Results of the Massachusetts Onsite Compact Fluorescent Lamp Surveys

FINAL

10/23/2012

Submitted to:

Cape Light Compact

NSTAR

National Grid

Unitil

Western Massachusetts Electric

Energy Efficiency Advisory Council Consultants

Submitted by:

NMR Group, Inc.

50-2 Howard Street, Somerville, MA 02144
Phone: (617) 284-6230 Fax: (617) 284-6239
www.nmrgroupinc.com

Contents

List of Tables

List of Figures

Executive Summary

This report presents the findings of research conducted to understand use, saturation, and purchases of lighting products in Massachusetts households in support of the Massachusetts ENERGY STAR® Lighting Program (the Program). The study also sought to understand baseline conditions early in the implementation of the Energy Independence and Security Act (EISA) of 2007 and search for possible impacts on lighting use and purchase behavior that may be the result of the new lighting standards.

Background and Methodology

To conduct this research, the team performed 150 onsite lighting inventories in Massachusetts households between January and April 2012. The onsite respondents were recruited through a prior telephone survey among 582 households in Massachusetts in 2011. We summarized the results of the telephone survey in a previous report,[1] but touched on pertinent findings here that inform our understanding of residential lighting and the potential impacts of EISA.[2]

The onsite survey data (and the telephone survey data) were weighted to reflect the population proportions for home ownership and education in Massachusetts based on the American Community Survey (ACS).

Summary of Findings

In this section, we present a summary of key findings from the onsites, and compare them to results from previous onsite inventories or the recent telephone survey where appropriate.

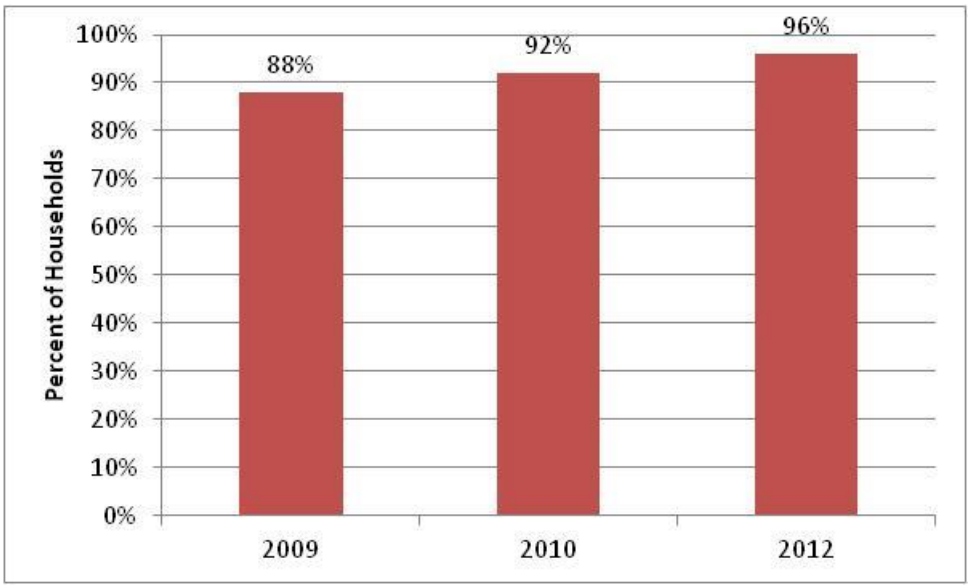
[1] NMR, *Massachusetts Consumer Survey Results*. Delivered to the Massachusetts Program Administrators on April 16, 2012. Appendix A compares the responses of the onsite subsample to all telephone survey respondents on key indicators of CFL awareness, familiarity, and use as well as demographic indicators in an effort to identify potential sources of bias.

[2] Appendix A also compares the onsite sample to the full telephone survey sample on key lighting indicators and demographic factors in order to assess potential sources of bias. For the most part, the onsite sample resembled the telephone survey sample, although they were somewhat more familiar with efficient lighting technologies and self-reported using them more, but we found no other systematic differences between the two groups.

