both 2016 (46%) and 2017 (47%) were LEDs in Massachusetts.
- In New York, one-third (35%) of other bulb shapes purchased in 2017 were LEDs, but more than one-half (52%) were incandescents.

Table 45: New Purchases by Bulb Shape, 2016 & 2017 (Massachusetts)

Bulb Type	2016 Purchases (n=315) All	A-line	Reflector	Other	2017 Purchases (n=381) All	A-line	Reflector	Other
Number of Bulbs	2,306	1,280	320	706	3,176	1,657	449	1,069
LED	46%	41%	63%	46%	56%	56%	78%	47%
CFL	16%	26%	10%	2%	12%	18%	6%	5%
Incandescent	24%	20%	11%	38%	23%	18%	6%	39%
Halogen	11%	13%	15%	5%	7%	9%	10%	3%
Fluorescent	2%	0%	0%	8%	2%	0%	0%	6%
DK/Other	1%	<1%	<1%	2%	<1%	<1%	0%	1%

Table 46: New Purchases by Bulb Shape, 2016 & 2017 (New York)

Bulb Type	2016 Purchases (n=105) All	A-line	Reflector	Other	2017 Purchases (n=217) All	A-line	Reflector	Other
Number of Bulbs	842	527	111	204	1,630	1,005	176	450
LED	27%	24%	41%	25%	40%	40%	50%	34%
CFL	15%	22%	3%	6%	16%	22%	11%	4%
Incandescent	41%	39%	38%	48%	33%	27%	18%	52%
Halogen	13%	14%	19%	4%	10%	10%	21%	6%
Fluorescent	4%	0%	0%	17%	1%	0%	0%	4%
DK/Other	<1%	<1%	0%	1%	<1%	0%	0%	1%

E.2 Sources of Bulbs by Income and Home Type

Non-low-income and single-family households purchased more LEDs, on average, than low-income and multifamily households, as shown in Table 47 and Table 48. The most common source of LED bulbs purchased last year was home improvement stores, across all demographic groups. MassSave was the second most commonly cited source of new LEDs to the home in all groups, except multifamily households. However, direct install program participation was only verified in single-family, non-low-income households.[44] Fewer LEDs obtained in 2017 in low-income (20%) and multi-family households (23%) were from home improvement stores than non-low-income (35%) and single-family households (35%), respectively. Table 47 and Table 48 show that some of the market share for these groups may have gone to discount and hardware stores for bulbs obtained in 2017.

In both 2017 and 2018, low-income households were more likely than non-low-income households to buy LEDs at mass merchandise and lighting and electronics stores. Multifamily households purchased more LEDs at mass merchandise and grocery stores in both 2017 and

[44] In 2018, the two households with verified program participation declined to share their income status.

2018 than single-family households. Comparisons between years may not be as reliable due to the increase in LEDs with unknown purchase source from 2017 to 2018.

Table 47: LED Source by Income (Massachusetts)

(Base: All LED bulbs obtained by all households in sample – panel and/or new)

Bulb Source	Obtained in 2016			Obtained in 2017		
	All	Low-income	Non-Low-income	All	Low-income	Non-Low-income
Sample Size	*465*	*134*	*285*	*381*	*94*	*251*
Households with new LEDs	***152***	***41***	***94***	***186***	***50***	***115***
Bulbs Purchased	**1,606**	**368**	**1,152**	**1,654**	**317**	**1,190**
Avg # Purchased	**11.8**	**9.3**	**13.4**	**9.5**	**8.0**	**10.3**
Home Improvement	36%	37%	39%	31%	20%[b]	35%[a]
MassSave – DI Verified[45]	5%	0%	7%[a]	1%[b]	0%	0%[b]
Mass Merchandise	7%	14%	5%[a]	7%	15%	5%[a]
Discount	1%	1%	1%	6%[b]	6%[b]	6%[b]
Hardware	3%	<1%	5%[a]	6%[b]	9%[b]	4%
Online	8%	0%	11%[a]	3%[b]	0%	3%[ab]
Grocery	1%	2%	1%	3%[b]	2%	3%
Lighting and Electronics	4%	12%	1%[a]	3%	11%	1%[a]
Membership Club	4%	3%	5%	2%[b]	2%	2%[b]
Electrician	4%	0%	1%	2%[b]	0%	3%[a]
EE Fair/Pop-up	<1%	0%	1%	2%[b]	1%	2%
Other	5%	8%	4%	2%[b]	2%	1%[b]
Don't Know*	25%	24%	22%	33%[b]	28%[b]	25%[b]
Legend		Most common source			2nd most common source	

[a] Significantly different from Low-Income at the 90% confidence level.
[b] Significantly different from 2017 at the 90% confidence level.
* "Don't know" includes bulbs reported as have been installed by MassSave at households that were unconfirmed program participants.

[45] The two households that were verified program participants in 2017 declined to give their income status.

Table 48: LED Source by Home Type (Massachusetts)

(Base: All LED bulbs obtained by all households in sample – panel and/or new)

Bulb Source	Obtained in 2016			Obtained in 2017		
	All	Multifamily	Single-Family	All	Multifamily	Single-Family
Sample Size	*465*	*97*	*368*	*381*	*172*	*209*
Households with new LEDs	***152***	***17***	***134***	***186***	***68***	***91***
Bulbs Purchased	**1,606**	**84**	**1,522**	**1,654**	**447**	**1,011**
Avg # Purchased	**11.8**	**5.6**	**12.6**	**9.5**	**6.9**	**11.5**
Home Improvement	36%	39%	36%	31%	23%[b]	35%[a]
MassSave – DI Verified	5%	0%	5%[a]	1%[b]	0%	1%[b]
Mass Merchandise	7%	17%	7%[a]	7%	13%	4%[a]
Discount	1%	0%	1%	6%[b]	14%[b]	2%[a]
Hardware	3%	3%	3%	6%[b]	8%[b]	6%
Online	8%	14%	7%[a]	3%[b]	4%[b]	4%
Grocery	1%	10%	1%[a]	3%[b]	7%	1%[a]
Lighting and Electronics	4%	0%	4%[a]	3%	0%	5%[a]
Membership Club	4%	4%	4%	2%[b]	2%	3%
Electrician	4%	0%	<1%	2%[b]	3%[b]	2%
EE Fair/Pop-up	<1%	0%	<1%	2%[b]	2%[b]	2%
Other	5%	1%	5%[a]	2%[b]	1%	1%[b]
Don't Know*	25%	13%	26%[a]	33%[b]	23%[b]	36%[b]
Legend		Most common source			2nd most common source	

[a] Significantly different from Multifamily at the 90% confidence level.

[b] Significantly different from 2017 at the 90% confidence level.

* "Don't know" includes bulbs reported as have been installed by MassSave at households that were unconfirmed program participants.

E.3 LED Satisfaction

Table 49: LED Satisfaction

(Base: Respondents with at least one LED installed in the home)

Level of Satisfaction	Massachusetts				New York			
	ENERGY STAR LEDS	Non-ENERGY STAR LEDS	Don't know	All LEDs	ENERGY STAR LEDS	Non-ENERGY STAR LEDS	Don't know	All LEDs
Households	*247*	*135*	*128*	*291*	*57*	*81*	*72*	*124*
Number of Bulbs	*2,636*	*785*	*829*	*4,249*	*312*	*492*	*308*	*1,111*
Very Satisfied	89%[a]	92%[a]	83%[a]	89%	83%	87%	88%	86%
Somewhat Satisfied	8%	5%[a]	11%	8%	12%	9%	11%	10%
Neither Satisfied nor Dissatisfied	1%[a]	2%	2%[a]	1%	5%	3%	1%	3%
Somewhat Dissatisfied	2%[a]	1%	2%	2%	0%	1%	1%	1%
Very Dissatisfied	0%	0%	2%[a]	0%	0%	0%	0%	0%

[a] Significantly different from New York at the 90% confidence level.

