Lighting Market Assessment and Saturation Stagnation Overall Report

August 2015

Prepared for:

The Electric and Gas Program Administrators of Massachusetts

Part of the Residential Evaluation Program Area

The Cadmus Group, Inc.

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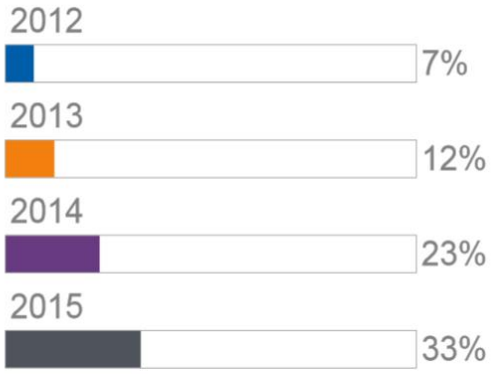
Massachusetts Residential Lighting Market Assessment

Fifteen years of market indicator data lead to the inescapable conclusion that the Massachusetts Residential Lighting Program has had a clear and dramatic impact on the residential lighting market in Massachusetts.

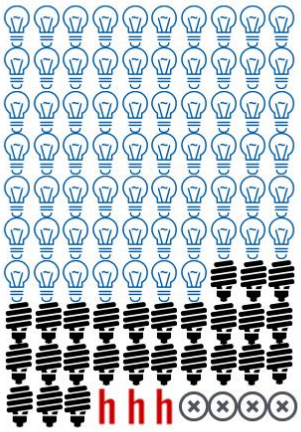
LEDs' Market Share is Increasing Rapidly and LEDs are Being Used in a Variety of Applications

LED Penetration

LED penetration (percent of households using at least one LED) is showing significant gains.



Bulbs LEDs Replaced



Incand. (67%)
CFL (26%)
h Halogen (3%)
Empty (4%)

LED bulbs comprised only 6% of all sockets in Massachusetts but made up 17% of replacement bulbs between 2013 and 2015.

New York Offers a Snapshot of a Market without Incentives

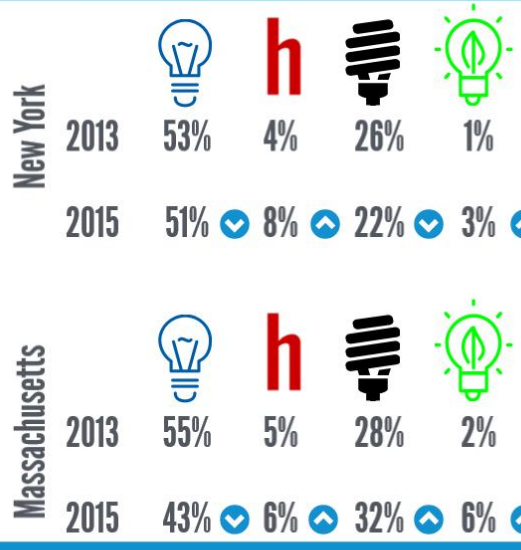
Supplier interviews suggest that standard CFL and LED incentives help combat backsliding to halogens.

This aligns with on-site results in Massachusetts and New York.

In the absence of residential lighting programs, New York households are showing signs of backsliding, with increases in halogen and decreases in CFL saturation.

Massachusetts households have managed to avoid large growth in halogen saturation.

In Massachusetts, inefficient bulbs are rapidly losing ground to efficient bulbs.



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Executive Summary

Overview

The Massachusetts Residential Lighting Program and its predecessors have experienced numerous changes in the residential lighting market. The Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) consultants have made multiple updates to the program's delivery over the years in response to these market changes. Two of the most recent changes include providing incentives, and other program support for general service Light Emitting Diode (LEDs) bulbs and expanding program activity in retail channels and specific store locations thought to serve "hard-to-reach" (HTR) consumers. At the same time, the PAs continued providing substantial support for both standard spiral and specialty Compact Fluorescent Lamps (CFLs) in what could be called the more traditional lighting channels (e.g., home improvement and hardware stores).

This report summarizes results from the following three studies that explored market reactions to these program interventions.

- 2014 Market Assessment Study
- 2015 Market Assessment Study
- 2014 Saturation Stagnation Study

The objective of the 2014 and 2015 Market Assessment Studies was to continue ongoing monitoring of the Massachusetts lighting market for the PAs and the EEAC. (Note that the 2015 study was called "Lighting Consumer Survey" in milestone trackers, but served the same purpose as the 2014 Market Assessment.) The Saturation Stagnation Study explored the factors that drove energy-efficient socket saturation in Massachusetts and other states across the nation. It also examined what circumstances might have explained the apparent stagnation of saturation that occurred in Massachusetts and other some states from 2009 to 2013.

Together, the three studies characterized the overall residential lighting market, yielding critical information on two aspects of the market and the Program's intervention in it:

1. **Current Market for LEDs and CFLs**, including the effects of Energy Independence and Security Act (EISA) on lighting purchases, use, and storage, and
2. **Socket Saturation and Bulb Replacement**, including understanding long-term trends in saturation, why saturation may sometimes appear to "stall," and the degree to which consumers replace efficient bulbs with other efficient bulbs.

The team also explored elements of the market and program impact on Hard-to-reach (HTR) Customers. However, for reasons discussed more fully in the paper, the evaluation largely provided information only on saturation and purchase behavior of the subset of HTR customers that are low-income households. The PAs consider HTR to include households with limited income or education, who do not speak English, and who are ethnic minorities. As explained later in this report, the Team was able to secure

adequate participation among low-income households only, hence the focus on this subset of HTR customers. We acknowledge that this narrow focus on HTR customers provides a limited perspective of program and markets effects on all HTR customers.

Table 1 in the main body of the report describes the individual tasks completed across the three studies and includes links to all finalized task-specific reports.

Overall Assessment

All three studies confirm what evaluators have found in over 15 years of evaluation activities: the Massachusetts Residential Lighting Program and its predecessors have had a clear and dramatic impact on the residential lighting market. Over these 15 years, we have observed a continuous trend of positive program performance including:

- Increased LED penetration and saturation;
- Nearly ubiquitous CFL penetration and increased saturation, especially among low-income households;
- Increased LED market share, with Massachusetts' share being even higher than many other program states;
- Steady CFL market share, even after the introduction of general service halogen bulbs, due at least in part to Massachusetts' continued program support for CFLs; and
- Decreased average wattage per bulb for all bulbs between 2013 and 2015.

Still, while the program has had a clear impact on the market, the PAs must look to the future and consider the potentially evolving impact that LEDs and other lighting technologies, coupled with legislation that increases lighting efficiency standards, will have on the residential lighting market moving forward. In particular, the Energy Independence and Security Act (EISA) of 2007 impacts the availability of incandescents and the Energy Policy Act (EPAct) of 2005, as implemented through the General Service Fluorescent Lamp (GSFL) Rulemaking, affects linear fluorescent tubes, common in residences in Massachusetts. National sales data from the past few years show tremendous growth in halogen market share, suggesting that consumers gravitate toward lighting with a lower initial cost and that looks relatively familiar (these halogens look nearly identical to phased-out incandescent bulbs). Concurrently, recent increases in LED market share serve as a sign that many consumers look beyond short-term price to consider the long-term financial, environmental, and convenience benefits of a long-lived, efficient bulb. Consumers' price sensitivity and overall lighting knowledge (awareness of EISA as well as different bulb types and performance) will continue to play an important role in their adoption of efficient lighting. Future planning should consider the implications of these multiple factors, while remaining forward-looking and keeping pace with new developments in the market.

Key Findings and Recommendations

The key findings presented below provide the background to understand the Team's overall conclusions, recommendations, and considerations. These have been organized into three general topic areas:

- Current Market for LEDS and CFLs
- Socket Saturation and Bulb Replacement
- Hard-to-Reach Customers

Current Market for LEDs and CFLs

The PAs and EEAC consultants have been tracking numerous lighting market indicators for over 15 years through regular process and impact evaluations. Historically, the studies focused on the CFL market but recent assessments have incorporated indicators that track the LED market as general service LEDs become more widely available at lower prices, both with and without program support. The current assessments continue the practice of learning more about the LED market. However, the Team still tracks some of the most critical CFL indicators in order to show progress over time and inform current planning regarding whether the PAs should exit the standard CFLs market and what those exit strategies may look like. The possibility for exiting the market is driven by widespread adoption of CFLs as well as declining annual and lifetime savings per bulb, a result of the lighting efficiency standards set by EISA that are producing shifts in assumed delta Watts and measures lives, as discussed more fully below and in the main body of the report (See the section on Standard CFL Incentives: Lessons from California and New York).

Market for LEDs

Collectively, the evaluation activities make clear that the market for LEDs is strong and growing. More specifically, while LED market share (the percentage of bulbs sold), household penetration (the percentage of households using a particular bulb type), and socket saturation (the percentage of sockets filled with a particular bulb type) remain quite small, these indicators have been rising dramatically with each measurement taken. Some of the most important findings regarding LEDs include the following:

- Penetration of LEDs doubled between 2012 and 2013 and again between 2013 and 2014, ultimately increasing from 7% in 2012 to 33% in 2015, while the percentage of sockets filed with LEDs has grown 500% during the same time period (from 1% of sockets in 2012 to 6% in 2015).

- Respondents who reported using both LEDs and CFLs showed a clear inclination towards LEDs. Nearly one-half of Massachusetts consumer respondents (45%) indicated that they prefer LEDs over CFLs while just 10% said that they prefer CFLs over LEDs. Close to three out of ten consumers (29%) reported that their preference depends on the situation, and 16% stated that they were not yet sure of their preference.

- The POS data suggest that LED market share in Massachusetts has grown among the retailers included in the dataset (which excludes home improvement and hardware stores), from

effectively 0% in 2009 to just over roughly 1.65% in 2015, with most of that growth occurring between 2013 and 2014 (see Figure 1 in the main body of the report). While LED market share in other areas has also increased in areas with and without lighting programs, neither group of states had achieved even a 1.0% market share as of 2014. Thus, the Team believes that a combination of market trends and PA program activity have boosted the rate of LED purchases in Massachusetts compared to other areas.

- Lighting suppliers and most retail lighting managers held the opinion that LED bulb prices would continue to drop over the next few years, but that prices currently remain too high for most consumers. For this reason, they advocated continued market intervention by the PAs in the form of incentives (and some suggested higher incentives).

Market for CFLs

Similar to the current market for LEDs, the market for CFLs remains strong. However, the Team believes the future for this technology—and the need for continued program support for it—remains unclear. Evidence that creates this lack of clarity includes the following:

- Nearly all households in Massachusetts use at least one CFL (96%), a value that has held steady since 2012. The estimate for socket saturation increased from 28% in 2013 to 32% in 2015. Together with LEDs (discussed above) and fluorescent tubes (saturation of 9%), the total socket saturation for efficient bulbs stood at 47%. Moreover, incandescent saturation comprised fewer than 50% of sockets in 2015.

- CFL saturation rates in the comparison areas, Georgia and Eastern Kansas in 2014 and Upstate New York in 2015, make clear that the CFL market still varies from place to place, and program activity is not the sole predictor of high saturation. Yet, the New York data in 2015, coupled with POS data from California and New York through 2014, strongly suggest that removing standard CFL incentives will cause a decline in saturation and sales of that bulb type.

- The widespread adoption of more efficient lighting over the years has reduced the baseline, lowering the annual and lifetime savings. Consumers are now replacing efficient bulbs with other efficient bulbs as the first crop of these bulbs burns out or otherwise gets replaced. Instead of assuming that all consumers are replacing a 60W incandescent with a 13W CFL, many are now facing situations in which they are replacing a 43W halogen, 13W CFL, or 10W LED for another bulb in those lower wattage categories. At the same time, lighting efficiency standards increase again in 2020, further lowering the baseline. Moving forward the PAs can only claim a part of the seven-year measure life of CFLs (i.e., the number of years between purchase and 2020), which also lowers lifetime savings. Together these factors may strain the cost effectiveness of continued support for CFLs.

Impacts of EISA

- One of the most critical questions facing the Massachusetts lighting program—and similar programs across the nation—is how long they should support standard CFLs in the post-EISA period of reduced delta Watts and measure life assumptions.
    - Most manufacturers and high-level retailers argue that the PAs should keep incentives for standard CFLs in order to avoid consumer "backsliding" to halogens. These suppliers claimed that California lost CFL market share to halogen bulbs in 2013, when the state removed standard CFL incentives but also implemented EISA the 40W and 60W incandescent phase-out one year ahead of the rest of the nation.
    - The POS data support the suppliers' claims. Among reporting retailers, the California market share of CFLs decreased from 21% to 17% between 2012 and 2014 while halogen market share increased from about 6% to about 31%. At the same time, Massachusetts—which continued incentives—saw its CFL market share remain relatively steady and its halogen adoption increase from 4% to 24%.
- Most lighting store managers believed that EISA will increase sales of standard and A-line CFLs and LEDs and decrease sales of incandescents. They had mixed opinions about EISA's impact on sales of halogen bulbs.
- Evidence from the consumer survey suggests that a considerable proportion of Massachusetts consumers remain unaware of EISA. In 2015, 49% of all respondents (42% of phone respondents and 62% of web respondents), stated that they were aware of this legislation, and consumers' level of awareness has remained relatively unchanged since first asked in 2011.
- Although a large proportion of consumers are unaware of EISA and related limitations on incandescents, the Team found evidence of limited incandescent stockpiling among very few households. Furthermore, most of the households storing incandescents (whether a few or many) indicated that they did so to have bulbs on hand when others burned out, not as a reaction to EISA. This implies that such behavior may have been in place prior to EISA, although evaluators did not measure incandescent storage prior to 2012.

Socket Saturation and Bulb Replacement

The PAs and EEAC consultants asked the Team to attempt to explain a perplexing finding from the past few on-site saturation studies: Why had CFL socket saturation seemingly stalled between 2009 to 2013—increasing from only 26% to 28% during the period despite the fact that the program had sold millions of CFLs in that same period? Additionally, evaluation results from California suggested that that state had seen a dramatic increase in saturation over roughly the same time period (22% in 2009 to 30% in 2012). One of the purposes of the saturation study was to confirm whether stagnation had, in fact, occurred in Massachusetts, but an examination of the 90% confidence intervals for Massachusetts' saturation between 2009 and 2015 all overlapped (see Appendix B for the confidence intervals). This

suggests that stagnation may not actually have occurred, given the size of the margins of error in individual estimates. Yet, the stagnation in individual point estimates and the need to understand what drives saturation indicated that the issue was still worth exploring.

The Team explored trends in socket saturation in general and saturation stagnation specifically through an on-site saturation study—including first time visits to homes and visits to a panel of households that has previously taken part in on-site studies—and comparisons of saturation and program activity in California, Massachusetts, and New York. This overall report also draws on insights from a Connecticut lighting market assessment.[1] The Team offers the following insights into saturation trends and stagnation:

- California made a decision prior to 2009 to shift incentives from CFLs sold through big box stores (i.e., home improvement and mass merchandise) towards grocery, drug, and club/warehouse stores. This decision may have resulted in CFLs getting into sockets of households that do not regularly shop at big box retailers, hence boosting saturation.

- Adopting EISA on a one year accelerated schedule meant that households in California moved from incandescents to CFLs earlier than one would have observed in Massachusetts and other states. This implies that Massachusetts and other states would begin to "catch up" to California as EISA implementation continued in their states.

- Households taking part in the Massachusetts panel study tended to replace all types of bulbs with CFLs, which, in general, served to increase CFL socket saturation in Massachusetts in 2014. However, extrapolating from the behavior of the 111 panel households, 3.4 million CFLS actually replaced other CFLs that had burned out, and 1.2 million LEDs replaced burned out CFLs. These efficient to efficient socket replacements limit how quickly saturation increases, even as they prevent backsliding to less efficient bulb types.

Hard-to-Reach Customers

The evaluation activities were designed to assess the overall residential lighting market, and the Team, therefore, is limited in its ability to provide conclusive results about the program's impact on HTR customers. However, we can offer the following HTR-specific findings from this exploration:

- Socket saturation of CFLs stood at 42% in low-income households (n=102) compared to 28% for non-low-income households (n=222). Saturation of LEDs and fluorescent tubes stood at 3% and 8% respectively for both income groups. Prior evaluations in Massachusetts also found higher

[1] The Connecticut Energy Efficiency Fund offset the cost of the Georgia and Kansas data collection. NMR, Cadmus, and DNV GL. 2015. *R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall Report.* Available at: http://www.energizect.com/about/eeboard/evaluationreports.

rates of saturation among low-income households in comparison to others, driven primarily by the fact that such households tend to live in smaller home sizes with fewer sockets, which allows households to achieve greater saturation even with fewer numbers of bulbs installed.

- Although some suppliers note that consumers in all demographic groups predominantly shop for light bulbs at home improvement and mass merchandise stores, most suppliers generally agree that the PAs' strategy of targeting HTR efforts on retail channels (e.g., bargain stores, thrift shops) and individual store locations (e.g., ethic groceries) represents the best approach to increasing efficient bulb adoption among this customer group.

Recommendations and Considerations

Collectively, the results point to the following recommendations and considerations.

Market for LEDs

- ***Recommendation 1***: The PAs should continue to provide incentives and educate consumers about LEDs in the next program cycle. At the same time, however, the PAs will have to pay careful attention to any new information available from future evaluations or other sources regarding delta Watts, measure life, price trends, and incremental costs and be ready to shift LED strategy if providing incentives ceases to be cost effective.

- ***Consideration 1****:* (From Task 3: On-site Saturation Visits) LEDs, unlike CFLs, are predominantly sold in single-bulb packages. The PAs should consider revisions to program design to encourage the purchase of multiple LEDs in one shopping trip. While there is certainly a role for single-bulb incentives, multi-bulb incentives may leverage recent increases in penetration by pushing consumers toward buying multiple LEDs in one trip.

- ***Consideration 2*****:** (From Task 3: On-site Saturation Visits) The PAs should consider commissioning a study to assess the direct connection between program activity (such as marketing and incentives) and increased awareness and adoption of LEDs.

- ***Consideration 3***: The PAs may want to shift incentives for specialty applications—particularly dimmable ones—from CFLs to LEDs, as most consumers hold that LEDs dim better than CFLs and have a superior light quality. In addition, the PAs may want to consider increasing promotions of controls that work with low-wattage bulbs in order to improve dimmability even for LEDs. The Team offers this as a consideration rather than a recommendation because it believes the jury is still out on whether LEDs truly dim better and have superior light quality than CFLs. Additional research (of the literature and product testing review type) may be needed before the PAs take action.

Market for CFLs

- ***Consideration 4:*** Based on the current state of the market, it is clear there is still a role for standard CFLs. To this end, the PAs should continue to support standard CFLs. At the same time,

the PAs should carefully monitor the market and consider adjusting course as needed. Any changes in program support for CFLs should be well coordinated with adjustments to program support for LEDs.

Consumer Shift to Energy-efficient Bulbs—the Good and the Bad

- ***Recommendation 2:*** (From Task 3: On-site Saturation Visits) The PAs and EEAC consultants should continue to fund regular on-site saturation studies—including the continued *annual* panel study—at least through the early 2020s in order to track the impact of EISA, changes in LED pricing and availability, and *possible* changes in whether and to what extent the program should incentivize standard and specialty CFLs and LEDs. Additionally, the PAs should work with the Team to develop a methodology for identifying the diameter and length of fluorescent tubes in use in homes as these bulbs are subject to increased efficiency standards through the Energy Policy Act (EPAct) of 2005, as implemented through the DOE General Service Fluorescent Lamp (GSFL) Rulemaking. Recognizing the expense of these efforts, the timing and depth of the *new on-site visits* could potentially deviate from those performed annually by the Team since 2009, but the Team stresses that annual visits are ideal for a panel study (or panelists lose interest, move, or otherwise become unavailable, resulting in more of them dropping out of the study) and ideal for new on-sites (especially as replacement panelists come from new on-site visits).

- ***Consideration 5:*** (From Task 3: On-site Saturation Visits) The PAs may want to consider a bulb buy-back program to persuade people to change out inefficient bulbs before they burn out and fill them with CFLs or LEDs. The high rate of incandescent-to-CFL and -LED conversion found in the panel study indicates that consumers are already inclined to replace incandescents with CFLs or LEDs still, the majority of bulbs are only replaced upon failure. The execution of such a program would require careful planning, but a presentation at the Northeast Energy Efficiency Partnership's Lighting Summit in October 2014 discussed the success of a similar program in Connecticut.

- ***Consideration 6:*** Given that the DOE's GSFL Rulemaking increases efficiency standards for fluorescent tubes and ballasts and because such bulbs and associated fixtures are commonplace among residential homes, the Team believes the PAs should consider program designs that help consumers identify the best way to replace T12 lamps, ballasts, and/or fixtures.

Hard-to-reach Customers

- ***Consideration 7:*** (From Task 3: On-site Saturation Visits) The PAs may wish to consider directly studying use and purchase behavior among HTR households. This would then inform the discussion of whether the current upstream model or a revised or different program design would be best able to achieve remaining potential in such households and increase their adoption of LEDs. To provide information on a wider range of households that are considered HTR, the study should be designed specifically to capture underrepresented households, likely

working with organizations, community groups, and recognized community leaders to spark interest and gain trust in the study.