CFL Use and Storage

The analysis of telephone survey results suggested that fewer households in 2012 (onsite visits conducted in January through April) compared to 2009 (July and August) and 2010 (June through September) reported currently using—or ever using—compact fluorescent lamps (CFLs),[3] raising concerns that CFL use had declined. However, the actual onsite inventories conducted in 2012, which relied on a trained technician counting the number and types of bulbs in use, showed that the percentage of households actually utilizing at least one CFL has steadily increased, from 88% in 2009 to 96% in 2012 (Figure ES-1). This lends further credence to the argument made in the earlier telephone consumer survey report that changing opinions about CFLs altered telephone survey responses about use of the products, which may or may not be in line with actual behavior.

Figure ES-1: CFL Penetration 2009 through 2012*



* Source: 2009 to 2012 onsite surveys

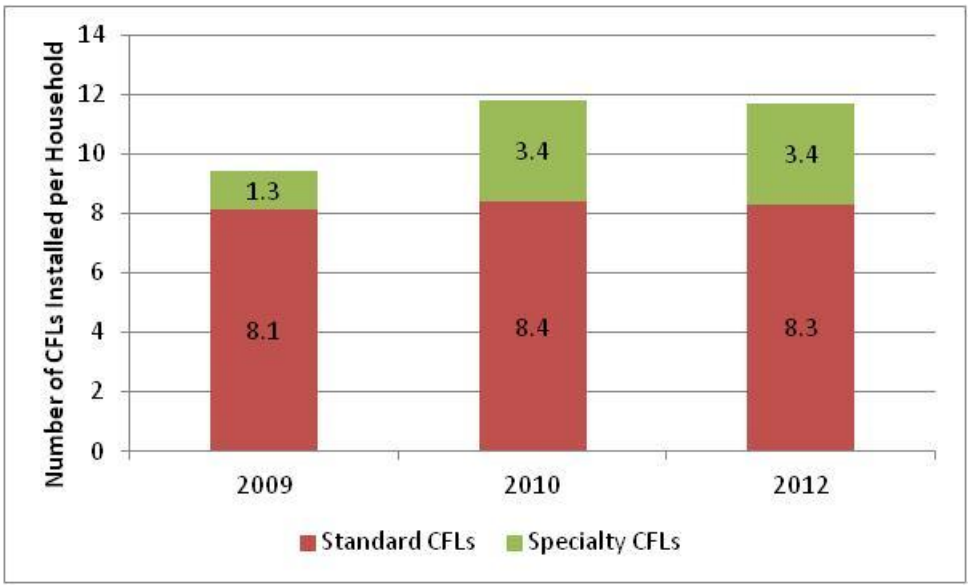
The actual number of CFLs in use in homes has increased over the past three years. In 2009, 53% of households used six or more CFLs, and in 2010, 61% of homes did. In 2012, 65% of homes used six or more CFLs. Further, the increase in use of *specialty* CFLs has been even more pronounced. While only 25% of households in 2009 used specialty CFLs, this number increased to 57% in 2010 and remained steady at 58% in 2012.[4] The number of households utilizing large numbers of specialty bulbs has also increased: only 10% of households used six or more specialty bulbs in 2009 compared to 19% in 2010 and 22% in 2012.

[3] NMR, *Massachusetts Consumer Survey Results*, 2012.

[4] Specialty CFLs identified include: dimmable, three-way, A-shaped, flood/spot, candelabra, circline, globe, tubes/bent tubes, and bullet/torpedo CFLs.

An investigation of the average number of CFLs in homes revealed gains from 2009 to 2010 and fairly steady numbers from 2010 to 2012. The average household used 9.4 CFLs in 2009, increasing to 11.7 in 2010 and 11.6 in 2012 (the median increased from seven to nine between 2010 and 2012). Specialty bulbs primarily account for the one-time gain in the average number of CFLs in use, coinciding with the start of the PAs' increased support of specialty CFLs in 2009.

Figure ES-2: CFL Use over Time*



* Source: 2009 to 2012 onsite surveys

Fewer than 40% of households stored at least one CFL in 2010 and 2012 compared with 28% of households in 2009. The average number of CFLs in storage was 1.6 in 2012 compared to 1.4 in 2009 and 2.5 in 2010. Of those households that stored CFLs, most stored one to five CFLs; only 13% of all households in 2012 stored six or more CFLs.

LED Use and Storage

Only 7% of onsite households used LEDs at the time of the onsite, and they collectively used 92 LEDs. Most of these LEDs did not have the A-shaped profile and were instead used as track or under cabinet lighting. One household accounted for 29 of the LEDs, and the mean number of LEDs was 0.6 for all households. Only two LEDs were found in storage.