Table 50: LED Satisfaction by Bulb Shape

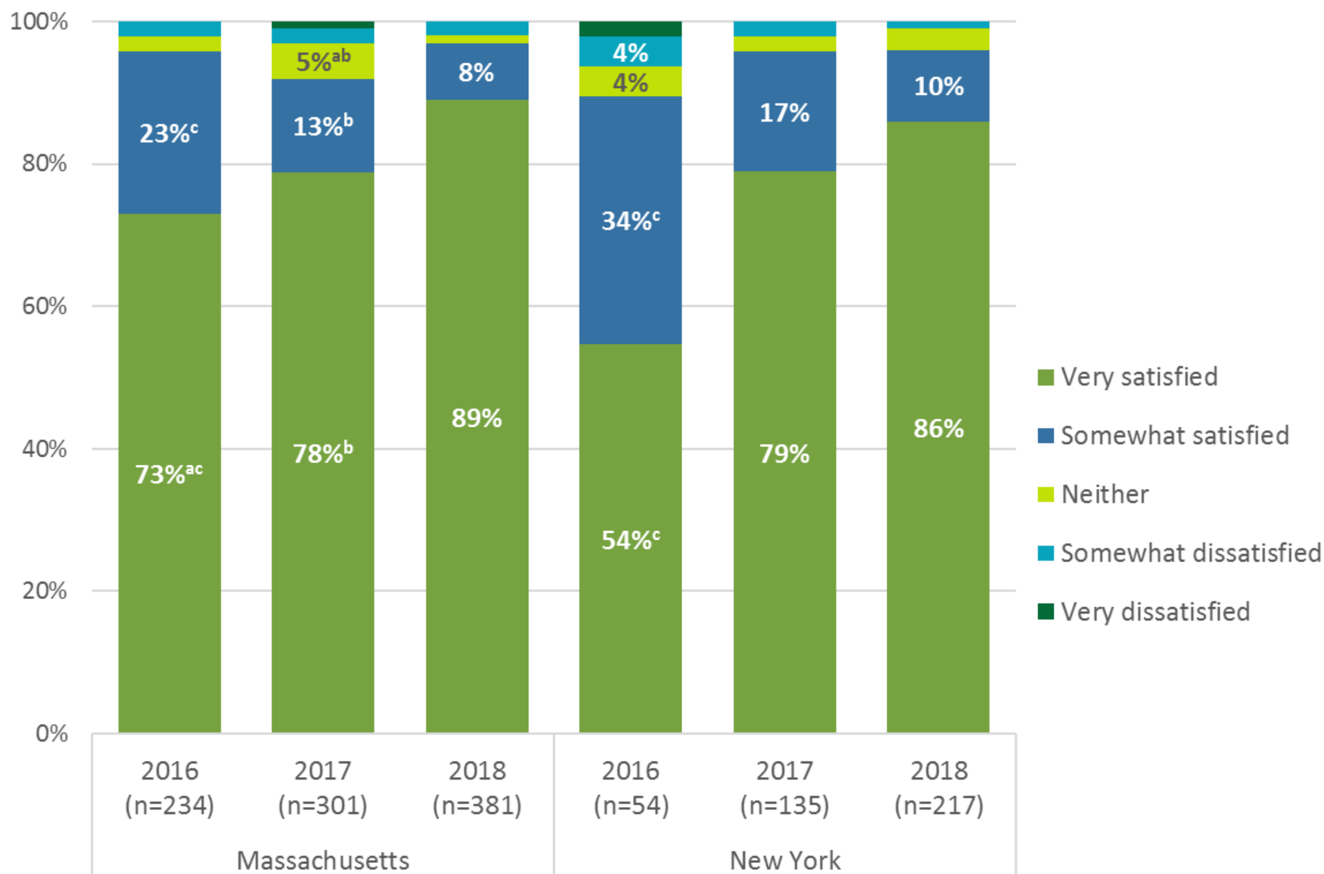
(Base: Respondents with at least one LED installed in the home)

Level of Satisfaction	A-Line	Reflector	Candle	Globe	Slim-style	Bullet/ Torpedo	Other
	Massachusetts						
Households	*245*	*161*	*66*	*42*	*20*	*10*	*21*
Number of Bulbs	*2,374*	*1,022*	*489*	*184*	*67*	*36*	*78*
Very Satisfied	89%[a]	89%[a]	86%[a]	87%[a]	97%	45%[a]	86%
Somewhat Satisfied	7%[a]	9%	11%[a]	11%[a]	2%	55%[a]	9%
Neither Satisfied nor Dissatisfied	1%	1%[a]	2%[a]	1%	1%	0%	4%[a]
Somewhat Dissatisfied	1%	1%	2%[a]	1%	0%	0%	0%
Very Dissatisfied	1%	0%	0%	0%	0%	0%	0%
	New York						
Households	*113*	*32*	*15*	*8*	*2*	*6*	*10*
Number of Bulbs	*768*	*138*	*82*	*24*	*4*	*29*	*19*
Very Satisfied	84%	83%	95%	93%	2	100%	18
Somewhat Satisfied	12%	10%	4%	7%	2	0%	1
Neither Satisfied nor Dissatisfied	3%	5%	0%	0%	0	0%	0
Somewhat Dissatisfied	1%	2%	0%	0%	0	0%	0
Very Dissatisfied	0%	0%	1%	0%	0	0%	0

Overall satisfaction ("very satisfied" and "somewhat satisfied") responses have remained steady in both areas since 2016, but the proportion of "very satisfied" responses has increased steadily over the past three years. In 2018, Massachusetts householders responded that they were "very satisfied" with more of their bulbs than in 2017, and at a higher rate than New York householders in 2018.

Figure 33: LED Satisfaction by Area

(Base: 2017/2018 – satisfaction by bulb; 2016 – overall response per household)



Category labels <3% not pictured.
a. Significantly different from New York at the 90% confidence level.
b. Significantly different from 2018 at the 90% confidence level.
c. Significantly different from 2017 at the 90% confidence level.

F Appendix F Storage

In both Massachusetts and New York, incandescents were the most common bulb type found in storage overall and across income types. CFLs were the second most common bulb type in storage in both areas. In Massachusetts non-low-income homes, LEDs followed close behind CFLs as the third most common bulb type in storage (Table 51).

Table 51: Stored Bulbs by Bulb by Income

(Base: All on-site respondents)

	Massachusetts*			New York**		
	All	**Low-income**	**Non-Low-income**	**All**	**Low-income**	**Non-Low-income**
Sample Size	*381*	*94*	*251*	*217*	*41*	*155*
Total Stored Bulbs	**5,515**	**982**	**4,041**	**2,614**	**412**	**1,960**
Avg. # of Stored Bulbs	**14.5**	**9.3**	**21.1**	**12.1**	**7.2**	**14.5**
Median	**11**	**4**	**12**	**5**	**3**	**8**
Incandescent	51%	50%	56%	58%	55%	58%
CFLs	22%	26%	21%	19%	20%	19%
LEDs	16%	12%	18%	12%	11%	12%
Halogen	9%	7%	9%	8%	9%	9%
Fluorescent	2%	0%	2%	3%	5%	2%
Other**	<1%	0%	<1%	0%	0%	0%

* 36 DK/Refused households for income.
**21 DK/Refused households for income.

Table 52 shows that storage habits were similar across home types within each area in 2017, apart from single-family households in Massachusetts. Storage habits across the two areas were similar as well, aside from single family households in New York which were storing incandescents at a significantly higher rate than singe family households in Massachusetts.

Table 52: Stored Bulbs by Home Type

(Base: All on-site respondents)

	Massachusetts			New York		
	All	**Multifamily**	**Single-Family**	**All**	**Multifamily**	**Single-Family**
Sample Size	*381*	*172*	*209*	*217*	*48*	*169*
Total Stored Bulbs	**5,515**	**2,007**	**3,508**	**2,614**	**444**	**2,170**
Avg. # of Stored Bulbs	**14.5**	**10.5**	**18.4**	**12.1**	**6.5**	**14.6**
Median	**11**	**6**	**12**	**5**	**3**	**8**
Incandescent	51%	52%	50%	58%	53%	59%*
CFLs	22%	20%	23%	19%	23%	19%
Halogen	16%	10%	8%	12%	12%	8%
LED	9%	16%	16%	8%	9%	12%
Fluorescent	2%	1%	2%	3%	4%	3%
Other	<1%	0%	<1%	0%	0%	0%

* Significantly different from MA at the 90% confidence level.