Introduction

The Massachusetts Residential Lighting Program (and its predecessors) has undergone three fundamental shifts since its inception in the late 1990s. The first shift reflected the 2003 decision by the Massachusetts Program Administrators (PAs) to move from a coupon- and catalog-based program to an upstream buydown / markdown model.[2] This change led to enormous increases in the number of compact fluorescent lamps (CFLs) purchased and installed in Massachusetts households. The second shift came in the late 2000s. The passage of the Energy Independence and Security Act (EISA) of 2007 coupled with evaluation results pointing to declining program influence on the adoption of standard CFLs led the PAs to refocus the upstream program in three ways: 1) they reduced—but did not eliminate—their support of standard CFLs, particularly in lighting destination stores such as home-improvement and hardware stores; 2) they increased incentives for specialty bulbs overall; and 3) they expanded support for standard CFLs sold through channels that predominantly served customers with limited incomes, limited education, or who were non-English speaking. The third shift, currently underway, is increased program support of omnidirectional, screw-in light emitting diodes (LEDs) meant to replace general service incandescent bulbs.[3] While LED bulbs have been available for quite some time—including in reflector and flood designs—only in the past few years have they become readily available in the A-line shape most consumers associate with a light bulb. This means that LEDs are an alternative not only to incandescent bulbs but also to the general service incandescent halogen (which hit the market in large numbers about the same time as general service LEDs) and to standard and A-line CFLs as well.

The research summarized in this report reflects the efforts of the PAs and the Energy Efficiency Advisory Council (EEAC) consultants to assess the impact of all of these changes on the current Massachusetts lighting market and to forecast future market conditions when possible. Additionally, the research explored the factors that drive socket saturation—the percentage of sockets filled with a particular bulb type—largely in response to previous study results suggesting that CFL saturation had stagnated in Massachusetts between 2009 and 2013 despite the sale of millions of program bulbs during the same period.[4] NMR Group, Inc., a member of the Cadmus-led Massachusetts Residential Research Area evaluation team (the Team), oversaw the research but all Team members—Cadmus, Navigant, DNV GL, and Tetra Tech—made significant contributions to the research efforts, as described in more detail below.

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2 The 2006 market progress report contains a useful summary of the history of the ENERGY STAR® lighting program from the late 1990s through 2006. NMR, RLW, Shel Feldman, and Dorothy Conant. 2007. *Market Progress and Evaluation Report (MPER) for the 2006 Massachusetts ENERGY STAR® Lighting Program.* Final delivered to the PAs and EEAC consultants on July 11.

3 To ease discussion, we will refer to these bulbs as "general service" LEDs.

4 NMR. 2013. *Results of the Massachusetts Onsite Lighting Inventory*. Final delivered to the PAs and EEAC consultants on June 7. Available at http://ma-eeac.org/wordpress/wp-content/uploads/Onsite-Lighting-Inventory-Results-Final-Report-6.7.13.pdf.

Study Objectives

This report summarizes three studies: the lighting market assessment studies conducted in 2014 and 2015 and the saturation stagnation study conducted in 2014.

The objective of the market assessment study was to continue ongoing monitoring of the Massachusetts lighting market for the PAs and the EEAC.

The *original* objectives of the saturation stagnation study were as follows:

- To explore reasons for the current plateau CFL saturation in Massachusetts;
- To determine ways to accelerate LED adoption; and
- To inform our understanding of the degree to which the program has prevented backsliding of saturation by leading consumers to replace CFLs with other CFLs or LEDs.

Meanwhile, early results from the on-site saturation study suggested that Massachusetts had overcome its CFL saturation plateau between Spring 2013 and Summer 2014, with the saturation estimate increasing from 28% to 33%. Therefore, while the study still retained some elements of the original three objectives, it became more focused on understanding the factors that drove energy-efficient socket saturation not only in Massachusetts but nationally as well, including addressing why the plateau occurred and why it came to an end.

Research Questions

Given the increase in saturation observed in Massachusetts, the research questions addressed by the three studies effectively merged. Collectively, the studies investigated the following research questions in varying levels of detail:[5]

- What are the programmatic, demographic, market, and regulatory drivers of energy-efficient bulb saturation in Massachusetts and beyond?
- What are the types of bulbs consumers use to replace those removed from service, focusing on the replacement of incandescent and CFL bulbs?
- Which consumers use LEDs and what is the role these bulbs play in establishing current rates of LED saturation?
- What is the impact of targeting a large subset of program bulbs to hard-to-reach (HTR) customers?
- What is the current and developing state of the market, especially as it relates to EISA, including CFL/LED saturation and sales/market share, availability and pricing of efficient lighting, and supplier and consumer attitudes and expectations?

[5] These questions differ somewhat from those included in the original work plans. The deviations reflect the apparent end to saturation stagnation and evolving priorities over the course of the evaluation.

This overall report addresses each of these research questions but focuses especially on trends related to energy-efficient socket saturation (including bulb replacement), LEDs, and elements of the HTR program focus (assessing bulb purchases and saturation among low-income households).[6] The report highlights these three topics as reviewers of individual task reports requested that the Team pay special attention to them.

Study Overview: Completed Research Tasks

The Team completed eight research tasks (three of these tasks in 2014 were repeated in 2015) designed to inform our understanding of the residential lighting market and to explore saturation stagnation. Table 1 describes these tasks, including the roles of the various Team members, while Appendix A: Summary of Tasks provides more information on each study. The current report synthesizes the results of the individual tasks into one integrated, holistic document; as such, we do not address study design, methodologies, or even some results in detail, but instead direct the reader to the individual reports (linked in Table 1) for such details.[7]

[6] The Team defined low-income households based on likely eligibility for the Low Income Heating Energy Assistance Program (LIHEAP) in the Winter of 2013-2014.

[7] For example, readers should consult the final report for *Market Assessment Task 2: Consumer Survey* to locate results by survey completion model (i.e., web and phone), unless otherwise noted. Discussing the rationale behind the mixed mode design as well as the methodology and the majority of results by group go beyond the scope of this overall report.

Table 1. Summary of Market Assessment and Saturation Research Tasks

Research Task	Description	Sample Sizes	Report Link	Team Role				
				Cadmus	NMR	Navigant	Tetra Tech	DNV GL
Primarily Market Assessment Studies								
Identify Compar-ison Areas	Team worked with PAs and EEAC consultants to ID areas to serve as comparisons to MA	N/A	N/A	Share program info from other areas	Lead	Share program info from other areas	Share program info from other areas	Share program info from other areas
Consumer Surveys	Web and phone survey designed to learn more about awareness and understanding of lighting technologies and issues; condensed version of the survey delivered in comparison areas	2014 MA n = 940 GA n = 526 KS n = 556 2015 MA n = 778 NY n = 398	2014 http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Lighting-Consumer-Survery-Final-Report.pdf	Quality control	Lead, data analysis	N/A	Data collection	N/A

Research Task	Description	Sample Sizes	Report Link	Team Role				
				Cadmus	NMR	Navigant	Tetra Tech	DNV GL
On-site Saturation Visits, including Panel Study	Visits to consumers' homes to determine lighting use, purchase, and storage behavior focusing on saturation; panel study revisited homes that took part in prior saturation studies in order to explore saturation stagnation and bulb replacement	2014 MA new visits = 150 MA panel visits = 111 GA = 78 KS = 67 2015 MA new visits = 151 MA panel visits = 203 NY = 101	2014 http://ma-eeac.org/wordpress/wp-content/uploads/On-Site-Lighting-Inventory-Final-Results.pdf	Quality control in analysis and reporting	Lead, data analysis, visits in MA/ GA, QC in KS	KS site visits	N/A	N/A
Supplier Interviews	Understand program partner assessments of trends in the residential lighting market and the role of the MA program in promoting bulb sales.	Manufacturers = 17 Buyers = 5 Store managers = 224	http://ma-eeac.org/wordpress/wp-content/uploads/Supplier-Retailer-Perspectives-on-Residential-Lighting-Market-Summary-of-Year-2014-Interviews-Final-Report-.pdf	Quality Control	Quality Control	N/A	Telephone surveys with store managers	Lead; in-depth interviews
Shelf-stocking Study	Determine the amount of shelf space devoted to bulbs of different types and the pricing of those bulbs	MA current participant = 100 MA former participants = 30	http://ma-eeac.org/wordpress/wp-content/uploads/Residential-Lighting-Shelf-Survey-Pricing-Analysis-Final-Report1.pdf	Lead	Quality Control	N/A	N/A	Data collection

Research Task	Description	Sample Sizes	Report Link	Team Role				
				Cadmus	NMR	Navigant	Tetra Tech	DNV GL
Market Adoption Models	Spreadsheet tools (multiple versions developed in 2014 and 2015 serving different purposes) drawing on information from other evaluation tasks used to inform program savings and planning	N/A		Review	Lead	N/A	N/A	N/A
Primarily Saturation Trend Studies								
Saturation Trend Compar-ison in CA, MA, NY	Compared trends in saturation in MA, CA, and NY and programmatic and other differences that may explain trends Involved interviews and a literature review.	CA Program Staff = 11 CPUC Staff = 3 CA Evaluators = 3	http://ma-eeac.org/wordpress/wp-content/uploads/Efficient-Bulb-Saturation-Comparison-of-Massachusetts-California-and-New-York-Final-Report1.pdf	Quality Control	Lead	N/A	N/A	Facilitate data collection, coordina-tion in CA

Research Task	Description	Sample Sizes	Report Link	Team Role				
				Cadmus	NMR	Navigant	Tetra Tech	DNV GL
Point-of-sale Data Analysis**	Statistical modeling*** of point-of-sale (POS) data for select retail channels from 44 states in order to understand role of program and other factors on energy-efficient bulb market share	n = 44 states		Quality control; assist data collection ****	Lead	N/A	N/A	N/A

* The Team conducted supplier interviews in 2015 but they supported the forthcoming Net-to-Gross Overall Report and Incremental Cost Studies, not the Lighting Market Assessment or Saturation Stagnation Studies.

** The information contained herein is based in part on data reported by IRI through its Advantage service for, and as interpreted solely by LightTracker Inc. Any opinions expressed herein reflect the judgment of LightTracker Inc. and are subject to change. IRI disclaims liability of any kind arising from the use of this information.

*** The statistical modeling component of this study yielded net-to-gross (NTG) estimates for CFLs and LEDs. The Team presents the model results and NTG estimates under separate cover and focuses here only on the descriptive trend analysis that informed the model development.

*** Apex, which coordinated the purchase of the POS data, also assisted with data collection for program variables

Current Market for LEDs and CFLs

The Massachusetts PAs and EEAC consultants have tracked various lighting market indicators since at least 1998. Although this chapter updates some of the indicators, many of them focused on elements of the CFL market that are no longer as critical given the relative maturity of the technology. Instead, the 2014 Market Assessment study shifted the focus toward the LED market, while still addressing critical indicators of the CFL market. Access to the LightTracker sales data (POS data) also expanded the options available to the Team for assessing the CFL and LED market in Massachusetts and beyond. Previous evaluations have struggled to describe market share as the sole estimates available were limited to program-supported sales only or came from customer or supplier self-reports, each of which suffers from measurement bias (e.g., recollection error or even intentional gaming of the estimates).[8] While the LightTracker data are not perfect—critically, they lack any estimates from the home improvement and hardware channels that have historically served as the base of the Massachusetts residential lighting programs—the dataset contains market-level sales for the reporting retail channels comprising both program and non-program sales for CFLs and LEDs as well as halogen and incandescent bulbs. As such, they have provided the Team with the ability to assess trends in market share for bulbs in Massachusetts and other areas across the nation.

One final note about the contents of this chapter: socket saturation and bulb replacement trends certainly play a key role in a full market assessment. However, because the PAs and EEAC consultants asked the Team to explore these two topics in-depth in 2014, we discuss them separately in the Socket Saturation and Bulb Replacement chapter below.

Market Shares for LEDs and CFLs

Evaluations of energy-efficient lighting programs face a persistent challenge in describing the market share of energy-efficient bulbs because of the inability to obtain reliable and accurate market-level sales data. The LightTracker initiative was formed in an attempt to pool the resources of various parties and work with a third-party source to compile a dataset of market-level light bulb sales data. This dataset, purchased by the Massachusetts PAs, contains sales information for participating retailers in certain retail channels from 2009 to 2014, with data aggregated at the state level for 44 of the states in the nation. The two most critical shortcomings of the POS data are that 1) it contains no data for the home improvement or hardware sectors, which still account for approximately 50% of program-supported sales in Massachusetts, and 2) the aggregated data limit the level of granularity of analysis and reporting (e.g., data on CFL sales and prices group specialty and standard models together). Despite these

[8] The LightTracker data contain estimates of overall sales for each of the 44 states in the dataset. However, because only some retailers report sales to IRI (the third-party data compiler), the Team has elected not to report the sales data due to state and regional variations in the concentration of reporting and non-reporting retailers across the nation. Similarly, the Consortium for Retail Energy Efficiency Data (CREED) has reported concerns about the reliability of the bulb price data, so the Team does not report prices in this report.

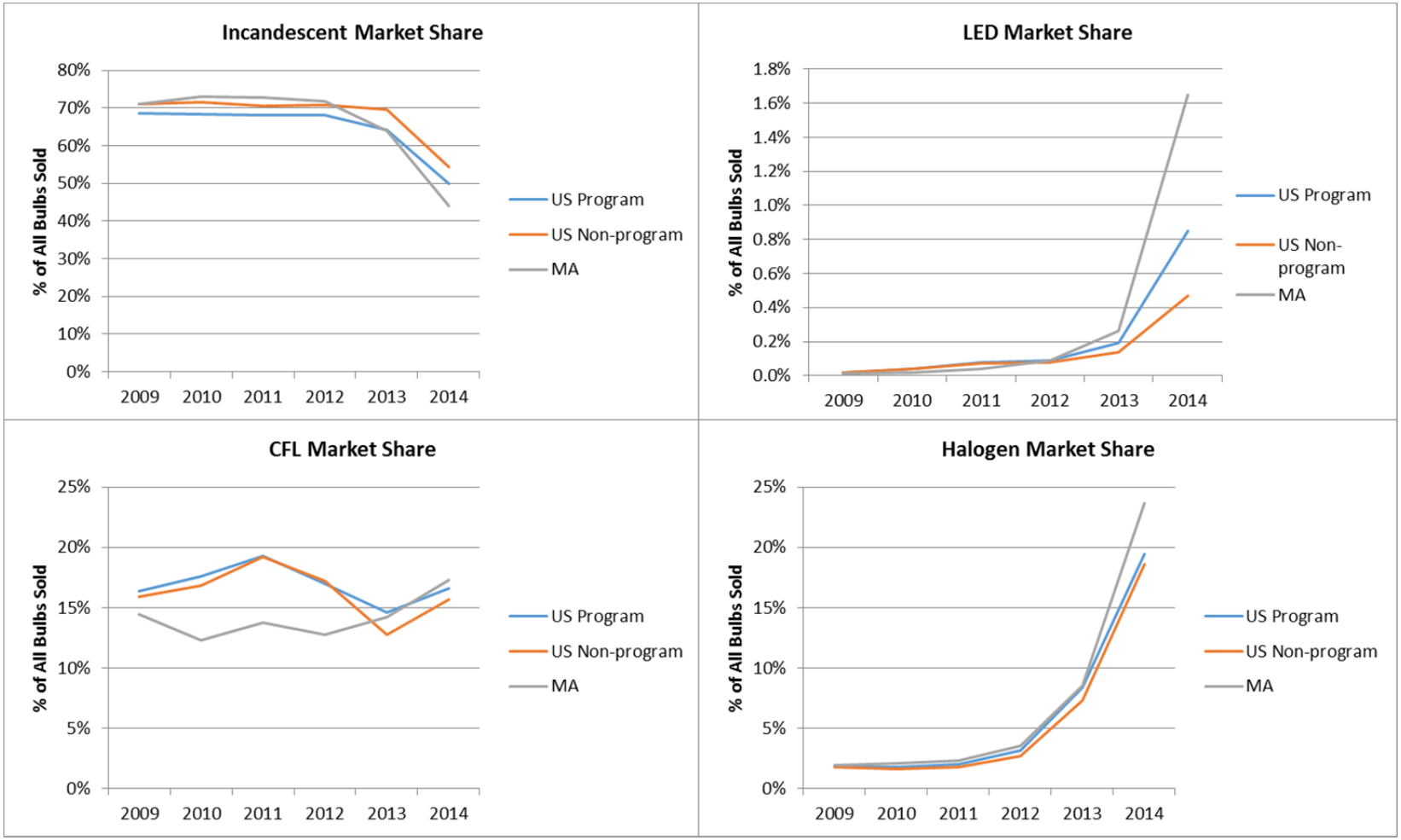
shortcomings, LightTracker likely represents the best opportunity available to understand the lighting market in Massachusetts in relation to the rest of the nation.

Figure 1 contains graphs of the market shares of incandescent, halogen, CFL, and LED bulbs from 2009 to 2014 for Massachusetts and for all program states (n=41) and non-program states (n=3) in the dataset. We recognize the potential pitfalls of relying on a non-program area trend that includes just three states, but we also felt that the trend lines demonstrated some critical differences from Massachusetts and program states that may be useful in understanding market share. With that said, of course the Team urges caution from drawing too strong a conclusion from the three non-program states.

One of the most critical findings from the graphs is the degree to which Massachusetts households have adopted LEDs more readily than in other states, both program and non-program. Certainly, LED market share remains very small but its rapid expansion suggests that the technology is "taking off," to use the language of the product adoption researchers. A second critical finding at first glance appears to be a negative one: that the CFL market share in Massachusetts is slightly lower throughout much of the period than in both other program and states. However, the Team believes that this is because Massachusetts households adopted CFLs—many of which are still installed—prior to 2009, while the other states are in the process of catching up with Massachusetts. Moreover, this finding for CFLs and the currently higher rate of LED adoption suggests that the Massachusetts PAs and EEAC consultants should expect the same trend to show up for LEDs in a few years when the rest of the nation will once again have to catch up with Massachusetts. Regarding market share of halogen bulbs, Massachusetts mirrors other program states, but non-program states have *lower* rates of halogen bulb adoption, mainly because they have higher incandescent market share than both Massachusetts and some other program areas.

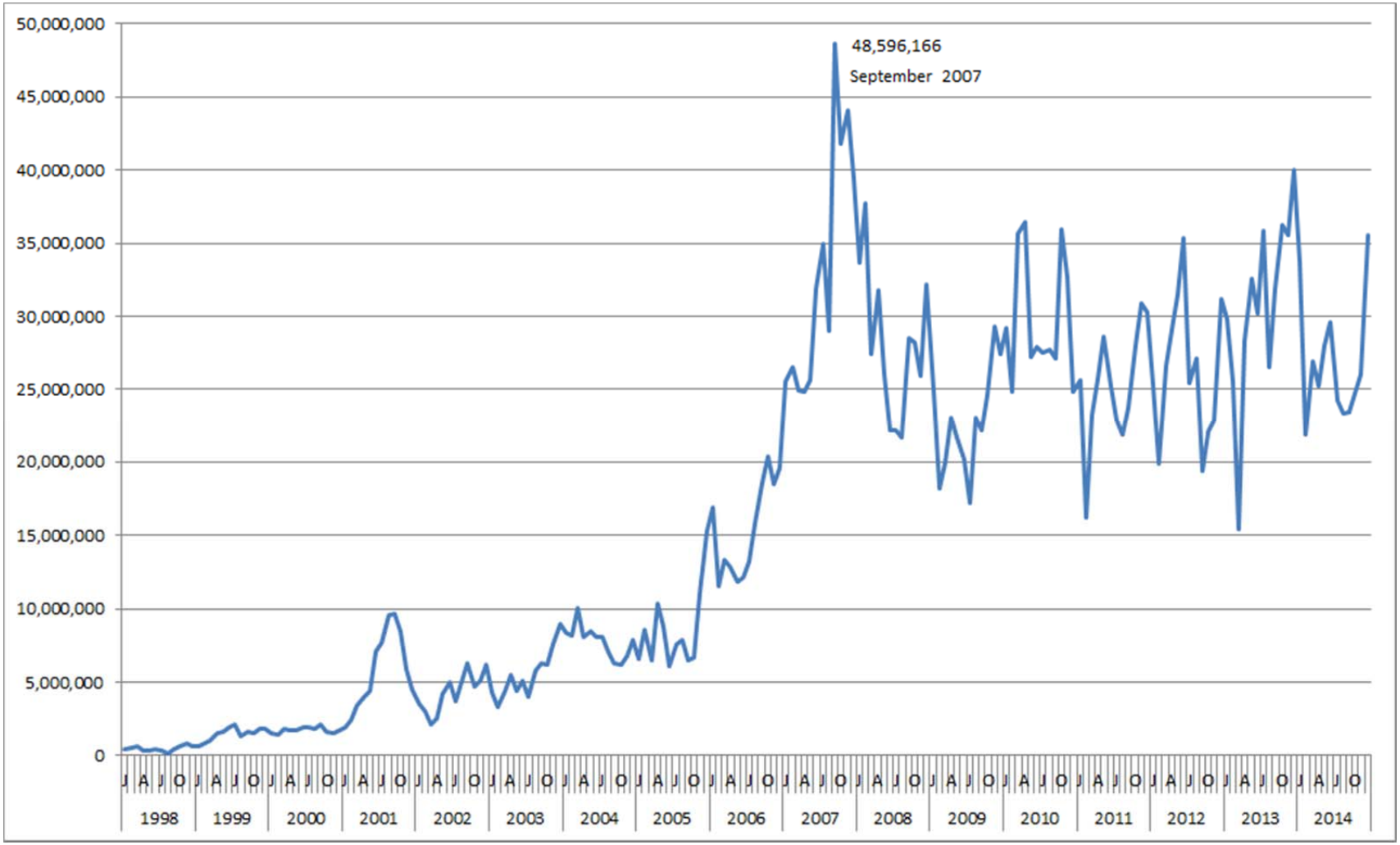
The Department of Commerce (DOC) shipment data presented in Figure 2 serve as another proxy of CFL sales. (The DOC has not yet specified a category solely for screw-base LEDs.) Because nearly all CFLs are manufactured overseas, shipment data provide some indication of sales, although admittedly some of these bulbs could still be sitting in warehouses or store shelves. The shipment data show a strong increase in adoption through September 2007 (the year Walmart held its CFL campaign), followed by a drop during the recession of the late 2000s. Since 2010, however, shipments have remained relatively stable over the years, with just a slight trending upward even after the start of nationwide EISA implementation in 2012, suggesting, as we discuss later, that the CFL bulb has not immediately become the *de facto* "baseline bulb" post EISA. Continued examinations of DOC shipment data and market share data will likely make clear if this supplanting of incandescents with CFLs will ever take place—or if consumers will bypass CFLs in favor of halogens and LEDs.