Socket Saturations

CFL socket saturation has remained very stable over the past three years, standing at 26% in both 2009 and 2010 and 27% in 2012; note that these results are not statistically different from each other. However, the NMR analyses also revealed that households taking part in the onsite visits tended to be slightly larger than the average home in Massachusetts. As smaller homes have higher saturation rates, we believe that the saturation rate in the state likely falls closer to 30%, as explained more fully in the body of the report. Only one percent of the sockets are filled with

an LED, and most of these are track or under cabinet lights that do not have the A-shaped profile. These numbers lead to an overall efficient lighting saturation of 28% if considering only CFLs and LEDS, and 36% if also including regular fluorescent bulbs—again noting that the values could be higher due to the slightly greater than average size of the homes included in the onsite study.

An additional analysis of saturation by household (as opposed to all sockets in the state) demonstrates that CFL use is less bifurcated than before—that is, previously, a few households used a lot of CFLs and many households used none or only a few. Between 2010 and 2012, in contrast, moderate CFL use in the range of 21% to 50% of sockets became more common across households.

This still begs the question, "Where have all the program CFLs gone?" As discussed below in this Executive Summary and in more detail in the main body of the report in Section 2, Section 3, and Appendix B, we hypothesize—and provide empirical evidence to support this hypothesis—that newly purchased CFLs replacing other CFLs may account for many, if not most, of the "missing" CFLs. Put another way, when a CFL burns out, many consumers appear to be replacing that CFL with another CFL, thereby preventing a decrease in saturation if consumers had instead opted for another type of bulb. In addition, the number of sockets has increased in homes overall in proportion to the number of CFLs added; therefore, while there are *more* CFLs in homes, they have been installed in similar percentages to their saturation rate in the sockets that were already in homes. Other possibilities not supported by empirical evidence include sales to the commercial sector, leakage to other states, and CFLs that have been returned to the store or discarded. In any case, additional research will be needed to determine with greater certainty what has happened to program CFLs purchased between 2009 and 2012. Despite the need for additional research to understand where the CFLs have gone, the results of the past three onsite studies suggest that consumers remain reluctant to install CFLs in the majority of applications in their homes. Overcoming this barrier will require increasing consumer satisfaction with energy-efficient lighting (including CFLs, LEDs, and regular fluorescent bulbs) in the post-EISA period, and possibly a change in program strategy.

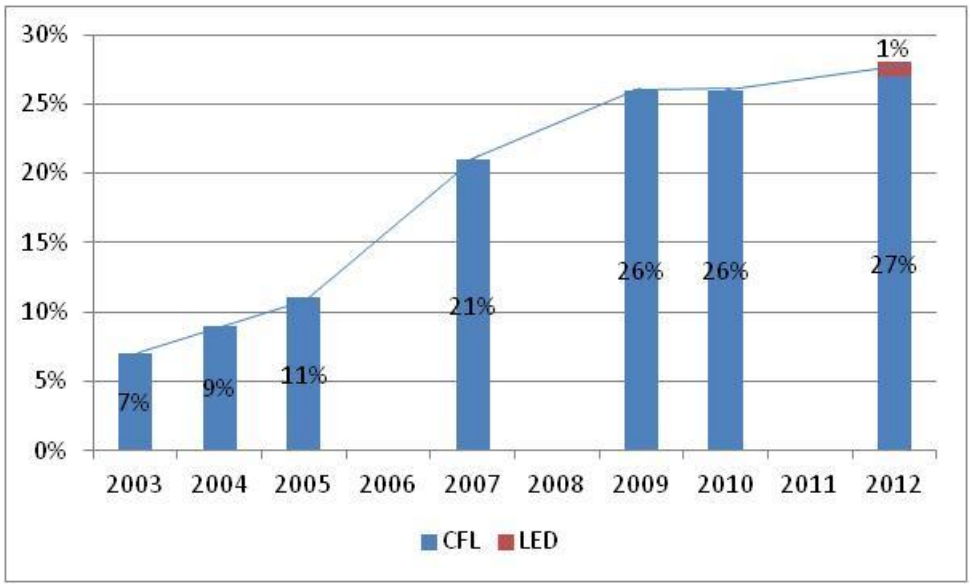
The percentage of sockets filled with incandescent bulbs decreased between 2009 and 2012 (62% to 53%) and was offset primarily by increases in regular fluorescent tubes (6% to 8%) and halogen bulbs (5% to 11%) rather than CFLs. Saturations of specialty bulbs of any type changed little from 2009 to 2010 (30% to 31%) but increased to 48% in 2012 due to large increases in the number of incandescent candelabra and flood-shaped bulbs counted in homes in 2012.