G Appendix G EISA Coverage, Exemptions, & Exclusions

Second perhaps only to the introduction of LEDs to the marketplace, the implementation of the Energy Independence and Security Act (EISA) of 2007 is one of largest influences on the residential lighting market during recent times.

Summary: There are two phases of EISA. Phase I was introduced in 2012; additional standards went into effect in 2013, and 2014. Phase II (often referred to as the EISA backstop) is set to go into effect in 2020. In January 2017, the DOE issued two rulemakings, which greatly expanded the scope of the backstop, to include additional previously exempt bulb categories and higher lumen lamps. The National Electrical Manufacturers Association (NEMA) filed a petition to review the DOE rulemakings. On July 7, 2017, DOE and NEMA reached a settlement, with NEMA agreeing to withdraw its petition and the DOE agreeing to complete the GSL rulemaking and other associated regulatory activities. While we expected DOE to present revised rules in September 2017, we still have not heard anything on their intended actions as of February 2018. What we know, is that the DOE has left enforcement specifics somewhat vague, has indicated that a sell-through period is likely, and has allowed for a possible delay in enforcement for some bulb categories. Final determination will be based on an ongoing dialog with lighting industry stakeholders. This is an area the PAs, evaluators and EEAC are carefully monitoring, especially as we approach 2019 and 2020.

G.1 Overview

The Energy Independence and Security Act (EISA) of 2007 has had and will continue to have a profound impact on the residential lighting market. EISA encompassed a wide variety of energy-related standards. For the purposes of this memo, we concentrate on the General Service Lighting (GSL) standards.

EISA laid out initial standards to be implemented between 2012 and 2014 (Phase I) and a schedule of events that would lead to increased standards in 2020 (Phase II) and 2025 (Phase III). The act envisioned the DOE issuing rulemakings that would take effect in 2020 and 2025. However, it also included a provision (backstop) that would go into effect in those years should the DOE fail to complete a rulemaking in accordance with the act or if the final DOE rulemaking did not produce savings greater than or equal to the savings of the backstop provision.

G.2 Current Status

Phase I of EISA went into effect in a staged process from 2012 through 2014. Phase I increased the efficacy requirements of the most common GSLs by about 28-30%. The standards essentially required that all GSLs provide the same efficacy as common Halogen lamps.

- Despite the standards taking effect up to five years ago, there is evidence of a long sell-through period, with lamps covered by 2012 standards still being purchased by consumers in 2017 (RLPNC 17-12).

On January 19, 2017, the DOE issued two rulemakings related to Phase II of EISA and indicated that the rules would go into effect as scheduled in January of 2020. The rules specifically cited an efficacy standard of 45 lumens per watt (equivalent to the backstop provision). In addition, the rules redefined GSL to include seven previously exempt categories of lamps and expanded the covered lumen range.

- Importantly, EISA directed the DOE to undertake a standards rulemaking for GSLs, to be completed by January 1, 2017. According to EISA, if the rulemaking was not complete, or if the rulemaking did not produce savings greater than or equal to the savings from a minimum efficacy standard of 45 lumens per watt, a statutory provision (backstop) would take effect.

In March of 2017, the National Electrical Manufacturers Association (NEMA) filed a petition to review the DOE rulemakings. On July 7, 2017, DOE and NEMA reached a settlement, with NEMA agreeing to withdraw its petition and the DOE agreeing to complete the GSL rulemaking and other associated regulatory activities. While we have been unable to obtain a copy of any settlement agreement, our understanding is that the DOE agreed to do the following:

- Issue a Notice of Data Availability (NODA) requesting market data for GSL incandescent lamps and other incandescent lamps. (See https://www.regulations.gov/document?D=EERE-2017-BT-NOA-0052-0001 for the NODA issued in August 2017.) This data will be used to help determine whether standards for incandescent lamps should be amended.
- Based on a review of data provided through the NODA, issue final rules for vibration and rough service lamps re: the backstop. Initial release estimated to occur September of 2017 – still not issued as of March 2018.
- Issue a Supplemental Notice of Proposed Rulemaking (SNOPR) for GSL lamps. This would be expected to include standards for GSL LEDs. Initially this was estimated to be released in the first quarter of 2018 but is likely to be delayed significantly given the delays in the vibration and rough service lamp action mentioned above. Reports indicate that this SNOPR was to be issued five months after the vibration and rough service lamp rules.

G.3 EISA Phase I - History

EISA 2007 set maximum wattage levels by lumen output for medium screw-base bulbs, ranging from 310 to 2,600 lumens and operating at a range from 110 to 130 volts. The standards took effect through a phased process, beginning in 2012 (Phase I). Table 53 shows the schedule for Phase I.

Phase I of EISA 2007 prohibits the manufacture and import of non-compliant bulbs, but does not affect the sale or use of such bulbs. For this reason, as observed in other studies, standard incandescent bulbs have remained available to consumers on retailers' shelves long after the implementation of EISA 2007 (NMR 2015).[46]

Table 53: EISA Phase I Schedule

Rated Lumen Ranges	Typical Incandescent Lamp Wattage	Maximum Rated Wattage	Effective Date
1,490–2,600	100	72	1/1/12
1,050–1,489	75	53	1/1/13
750–1,049	60	43	1/1/14
310–749	40	29	1/1/14

G.4 EISA Phase II - History

In January 2017, the DOE issued two final rules related to General Service Lamps (GSLs). The complete rules can be found in the federal register through the following links:

- https://www.gpo.gov/fdsys/pkg/FR-2017-01-19/pdf/2016-32012.pdf
- https://www.gpo.gov/fdsys/pkg/FR-2017-01-19/pdf/2016-32013.pdf

The first link provides an overview of the DOE's decision to amend the definition of GSLs. The two most important takeaways from the amended definition are the expansion of covered lumen range and the elimination of seven exemptions. Combined, the revised EISA Phase II backstop now covers the vast majority of residential lighting options – meaning that very few bulbs will be exempt from EISA after January 1, 2020.

Lumen Range Expansion. Phase I of EISA covers GSLs from 310 to 2,600 lumens. The amended GSL lumen range, beginning January 1, 2020, will cover 310 to 4,000 lumens – meaning that EISA Phase II will apply to higher lumen-output lamps than Phase I.

Elimination of Exemptions. For Phase I of EISA, the DOE specifically identified 22 lamp types that were exempt (not covered) by the EISA efficiency standards. Table 54 provides a listing of all 22 originally exempt GSL categories, as well as approximate national sales (as estimated by the DOE). The final rules for Phase II of EISA discontinue exemptions for seven important categories (highlighted in bold in Table 54):

- Reflector Lamps
- Rough Service Lamps
- Shatter-Resistant Lamps

[46] MA EEAC, Lighting Market Assessment and Saturation Stagnation Overall Report, 2015. http://ma-eeac.org/wordpress/wp-content/uploads/Lighting-Market-Assessment-and-Saturation-Stagnation-Overall-Report.pdf.

- 3-Way Lamps
- Vibration Service Lamps
- T-Shape Lamps of 40 Watts or less or length of 10 inches or more
- B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less

As the sales data provided in the table demonstrate, the categories for which exemptions will be discontinued are also some of the higher sales categories for bulbs not already covered by EISA. In their rationale for changing the exempt status, the DOE discusses a desire to avoid potential lamp switching.