Figure 1. Massachusetts Consumers Adopting LEDs at a Faster Rate than the Rest of the Nation*



* Source: LightTracker data and Team investigation into program activity 2009 to 2013. Of the 44 states in the data analysis, only three lacked any program activity for 2009 to 2013.

Figure 2. US Department of Commerce Monthly CFL Shipment Data – 1998 to 2014

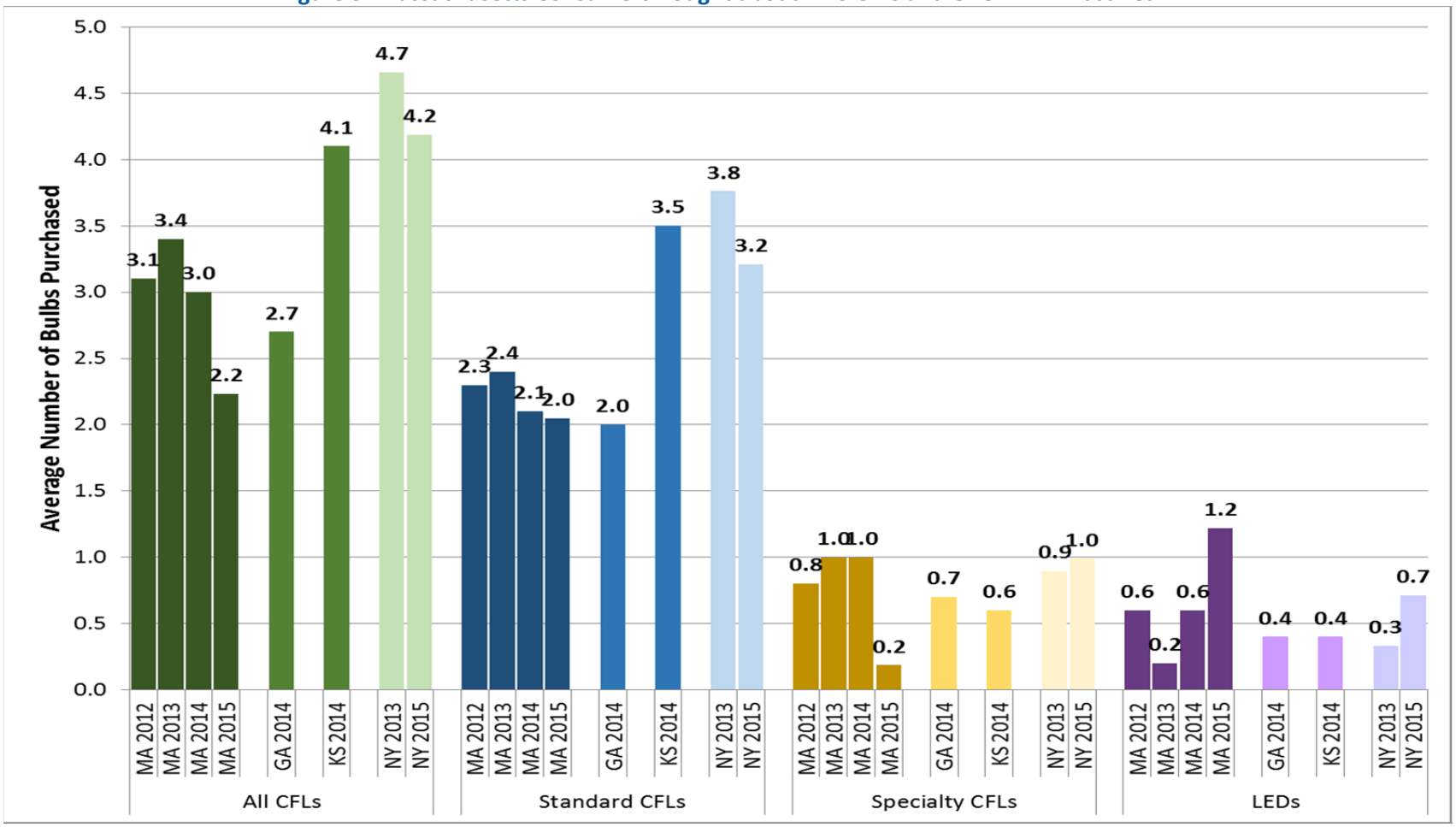


On-site Reported Purchases of LEDs and CFLs

During the 2014 and 2015 on-site visits, homeowners were asked when they had obtained the LED and CFL bulbs that were installed or stored in their homes. Using these results along with findings from previous years, we observed an overall increase in LED purchases and a decrease in CFL purchases. In early 2015, reported purchases of LEDs "in the past year" in Massachusetts stood at 1.2 per household, up from 0.6 in early 2014 (Figure 3). Massachusetts homeowners reported higher purchases of LEDs than the comparison areas, as shown in Figure 3 below.[9] Average annual CFL purchases in Massachusetts decreased from 3.0 in early 2014 to 2.2 in early 2015. In 2014, Massachusetts homeowners' average CFL purchases were lower than those in Kansas and slightly higher than Georgia. In both 2013 and 2015, New York households reported buying more CFLs than Massachusetts households, which may indicate some "catching up" to Massachusetts. Figure 3 below shows the average number of bulbs per household in Massachusetts and the three comparisons areas.

[9] The Team discusses the selection of the comparison areas in the sub-section Saturation in Comparison Areas.

Figure 3. Massachusetts Consumers Bought about Two CFLs and One LED in Past Year*



Base: All on-site respondents by state and year.

* 2014 estimates for all three states are exclusive of direct install bulbs. The number of bulbs obtained through direct install programs prior to 2014 were minimal.

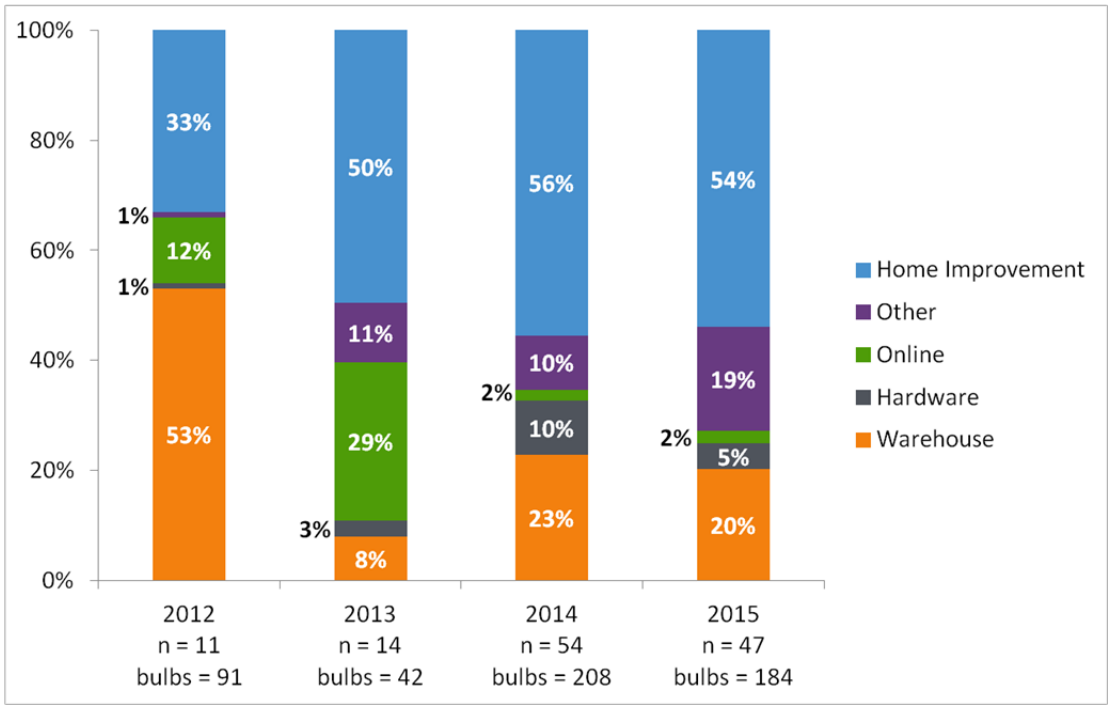
Where On-site Households Obtained CFLs and LEDs

Not only did the Team ask respondents when they had bought CFLs and LEDs found in their homes, we also asked them to recall where they had obtained the bulbs. In 2014 and 2015, the PAs' direct install programs served as one of the most commonly named sources of energy-efficient bulbs obtained in the prior year. For example, in 2015, the PA's direct install programs provided 27% of the CFLs and LEDs obtained in the past year; this was the second most commonly named source, behind home improvement stores (33% for combined CFLs and LEDs). This finding occurred despite the fact that only 10 of the 151 new homes visited in 2015 homes took part in such a program. These 10 respondents accounted for 30% of the LEDs obtained from all on-site households in the past year and 25% of the CFLs obtained. Results were similar for 2014, as outlined in the task specific on-site saturation report.[10] The Team believes this reflects the Home Energy Solutions practice of replacing every socket in the home with an energy-efficient bulb.

Looking solely at bulbs obtained from retail stores, home improvement stores (e.g., Home Depot or Lowe's) accounted for more than one-half (54%) of the LEDs on-site respondents reported buying in the past year (Figure 4 on the next page); this coincides with the percentage of program LEDs sold through this channel in 2013 and 2014. Another 20% of LEDs came from warehouse stores, and 19% from miscellaneous "other" stores (e.g., mass merchandise, bargain, grocery). In 2015, purchased CFLs (41%) came from home improvement stores, yet this represented a declining percentage over time (Figure 5 on the next page). In contrast, the past three years have generally seen an increase in the percentage of CFLs obtained through the "other" category, which for CFLs (the list differs between CFLs and LEDs due to sample sizes) includes bargain stores (e.g., Ocean State Job Lot, thrift stores), grocery stores, and lighting and home furnishing stores (among a handful of others). Importantly, the PAs have been supporting an increasing number of energy-efficient bulbs in bargain stores and grocery stores in an effort to increase purchases among hard-to-reach customers (discussed later in the report)—and the increased purchase rates from these stores over the past few years suggest the strategy is working to some extent. The reported purchases at mass merchandise stores (e.g., Walmart, Target, and K-mart) has fluctuated over the past three years.

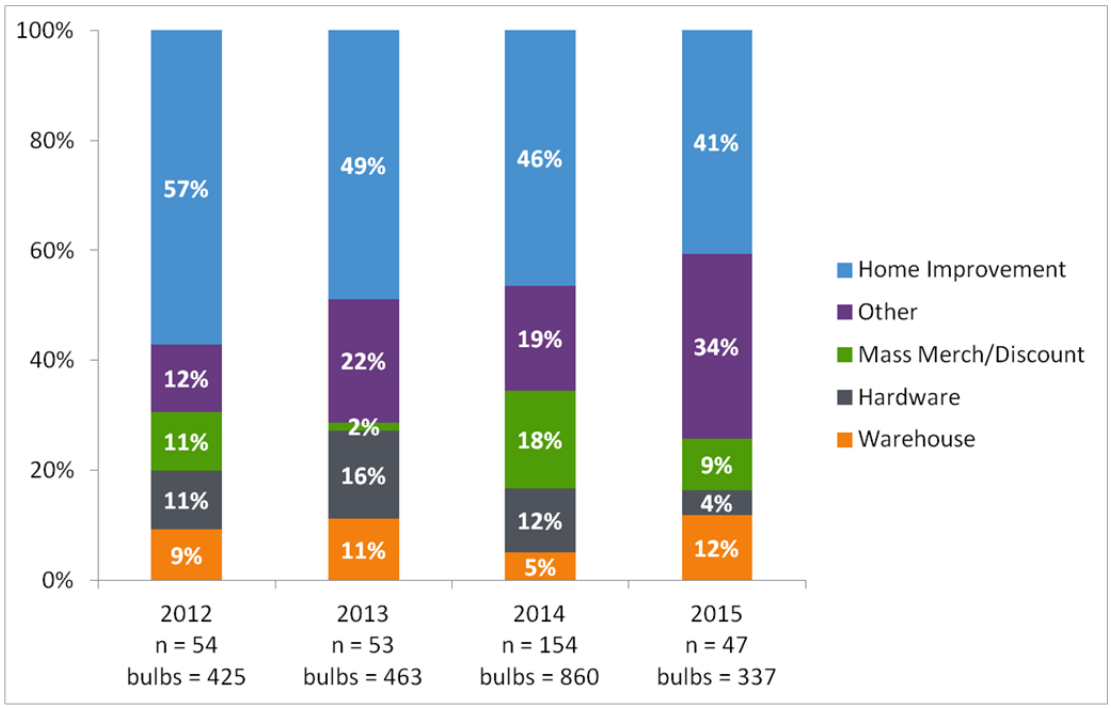
[10] NMR, Cadmus, and Navigant. 2015. *Lighting Market Assessment Residential Lighting On-Site Lighting Inventory Findings* Available at: http://ma-eeac.org/wordpress/wp-content/uploads/On-Site-Lighting-Inventory-Final-Results.pdf :

Figure 4. Home Improvement Remains the Most Common Place to Buy LEDs



Base: LEDs purchased in the past year; for 2015, only newly visited homes were included.

Figure 5. Home Improvement Stores Losing CFL Market Share to Mass Merchandise/Other Stores



Base: CFLs purchased in the past year; for 2015, only newly visited homes were included.

Suppliers' Perspectives on the LED Market

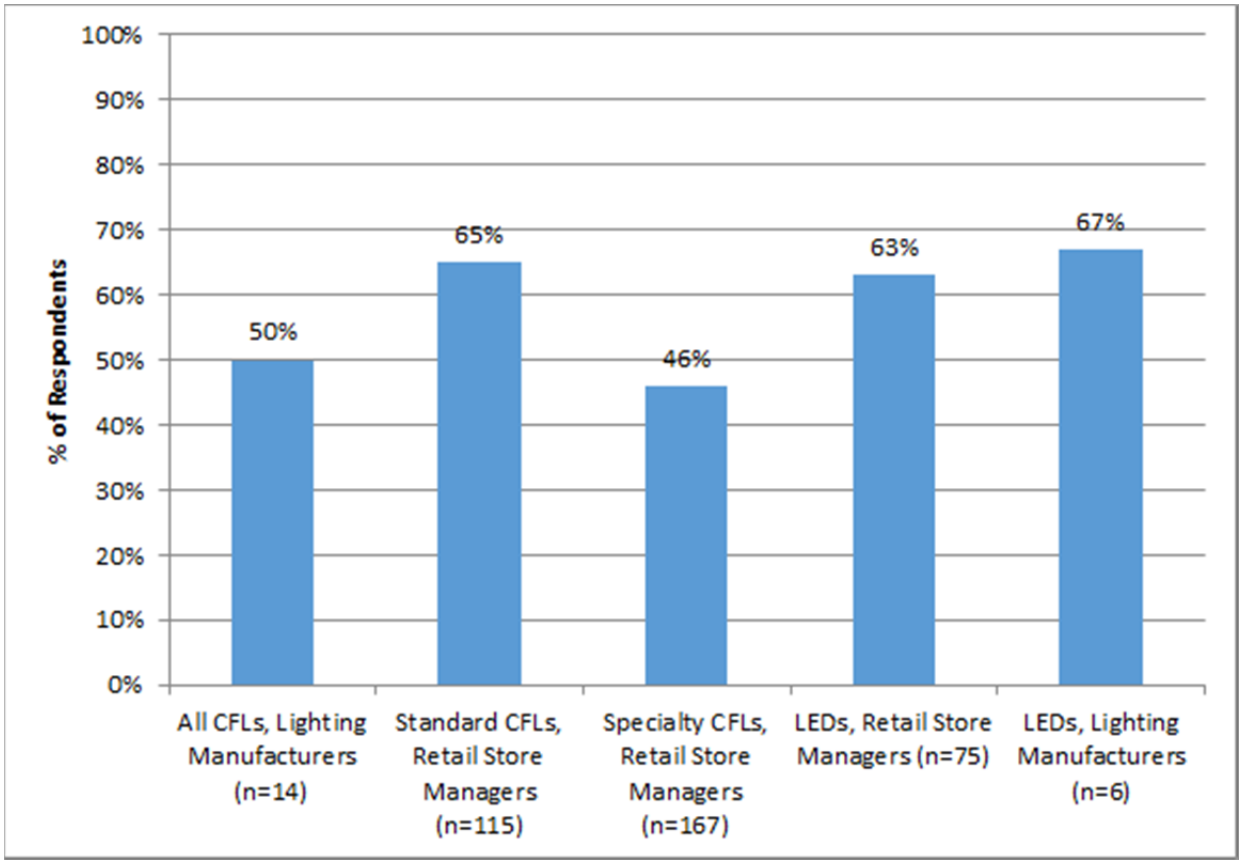
The interviews with lighting manufacturers and high-level retail buyers examined various aspects of the current LED market, including market actors' sales prior to involvement with the ENERGY STAR Lighting program, barriers preventing LED bulb and fixture sales, future LED pricing trends, and suggestions for increasing LED bulb sales.

Many of the market actors interviewed for this effort indicated that their businesses were already selling LED bulbs before becoming involved with the Massachusetts program (88% of manufacturers and 50% of retail buyers). Roughly one-half of the retail managers (53%) reported selling LEDs prior to 2013.

Market actors were asked their opinions about future LED pricing trends. Lighting manufacturers and retail buyers discussed pricing trends over the next few years while store managers speculated about trends for LED bulbs and fixtures in 2015. All of the manufacturers and the majority of retail buyers indicated that pricing for LED lighting products would decrease overall in the next few years. Although the majority of store managers (58%) indicated that they felt that prices for LED bulbs would decrease in 2015, only about a one-third (31%) thought that prices for LED fixtures would decrease.

In addition to responding to general questions about the LED market, market actors shared their perspectives on the program's influence on CFL and LED lighting sales. These respondents generally indicated that they believed that the Massachusetts lighting program positively affected LED and CFL sales. Although sample sizes of manufacturers were small, four of the six who sold LEDs in Massachusetts said the program had influenced them to do so, as did seven of the 14 who sold CFLs. Just under two-thirds of retail store managers selling CFLs and LEDs said the program had a role in that decision. Somewhat unexpectedly, however, only 46% of retail store managers said that PA programs had influenced their decision to sell specialty CFLs.

Figure 6. Massachusetts Program Induces Many Stores to Sell Energy-Efficient Bulbs



Base: Suppliers selling each bulb type

Effects of EISA on Bulb Sales and Consumer Behavior

The year 2014 was an important one for EISA.[11] The phase-out reached its zenith in January when the most common bulb in use in the United States, the 60W incandescent (along with the less common 40W bulb), became subject to EISA lighting efficient standards. Despite this fact, evidence from the consumer survey suggests that a considerable proportion of Massachusetts consumers remain unaware of EISA. In 2015, 49% of all respondents (42% of phone respondents and 62% of web respondents), stated that they were aware of this legislation, and consumers' level of awareness has remained relatively unchanged since first asked in 2011.

[11] The Energy Policy Act (EPAct) of 2005, as implemented through the Department of Energy's (DOE) General Service Fluorescent Lamp (GSFL) Rulemaking, also increased efficiency standards for some T5, T8, and T12 fluorescent tubes that are commonly used in residential settings. The Team did not uncover much evidence about the impact of this legislation as on-site protocols did not include determining the diameter or length of the fluorescent tubes. We do present saturation estimates for this bulb type in general and address it in the Conclusions and Recommendations Section.