If each incandescent and halogen bulb were converted to a CFL, approximately 64% of sockets in the 2012 sample could be converted to screw-in CFLs or LEDs. Specialty sockets (based on non-A-line bulb shape as well as fixture controls) account for 60% of the potential (or 38% of all potential sockets in the home). In particular, utility/laundry rooms, garages, dining rooms, and home exteriors showed the lowest CFL saturation in 2012, and thereby the highest potential for CFL adoption. The actual potential for CFLs and LEDs is likely less than 64%, however, as

fixture shape, the nature of various applications, and the preferences of householders will limit the number of sockets that will be converted to CFLs or LEDs.

As we first reported in the 2010 annual report, it appears that socket saturation continues to resemble the "S" curve of adoption suggested by Rogers (2003) by showing a relatively low adoption rate in earlier years (2003 to 2005), a period of rapid adoption (2005 to 2009), and then a gradual decrease in the adoption rate (2009 to 2012) (Figure ES-3).[5] The advent of EISA, of course, could alter this trend. Note that we have added LED saturation to the figure for 2012; prior to that year, LED saturation was below one percent. We will continue to monitor the trend in CFL and LED saturation in the 2013 onsite analysis.

Figure ES-3: CFL and LED Socket Saturation 2003 through 2012*



* Source: 2007 MPER and 2009 to 2012 onsite surveys. Data not available for 2006, 2008, or 2011.

CFL and LED Purchases

The 2012 onsite survey asked respondents when they had bought any of the CFLs found installed or stored in their homes.[6] Approximately one out of three onsite respondents (30%) recalled purchasing one or more of the CFLs found in their homes in 2011, while only 9% of respondents purchased them in early 2012 (i.e., between January 1 and the time of the onsite). Respondents buying CFLs in 2011 and 2012 usually purchased 15 or fewer bulbs. Most of the CFLs purchased in both time periods were standard CFLs; only 15% of households bought specialty CFLs in 2011 and only 5% did so in 2012; these households usually bought five or fewer specialty bulbs. On average, the onsite respondents recalled purchasing 2.9 CFLs in 2011 and 0.6

[5] Rogers, E.M. (2003) *Diffusion of Innovations*. (Fifth Edition). Free Press: New York.

[6] Due to concerns about the reliability of self-reported purchases, we do not compare the results presented here to those from earlier inventories. The time periods in question overlap, but recall error means the results should not be compared directly. For example, estimates of purchases in the first half of 2010 are available from both the current and 2010 analysis, but the results point to different purchase rates, as would be expected because of recall error.

CFLs in early 2012; this encompasses all households, including those that did not purchase any CFLs. Standard CFLs accounted for 78% of the CFL purchases in 2011 and 69% in 2012.

Only 86 LEDs were purchased by onsite respondents in 2011. In early 2012, only three LEDs were purchased by onsite respondents.

Trends in the number of CFLs found in use or in storage in Massachusetts homes between 2005 and early 2012 were similar to trends in national shipments and estimates of market-level sales; however, trends in program-supported sales diverge from these others, likely reflecting the fact that program sales are determined largely through agreements between the PAs and program partners. When taking market-level sales, stored bulbs, and persistence rates into account, there is evidence that many of the CFLs obtained in 2011 could have been used to replace existing CFLs that burned out. Considering the increase in the number of sockets filled with CFLs and estimates of commercial purchases, the team members believe that our analysis can account for the whereabouts of most of the CFLs obtained not only through PA programs but also in the broader market, although future research will be needed to answer this question definitively.

The PAs have expressed interest in finding out which manufacturers produced the CFLs and LEDs found in onsite homes and where the households purchased these bulbs. General Electric accounted for the largest number of CFLs that respondents reported purchasing in 2011 and early 2012, and Earthmate led the number of specialty CFLs purchased. FEIT Electric was the leading manufacturer of LEDs. Massachusetts onsite respondents purchased about one-half of their CFLs in 2011 (45%) from home improvement stores. Another major source of CFL purchases in 2011 was mass merchandise or discount stores. Onsite households recalled purchasing fewer CFLs at warehouse stores, bargain stores, hardware stores, grocery stores or supermarkets, and drugstores. We did not perform a detailed analysis of the store of purchase for LEDs due to the very low numbers of purchases in 2011 and 2012, but home improvement stores provided the majority of LEDs.