Table 54: EISA Exemptions

Number	GSL Exempt Category	Approx. Sales (DOE)	Exemption Status
1	Appliance Lamp	2 million	Maintain
2	Black Light Lamp	<1 million	Maintain
3	Bug Lamp	<1 million	Maintain
4	Colored Lamp	<2 million	Maintain
5	Infrared Lamp	<1 million	Maintain
6	Left-Hand Thread Lamp	<1 million	Maintain
7	Marine Lamp	<1 million	Maintain
8	Marine Signal Service Lamp	<1 million	Maintain
9	Mine Service Lamp	<1 million	Maintain
10	Plant Light Lamp	<1 million	Maintain
11	**Reflector Lamp**	**30 million**	**Discontinue**
12	**Rough Service Lamp**	**11 million**	**Discontinue**
13	**Shatter-Resistant Lamp**	**0.7 Million**	**Discontinue**
14	Sign Service Lamp	1 million	Maintain
15	Silver Bowl Lamp	1 million	Maintain
16	Showcase Lamp	<1 million	Maintain
17	**3-Way Lamp**	**33 million**	**Discontinue**
18	Traffic Signal Lamp	<1 million	Maintain
19	**Vibration Service Lamp**	**7 million**	**Discontinue**
20	G shape Lamp with diameter of five inches or more	0.9 million	Maintain
21	**T shape lamp of 40 W or less or length of ten inches or more**	**10 million**	**Discontinue**
22	**B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less**	**72 million**	**Discontinue**

G.5 Enforcement and Sell Through Period

Enforcement

It is important to note that, in the final rules, the DOE has explicitly stated that they may not enforce the standards for all lamp types beginning in 2020 and may instead delay enforcement based on an ongoing dialog with lighting industry stakeholders.

> *DOE acknowledges that manufacturers may face a difficult transition if required to comply with a 45 lm/W standard. Manufacturers have voiced concern regarding the loss of domestic manufacturing jobs, the stranding of inventory, the ability to meet the demand for all general service lamps with lamps using LED technology, and the burden associated with testing and certifying compliance for all general service lamps in DOE's Compliance Certification Management System (CCMS). Manufacturers have requested an end to or delay in imposing any new standards for general service lamps and a two- to three-year delay in enforcing the backstop standard.*
>
> *DOE is committed to working with manufacturers to ensure a successful transition if the backstop standard goes into effect. DOE will continue to have an active dialogue with industry, including meetings and other stakeholder outreach, throughout the period between publication of this rule and the compliance date of any backstop standard for general service lamps, including IRLs. During this period, DOE will keep stakeholders and the public apprised of its plans for any broad exercise of enforcement discretion with respect to the standard.*

Sell Through

In addition, while the final rules say that manufacture and sale of lamps are covered, the DOE further clarified in a footnote that they would likely allow manufacturers to sell through non-compliant lamps manufactured before the backstop goes into effect.

> *In that vein, DOE also notes NEMA's comment that because the backstop requires DOE to "prohibit sales," it could present a substantial practical difficulty regarding compliance. For most products, NEMA states, after a standard comes into effect distributors can continue to sell inventory still on hand that complied with the previous standard. If, by contrast, distributors cannot sell old lamp inventory after January 1, 2020, that inventory will be stranded. Although it is premature for DOE to explain in detail how the backstop would work if it comes into force, DOE notes that under subsection (i)(2), "it shall not be unlawful for a manufacturer to sell a lamp which is in compliance with the law at the time such lamp was manufactured." DOE expects it would interpret and apply the backstop with subsection (i)(2) in mind.*

G.6 Backstop

Here we provide the backstop language from EISA 2007.

> *Backstop <<NOTE: Effective date.>> requirement--If the Secretary fails to complete a rulemaking in accordance with clauses (i) through (iv) or if the final rule does not produce savings that are greater than or equal to the savings from a minimum efficacy standard of 45 lumens per watt, effective beginning January 1,2020, the Secretary shall prohibit the sale of any general service lamp that does not meet a minimum efficacy standard of 45 lumens per watt.*

Note that the backstop provision does not define whether the standard (45 lm/W) should be applied on a per lamp basis or as a fleet average. Some manufacturers have argued it should be interpreted as a fleet average. In the DOE's January 2017 rulemakings, they clearly articulated it as a per lamp standard. In addition, while the backstop explicitly states prohibit sales, as described above, the DOE has left room for a sell through period.

G.7 Exemptions

Here we provide the language on exemptions from EISA – bolding added by NMR. The bolded text would seem to indicate that if sales in exempt categories have not increased, the exemptions should not be removed. That is the argument NEMA is making and asking the DOE to revisit the definition of GSL. Their argument centers on the fact that sales of incandescent lamps in exempt categories have not increased (and have in fact decreased), with the exception of rough service and vibration resistant lamps.

> *(D) Exemptions.-- (i) Petition.--Any person may petition the Secretary for an exemption for a type of general service lamp from the requirements of this subsection. (ii) Criteria.-- The Secretary may grant an exemption under clause (i) only to the extent that the Secretary finds, after a hearing and opportunity for public comment, that it is not technically feasible to serve a specialized lighting application (such as a military, medical, public safety, or certified historic lighting application) using a lamp that meets the requirements of this subsection. (iii) Additional criterion.-- To grant an exemption for a product under this subparagraph, the Secretary shall include, as an additional criterion, that the exempted product is unlikely to be used in a general service lighting application. (E) Extension of coverage.-- (i) Petition.--Any person may petition the Secretary to establish standards for lamp shapes or bases that are excluded from the definition of general service lamps. (ii) Increased sales of exempted lamps.-- The petition shall include evidence that the availability or sales of exempted incandescent lamps have increased significantly since the date on which the standards on general service incandescent lamps were established. (iii) Criteria.--The Secretary shall grant a petition under clause (i) if the Secretary finds that--(I)* ***the petition presents evidence that demonstrates that commercial availability or sales of exempted incandescent lamp types have increased significantly since the standards on general service lamps were established and likely are being widely used in general lighting applications****; and (II) significant energy savings could be achieved by covering exempted products, as determined by the Secretary based on sales data provided to the Secretary from manufacturers and importers. (II) the exemptions for certain incandescent lamps should be maintained or discontinued based, in part, on exempted lamp sales collected by the Secretary from manufacturers.*

Appendix H Demographics

The demographic information was collected over the phone through the consumer survey. Massachusetts census data comes from the 2016 American Community Survey (ACS) five-year estimates. In addition to data from the comparison area, Upstate New York, we have provided census data in comparison to the consumer survey and on-site participant sample when available. Throughout the demographic section, the team has tested for significant differences across samples using a two-tailed t-test; significance is indicated in Figure 34 and discussed below.

On-site visits in Massachusetts and New York significantly differed from American Community Survey (ACS) five-year estimates on several key demographic variables, including income, home type, age, age of home, and education. On-site participants were relatively similar between Massachusetts and New York, although the New York on-sites had significantly more single-family homes and significantly fewer low-income participants than Massachusetts.

Massachusetts

Income: Roughly two-thirds (66%) of Massachusetts on-site participants were non-low-income, while one fourth (25%) identified as low-income (remaining participants declined to respond). This is significantly different from Massachusetts 2016 ACS five-year estimates, which show that 81% of Massachusetts households are non-low-income.

Home Type: Just over one-half (55%) of on-site participants lived in single-family homes. This figure is significantly different from the Massachusetts 2016 ACS five-year estimate, which indicate that 79% of Massachusetts residents live in single-family homes.

Tenure: Over three-quarters (76%) of on-site participants own their homes, which is significantly more than the ACS five-year estimates (62%).

Education: Respondents in 36% of on-site households held an advanced or graduate degree, significantly more than the 16% identified in the ACS five-year estimates. Thirty-one percent of respondents had achieved a Bachelor's degree, compared to 22% statewide per the ACS estimates. Just 9% of respondents had achieved a high school diploma or GED as their highest level of educational attainment, far less than the 30% reported in this category in the five-year estimates. These differences were statistically significant.

Age: The consumer survey was comprised of significantly more respondents aged 55-64 and over 65, than in the state population as reported by the ACS. There were also significantly fewer survey respondents in the 25-34 year-old category than in the general population.