Lighting program administrators and regulators across the nation hold differing assumptions about the effect of increased lighting efficiency standards resulting from EISA on bulb sales. Some programs—notably those run by the investor-owned utilities in California (in 2013) and the New York State Energy Research Development Authority (NYSERDA, in 2012)—dropped incentives for standard CFLs, assuming EISA would force these bulbs to be the new baseline. In contrast, Massachusetts and some other programs have continued to support incentives for standard CFLs based on the assumption that some incandescent bulbs remain on shelves and CFLs face stiff competition from halogen bulbs, which also could lay claim to being the new baseline bulb.

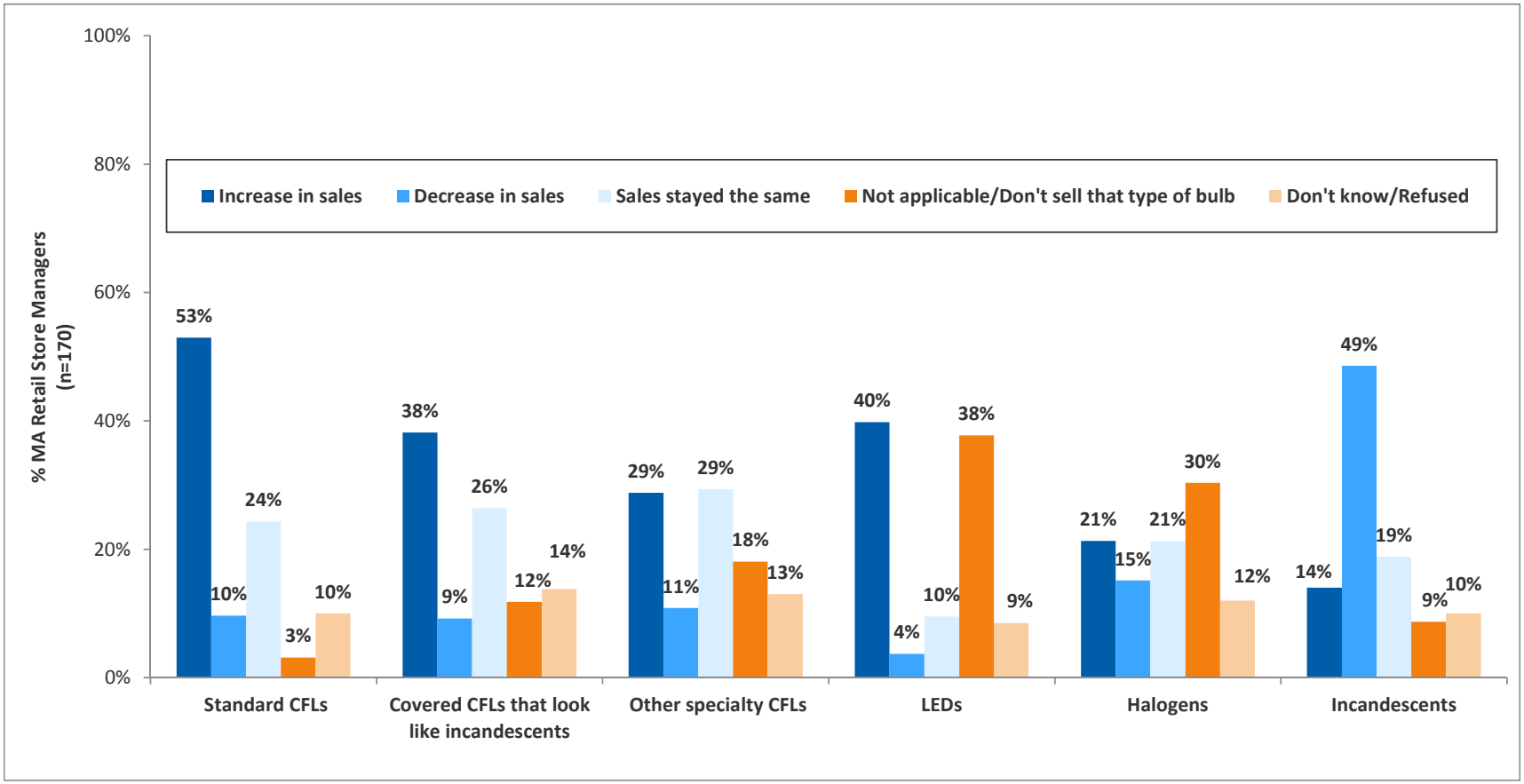
This section addresses EISA impacts using a variety of sources, namely supplier interviews, POS data analysis, and consumer behavior observed on-site.

Supplier Perspectives on EISA's Effect on Bulb Sales and Prices

Manufacturers, retailers, and retail lighting managers voiced different opinions about the effect of EISA on sales of different types of light bulbs. Manufacturers and high-level buyers tended to agree that EISA had largely increased sales of LEDs and halogens, with very few respondents voicing alternative positions. In contrast, manufacturers were fairly evenly split among those arguing that EISA had any influence on CFL sales – increased, decreased, or no effect. Likewise, while 60% of the high-level buyers said EISA had increased CFL sales, another 40% said the legislation had decreased sales. Those arguing for reduced CFL sales generally cited increased competition from halogens and decreased incentives in some jurisdictions—a fact that the PAs may want to take into account as they consider the future of CFL incentives in the post-EISA period.

Retailer lighting managers also voiced different opinions about the effect of EISA on sales of various bulb types. We asked Massachusetts store managers who reported awareness of the EISA legislation if they thought their sales of CFLs (standard, covered, and other specialty), LEDs, halogens, and incandescent bulbs had changed since 2012. Figure 7 shows they were most likely to say that standard CFL sales had increased over this two-year period (53% of respondents) and that incandescent sales had decreased (49%). Likewise, despite large percentages of retail lighting managers who said they did not sell LEDs or halogens, most of the managers who did sell these bulb types said that EISA had increased their sales. The managers were less certain about the effects of EISA on covered CFLs and, especially, other specialty CFLs. While more managers thought EISA had increased sales of covered CFLs, quite a few argued that they had no effect on sales. Equal percentages of managers said EISA had a positive effect or no effect on specialty CFL sales, which likely reflects the fact that many specialty bulbs are not subject to EISA.

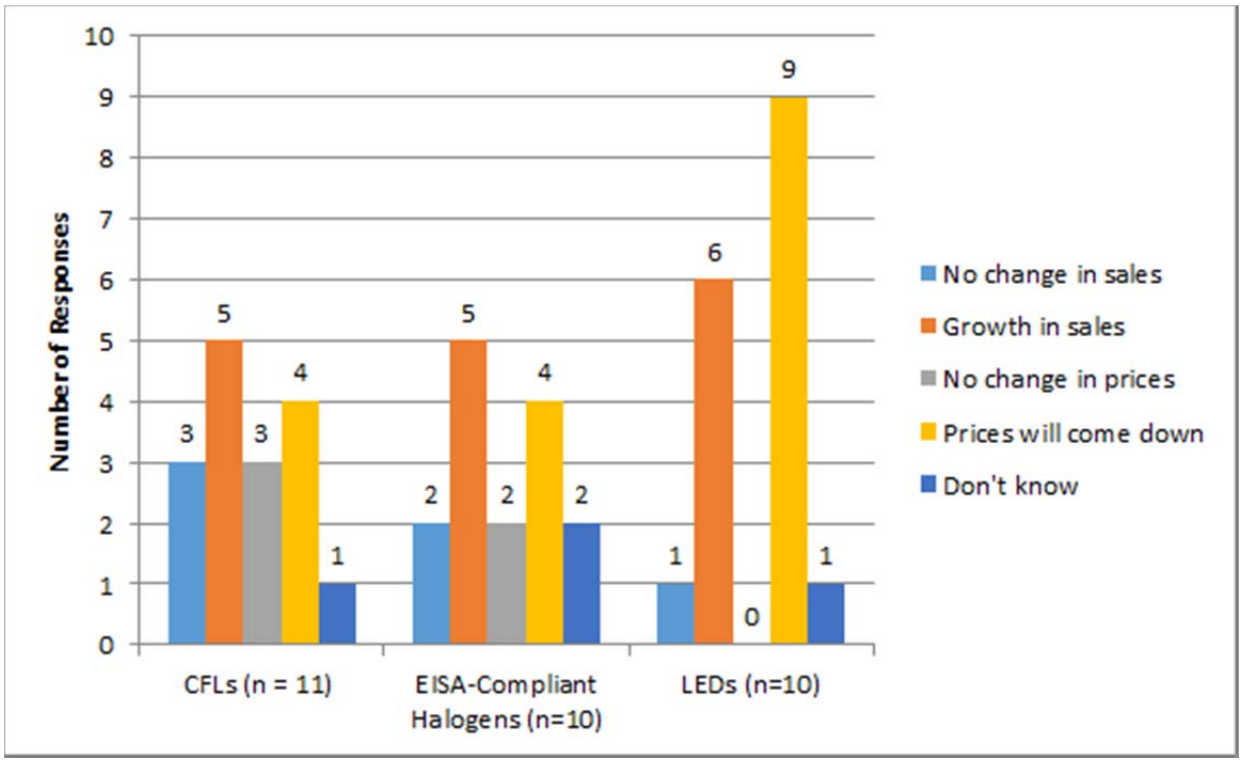
Figure 7. Lighting Managers Saw Increase in Standard CFL, LED, and Halogen Sales since 2012



Base: Retail store lighting managers selling each type of bulb

We also asked lighting manufacturers and high-level retail buyers about their expectations for future effects of EISA legislation on CFLs, EISA-compliant halogens, and LED bulb sales. Most responses focused on changes in sales and pricing for energy-efficient lighting (respondents could provide more than one response) as summarized in Figure 8. The manufacturers and high-level buyers largely expected halogen and LED sales to increase and prices to decrease. However, respondents showed less agreement on the future of CFL sales and prices; while the largest number of respondents also expected CFL sales to go up and prices to come down, nearly as many respondents said sales and prices would not change.

Figure 8. Suppliers Expect Halogen and LED Sales to Increase, Prices to Decrease



Base: Manufacturers and high-level buyers providing response.

Standard CFL Incentives: Lessons from California and New York

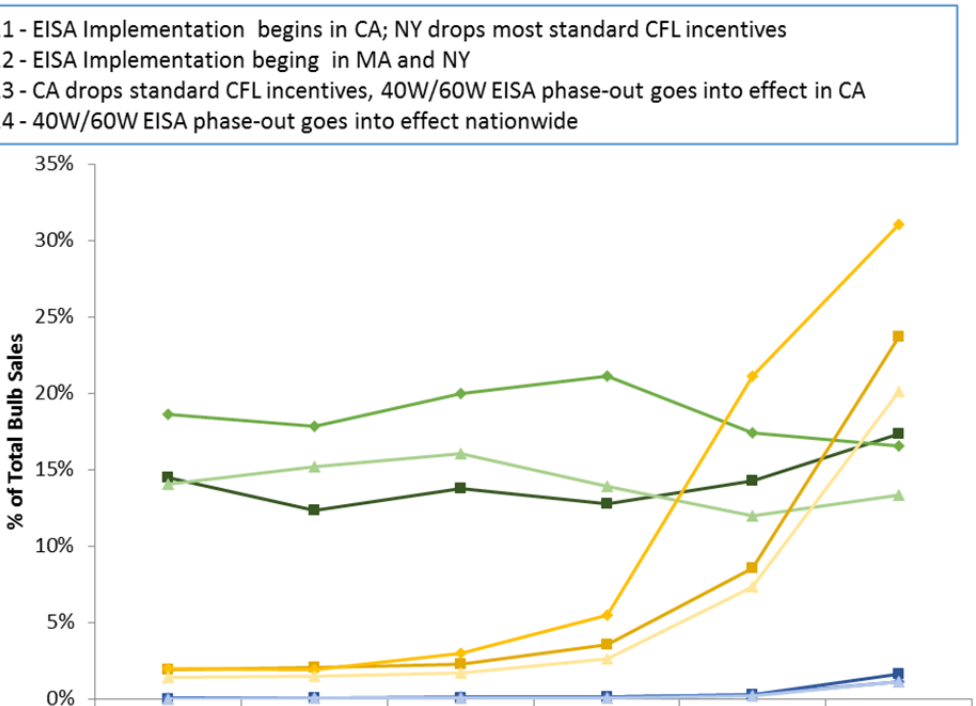
During the in-depth interviews, suppliers who were familiar with both the California and Massachusetts markets urged Massachusetts to continue offering incentives for CFLs, warning that the failure to do so would likely lead consumers to backslide to halogen bulbs rather than sticking with CFLs or switching to LEDs. These suppliers explained that California had discontinued standard CFL incentives in 2013, just when the 40W and 60W incandescent phase-outs went into effect in that state—one year ahead of the rest of the nation. That same year, the suppliers claimed, halogen market share increased substantially while CFL market share decreased substantially.

The Team turned to the LightTracker data to see if they supported the claims of these suppliers—and the data did. Additionally, the Team also looked at data for New York, which, unlike Massachusetts, had

ceased most standard CFL incentives in 2012 but, like Massachusetts, was not subject to the 40W/60W incandescent phase-out until 2014. Figure 9 compares market share trends from LightTracker for CFLs and halogen bulbs in California, Massachusetts, and New York from 2009 to 2014. The data demonstrate that the removal of standard CFL incentives in New York in 2012[12] and California in 2013 are associated with decreases in CFL share, despite previously positive trends. In contrast, Massachusetts saw its CFL market share increase. The halogen market share in all three states has increased since the widespread arrival of general service, screw-in models to the market around 2011, with accelerated adoption coinciding with the EISA mandated phase-out of incandescent bulbs in 2011 in California and 2012 in Massachusetts and New York. In fact, in 2014, halogen market share exceeded CFL market share in all three states. Thus, halogens—even more than CFLs (and LEDs) seem to be filling the gap created by the incandescent phase-out, at least among the reporting retailers. Finally, while still small, LED market share among the reporting retailers increased between 2013 and 2014 by 300% in California and by over 500% in Massachusetts and New York, comprising 1.11% of the market share in California and New York, and 1.65% of the market share in Massachusetts. While LEDs currently play a small role in filling the market gap created by the incandescent phase-out, most market indicators suggest that this will change in the coming years.

[12] NYSERDA ended program support for standard CFLs in 2012, except for in limited types of stores in New York City (e.g., small convenience stores and "bodegas"). In June 2014, NYSERDA decided not to support any new lighting products or locations, but allowed existing agreements to continue to operate through already approved funding, with all activity ending by December 31, 2014.

Figure 9. CFL Market Share Fell in California and New York While Massachusetts Experiences Greatest Relative Growth in LED Market Share



	2009	2010	2011	2012	2013	2014
MA CFL Market Share	14%	12%	14%	13%	14%	17%
CA CFL Market Share	19%	18%	20%	21%	17%	17%
NY CFL Market Share	14%	15%	16%	14%	12%	13%
MA Halogen Market Share	2%	2%	2%	4%	9%	24%
CA Halogen Market Share	2%	2%	3%	6%	21%	31%
NY Halogen Market Share	1%	1%	2%	3%	7%	20%
MA LED Market Share	0.01%	0.02%	0.04%	0.09%	0.26%	1.65%
CA LED Market Share	0.02%	0.05%	0.13%	0.15%	0.29%	1.11%
NY LED Market Share	0.01%	0.02%	0.03%	0.05%	0.19%	1.11%

Source: LightTracker data from the Point-of-sale Data Analysis.

The finding that CFL market share drops when standard CFL incentives are removed raises an important issue for future program planning: How long should the PAs continue to support standard CFLs and what should such support look like? Superficially, one may conclude that, of course, the PAs should continue to support standard CFLs to protect market share and energy and demand savings. Yet, answering this question requires one to dig deeper and also to consider that most studies indicate that LEDs offer superior performance and consumers like them. Additionally, due to EISA, as incandescent bulbs become phased out and consumers turn to more efficient choices such as halogens, CFLs, and LEDs, the average difference in Wattage between bulbs formerly installed in sockets and new bulbs installed in a sockets will decrease, affecting assumptions for calculations of annual and lifetime energy savings.

Moreover, EISA also has provisions for increased efficiency standards in 2020. At this time, only CFLs and LEDs meet those standards, leading most experts to conclude that CFLs will become the new "baseline" bulb in 2020. Because CFLs have a measure life of about seven years, this may mean that PAs can claim lifetime savings for CFLs only through 2020. Thus, as we address again in our recommendations, the PAs and EEAC consultants must continue to keep a close eye on socket saturation and market share while being mindful of the continued cost effectiveness (or lack thereof) of supporting standard CFLs.

Incandescent Stockpiling

Because it involves the phase-out of the much loved "traditional" incandescent light bulb, EISA has raised concerns that consumers would stockpile incandescent bulbs to avoid switching to other bulb types. For this reason, the Team took an inventory of all stored bulbs during the 2014 and 2015 on-site visits, keeping an eye out for incandescent bulbs and asking follow-up questions to explore stockpiling behavior.

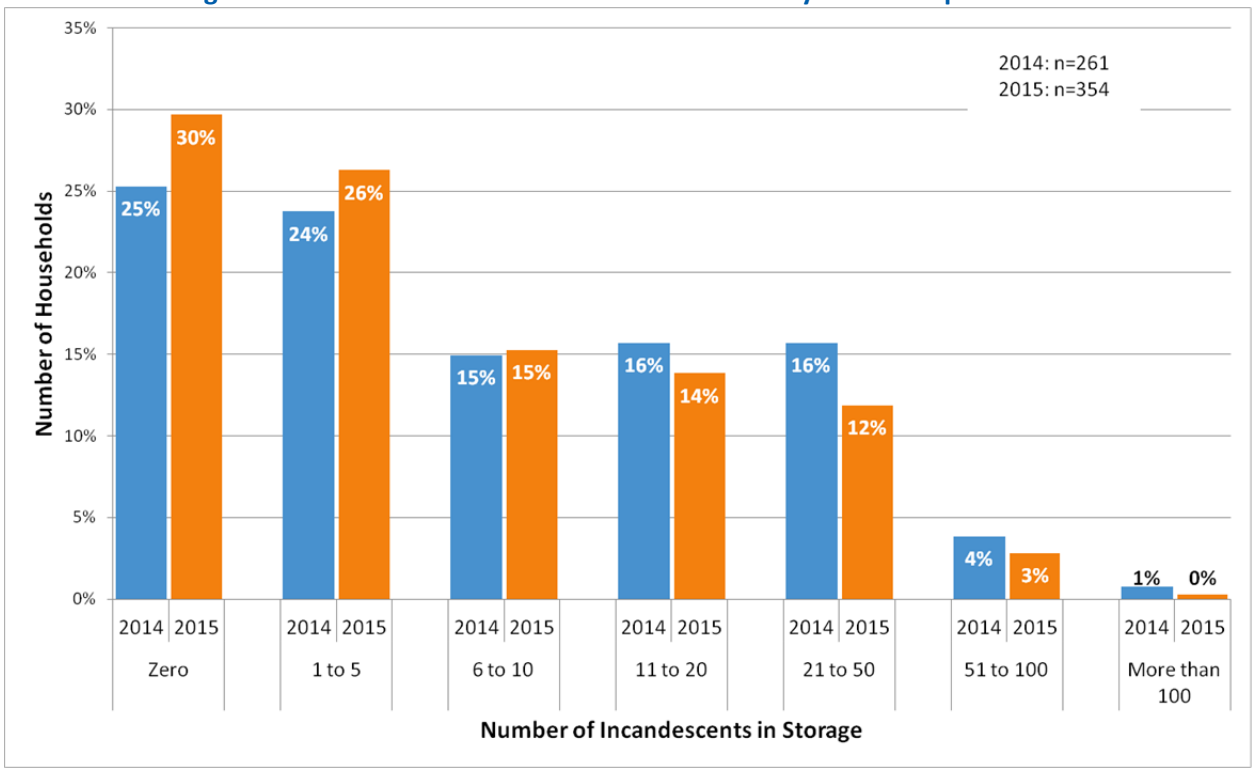
During both the 2014 and 2015 on-site visits, for each 60W, 75W, and 100W incandescent bulb found in storage, the technician asked the homeowner if he or she was stockpiling that specific bulb because it was no longer manufactured. In Massachusetts in 2015, 6% of houses said they were stockpiling 60W incandescent bulbs, up from 4% in 2014; 3% said they were stockpiling 75W bulbs and 4% said they were stockpiling 100W bulbs, up from 2% each in 2014. A similar pattern emerged in upstate New York in 2015: 9% reported stockpiling 60W incandescent bulbs, 4% were stockpiling 75W bulbs, and 3% were stockpiling 100W bulbs.[13] In Massachusetts in 2015, we again found little evidence of substantial stockpiling; of the 26 Massachusetts households that said they were stockpiling only twelve had 11 or more incandescents in storage. Five self-identified stockpilers had more than 20 incandescents in storage and one had 67. While this may seem like a large number of bulbs, it is similar to the average number of incandescent bulbs stored by those households who had at least one stored incandescent bulb but did not self-identify as a stockpiler; each group had an average of 13 stored incandescent bulbs. In New York, stockpilers kept fewer bulbs on hand: one of the stockpilers had 24 bulbs, another 13, and a third 11. The rest had fewer than five incandescents in storage.