CFL Satisfaction and Use, Saturation, and Purchase Rates

The 2011 telephone survey results demonstrated a persistent decrease in satisfaction with CFLs between 2009 and 2011; 55% of respondents were very satisfied with standard CFLs in 2009 compared to 50% in 2010 and 34% in 2011.[7] This trend raised the concern that lower satisfaction could translate into lower CFL use. In order to determine if satisfaction had an effect on verified CFL use, saturation, and purchases, the team compared these indicators between respondents who said they were "somewhat satisfied" or "very satisfied" with CFLs to those who were less satisfied or did not know their level of satisfaction. As expected, the results suggest that households that are satisfied with CFLs buy more CFLs and have them installed in more sockets (Table ES-1). This confirms the concern that decreased satisfaction may eventually lead to lower rates of CFL use, and this will be particularly important if consumers turn to halogens instead of LEDs or CFLs to replace incandescent bulbs in the post-EISA lighting market. Yet, it is also the case that households reporting greater levels of satisfaction with CFLs also have fewer sockets, suggesting that the homes are smaller. It may be that households living in bigger homes have more specialty applications and are dissatisfied with the performance of CFLs in those sockets.[8]

Table ES-1: Satisfaction with CFLs Compared to Those Installed CFLs

(Base: telephone survey current or past CFL users, onsite respondents)

Satisfaction	Average # Sockets per Home	Average # of CFLs Installed	Average Saturation Rate	Average 2011 CFL Purchases
Satisfied n = 85	45	14.1	35%	3.6
Everyone else n = 30	65	12.3	22%*	1.3*

*Statistically different from satisfied respondents at the 90% confidence level

Federal Lighting Standards

The Energy Independence and Security Act of 2007 (EISA) has raised concerns about the stockpiling of incandescent bulbs, a practice that has already been observed to varying degrees in parts of Europe and the United States. In fact, the telephone survey results suggested that households self-reporting that they would be likely to stockpile incandescent bulbs also self-reported a greater number of recent 100-Watt incandescent bulb purchases than those who said they would be unlikely to stockpile.[9] Given the concern about stockpiling, the onsite inventory looked for evidence of that behavior, with an emphasis on whether self-reported likelihood to stockpile related to actual stockpiling as verified on site.

We found, on average, approximately four incandescent bulbs between 40 Watts and 100 Watts in storage in onsite homes; only 0.6 of these, on average, were 100-Watt bulbs. Because we

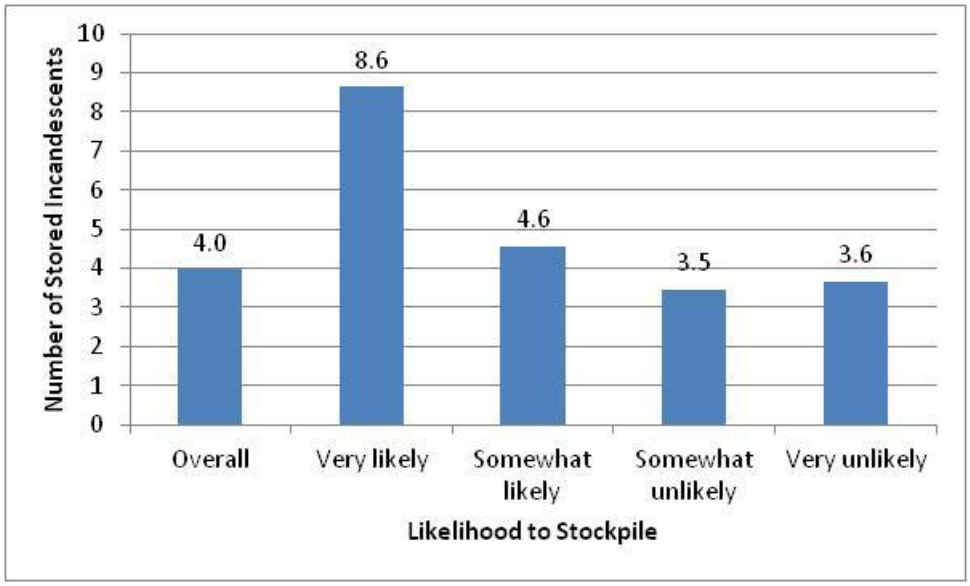
[7] NMR, *Massachusetts Consumer Survey Report,* 2012. NMR will continue to track satisfaction—and explore the issue in more depth—in the second wave of the telephone survey, to be fielded in mid-June 2012.