When Home Built: On-site and survey participants generally reported the build year of their homes as similar to those in the ACS. The only significant difference between the two groups was in homes built in the 1930s or earlier, which accounted for 34% of homes in the ACS estimates and 24% of homes in the on-site visits.

New York

Income: Nearly three-quarters (71%) of New York on-site households visited were non-low-income, while 19% were low-income. The percentage of low-income participants in New York was significantly less than the 25% in Massachusetts.

Home Type: The majority (78%) of households in New York on-site visits were single-family, almost equal to the Massachusetts ACS five-year estimates (79%). New York households also differed significantly in this respect from those visited in Massachusetts during on-sites.

Tenure: There were no significant differences between the proportion of home-owning householders in New York on-site visits and Massachusetts on-site visits.

Education: Residents at 40% of the New York households visited held an advanced degree, significantly more than the 16% reported in ACS five-year estimates, but similar to the 36% in Massachusetts. There were significantly fewer people with a Bachelor's degree (24%) in New York on-site households than in Massachusetts (31%). The ACS estimates were significantly higher for those having attained a high school diploma or GED as their highest level of education (27%) compared to New York on-site participants (8%).

Age: New York on-sites had significantly fewer people who were 25-34 (11%), 35-44 (24%), 55-64 (25%), and 65 or older (16%) compared to the ACS estimates (15%, 17%, 20%, and 24%, respectively). There were significantly more 35-44-year-olds (24%) in New York on-sites than in Massachusetts (16%), while there were significantly fewer 65 and older participants in New York (16%) compared to Massachusetts (28%).

When Home Built: New York homes were relatively similar to both Massachusetts and the ACS estimates for most comparisons of build year. The only significant difference between New York and Massachusetts was in homes built in the 1970s (14% in Massachusetts vs. 9% in New York); and the only significant difference between New York and the census was in homes built in the 1930s or earlier, which accounted for 34% of homes in the ACS estimates and 22% of homes in the New York on-site visits.

Figure 34: Comparison of MA & NY On-Sites with Census

* Significantly different from the Census at the 90% confidence level.
^ Significantly different from MA On-Site at the 90% confidence level.

I Appendix I Panel Non-Response Bias

Each year since the initial wave of panel visits in Massachusetts in 2014, we compare the sample of potential panelists to the actual panelists to see if they differ in ways that would point to non-response bias. For the 2018 visits, we had 465 sites to draw upon for the sample – 315 panelists and 150 new visits from the 2017 wave. As there were no visits to new sites this year, the completed panel visit population also represents the sample population for on-site participants in 2018.

As in previous years, we continue to see a high response rate and very similar demographic characteristics and saturation rates when comparing the panelists to the pool of potential respondents. Our analysis finds no cause for concern regarding non-response bias.

I.1 MA Panel Response Rates

Table 55 shows that we continue to have a robust response rate among previous panelists. We completed visits at 82% of all available sites, the highest percentage of returning respondents since the start of the panel visits. The share of sites that did not respond decreased by one-half (from 12% to 6%) this year, after it had been at its highest percentage in 2017.

Table 55: MA Panel Disposition

Disposition	2014		2015		2016		2017		2018	
	n	%	n	%	n	%	n	%	n	%
Complete	111	74%	203	78%	270	77%	315	75%	381	82%
No Response	9	6%	29	11%	15	4%	51	12%	30	6%
Did Not Contact	4	3%	6	2%	37	11%	20	5%	13	3%
Ineligible	24	16%	16	6%	21	6%	22	5%	23	5%
Wait List	--	--	6	2%	3	1%	6	1%	4	1%
Visit Cancelled	--	--	--	--	4	1%	5	1%	10	2%
Refused	2	1%	1	<1%	1	<1%	2	<1%	4	1%
Total	150	100%	261	100%	351	100%	420	100%	465	100%

I.2 MA Panel Demographic Analysis

The demographic characteristics of the 2018 completed panel visits are again quite similar to the overall respondent pool (Table 56). The largest demographic difference between the two groups was in home type. Of the 381 completed panel visits in Massachusetts, 55% took place at single-family homes and 45% at multifamily homes. Both these numbers differed significantly from the overall sample pool from which the panel visit sites were drawn. The overall pool was comprised of 79% single-family and 21% multifamily homes. Otherwise, the two groups were very similar demographically across all other metrics.

Table 56: MA Panel Demographics

Demographics	2014		2015		2016		2017		2018	
	All (n=150)	Comp. (n=111)	All (n=261)	Comp. (n=203)	All (n=351)	Comp. (n=270)	All (n=420)	Comp. (n=315)	All (n=465)	Comp. (n=381)
Home Type										
Single -Family	66%	67%	66%	67%	74%	73%	76%	75%	79%	55%[a]
Multifamily	34%	33%	34%	33%	27%	27%	25%	25%	21%	45%[a]
Education										
Graduate Degree	38%	38%	36%	36%	33%	32%	33%	33%	36%	36%
Bachelor's Degree	20%	21%	26%	29%	28%	28%	31%	29%	32%	31%
Some College/ Associate's Degree	27%	29%	25%	24%	25%	27%	23%	25%	23%	22%
High School/GED	13%	11%	11%	9%	10%	9%	9%	10%	8%	9%
Less than High School	2%	2%	1%	1%	2%	2%	2%	2%	2%	1%
DK/Ref	--	--	1%	1%	2%	2%	2%	2%	3%	1%
Income										
Low-Income	31%	27%	31%	31%	29%	30%	24%	24%	29%	25%
Non-Low-Income	69%	73%	63%	63%	63%	62%	63%	63%	61%	66%
DK/Ref	--	--	6%	6%	9%	8%	13%	13%	10%	9%
Tenure										
Own/Buying	65%	72%	66%	67%	69%	70%	69%	73%	72%	76%

[a] Significantly differs from all potential panelists at the 90% confidence level.

I.3 MA Panel Saturation Comparison

Socket saturation is the most important comparison for this study to measure any non-response bias. As in every previous wave, there are no lamp types that exhibit a saturation difference of greater than 1% that were significantly different for the completed sites versus the sample of potential panelists in 2018 (Table 57).

Table 57: MA Saturation Comparison*

Bulb Type	2014		2015		2016		2017		2018	
	All n= 150	Comp. n= 111	All n= 261	Comp. n= 203	All n= 351	Comp. n= 270	All n= 420	Comp. n= 315	All n= 465	Comp. n= 381
Incans	53%	53%	45%	45%	42%	43%	37%	37%	33%	28%
CFLs	30%	31%	34%	33%	32%	33%	30%	30%	29%	26%
Fluorescent	8%	9%	9%	9%	9%	8%	7%	7%	7%	7%
Halogen	5%	4%	7%	7%	7%	7%	9%	8%	9%	8%
LEDs	2%	1%	3%	3%	7%	6%	13%	14%	18%	27%
Other/Empty Socket	2%	2%	3%	3%	3%	3%	4%	4%	4%	4%

* For each panel year column, the saturation figures are for the previous year's visits. For example, the 2014 column has 2013 saturation rates for those panelists.

I.4 NY Panel Non-response Bias Assessment

As with the Massachusetts sites, we analyzed the New York panelists for non-response bias. As in Massachusetts, we find little to no indication of non-response bias for the panelists in New York. We completed visits at 86% of the sites in the respondent pool, the highest in the three years of tracking and received no refusals (Table 58).

Table 58: NY Panel Disposition

Disposition	2016		2017		2018	
	n	%	n	%	n	%
Complete	80	79%	105	70%	217	86%
Did Not Contact	6	6%	17	11%	11	4%
No Response	4	4%	17	11%	10	4%
Wait List	0	-	6	4%	2	1%
Ineligible	2	2%	3	2%	8	3%
Visit Cancelled	6	6%	2	1%	6	2%
Refused	3	3%	0	-	0	0%
Total	101	100%	150	100%	254	100%

As Table 59 shows, the demographics of the panelists in New York are largely similar to those of the sample pool. The 78% of single family homes visited in 2018 differed significantly from the 91% in the overall panel pool, as did the 22% of multifamily sites visited, compared to the 9% in the overall pool. There were no other significant differences between the New York sample pool and completed panel visits, and the two groups were fairly similar across all other measured demographic categories.