Furthermore, the few households storing more than ten incandescent bulbs failed to attribute this behavior to EISA—they simply liked to have bulbs on hand. More specifically, the average number of 40W to 100W incandescent bulbs in storage in all households in Massachusetts (including households that had none in storage) increased from approximately four bulbs in 2013 to approximately eight bulbs in 2015. However, as Figure 10 shows, very few homes were actually stockpiling incandescent bulbs. Nearly one-third (30%) of homes had zero incandescent bulbs in storage in 2015, up from one-quarter

[13] It is important to note that "stockpiling" simply refers to whether an on-site participant was storing incandescent bulbs because they are no longer being manufactured. None of these participants were actually storing a significant number of incandescent bulbs.

(25%) in 2014. A considerable portion of 2015 homes (41%) had between one and 10 incandescent bulbs in storage.

Figure 10. Households Store Incandescents but Very Few Stockpile Them



Consumer Reactions to LEDs and CFLs

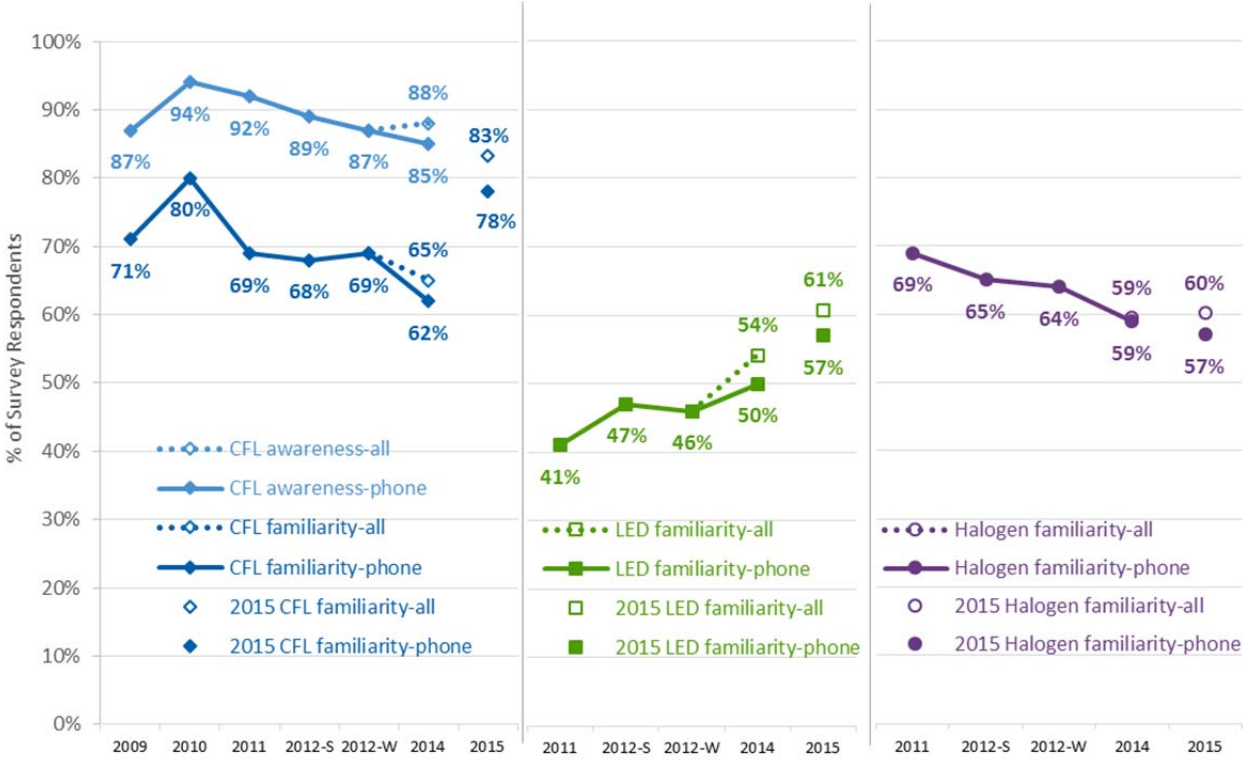
Thus far, we have addressed elements related explicitly to the marketplace—namely past, current, and expected bulb sales and prices as well as consumer bulb purchasing behavior. The Team has also continued to track key indicators of consumer awareness of and reaction to LEDs, CFLs, and halogens, which over time have provided important insights into the progression of market transformation.

Bulb Familiarity

The Massachusetts Consumer Survey shows very high consumer familiarity with CFLs and LEDs. Comparing responses from the 2015 survey to prior years shows that Massachusetts consumers' familiarity with both CFLs and LEDs appears to have increased considerably over the past few years. As explained in the On-site Visit and Consumer Survey Results (delivered under separate cover), the change in the 2015 survey in the way that respondents were asked to report their familiarity with CFLs and a new item regarding LED awareness made it difficult to compare the CFL and LED awareness indicators

consistently over time.[14] An analysis of respondents' familiarity with halogen bulbs reveals a significant decrease since 2011. This decrease may be due, in part, to fact that halogen bulbs look so much like incandescents that the casual observer may not realize they are different, but the Team cannot fully explain why the same description repeated over time would show this decrease in familiarity.

Figure 11. Massachusetts Consumers' Familiarity with CFLs and LEDs Appears to Have Increased Significantly in Recent Years



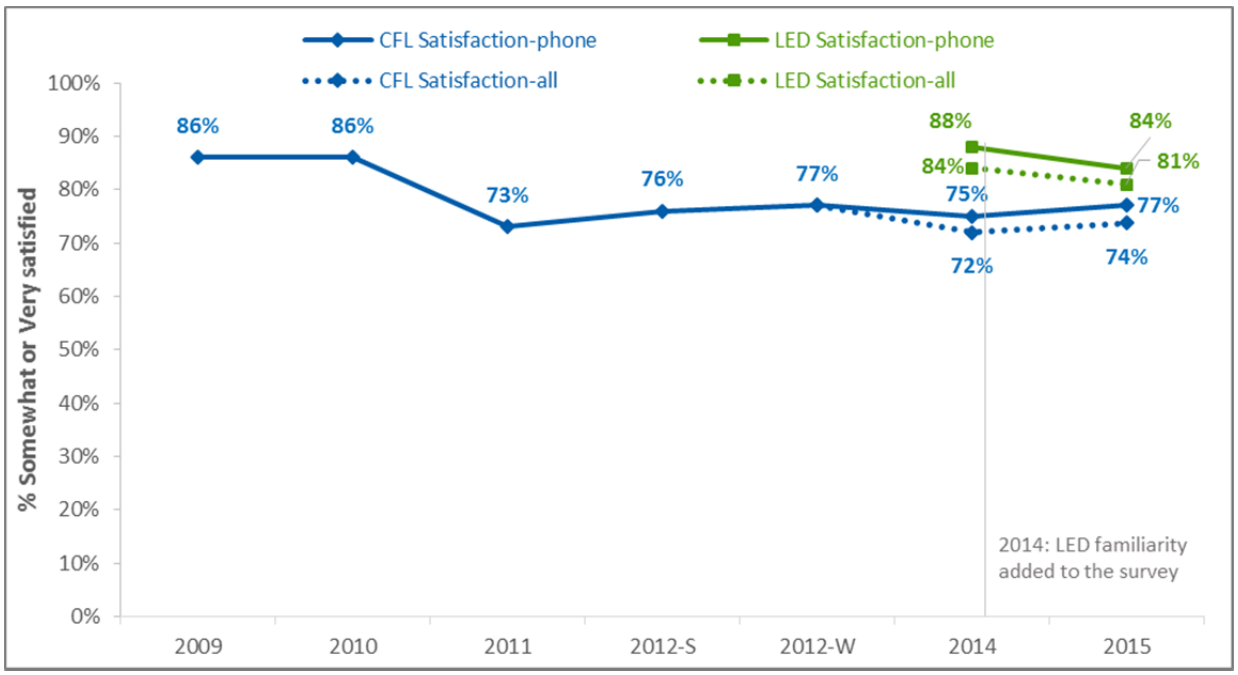
Sample Sizes	2009	2010	2011	2012-S	2012-W	2014	2015
All respondents (phone+web)	--	--	--	--	--	940	778
Phone respondents	503	381	582	604	600	731	478

[14] The 2015 survey differed from previous surveys in the structure of the questions related to CFL familiarity. Because consumers were no longer asked to report their awareness of CFLs on the 2015 survey, their self-reported familiarity may be overstated compared to previous years. In contrast, the addition of a new item which asked respondents to indicate if they were aware of LEDs, which served as a screener for the question regarding LED familiarity (such that anyone "not aware" of LEDs was assumed to be "not familiar" with them), may have exerted downward pressure on the LED familiarity indicator.

LED and CFL Consumer Satisfaction

Respondents who reported using either CFLs or LEDs were asked about their levels of satisfaction with these bulbs. Overall, Massachusetts consumers have reported fairly high levels of satisfaction with CFLs and LEDs (Figure 12). However, compared to prior survey waves consumers' satisfaction with CFLs has declined and leveled off. In addition, while the Team only has data on LED satisfaction for the past two surveys, consumers have reported higher satisfaction with LEDs relative to CFLs.[15]

Figure 12. Satisfaction with CFLs has Declined and Leveled Off while LED Satisfaction Remains High



2015 phone respondents' satisfaction with CFLs is significantly different from 2010 and 2009 at the 90% confidence level.

The Team also asked respondents who reported using both CFLs and LEDs to indicate which bulb they prefer. Nearly one-half of all respondents (45%) stated that they prefer LEDs over CFLs while just 10% indicated that they prefer CFLs over LEDs. Close to three out of ten consumers (29%) reported that their preference depends on the situation, and 16% stated that they were not yet sure of their preference.

Supplier Program Satisfaction

The Team also asked suppliers about their satisfaction with the program and various elements of it. In this overall report we highlight the adequacy of LED incentives and overall program satisfaction, and provide a subset of suggestions for program improvements.

[15] The slight decline in LED satisfaction between 2014 and 2015 is not statistically significant.

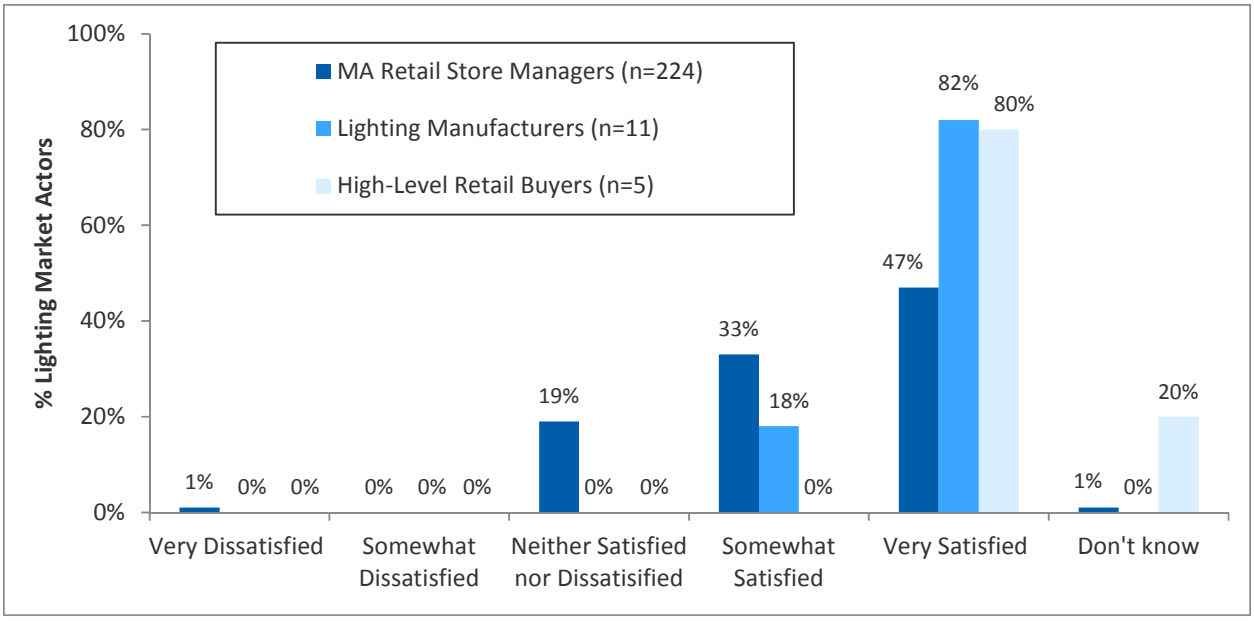
Adequacy of LED incentives

Store managers were asked whether they thought the average buydown discount for LED bulbs (about $12 per bulb) was adequate to stimulate consumer demand. Overall, the majority of respondents felt that this was a sufficient level, but there was some variability among retail channel store managers. While 100% of store managers in the home improvement and mass merchandise channels found LED incentive levels adequate, only 57% of those in the bargain channel (e.g., dollar stores, closeout stores) felt they were sufficient. The disparate responses may reflect the greater price sensitivity of bargain channels and the ability of large home improvement and mass merchandise stores to take advantage of bulk pricing from lighting manufacturers that are not typically available to bargain stores.

Overall Program Satisfaction

We asked lighting market actors to rate their overall satisfaction with the Massachusetts ENERGY STAR program. Store managers provided ratings on a 5-point scale, and manufacturers and high-level retail buyers used a zero-to-ten scale. Figure 13 shows all market actor groups expressed satisfaction with the program in general, with at least 80% of any market actor group surveyed being somewhat or very satisfied with the program. About one-fifth of store managers offered neutral responses (e.g., neither satisfied nor dissatisfied), and only 1% of store managers expressed being very dissatisfied with the program. Note that satisfaction with the program increased among store managers from 71% in 2012 to 80% in 2014.

Figure 13. Suppliers are Satisfied with the Program



Base: All supplier respondents

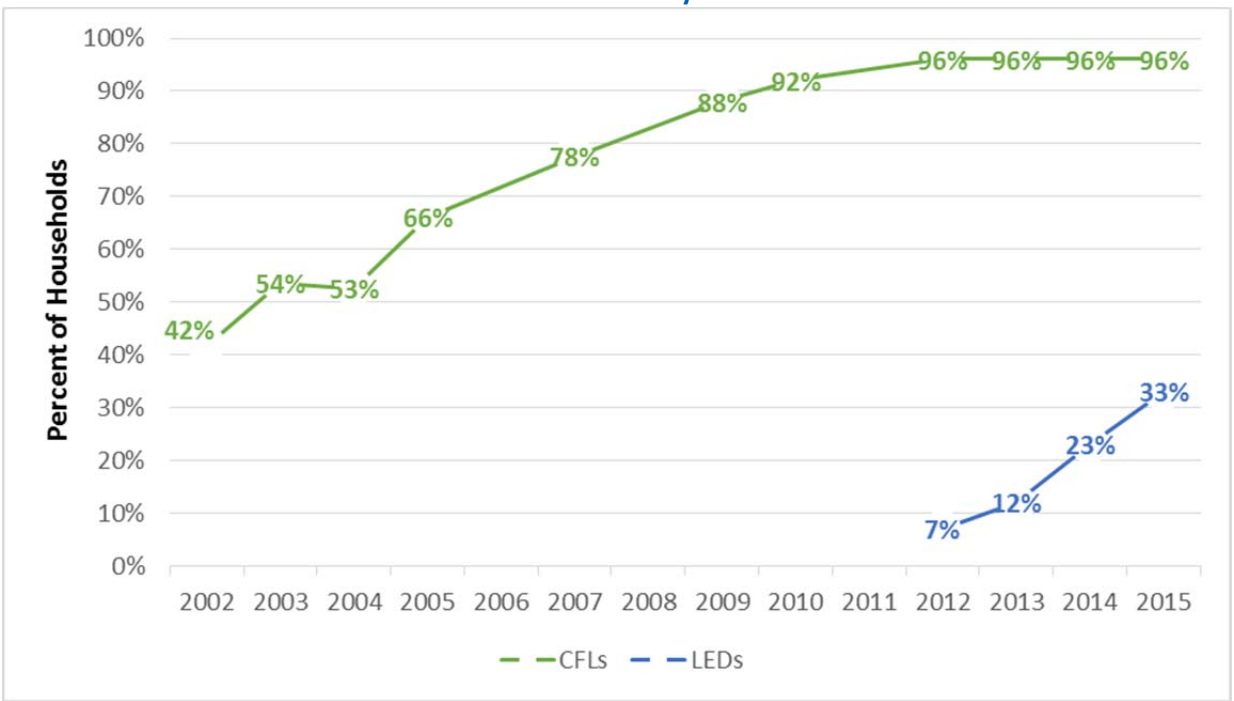
Socket Saturation and Bulb Replacements

The Massachusetts PAs and EEAC consultants have been tracking the household penetration (the percentage of households using the product) and socket saturation (the percentage of sockets filled with the product) of CFLs since the early 2000s. This research expanded to reporting saturation for most bulb types in 2006, specifically including LEDs since 2009. This section explores trends in penetration and socket saturation for CFLs and LEDs as well as other bulb types such as tube fluorescents, incandescents, and halogens.

Household Penetration

Nearly all (96%) Massachusetts households used at least one CFL, and one-third (33%) used at least one LED (Figure 14). The penetration for CFLs steadily increased from 42% in 2002 to 96% in 2012, where it has remained. The penetration rate for LEDs shows significant gains. Importantly this rate nearly doubled between 2012 and 2013 and again between 2013 and 2014, reaching 33% in 2015. This suggests that the word has gotten out and more households are giving LEDs a try. Additionally, LED use shifted during this time period from being dominated by integrated novelty fixtures, reading fixtures, and under-the-cabinet lights to greater use of screw-based models, including both general service bulbs and spot/reflector/flood types.

Figure 14. Most Massachusetts Households Have CFLs Installed and LED Penetration is Rising Dramatically



Base: All on-site households

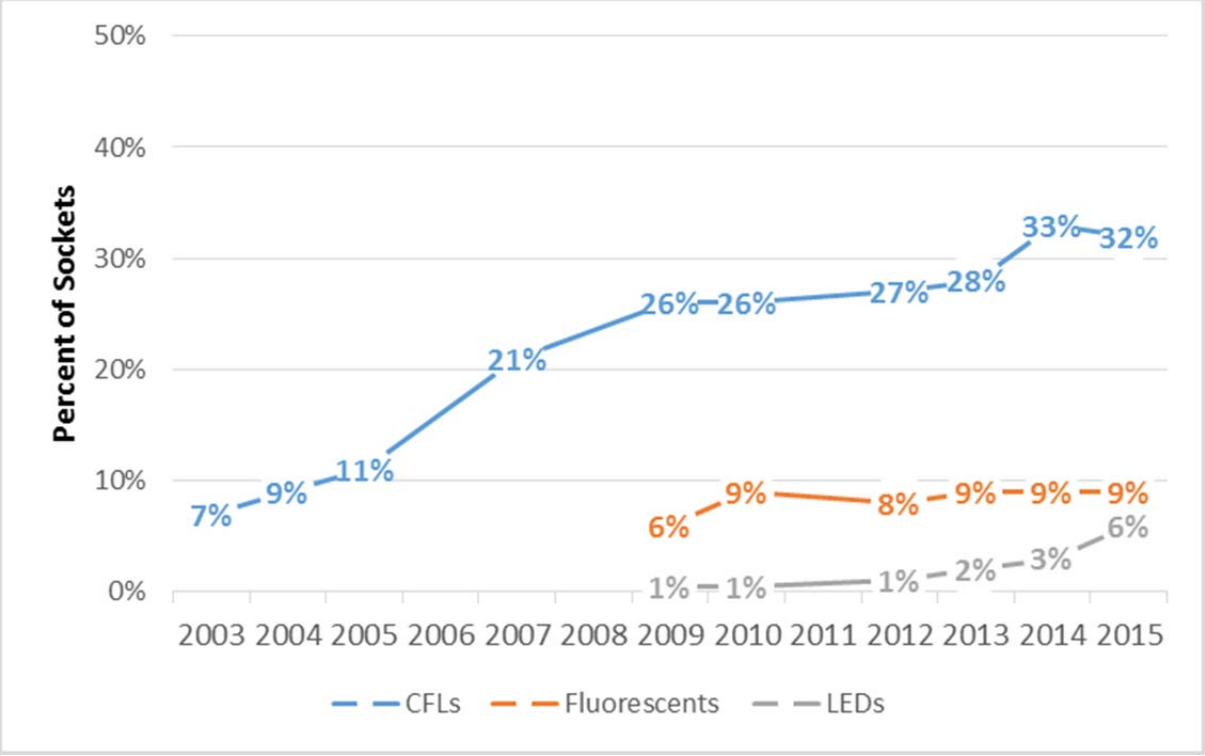
Socket Saturation

As discussed in the Introduction, one impetus for this study involved the apparent stagnation in the percentage of sockets filled with CFLs between 2009 and 2013. For this reason, the Team explored the question of trends in socket saturation in considerable depth.

Socket Saturation Over Time

The 2014 and 2015 on-site saturation studies revealed that after several years of stagnated growth, CFL saturation in Massachusetts rose considerably. CFL saturation increased from 28% in 2013 to 33% in 2014 and 32% in 2015 (Figure 9). LED saturation also increased substantially, growing from 2% in 2013 to 3% in 2014 and 6% in 2015. Collectively, saturation of CFLs, fluorescents (including linear fluorescents no matter the diameter of the tube),[16] and LEDs was 47%, an increase of 14 percentage points (from 33%) since 2009. The 2014 and 2015 on-site saturation visits also found that fewer than 50% of sockets were filled with incandescents.