[8] Persistently low rates of saturation in dining rooms serves as an example. Smaller homes are less likely to have a dining room than are larger homes and would not be faced with the concerns about dimmability and light quality that consumers often raise about using CFLs in dining rooms.

[9] NMR, *Massachusetts Consumer Survey Report,* 2012.

found so few 100-Watt incandescents in storage and because consumers may not understand the phased implementation of EISA and could be stockpiling all incandescent wattages, we expanded the analysis to all incandescent bulbs between 40 Watts and 100 Watts. The analysis indicates that households reporting the greatest likelihood to stockpile had more incandescent bulbs in storage than households saying they were less likely to stockpile (Figure ES-4). There is suggestive evidence that those likely to stockpile are indeed storing more incandescent bulbs than those who are not, but, because we have not tracked storage of incandescents bulbs over time, we cannot conclude with certainty that any changes in storage rates are because of EISA. Only one respondent explicitly indicated purchasing and storing 100-Watt incandescent bulbs because the bulbs "would stop being made." The most common reason for stockpiling incandescent bulbs was simply to have them as back-ups for when others burned out.

Figure ES-4: Storage of Incandescent Bulbs by Likelihood to Stockpile*



* Source: Telephone survey and onsite visits

Conclusions and Recommendations

Based on the onsite analysis, the team concludes that most households in Massachusetts use CFLs, even if some of them are dissatisfied with the products or are not aware that they are using them. Despite high rates of penetration (i.e., households using CFLs), the number of CFLs in use and the percentage of sockets in which they are installed appear to have leveled off over the past two years, and there is evidence that recently purchased CFLs are largely being used to replace installed CFLs that have burned out. Between 2009 and 2010, statistically significant gains were made in increasing the number of specialty CFLs in homes, but this increase was not repeated between 2010 and 2012. LEDs remain an emerging technology in Massachusetts, with very few homes using any LED bulbs; most of the LED bulbs in use do not adhere to the A-shape profile and are installed in track lighting or under cabinets. Most sockets in the state could still be

converted to CFLs and LEDs using bulb shapes and sizes already available—and often program supported—at stores where consumers buy most light bulbs.

Use of incandescent bulbs has also decreased, but this trend started well before the January 1, 2012, implementation of the first phase of EISA. The rate at which sockets are being converted *away* from incandescents will likely accelerate with later stages of EISA, particularly the 2014 implementation of the 60-Watt phase-out. The question remains: what bulbs will consumers adopt in place of incandescent bulbs? The saturation results suggest that, even while CFL saturation has stagnated, households have increased the number and proportion of sockets filled with halogens, although virtually none of those found in onsite homes was the more recently introduced A-shaped variety; instead, consumers used pin-base and flood-shaped halogens. Yet, the team expects that the use of A-shaped halogen bulbs will increase as incandescents become scarce simply because they look so much like traditional incandescent bulbs; consumers may not even realize that they are buying halogens. Continued incentives for all types of CFLs and LEDs and increased education focusing on A-shaped CFLs could help offset consumers' move toward the less efficient A-shaped halogen.[10] Whether increasing the saturation of energy-efficient lighting remains a challenge for the program will depend on how consumers respond to EISA over the next few years. Therefore, continuation of incentives for all types of CFLs and LEDs should be paired with continued regular tracking of saturation to understand if and how saturation shifts in the coming years.

Finally, we found some evidence of incandescent stockpiling in the households that self-report being likely to stockpile, as those homes actually had more incandescents in storage than households that said they were not likely to stockpile. Overall, though, the onsite households are storing about four incandescents per household, the size of one typical pack of these bulbs. In short, stockpiling is occurring and may increase with the impending 2014 phase-out of the popular 60-Watt bulb, but, for now, it appears that stockpiling rates are likely to remain low and confined to a small but important subset of consumers.