Table 59: NY Panel Demographics

Demographics	2016 All (n = 101)	2016 Completes (n = 80)	2017 All (n = 150)	2017 Completes (n = 105)	2018 All (n=255)	2018 Completes (n=217)
Home Type						
Single-Family	84%	84%	79%	79%	91%	78%[a]
Multifamily	16%	16%	21%	21%	9%	22%[a]
Education						
Graduate Degree	37%	40%	33%	29%	38%	40%
Bachelor's Degree	19%	21%	19%	23%	26%	24%
Some College/ Assoc Degree	23%	16%	24%	24%	28%	27%
High School/GED	16%	16%	19%	18%	7%	8%
Less than High School	5%	5%	5%	5%	1%	<1%
DK/Refused	1%	1%	1%	1%	<1%	1%
Income						
Low-Income	24%	20%	24%	25%	25%	19%
Non-Low-Income	66%	71%	63%	63%	70%	71%
DK/Refused	10%	9%	13%	12%	5%	10%
Tenure						
Own/Buying	72%	78%	71%	76%	74%	74%

[a] Significantly differs from all potential panelists at the 90% confidence level.

Socket saturation between the 2018 New York on-site panel participants, and the overall sample pool was largely similar across all bulb types (Table 60).

Table 60: NY Saturation Comparison*

Bulb Type	2016 All (n = 101)	2016 Completes (n = 80)	2017 All (n = 101)	2017 Completes (n = 80)	2018 All (n=255)	2018 Completes (n=217)
Incandescent	50%	49%	46%	48%	44%	42%
CFLs	23%	22%	23%	21%	22%	21%
Fluorescent	12%	12%	11%	10%	9%	8%
Halogen	9%	9%	8%	8%	9%	9%
LEDs	3%	3%	7%	8%	10%	14%
Other/Empty Socket	4%	4%	5%	5%	5%	5%

* For each panel year column, the saturation figures are for the previous year's visits. For example, the 2016 column has 2015 saturation rates for those panelists.

J

Appendix J RLPNC 16-9: Residential Baseline Mid-Year Saturation Update

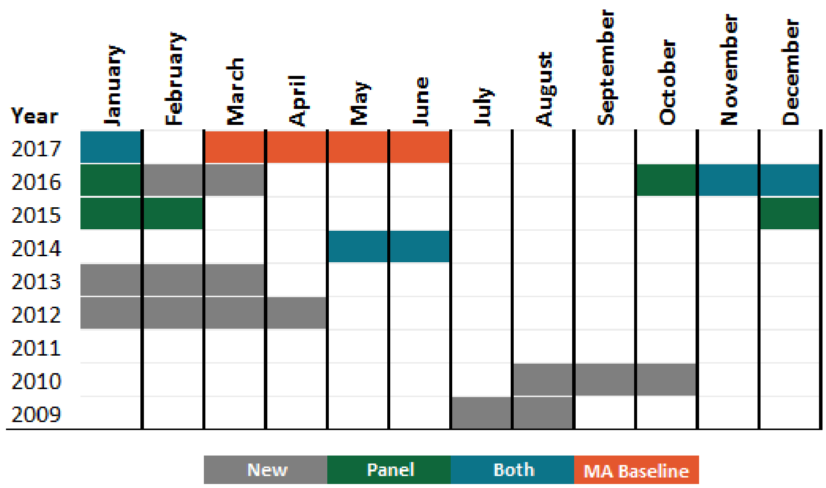
This memo presents a brief update to the results of the 2016-17 Massachusetts Residential Lighting Market Assessment conducted by NMR Group, Inc. and delivered to the PAs in August of 2017. It is important to note that this on-site study differs from the usual Lighting Market Assessment studies in five key ways:

1. **Part of a larger baseline effort.** The data included in this memo was collected as part of a larger study, led by Navigant, on residential plug load. Navigant recruited and scheduled all visits. Each visit consisted of a three- or four-person team; Navigant technicians collected data on appliance plug load while the NMR technician focused on lighting.
2. **No follow-up questions.** Technicians gathered information on all exterior and interior installed bulbs, as well as stored bulbs; the collected data focused on the characteristics of each fixture, fixture control, and bulb, including the make and model numbers of screw-base LEDs. There were no additional questions asked about LED purchase behavior or satisfaction, as were asked during the larger lighting market assessment study.
3. **New visits only.** The 308 participants were new to the Baseline Study; no panel visits were conducted.[47] These homes have not been screened for program participation and will also not be included in the larger Market Transformation panel study (RLPNC 17-9).
4. **Timing of on-site visits.** The NMR lighting technicians visited 308 new sites from March through June of 2017 (Figure 22). This data collection period occurred just a few months after the wrap-up of the on-site visits conducted for the 2016-17 Massachusetts Residential Lighting Market Assessment (October 2016 – January 2017).
5. **Sampling.** Stratifications, potential oversamples, and proportional quotas were based on specific demographic and utility quotas. Lighting visits were conducted in the first 308 sites completed. This sampling methodology differs from the usual residential lighting studies conducted by NMR, which are typically based on home type and income. As the data show, there are some large changes given the short time period between the two surveys; we cannot rule out the possibility that sampling may have played a role. That said, differences in sampling may be minimized by weighting. The on-site data presented in this memo have been weighted to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on Public Use Microdata Sample (PUMS) from the American Community Survey (ACS)

[47] Three homes had previously participated in the larger NMR lighting market transformation study; two were part of the panel study with initial visits in 2014 and 2015, while a third participated in 2015 only. These homes were treated as new visits for the purposes of the baseline study.

1-Year Estimates. This weighting scheme is consistent with previous lighting market characterization studies conducted in Massachusetts.