Figure 15. Saturation of Efficient Sockets is on the Rise



Base: All sockets found in on-site households

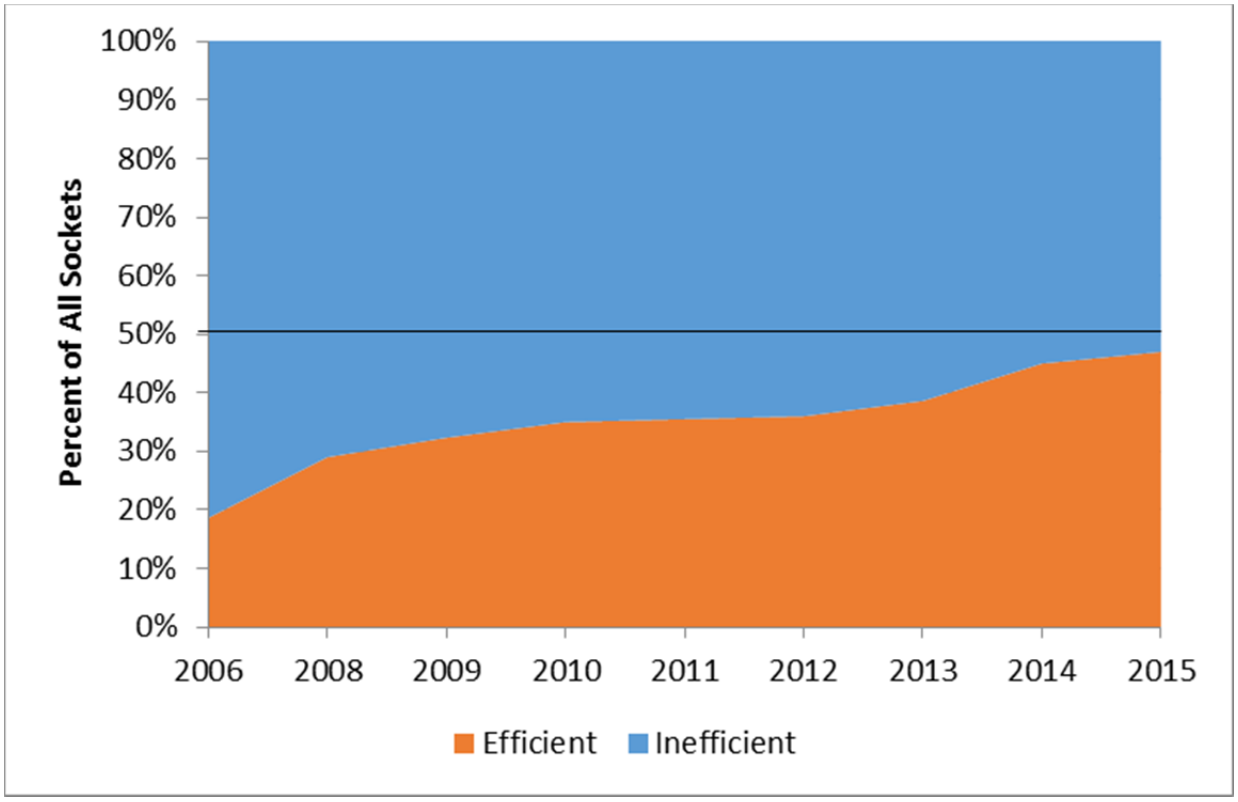
[16] Since 2012, the Team has tracked fluorescent tubes as "efficient" bulb types based on the argument that they use less energy than many other bulb styles and retrofits of them in most residential settings do not usually yield cost effective savings. However, more efficient linear fluorescent tubes—such as T5s, T8s—and linear LEDs meant to replace fluorescent tubes do exist. We return to this topic in the Conclusions and Recommendations section.

* ODC collected data in 2003; RLW in 2004 and 2007; KEMA in 2009 and 2010; DNV KEMA in 2012; and NMR in 2014. Saturation data were not collected in 2006, 2008, and 2011.

** Total Efficient includes CFLs, Fluorescents (primarily linear tube), and LEDs.

Figure 16 illustrates how saturation of efficient bulbs (CFL, LEDs, and fluorescent tubes) has eaten away at saturation of less efficient bulb types (incandescent and halogen) bulbs over time, increasing from 19% in 2006 to 47% in 2015. Additionally, the information shows the distribution of CFL socket saturation across households in the on-site studies from 2010 to 2015 (showing only "new visit" households in 2010, 2014, and 2015).[17]

Figure 16. Energy Efficient Sockets Will Soon Overtake Inefficient as the Most Common Bulb*



Base: All sockets found in on-site households

* The Team lacks information on non-CFL socket saturation prior to 2006. Efficient bulbs include CFLs, LEDs, and fluorescent bulbs. Inefficient bulbs include all other bulb types but predominantly incandescents.

~~at lacked panel visits.~~

Saturation in Comparison Areas

In 2014 and 2015, the Team conducted saturation visits in comparison areas. The 2014 visits took place in Georgia and Eastern Kansas, and the 2015 visits were in Upstate New York. While not perfect comparisons to Massachusetts, the PAs, EEAC consultants, and Team selected these regions for the following reasons:

- Eastern Kansas has never had a lighting program;
- Until recently Georgia had limited program activity, although in 2013 Georgia Power supported two million standard CFLs;
- Of the remaining no-program or limited-program areas, Georgia and Eastern Kansas most closely aligned with the demographics of Massachusetts;
- New York ended program support for standard spiral CFLs in 2012 and essentially all upstream incentives throughout the last six months of 2014[18]; and
- Team members had access to prior saturation estimates from each area.

The Team additionally has access to saturation estimates over time from other areas, including Downstate New York, portions of California served by the investor-owned electric utilities, and Connecticut.[19] Figure 17 below plots the CFL saturation rates over time for each of these areas and presents the data table listing the individual estimates when available. (LED and fluorescent saturation rates are not consistently available for these areas.)

The results show that saturation rates have increased overall in all these areas. Given the rather widespread availability of CFLs in the face of wider market adoption and EISA, one would expect this universal increase. Yet, the trends also present paradoxes. First, despite having at least some program activity during the 2009 to 2012 time period, Massachusetts, New York[20], and Connecticut all exhibited saturation stagnation, while California does not appear to have experienced the same stagnation. Yet, Connecticut saw saturation increase between 2012 and 2013, and Massachusetts followed suit between 2013 and 2014. In contrast, recent saturation estimates for Upstate New York reveal a slight drop in CFL

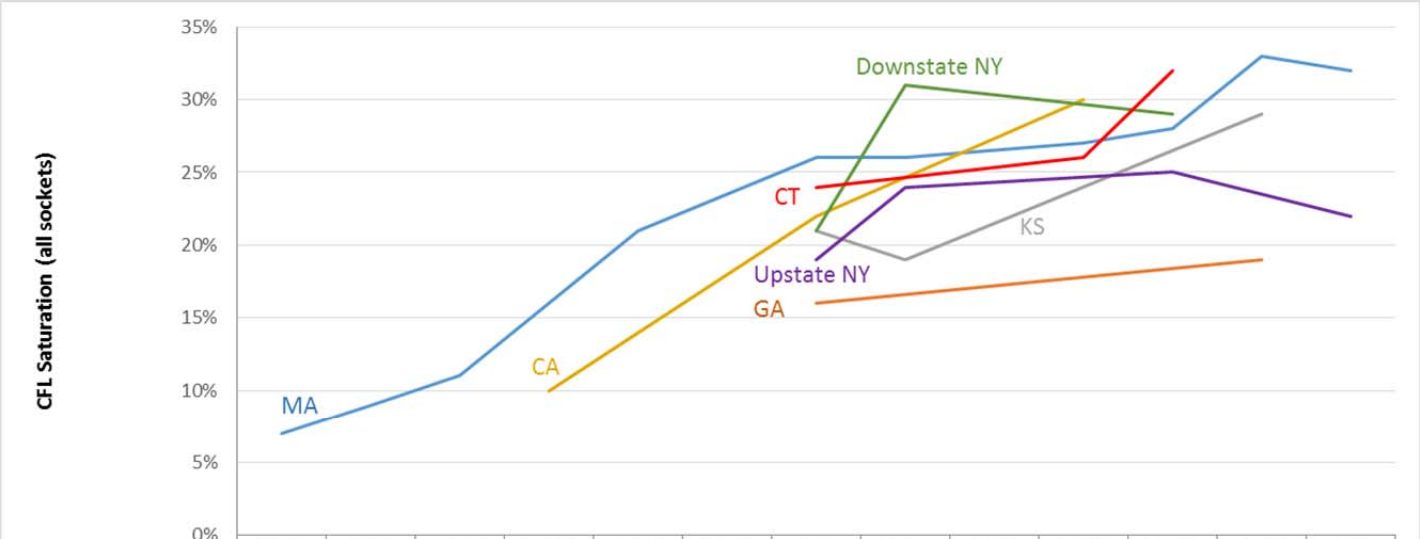
[18] NYSERDA continued limited support for specialty CFLs and LEDs through mid-2014, but the volume of incentivized bulbs was very small compared to those supported in Massachusetts.

[19] Connecticut leveraged data collection costs with Massachusetts for the Georgia and Kansas data collection and POS data analysis. With permission from the Massachusetts PAs, Connecticut also piggy-backed on the supplier interviews, asking respondents to comment on both states during the interviews.

[20] The NYSERDA program differs from those in the other three strong program areas. Prior to 2009, NYSERDA largely promoted CFLs through cooperative marketing and education efforts with individual manufacturers and retailers. Only in 2009 did it move to an upstream model. Also, as mentioned earlier, NYSERDA ceased incentives for most standard CFLs in 2012. It did continue standard CFL incentives in certain retail stores (e.g., small convenience stores and "bodegas") in Downstate NY through 2014 and also incentivized specialty CFL incentives (and LEDs too) through 2014. Thus, the Team finds it difficult to suggest what one *should* have expected to happen with saturation rates in New York during this time period.

saturation between 2013 and 2015 (from 25% to 22%), coinciding with the period in which it stopped most support for standard CFLs. Second, saturation in Eastern Kansas increased dramatically between 2009 and 2014 despite its complete lack of program activity, while Georgia's rate barely increased even though the state had some program efforts. In short, Figure 17 makes clear that program activity is not the only factor affecting CFL socket saturation.

Figure 17. CFL Socket Saturation Increased at Different Rates Across the Nation[21]



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MA	7%	9%	11%		21%		26%	26%		27%	28%	33%	32%
GA							16%					19%	
KS							21%	19%				29%	
CA - IOUs				10%			22%			30%			
Upstate NY							19%	24%			25%		22%
Downstate NY							21%	31%			29%		
CT							24%			26%	32%		

Base: All sockets in each state and year (although some exclude empty sockets, which has very little impact on saturation estimates

[21] There are two caveats to note: 1) This graph assumes consistent, linear changes between estimates, which may not be accurate. For example, Georgia had a saturation rate of 16% in 2009 and 19% in 2014, and the graph shows this change as linear, when, in reality, the increase in saturation may have occurred only between 2013 and 2014. 2) Massachusetts has performed on-sites visits more regularly than any other program administrator in the nation, accounting for the nearly annual estimates and more nuanced understanding of when changes in saturation have occurred—and when they have stagnated.

The next section of this chapter explores the issue of saturation stagnation in more depth, but here we summarize our efforts to explain the somewhat perplexing trends in saturation rates when comparing Massachusetts and the two states with little or no history of CFL programs—Kansas and Georgia. We examined multiple additional possibilities for the differences in saturation trends, including the following:

- Size of homes
- Number of sockets in homes
- Familiarity with bulbs
- Systematic differences in saturation rates between Kansas counties included in earlier studies and those included in the 2014 study[22]
- Variations in electricity rates[23]
- Potential impact of natural disasters such as floods or tornadoes[24]
- Concentration of home improvement and mass merchandise stores in Massachusetts, Kansas, and Georgia.

Only the last element revealed a specific pattern that helps to—but does not fully—explain the divergent saturation trends leading up to 2014. We suspect that the higher concentration of mass merchandise stores, specifically Walmart, may be a contributing factor to saturation increases in Kansas. Based on analyses explored more in the 2014 on-site report, the Team believes that mass merchandise stores such as Walmart may play a critical role in affecting CFL saturation.

Possible Explanations for Saturation Stagnation

As mentioned above, the trend lines in Figure 17 display an apparent "stagnation" in saturation between approximately 2009 and 2011 for Massachusetts, Downstate NY, Upstate NY, and Connecticut, all of which had substantial lighting programs during this period. However, the same stagnation does not seem to have occurred in California, which experienced a large increase in saturation over the same period. A few points must be considered before deciding that the various states in the Northeast stagnated and California did not. First, California's saturation rate was lower than that of Massachusetts

[22] The saturation rate for all of Kansas was 19% in 2009, and it was also 19% for the subset of Kansas counties included both in 2009 and 2013.

[23] Massachusetts has the highest rate (at 15.9 cents per kWh in August 2013), Georgia has the second highest rate (12.3 kWh), and Kansas the lowest (12.1 kWh). Moreover, higher rates do not necessarily translate into higher bills because the nature of the home—its appliances and equipment, insulation level, and other factors—and the climate affect bills as well.

[24] Flooding, blizzards, and tornadoes certainly plagued parts of Kansas between 2009 and 2013. In particular, Wichita, in Sedgewick County, had extensive flooding in the summer of 2013. For a natural disaster to explain the increase in saturation, the increase would need to be localized to the area affected. However, the saturation increases in Kansas were fairly widespread. In fact, Sedgewick County's saturation rate increased from 25% to 33% (eight percentage points), compared to 19% to 29% (10 percentage points) for all of Kansas.

and Connecticut until 2012; therefore, its increase between 2009 and 2012 could simply represent "catching up" to these two states. Second, the CPUC has a three-year evaluation cycle, so we are not certain when during the time period California's saturation rate increased. Even with these two caveats, it still seems rather unexpected that California would experience a 9% increase during the same time that Massachusetts and Connecticut increased only one or two percent and Upstate NY and Downstate NY experienced a one-year increase between 2009 and 2010 (when the NYSERDA program increased incentives) and then stabilized the rest of the period.

The Team explored the issue of saturation trends across states through three studies: 1) On-site Saturation Study, 2) POS data analysis, and 3) Saturation Stagnation Comparison. Table 2 summarizes the conclusions we drew from these investigations. In short, the most compelling explanations for the differences in saturation seem to be as follows:

- The confidence interval for Massachusetts saturation in 2012 overlaps with the California point-estimate of saturation, suggesting that the two rates may not have been statistically different from each other (Table 5 in Appendix B and Figure 18).[25] In 2012, CFL saturation in Massachusetts was 27% with a confidence interval of 24% to 30% while the point-estimate for CFL saturation in California was 30%. The confidence intervals along with the timing for saturation surveys also make it possible that the Massachusetts saturation rate may have broken stagnation in the 2009 to 2013 time period—and similarly that stagnation may not have really ended in 2014.
- California's programmatic move away from big box stores (apart from club/warehouse stores) to grocery, drug, and club/warehouse stores during the 2006-2008 program cycle likely led to a boost in saturation. The CFL saturation rate in California rose from 22% in 2009 to 30% in 2012 as the state moved bulbs from more typical venues with assumed high free ridership rates to those reaching customers who had not really used CFLs before.
- California's accelerated adoption of EISA (i.e., one year ahead of the rest of the nation) may also have enhanced CFL saturation. The implementation during 2011 to 2013 in California compared to 2012 to 2014 for the rest of the nation likely meant that EISA-induced saturation increases occurred earlier in California (thus showing up in 2012) than the rest of the nation (e.g., showing up in Connecticut and Massachusetts in 2013 and 2014, respectively). Future saturation estimates for California, Massachusetts, and other states will help determine the actual impact of the accelerated adoption of EISA in California.

[25] These estimates rely on methods that take the clustered nature of sockets into account. That is, each house in the sample is a "cluster". The household residents do not randomly decide which bulb type to install in each socket, but instead their preferences and biases affect all sockets in the home, therefore violating assumptions of statistical independence. Our analysis adjusts for this "clustered" nature of the data.

Figure 18. California's CFL Saturation Point-Estimate Fell within the Range of Estimates for Massachusetts

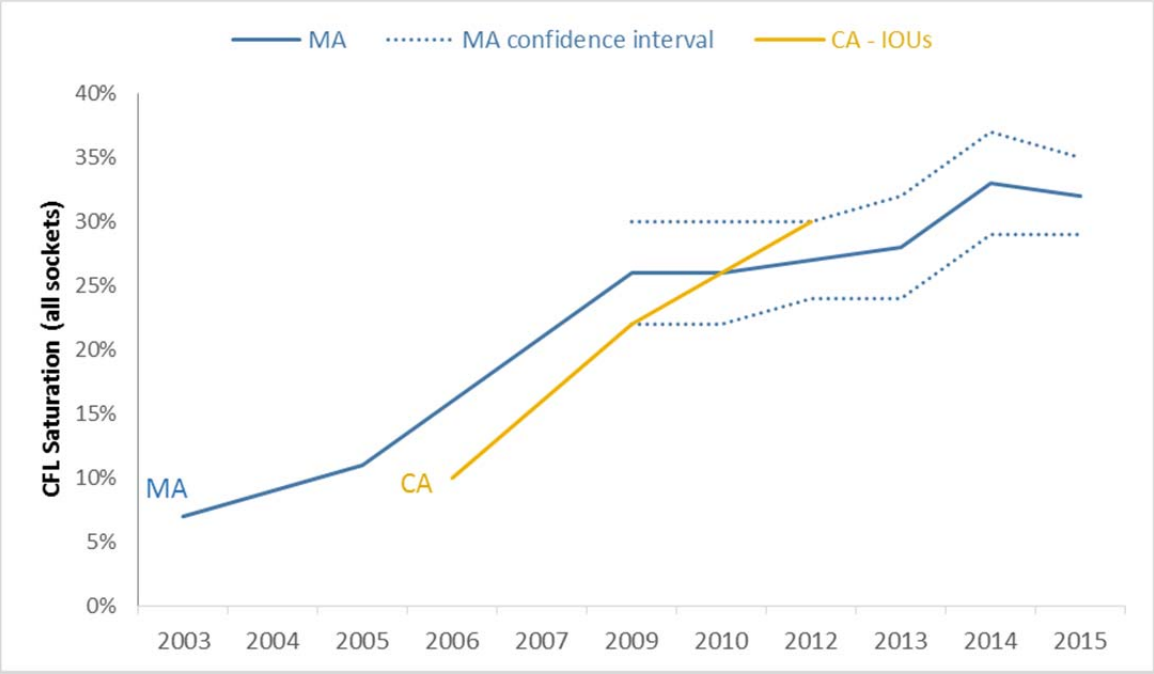


Table 2. Accepted – and Rejected – Explanations for Saturation Stagnation

Possible Explanation	Evidence	Conclusion
Team concludes explanation played at least some role in saturation differences		
Saturation point estimates are not truly different if confidence intervals and error bounds are taken into account.	When taking the confidence intervals (see Table 5 in Appendix B) into account the MA 2012 saturation estimate overlaps with that of CA.	This analysis demonstrates that, although the saturation point estimates differ between MA and CA, actual saturation rates may not.
Focus on retail channels other than the "big box stores"*	CA moved majority (~86%) of bulbs through grocery, drug, and other "small store" channels; MA moved a smaller proportion (~50%) through those channels. CA also began adopting this strategy in its 2006 to 2008 program cycle (sooner than MA). NY's reporting requirements meant that few "big box stores" were ever a part of its program.	Seems likely that CA earlier adoption and embracing of a "small store" approach had some role in its boost in saturation between 2009 and 2012.

Possible Explanation	Evidence	Conclusion
Early adoption of EISA in CA	CA adopted EISA incandescent phase-outs one year ahead of the rest of the nation (2011 to 2013 vs. 2012 to 2014) and experienced saturation boost by or in 2012. No other state in comparison groups experienced this boost until 2013.	Given the increased saturation in CA in 2012, the Team thinks it is likely that early EISA implementation may have played a role. Future saturation estimates from CA, MA, and other states may provide more clarification on how much impact EISA had on this measure.
Team concludes explanation may have played a role in saturation differences, but evidence is mixed		
CFLs replacing other CFLs	As discussed in the Bulb Replacements section, the on-site panel study provided the opportunity to measure how often newly purchased CFLs replaced CFLs that had burned out. The evidence supported high rates of CFL-to-CFL replacement between 2013 and 2014. Prior research had already shown that the CFL measure life, installation rates, and purchase rates made this theoretically possible.	Although lacking the CFL-to-CFL replacement rate from prior years, the evidence from earlier explorations and the current panel study strongly suggest the possibility that CFL-to-CFL replacement could explain why the millions of bulbs sold through the MA program achieved only modest increases in saturation through 2013. While we lack data to draw definitive conclusions, the lower saturation rates in CA in 2006 and 2009 suggest that proportionally fewer CFLs burned out in that state, so that more newly purchased CFLs entered new sockets, boosting saturation. In other words, the newly purchased CFLs in CA are just starting to burn out, in contrast to MA which has older bulbs that have burned out earlier.
Team concludes explanation likely played little or no role in saturation differences		
Relative support of standard and specialty bulbs	In the 2009-to-2012 period, CA decreased support for standard bulbs and increased support for specialty bulbs. However, MA did the same in 2010, and NY dropped all standard CFL incentives in 2012 but kept specialty ones.	Evidence suggests that this may not play a large role in explaining saturation rates. Depends largely on the proportion of specialty sockets in the state and the assumption that consumers fill specialty sockets with specialty bulbs. On-site saturation visits make clear that many specialty sockets hold standard bulbs.