Figure 35: On-site Visits over Time



J.1 Socket Saturation Trends

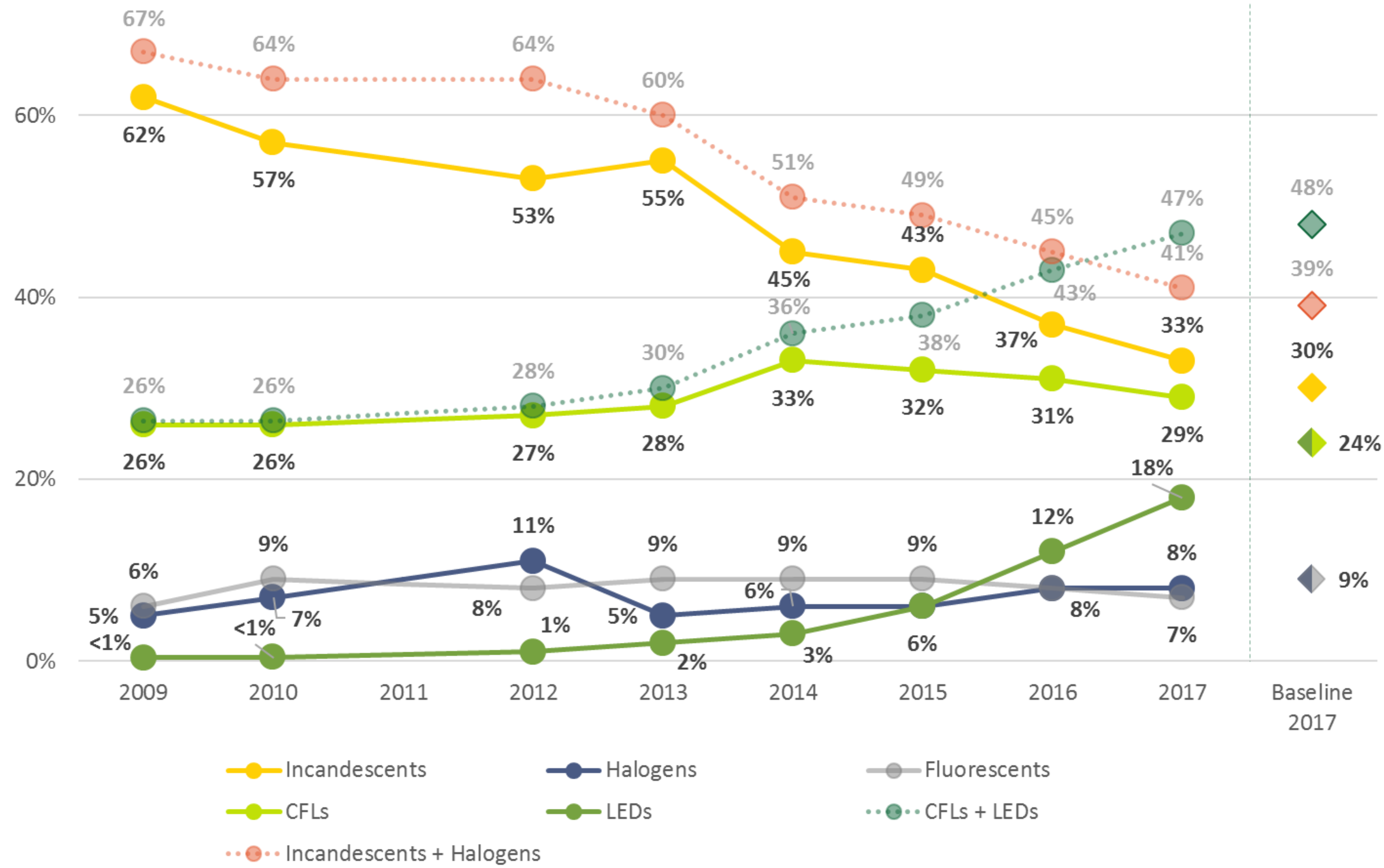
Figure 36 shows saturations for all bulbs types from 2009 through the new 2017 baseline study. To aid in understanding trends, we have interpolated data to represent 2011, a year when no study was completed. The key points below focus on changes in saturation since those presented in the 2016-17 Massachusetts Residential Lighting Market Assessment.

- **LED** saturation increased six percentage points (from 18% to 24%, a statistically significant difference) compared to the most recent lighting study, which ended data collection only one month before the data collection for the baseline study began. As noted above, these differences – observed over a relatively short timeframe – may be driven, in part, by different sample designs.
- **CFL** saturation decreased five percentage points in this study compared to the prior lighting study (from 29% to 24%, a notable, but not statistically significant, decrease), continuing on a steady decline.[48]
- **Incandescent** bulbs filled less than one-third (30%) of all sockets, a decrease in saturation of three percentage points compared to the prior lighting study.[49]
- **Halogen** and **Fluorescent** saturation both remained relatively steady (9% each).

[48] Program support for CFLs ended on December 31, 2016, which took place towards the end of the previous study and a month before the first baseline 2017 study visit.
[49] Note that halogen and incandescent bulbs are nearly indistinguishable. We make every effort to train technicians to identify halogen bulbs but recognize that some bulbs labeled as incandescent are likely halogen, and vice versa.

- **Combined CFL and LEDs (dotted green line)** filled nearly three-fifths of all sockets (48%), an increase of only one percentage point. As shown in the points above, this increase is entirely due to LEDs, the use of which is increasing rapidly enough to offset the decrease in CFL saturation.
- **Combined efficient bulbs (CFLs, LEDs, and fluorescents)** accounted for nearly one out of every six sockets (57%) in the Massachusetts baseline study.
- **Combined inefficient (incandescents and halogens; dotted red line)** bulb saturation was lower by two percentage points – to 39% – in the Massachusetts baseline study compared to lighting study.

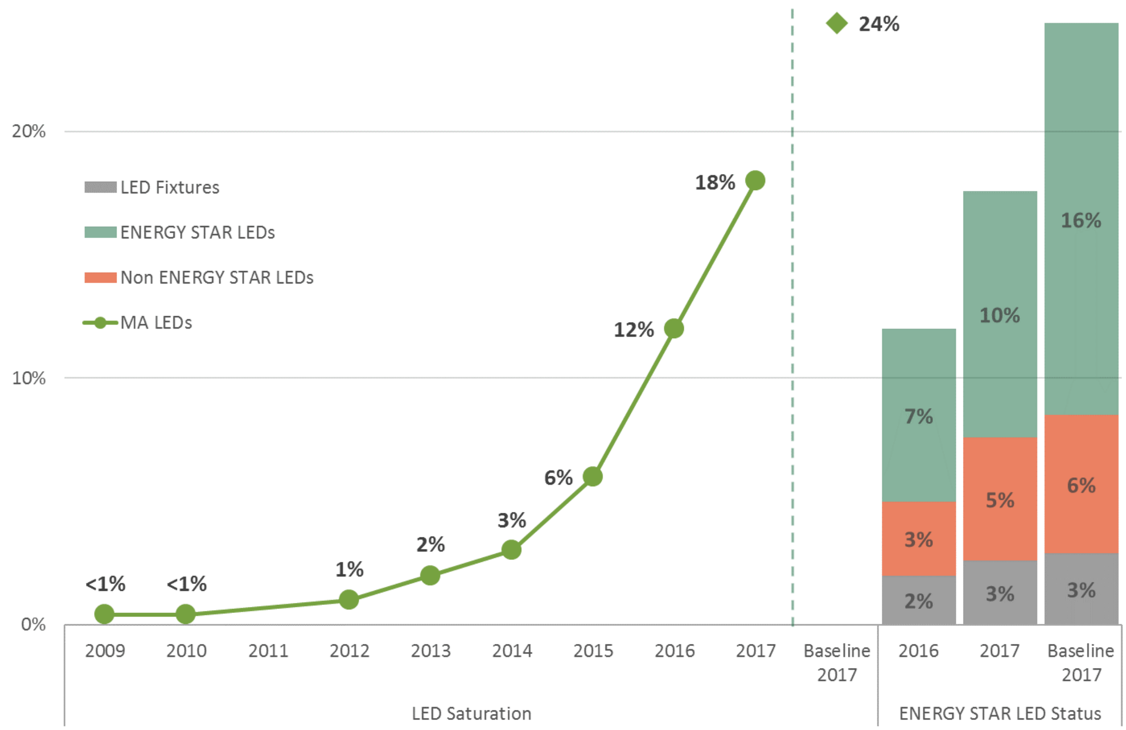
Figure 36: MA Saturation Rates 2009-Spring 2017



Energy Star LEDs

During the on-site visits, we again collected model numbers for all screw-base LED bulbs, which were then used to determine if an LED was ENERGY STAR qualified or not.[50] ENERGY STAR-qualified LEDs accounted for two-thirds of all installed LED bulbs, recessed cans, and fixtures. Notably, ENERGY STAR LEDs filled 16% of all sockets, nearly equivalent to overall LED saturation in the prior lighting study (18%) (Figure 37)

Figure 37: LED Bulb Saturation 2009-Baseline 2017 with ENERGY STAR LEDs in 2016-Baseline 2017