Possible Explanation	Evidence	Conclusion
CA's Title 20 Lighting Standards that mandated bulbs with lower wattages per lumens in CA than rest of nation.	None of the CA interviewees believed Title 20 affected saturation rates.	With no evidence to the contrary, the Team accepted the conclusions of the interviewees.
CA's Title 24 Building Codes and Standards	None of the CA interviewees believed Title 24 affected saturation rates.	With no evidence to the contrary, the Team accepted the conclusions of the interviewees.
CA program marketing and education	None of the CA interviewees believed the marketing and education in CA was influential or varied in ways from MA to explain differences in saturation.	With no evidence to the contrary—and knowing that the MA PAs invested a great deal in marketing and education—the Team accepted the conclusions of the interviewees.
Methodological differences (e.g., weighting schemes, screw-base types, treatment of empty sockets, etc.)	The CA evaluation team was able to provide estimates for all base types, thereby making them comparable with MA. Inquiries into weighting schemes and the handling of empty sockets revealed minimal impact on saturation rates.	Given steps taken to bring screw-bases into alignment and little evidence that other differences affected saturation rates, the Team concludes methodological variations did not underlie differences in saturation rates.
Differences in operationalization of similar on-site protocols	While following fairly similar protocols, the firms conducting the work may vary in how they interpret those protocols while on-site. Table 5 in Appendix B presents the firm collecting the data in each year and the saturation rate.	As Table 5 shows, there are no discernible patterns in saturation rates by data collection firm.

* "Big box" is defined largely as home improvement, mass merchandise, and warehouse.

Bulb Replacements

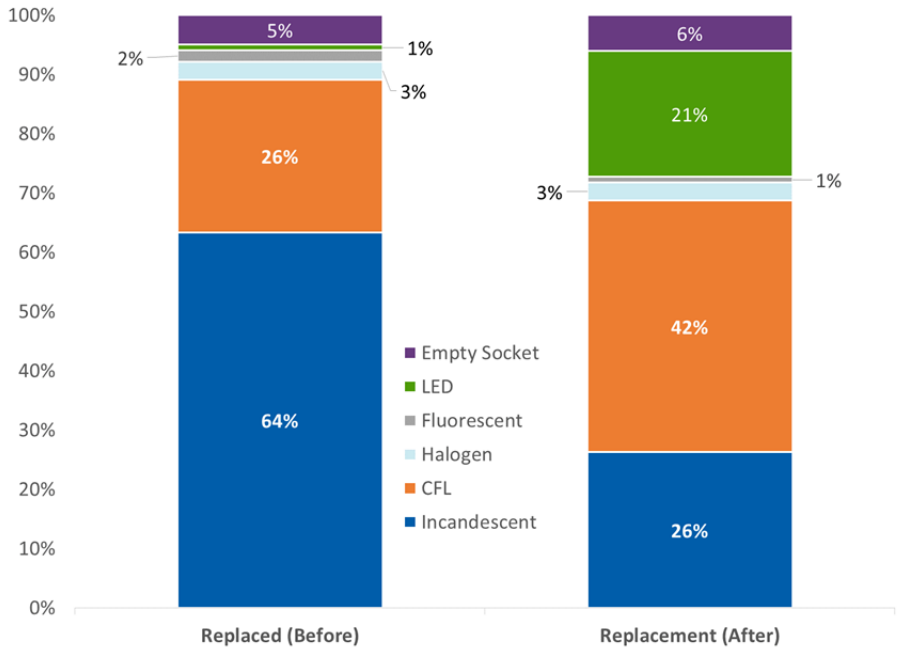
The 2015 on-site study included 203 Massachusetts panel participants. Eighty-nine homes were previously visited in both 2013 and 2014, and 114 were first visited in 2014. This panel of participants allowed the Team to make direct comparisons about lighting use and storage across these years within these homes. In addition, the visits with the panel participants provided an opportunity to identify instances where specific bulbs had been replaced and to ask participants about reasons for those changes.

The results of the panel visits revealed a noticeable shift away from inefficient to efficient bulbs. Between 2014 and 2015, panelists replaced bulbs in a total of 941 sockets, or 9% of the total observed sockets (10,930) in their homes.

Figure 19 provides a graphic overview of the bulb changes between 2014 and 2015 overall and Figure 20 shows the breakdowns of what type of bulbs were used to replace incandescent, CFLs, and LEDs. In Figure 19, the left column shows the distribution of bulbs before replacement (replaced bulbs); this reveals what bulbs were installed in these sockets during the 2014 visits. The right column shows the distribution of bulbs in the same 941 sockets at the time of the 2015 visits (replacement bulbs). To offer an example, of the 941 sockets replaced between visits, 64% had held incandescent bulbs in 2014 but only 26% of the same sockets held incandescents in 2015.

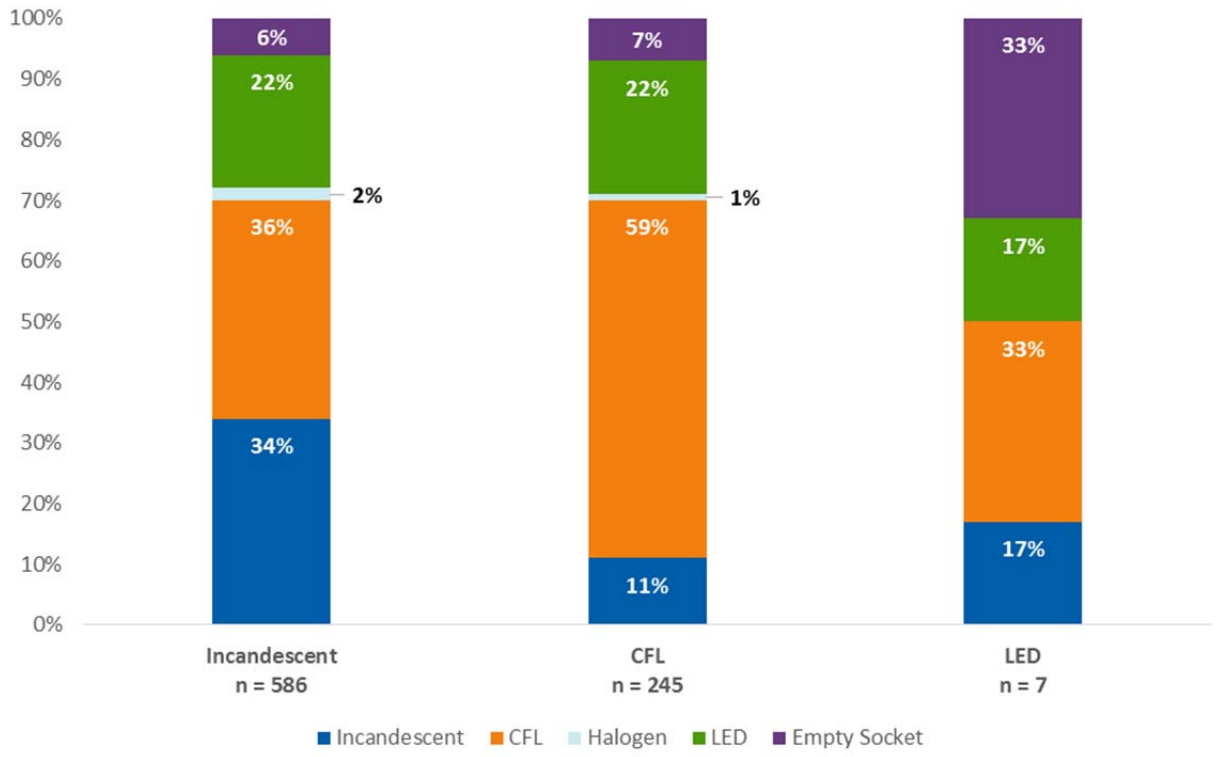
Figure 20 provides an overview of the types of bulbs that replaced incandescent bulbs, CFLs, and LEDs. For example, panelists changed out 586 incandescent bulbs between visits, replacing 34% with another incandescent, 36% with CFLs, and 22% with LEDs. Note that relatively few LEDs (seven) were replaced between 2014 and 2015, but we show the changes for illustrative purposes.[26] The upshot of Figure 20 is that households largely turned to CFLs and LEDs when they needed to replace a bulb, whether that be an incandescent, CFL, or LED. Panelists were not embracing halogens as replacements for incandescents.

Figure 19. Panelists Were Most Likely to Replace Incandescent Bulbs (weighted, 203 households, 941 sockets)



[26] LED replacement is something the Team will continue to monitor; it may increase as LEDs become more common.

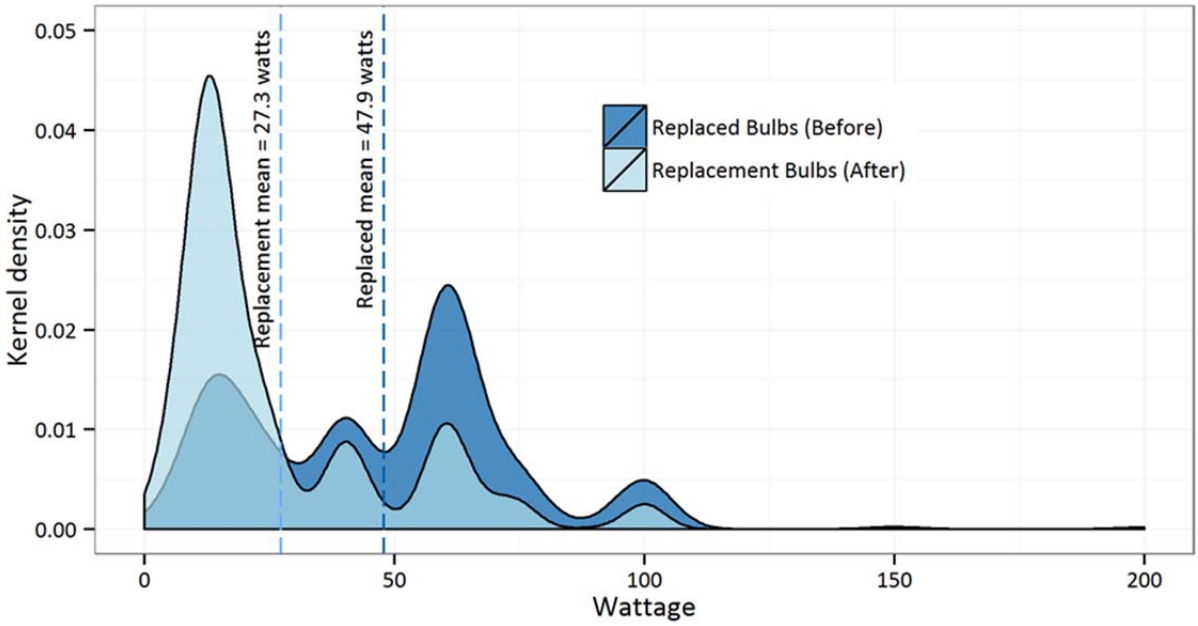
Figure 20. CFLs Most Commonly Chosen to Replace Incandescent Bulbs and CFLs (weighted, 203 households, 941 sockets)



Changes in Average Bulb Wattage Over Time

As households replace incandescent and other inefficient bulbs with CFLs and LEDs, the average wattage of bulbs installed in homes will decrease. This decrease will likely reduce the percentage of residential electricity use accounted for by lighting. Panelists changed bulbs in a combined total of 1,554 sockets between 2013 and 2015. Examining the wattage of replaced (before) bulbs and replacement (after) bulbs shows a large drop in the observed wattage in those same sockets. When we look at all bulbs replaced among panel households between 2013 and 2015, the average wattage in those sockets before replacement was 47.9W. After replacement, the average wattage dropped to 27.3W (delta watt of 20.6). Figure 21 provides a graphic overview of the change in the distribution of wattage between 2013 and 2015 for replaced bulbs.

Figure 21. Average Wattage per Bulb Dropped Dramatically Between 2013 and 2015 (unweighted, n = 193, 1,597 sockets)[27,28]



[27] Excludes sockets that were empty either before or after replacement.

[28] Kernel density plots are akin to histograms. They show the distribution of values of a variable, but reduce the distortions that can be introduced by varying the bin widths in a histogram. In this plot, the y-values on the curves represent the probability density for a given wattage. Taking a particular wattage range and calculating the area under the curve for that range would give the probability of finding bulbs of that wattage range.

Hard-to-Reach Customers

The PAs instituted a program change in 2010 meant to increase adoption of energy-efficient lighting among so-called "hard-to-reach" (HTR) households. The program has generally defined the HTR lighting markets as those that serve low-income, ethnic minority, non-English-speaking, and less educated customers. With some slight variations,[29] the program has largely targeted HTR households by increasing the number of supported bulbs sold through the discount or bargain channel (e.g., bargain and liquidation stores, dollar stores), ethnic grocery stores, and charity or community stores (e.g., thrift stores, food banks, and cultural centers). In this section, we summarize findings stemming from investigations into the effectiveness of this strategy.

Supplier Perspectives on the HTR Market

The interviews with residential lighting manufacturers and retailers revealed that these market actors generally agreed with the definition of HTR markets for energy-efficient lighting as currently defined by the PAs. Seventy-eight percent of manufacturers and 80% of retail buyers agreed with this definition.[30] Those who felt that this definition was inadequate most commonly said it should be expanded to include other factors such as age (elderly), geographic location (rural and remote locations), or higher income (when cost is not a major consideration, such households do not take action to save energy).

Lighting manufacturers and retail buyers were also asked their opinions on whether bargain stores and small/ethnic grocery stores offer the best avenues for reaching HTR customers, as this is a strategy that the program currently employs. The large majority (80%) of lighting manufacturers and a majority (60%) of high-level retail buyers felt that these were the best ways to reach HTR customers. In addition, two manufacturers and one high-level retail buyer who agreed with this focus offered suggestions for additional retail channels for targeting HTR lighting customers, such as major chain stores serving low-income demographics. Examples that were mentioned included Walmart, Home Depot, Walgreens, and Rite-Aid, most of which already serve as program partners.

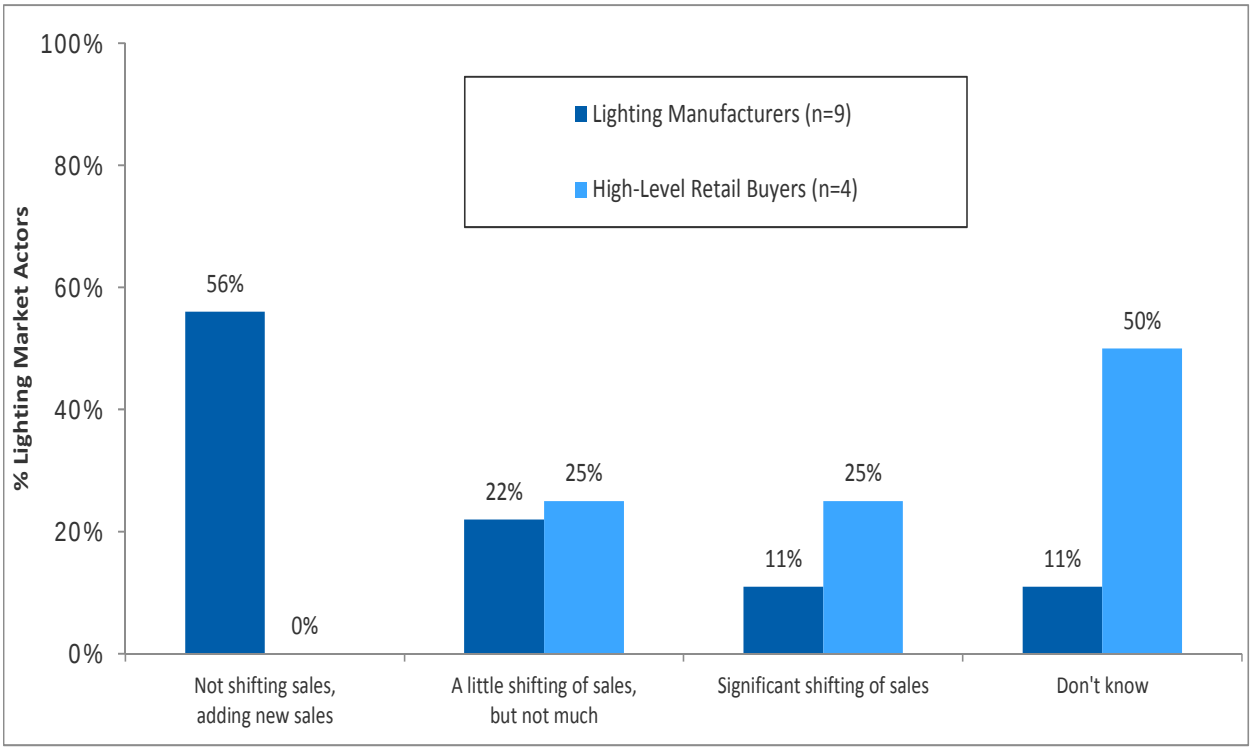
The Team also asked about retail channel shifting; such shifting would occur if consumers who used to buy at home improvement stores instead buy at the bargain and grocery stores which now have the lowest prices. While market share in those stores goes up, very few bulbs would actually reach the targeted HTR consumers. When asked about the potential for retail channel shifting, there was some diversity of opinions among lighting manufacturers and high-level retail buyers. Market actors were asked if they thought these bargain and small grocery stores stimulated new CFL product sales or took

[29] It is the Team's understanding that earlier manifestations also included bulbs sold through more traditional retailers located in zip codes with large numbers of households meeting this definition.

[30] Note that in 2010 and 2012 the previous evaluation team asked a similar question of retail store managers, and similar percentages (82% in 2010 and 78% in 2012) also agreed with the definition. Thus, this indicator shows stability over time and among different types of suppliers.

CFL sales otherwise achieved by national chain retailers. Figure 22 shows that a slight majority of lighting manufacturers said shifting of sales did not occur. About one-quarter of lighting manufacturers and high-level buyers said a little shifting of sales had occurred, but not much. Only one lighting manufacturer and one high-level buyer cited a significant shift in sales.

Figure 22. Mixed Views among Lighting Manufacturers and High-Level Retail Buyers about whether the Program was Creating New Sales or Shifting Sales from National Chain Retailers



Base: Manufacturers and high-level buyers providing responses.

Socket Saturation among Low-Income Households

The on-site saturation study also provided some insights into lighting use and purchases among the low-income subgroup of the HTR customer base.[31] We defined low-income households as designated by their eligibility for each state's Low Income Heating Energy Assistance Program (LIHEAP). It is important to recall that prior lighting studies have shown that low-income households tend to have higher saturation rates than non-low-income households.[32] This largely reflects the smaller home size—and

[31] The on-site saturation study sample size is too small to garner adequate numbers of households of other subgroups in the diverse HTR customer population.

[32] NMR, KEMA, Cadmus, Tetra Tech. 2011. *Massachusetts ENERGY STAR Lighting Program 2010 Annual Report: Volume 1*. Available at: http://ma-eeac.org/wordpress/wp-content/uploads/2010-Annual-Report-Volume-1-Final-Report.pdf.

therefore fewer sockets—in these homes; they can achieve greater saturation with fewer installations of energy efficient bulbs.

Table 3 shows some indication that efforts to increase CFL adoption in so-called HTR households through the upstream lighting and low-income direct-install programs (single-family and multifamily) have been successful. More specifically, CFL saturation rates in low-income households increased by 12% between 2013 (27%) and 2014 (39%) and then again by 3% in 2015 (to 42%); saturation in non-low income households did not change greatly during the same period. Saturation of LEDs increased from less than 1% to 4% in low-income households over the past year, compared to a similar increase in terms of percentage points of 2% to 6% among non-low-income households. Together, saturation of all energy-efficient bulb types in low-income homes was 54% compared to 43% for non-low-income households. Finally, low-income CFL saturation rates were much higher in Massachusetts than in the comparison areas in nearly every year examined.