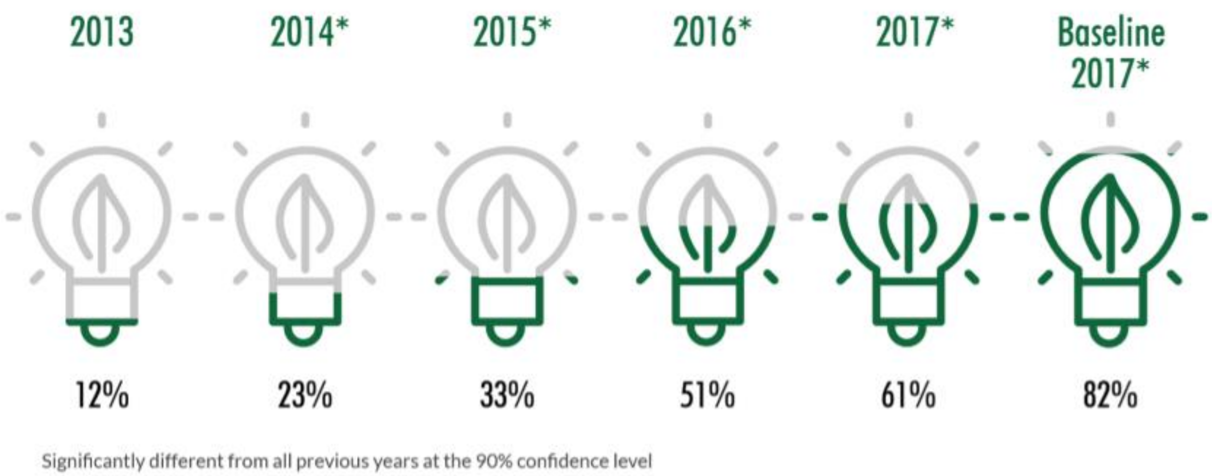


[50] Model numbers were matched to ENERGY STAR lists from late 2015 through May 2017, as well as any web search results that showed a bulb had been ENERGY STAR certified currently or in the past.

J.2 LED PENETRATION

LED penetration increased by twenty-one percentage points, a statistically significant jump, since the 2016-17 Massachusetts Residential Lighting Market Assessment. This means that in the winter of 2016-17, just over three out of every five households in Massachusetts had at least one LED installed; a few months later, more than four out of every five households in Massachusetts had at least one LED installed.

Figure 38: LED Bulb Penetration 2013-Baseline 2017

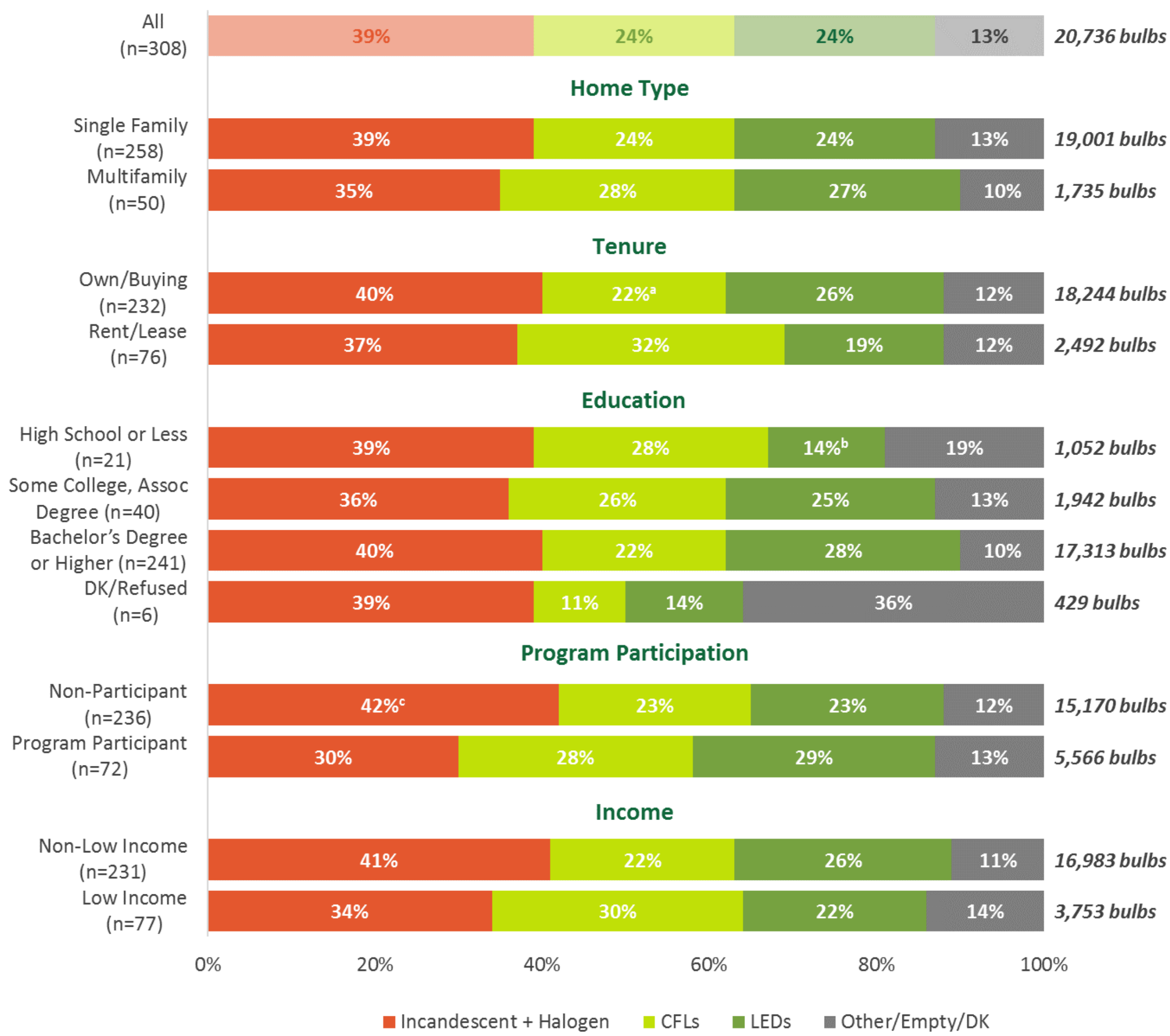


J.3 DEMOGRAPHICS

- Figure 39 looks at saturation across selected demographics for CFLs, LEDs, and combined incandescent and halogen bulbs in the Massachusetts baseline 2017 study. **Education** – LED saturation among those with a high school degree or less (14%) was significantly lower than those with a Bachelor's degree or higher (28%). Otherwise, saturation was largely similar across levels of education.
- **Tenure** – LED saturation in own/buying households was relatively higher than in rent/lease households (26% vs. 19%), though CFL saturation in own/buying households was significantly lower (22% vs. 32%).
- **Home Type** – LED saturation was similar across home types.
- **Program Participation –** While on-site, Navigant technicians asked customers if they had participated in any energy-efficiency programs. In total, 72 of 308 (24%) of on-site participants indicated that they had previously participated in an energy-efficiency program. It is unclear how many participated in the upstream lighting program. Combined, incandescent and halogen saturation was significantly higher in non-participant homes than in program participant homes (42% vs. 30%). Not surprisingly, LED and CFL saturations were both relatively lower in non-participant homes than in participant homes.

- **Income –** LED saturation was relatively higher in non-low-income homes, while CFL saturation was relatively higher in low-income households; interestingly, combined incandescent and halogen saturation was relatively lower in low-income households.

Figure 39: Saturation by Demographics, MA Baseline 2017



[a] Significantly different from Rent/Lease at the 90% confidence level.
[b] Significantly different from Bachelor's Degree or Higher at the 90% confidence level.
[c] Significinatly different from Participant at the 90% confidence level

J.4 Weighting Scheme

Navigant conducted all recruiting and scheduling for on-site visits during this study. Stratifications, potential oversamples, and proportional quotas were based on specific demographic and utility quotas. Lighting visits were conducted in the first 308 sites completed.

As in previous lighting saturation reports, the on-site survey data were weighted to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on Public Use Microdata Sample (PUMS) from the American Community Survey (ACS) 1-Year Estimates.

Table 61: Weighting Scheme – Baseline 2017

Tenure and Home Type	Households	Sample Size	Proportionate Weight
Total	2,549,721	308	
Owner-Occupied			
Some College or Less	807,806	37	2.64
Bachelor's Degree or Higher	775,861	194	0.48
Renter-Occupied			
Some College or Less*	656,897	24	3.31
Bachelor's Degree or Higher**	309,157	52	0.72

*Includes 5 education = prefer not to answer.
**Includes 1 education = prefer not to answer.