Table 3. Comparison of Saturation Rates between Low-Income and Other Households

Sockets Containing	Massachusetts						Georgia		Kansas		New York			
	2013		2014*		2015		2014		2014		2013		2015	
	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI
Sample Size	*47*	*103*	*82*	*166*	*102*	*222*	*32*	*46*	*20*	*47*	*56*	*71*	*24*	*67*
Total Sockets	**1,568**	**5,014**	**2,900**	**9,137**	**4,639**	**12,000**	**1,358**	**2,694**	**822**	**3,141**	**1,778**	**4,403**	**752**	**5,054**
Incandescent	56%	55%	40%	47%**	36%	46%**	62%	67%**	53%	50%	43%	56%	50%	51%
CFLs	27%	28%	39%	31%**	42%	28%**	23%	17%**	24%	31%**	29%	25%	23%	20%
Fluorescent	12%	8%**	9%	9%	8%	9%	6%	7%	12%	5%**	15%	10%	11%	13%
Halogen	3%	5%**	3%	8%**	3%	8%**	5%	6%	2%	7%**	3%	5%	3%	9%
LEDs	<1%	2%**	3%	3%	4%	6%	2%	2%	2%	3%**	2%	1%	2%	3%
Other[δ]	2%	2%	6%	3%	6%	3%	3%	2%**	7%	5%**	8%	4%	11%	4%
Any specialty bulb	32%	41%**	36%	43%**	34%	44%**	35%	41%**	20%	31%**	27%	43%**	16%	40%**
Any specialty CFL	5%	9%**	13%	11%**	13%	9%	4%	3%	3%	3%	5%	6%	2%	5%
Any specialty CFL (not including A-line CFLs)	4%	7%**	11%	9%**	11%	7%	1%	3%**	3%	3%	4%	5%	2%	4%

Base: All sockets found in homes

*13 DK/Refused income responses removed in MA 2014; 30 DK/Refused removed in MA 2015; 10 DK/Refused removed in NY 2015;

**Significantly different from Low Income at the 90% confidence level.

δ Other includes sodium bulbs, xenon bulbs, unknown bulb types, empty sockets, etc.

Bulb Purchases among Low-Income Households

The Team also examined bulb purchases among low-income households. In 2013, low-income households reported buying an average of 3.4 CFLs and LEDs compared to an average of 3.0 for non-low-income households. In 2014, low-income households bought an average of 3.7 CFLs and LEDs compared to an average of 3.5 for non-low-income households. In 2015, low-income households reported buying an average of 2.0 CFLs and LEDs compared to an average of 4.6 for non-low-income households (

Table 4).[33] In contrast to Massachusetts, low-income households in New York bought far fewer bulbs than non-low-income households in that comparison state. The data from Kansas and Georgia are also indicative of wider disparities between purchases among low-income and non-low-income households, but the sample sizes limited our ability to draw statistically significant conclusions.

[33] It is important to note a number of limitations in the data for 2015, including small sample sizes for non-low income households, which was made smaller by a relatively high number of respondents who opted out of these questions by stating that they "don't know" or refused the survey items. Because the sample sizes are small and variable across years, these results should be interpreted with caution.

Table 4. Low-income Households in Massachusetts Bought Significantly Fewer CFLs and LEDs than Other Households

Sockets Containing	Massachusetts						Georgia		Kansas		New York			
	2013		2014*		2015*		2014		2014		2013		2015*	
	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI	LI	NLI
Means by Total Sample Size (All on-site households)														
Sample Size	*47*	*103*	*82*	*166*	*39*	*95*	*32*	*46*	*20*	*47*	*56*	*71*	*24*	*67*
Total Bulbs Purchased	**3.4**	**3.0**	**3.7**	**3.5**	**2.0**	**4.6****	**2.0**	**3.8**	**2.9**	**5.2**	**3.2**	**7.5****	**2.5**	**7.1****
CFLs	3.3	2.8	3.5	2.8**	1.9	2.7	2.0	3.2	2.8	4.6	3.0	7.0**	2.2	5.7**
LEDs	0.1	0.3	0.1	0.7	0.1	1.9**	0.0	0.6	0.0	0.6	0.1	0.6**	0.3	1.4
Means by Sample Size of Households that Purchased CFLs or LEDs in Past Year														
Sample Size that purchased bulbs in past year	*18*	*39*	*38*	*107*	*9*	*52*	*9*	*19*	*11*	*23*	*26*	*47*	*10*	*36*
Total Bulbs Purchased	**8.1**	**8.1**	**7.9**	**5.4****	**8.7**	**8.9**	**7.2**	**9.2**	**5.2**	**10.5**	**6.8**	**11.4****	**6.1**	**13.2****
CFLs	7.9	7.3	7.6	4.3**	8.1	5.2**	7.2	7.8	5.2	9.4	6.5	10.5**	5.3	10.7**
LEDs	0.3	0.8	0.3	1.2**	0.6	3.7**	0.0	1.5	0.1	1.2**	0.3	0.9**	0.8	2.6**

*In MA 2014, 10 DK/Refused income purchased 63 CFLs and 25 LEDs for a total of 88 bulbs in the past year (unweighted); in MA 2015, 17 DK/Refused income purchased 26 CFLs and 42 LEDs for a total of 68 bulbs in the past year (unweighted); in NY 2015, 10 DK/Refused income purchased 74 CFLs and 1 LED for a total of 74 bulbs in the past year (unweighted).

**Significantly different from Low Income at the 90% confidence level.

Conclusions and Recommendations

The research performed for the Lighting Market Assessment and Saturation Stagnation studies points to the following key takeaway messages. This section draws on findings throughout the report rather than tying them to any specific section. Most of the recommendations and considerations are new to this overall report; we have only repeated those from individual research tasks if we felt they contributed to understanding the entirety of the Residential Lighting Market.

Market for LEDs

All indicators point to a strong and growing market for LEDs. Although LED market share (as indicated by the POS data and self-reported purchases) remains quite small compared to other common bulb types, the share has been expanding rapidly since the introduction of general service, omnidirectional LEDs around 2010. An increasing proportion of households use LEDs (about one in four in Massachusetts in 2014), and the percentage of sockets in which customers have installed LEDs continues to grow (6% in Massachusetts in 2015). Suppliers report that the market for LEDs is strong but believe that price still remains a barrier to many consumers; as such, the suppliers call for continued—and sometimes increased—incentives to assist transformation of this market. Of course, the Massachusetts program must balance providing deeper incentives to boost consumer adoption with the cost effectiveness of doing so, particularly in light of decreased delta Watts brought about by EISA and the introduction of general service halogens.

- ***Recommendation 1***: The PAs should continue to provide incentives and educate consumers about LEDs in the next program cycle. At the same time, however, the PAs will have to pay careful attention to any new information available from future evaluations or other sources regarding delta Watts, measure life, price trends, and incremental costs and be ready to shift LED strategy if providing incentives ceases to be cost effective.

- ***Consideration 1****:* (From Task 3: On-site Saturation Visits) The PAs should consider revisions to program design to encourage the purchase of multiple LEDs in one shopping trip. Penetration of LEDs has been increasing rapidly, more than tripling since 2012, and saturation has doubled since 2014. LEDs, unlike CFLs, are predominantly sold in single-bulb packages. While there is certainly a role for single-bulb incentives, multi-bulb incentives may leverage increases in penetration by pushing consumers toward buying multiple LEDs in one trip.

- ***Consideration 2*****:** (From Task 3: On-site Saturation Visits) The PAs should consider commissioning a study to assess the direct connection between program activity (such as marketing and incentives) and increased awareness and adoption of LEDs.

- ***Consideration 3***: The PAs may want to shift incentives for specialty applications—particularly dimmable ones—from CFLs to LEDs, as most consumers hold that LEDs dim better than CFLs and have a superior light quality. In addition, the PAs may want to consider increasing promotions of

controls that work with low-wattage bulbs in order to improve dimmability even for LEDs. The Team offers this as a consideration rather than a recommendation because it believes the jury is still out on whether LEDs truly dim better and have superior light quality than CFLs. Additional research (of the literature and product testing review type) may be needed before the PAs take action.

Market for CFLs

The current market for CFLs appears strong, but the future of this technology—and the need for the program to support it—remains less clear. Currently, most households in Massachusetts use CFLs (96%), and about 32% of sockets are filled with CFLs. In fact, the saturation rate in 2014 and 2015 deviated from what appeared to be stagnation in saturation between 2009 and 2013, when the percentage of sockets filled with CFLs increased from only 26% to 28%. The year 2014 also saw the implementation of the 60W incandescent bulb phase-out; strong non-incented sales of CFLs coupled with this phase-out lead some people to conclude that the time was ripe to discontinue support for standard CFLs. Other evidence, however, suggests that such a conclusion may be premature. Specifically, CFL market share in California plummeted between 2012 and 2013 (from 25% to 19% based on the POS data set) when the state simultaneously implemented the 60W incandescent phase-out (a year ahead of the rest of the nation) and removed incentives for standard CFLs. Concurrently, halogen market share jumped from 4% to 15% from 2012 to 2013 based on POS data, suggesting that consumers—faced with increasing CFL prices and dwindling incandescent stock—"backslid" to halogen bulbs, depriving the state of energy savings that perhaps could have been achieved had incentives continued.[34] California will not finalize new saturation numbers for some time, but findings from the Massachusetts on-sites in 2015 indicate an end to CFL saturation stagnation experienced in prior years. Results from the on-site visits in New York reveal a slight drop in CFL saturation compared to 2013, which may point to a reversal stemming from the cessation of programs in that area.

- ***Consideration 4:*** Based on the current state of the market, it is clear there is still a role for standard CFLs. To this end, the PAs should continue to support standard CFLs. At the same time, the PAs should carefully monitor the market and consider adjusting course as needed. As stated above, changes in support for CFLs must simultaneously take into account rapid changes in the LED market and related program support for these bulbs.

Consumer Shift to Energy-efficient Bulbs—the Good and the Bad

As mentioned above, most consumers use CFLs and many use LEDs; households are installing these bulbs in an increasing number of sockets. Together, LEDs, CFLs, and tube fluorescents fill 47% of sockets in Massachusetts homes, and incandescents filled fewer than 50% of sockets. Additionally, the on-site panel study made clear that households tend to replace inefficient bulb types with CFLs and LEDs,

[34] LED market share remained less than 1%.

meaning that saturation will only continue to increase over time. While helping consumers to save energy and reduce demand, the shift to efficient bulbs does create a long-term challenge. Consumers have also been replacing efficient bulbs with other efficient bulbs (either CFLs or LEDs) when the efficient bulbs burn out, which partly explains the socket stagnation over the past few years. This efficient-bulb-to-efficient-bulb replacement means that the delta Watts—the difference between the previous and the new bulb wattage that factors into energy savings—will dwindle. Additionally, the increased energy efficiency standards of EISA 2020 (if in fact implemented) will make CFLs the new baseline bulb unless manufacturers introduce improved or new technologies that meet the standards. This has two effects on energy-savings and cost effectiveness calculations. First, the measure life of CFLs is about seven years. This means that a CFL sold in 2015 has an effective measure life of only five or six[35] years from an energy-savings standpoint—and that goes down each year as we approach 2020. In addition, the new, post-2020 delta Watts will be very small, essentially equivalent to the difference in wattage between CFLs and LEDs. These two factors will greatly strain the ability of CFLs and LEDs to meet cost-effectiveness tests for continued inclusion among residential program offerings. Finally, although opinions differ on whether T12 linear fluorescent lamps should be considered "efficient" given that more efficient models exist, the DOE's GSFL Rulemaking also sets efficiency standards for tube fluorescents, which will mean that many current T12 lamps will need to be retrofitted to linear LEDs, T8s, or T5s.

- ***Recommendation 2:*** (From Task 3: On-site Saturation Visits) The PAs and EEAC consultants should continue to fund regular on-site saturation studies—including the continued *annual* panel study—at least through the early 2020s in order to track the impact of EISA, changes in LED pricing and availability, and *possible* changes in whether and to what extent the program should incentivize standard and specialty CFLs and LEDs. Additionally, the PAs should work with the Team to develop a methodology for identifying the diameter and length of fluorescent tubes in use in homes as these bulbs are subject to increased efficiency standards through the DOE GSFL Rulemaking. Recognizing the expense of these efforts, the timing and depth of the *new on-site visits* could potentially deviate from those performed annually by the Team since 2009, but the Team stresses that annual visits are ideal for a panel study (or panelists lose interest, move, or otherwise become unavailable, resulting in more of them dropping out of the study) and ideal for new on-sites (especially as replacement panelists come from new on-site visits).

- ***Consideration 5:*** (From Task 3: On-site Saturation Visits) The PAs may want to consider a bulb buy-back program to persuade people to change out inefficient bulbs before they burn out and fill them with CFLs or LEDs (as evidenced by the high rate of incandescent-to-CFL and -LED conversion found in the panel study). The execution of such a program would require careful

[35] Depending on how long halogens continue to be available after 2020.

planning, but a presentation at the Northeast Energy Efficiency Partnership's Lighting Summit in October 2014 discussed the success of a similar program in Connecticut.

- ***Consideration 6:*** Some energy-efficiency experts argue that T12 linear fluorescent tubes are an "efficient" bulb type in residential settings, and that retrofits normally are not cost effective given low hours of use. However, the DOE's GSFL Rulemaking increases efficiency standards for fluorescent tubes and ballasts and because such bulbs and associated fixtures are commonplace among residential homes, the Team believes the PAs should consider program designs that help consumers identify the best way to replace T12 lamps, ballasts, and/or fixtures.

Hard-to-reach Customers

The evaluation activities provide mixed results about the program's impact on HTR customers. Saturation rates among low-income households increased a great deal between 2013 and 2015—far more than among other households during the same time period. LED and CFL bulb purchases for low income households were significantly lower than non-low-income households. Low-income households reported purchasing about 2.0 CFLs on average in the past year, compared to 4.6 for other households. Their rates of LED purchase were also lower – 0.1 LED per low-income household versus 1.9 per non-low-income household.

Suppliers generally agreed with the PAs' definition of HTR households to include low-income, ethnic, non-English-speaking, and less educated customers. Most also agreed with the PAs' strategy of reaching such customers through increased program activity in discount/bargain stores, ethnic grocery stores, and charity or community stores. However, other commentators pointed out HTR households often shop at the same stores as other customers.

The evaluation provided very little information about HTR households that belong to racial, ethnic, or linguistic minority groups or that have lower education levels. The evaluation design attempts to describe the entire market, with the HTR interest as just one objective. Targeting the various minority groups in large enough numbers to draw conclusions does not align with the other objectives of the study or its selected methodologies and budget. Therefore, the PAs and EEAC consultants may want to consider alternative research designs to target such households.

- ***Consideration 7:*** (From Task 3: On-site Saturation Visits) The PAs may wish to consider directly studying use and purchase behavior among HTR households. This would then inform the discussion of whether the current upstream model or a revised or different program design would be best able to achieve remaining potential in such households and increase their adoption of LEDs. To provide information on a wider range of households that are considered HTR, the study should be designed specifically to capture underrepresented households, likely working with organizations, community groups, and recognized community leaders to spark interest and gain trust in the study.

Appendix A: Summary of Tasks

The Team completed six tasks for the Market Assessment and Saturation Stagnation studies that contributed to the findings reported in this document. This appendix provides a brief summary of each of those tasks.

Consumer Surveys

The consumer survey allowed the Team to explore issues such as awareness of and familiarity and satisfaction with CFLs and LEDs as well as reactions to EISA legislation. Massachusetts has conducted lighting consumer surveys addressing at least some of these topics since the late 1990s, yielding what is arguably the richest dataset tracking lighting market indicators over time.

The 2014 survey effort survey also afforded the opportunity to conduct two methodological experiments by offering about one-half of the sample the opportunity to answer via an internet survey and by offering the other half a pre-paid $5 incentive delivered with an advance letter. In total, 940 households responded to the survey, with 731 actually responding by phone and 209 via the internet survey. In 2014, the Team also fielded comparison area, random-digit-dial, telephone surveys in Eastern Kansas and in Georgia, with 526 respondents in Georgia (7% response rate) and 556 in Kansas (9% response rate). The Team used all three surveys (Massachusetts, Kansas, and Georgia) to recruit households for the 2014 on-site saturation visits.

In 2015, the Team completed 778 consumer surveys in Massachusetts and 398 surveys in Upstate New York.[36] Three hundred Massachusetts households responded via a web version of the survey, while the remaining 478 Massachusetts households completed via telephone. All New York households responded via telephone, and for the sake of comparability, the Team limits all consumer survey comparisons of Massachusetts and New York to these phone respondents.

On-site Saturation and Panel Study Visits

The Team conducted on-site visits to assess lighting socket saturation, to understand patterns of lighting use, storage, and purchase behavior, and to search for evidence of EISA-related stockpiling of incandescent bulbs. Similar to the lighting consumer surveys, the Massachusetts PAs and EEAC consultants have been tracking many of these indicators since the late 1990s.

In 2014, the Team visited 150 homes in Massachusetts, 78 in Georgia, and 67 in Eastern Kansas that had been identified through the consumer surveys. An additional 111 homes took part in a panel study; these homes were first visited as part of an on-site saturation and hours-of-use study in 2013. The Team

[36] The On-site Visit and Consumer Survey Results (delivered under separate cover) provides greater detail on methodological differences between the 2014 and 2015 surveys, including the use of the pre-paid incentive, the use of a mixed-mode survey, and changes in the structure of questions regarding CFL and LED familiarity.

went back to their homes to understand how their saturation had changed over the past year and to see what types of bulbs they used to replace ones that burned out or were removed.

The 2015 on-sites included 354 homes in Massachusetts and 101 homes in New York. The Massachusetts visits comprised 151 first-time (new) visits as well as 203 panel visits; 89 homes from the panel were previously visited in both 2013 and 2014 and 114 homes were previously visited in 2014 only. All of the on-sites in New York were first-time visits.

Shelf Stocking Study

The Team worked with implementation contractor Lockheed Martin to perform a shelf-stocking study in the fall of 2013. The study included currently participating (n=100) and formerly participating (n=30) stores. The Team and Lockheed Martin collected data on the amount of shelf-space devoted to different types of light bulbs (CFL, LEDs, halogen, incandescent, and other bulb types), the number of bulb packages, and the number of bulbs of each type. The effort also examined the prices of bulbs and estimated the price differential between program-supported and non-supported standard and specialty CFLs and A-line and reflector LEDS.

Supplier Interviews

Supplier interviews provided the opportunity to learn how partnering manufacturers, high-level buyers, and store managers familiar with lighting viewed the current lighting market and the program's impact on it. Specifically, the Team performed in-depth interviews with 15 manufacturers and 5 buyers as well as computer-assisted telephone surveys with 224 store or lighting-department managers. They answered questions on a wide-range of topics including, but not limited to, the impact of EISA on sales of various bulb types, the impact of program activity on sales of various bulb types, expectations for future sales and price trends, the effectiveness of program strategies to increase sales among hard-to-reach customers, and satisfaction with various elements of the program. The questionnaire also addressed net-to-gross and market lift, as discussed under separate cover.

Saturation Trend Comparison

In an effort to understand trends in saturation in Massachusetts, the Team compared program and evaluation design and results among Massachusetts, New York, and California. The Team accomplished this through review of program reports and saturation data from New York and California and in-depth interviews with 17 individuals associated with investor-owned utility lighting programs in California or who worked for the California Public Utilities Commission. The Team selected these two states based on their saturation rates: New York's rate was just below that in Massachusetts and also showed signs of stagnating, while California had seen a boost in saturation over the same time period—. New York had ceased offering standard CFL incentives in 2012 while California continued offering incentives through 2012 but had focused their efforts on largely on grocery, drug store, and bargain channels. California ceased offering incentives for standard CFLs in 2013, a point addressed in the study, although vetted saturation data are not yet available for that year.

Point-of-Sale Data Analysis

The Team examined data obtained from LightTracker Inc., an initiative of CREED to assess trends in light bulb sales, prices, and market share for California, Connecticut, Kansas, Georgia, Massachusetts, and New York. This examination made clear that program activity could not solely explain these trends, so the Team then used data from all 44 states in the LightTracker dataset to create statistical models meant to explain the effect of program activity on market share, controlling for other demographic and economic factors.

Appendix B: Firms who Performed Saturation Studies Over Time

The table below shows which firm performed saturation studies over time in Massachusetts and numerous comparison areas. They show that differences in saturation cannot be explained by which firm collected the data. When available, the table reports confidence intervals in parentheses. These estimates rely on methods that take the clustered nature of sockets into account. That is, each house in the sample is a "cluster." The household residents do not randomly decide which bulb type to install in each socket, but instead their preferences and biases affect all sockets in the home, therefore violating assumptions of statistical independence. Our analysis adjusts for this "clustered" nature of the data.

Table 5. No Pattern in Saturation by Firm Performing the Study*

State	2003	2004	2005	2006	2007	2009	2010	2012	2013	2014	2015
MA	7%	9%	11%		21%	26% (22%, 30%)	26% (22%, 30%)	27% (24%, 30%)	28% (24%, 32%)	33% (29%, 37%)	32% (29%, 35%)
	ODC	ODC	RLW		RLW	KEMA	KEMA	DNV-KEMA	DNV GL	NMR	NMR
GA						16% (13%, 19%)				19% (16%, 22%)	
						Cadmus				NMR	
KS						21% (17%, 25%)	19% (15%, 23%)			29% (25%, 33%)	
						Cadmus	Cadmus			Navigant	
CA - IOUs				10%		22%		30%			
				Itron		Cadmus		DNV-KEMA			
Upstate NY						19% (17%, 21%)	24% (22%, 26%)		25% (20%, 30%)		22% (18%, 26%)
						Apprise	Apprise		NMR		NMR
Downstate NY						21% (18%, 24%)	31% (28%, 34%)		29% (25%, 33%)		
						Apprise	Apprise		NMR		
CT						24% (20%, 26%)		26% (22%, 30%)	32% (27%, 37%)		
						KEMA		NMR	NMR		

Base: All sockets found in on-site homes (empty sockets treated differently by firm, but with little impact on saturation estimates)
* Note that no estimates exist for 2008 and 2011