Based on the results of the onsite inventory, the team makes the following four recommendations; these are in addition to those made previously in the Wave 1 telephone survey report:

Recommendation 1: Consider revisions to program design to reinvigorate adoption of standard and specialty CFLs. These revisions should include updated marketing strategies to boost use of energy-efficient bulbs in standard and specialty applications. A high-volume program would need to continue with the PAs' current upstream approach. Even so, the slowing saturation calls for other creative approaches. NMR understands that the PAs will soon pilot a market lift strategy to promote CFLs and LEDs, and the program design incorporates an

[10] Focus groups held in Connecticut in fall 2011 suggested that consumers wary of CFLs for certain applications enjoyed the shape and light quality of A-shaped CFLs included in a light bulb demonstration. See NMR, *Connecticut Lighting Focus Groups: Exploration of Changes in the Lighting Market and Reactions to Various Efficient Lighting Choices*. Delivered to the Energy Efficiency Board in December 2011.

evaluation strategy that will facilitate determining program impact. The results of the pilot evaluation, together with those from the second and third waves of the telephone survey and 2013 onsite saturation study, will help to clarify whether any changes in CFL use, saturation, and purchase rates have resulted from the pilot and from the first full year of EISA implementation. It may be worth considering some new approaches in addition to market lift—perhaps some approaches that are untried and could be explored. NMR does not have evidence of the efficacy of these approaches; they are offered simply for PAs' consideration. It may be worthwhile to explore the feasibility of some of the following approaches, perhaps in the form of pilots:

- Although the CFL potential for non-converted sockets is greater for specialty shaped bulbs than for standard A-line bulbs, the likely high rate of newly purchased CFLs replacing burned out CFLs suggests that the program may want to promote a higher ratio of standard CFLs and A-line CFLs.[11] This will work to keep the saturation rate of CFLs steady while still offering consumers the opportunity to convert remaining specialty and standard sockets to CFLs and LEDs.
- Bulb buyback programs – Either buying working incandescents back at slightly below their retail value, or offering to replace incandescents with CFLs. This could be accomplished at store kiosks or other central locations.
- Ending "get them while you can" incandescent promotions at program retailer stores – Last September (prior to the 100-Watt phase-out), a team member noted that some program retailers had displays of incandescents in or near lighting aisles and even at the check-out lanes with signs urging consumers to "get them while you can." To the extent that this is still occurring or may occur again prior to the phase-out of 40-Watt to 75-Watt incandescents, the PAs may want to exert pressure to stop the practice, perhaps by negotiating a "cease fire" among some of the major retail partners to stop promoting incandescents at the very least, and preferably to phase them out early.
- Neighborhood swarm light bulb replacement – The PAs would pick an area and then have representatives knock on doors and offer to change a specified number of inefficient bulbs in homes with CFLs and LEDs.

Recommendation 2: Continue working with the residential retail products and other residential evaluation teams as well as program implementers to understand the dynamics of consumer satisfaction with CFLs and LEDs more fully. The telephone survey demonstrated that respondents who say they are satisfied with CFLs often have similar concerns about the technology as those who are dissatisfied with CFLs. The onsite analysis suggested that dissatisfied households used and purchased fewer CFLs, on average, than did those who were satisfied with CFLs. Yet, despite these findings, we still do not have a clear understanding of

[11] The A-line CFL is currently considered a specialty bulb because of its higher price and non-spiral shape. However, the profile mimics that of the most common A-line incandescent shape, meaning that the A-line CFL is meant to fill standard sockets, not specialty ones (as are, for example, candelabra or flood-shaped CFLs).

what makes one person decide not to use CFLs; for example, one person may decline to use them because he or she takes a while to warm up and another person may shrug this concern off as unimportant when compared to the things he or she likes about CFLs. The Wave 2 consumer survey will explore reasons for satisfaction and dissatisfaction with CFLs—including the role of media attention—in more depth. However, additional strategies, such as more in-depth questioning during onsite inventories or focus groups, may be needed to understand these dynamics more fully and could also reveal steps the PAs could take to increase satisfaction among consumers.

Recommendation 3: Work with manufacturers, perhaps through national organizations like CEE or manufacturers' associations, to try to persuade them to remove the phrase "energy-efficient" from A-line halogen bulbs. A-line halogen bulbs will be the new standard bulb when the lumen-equivalent incandescent bulbs are phased out. Labeling them as "energy-efficient" is misleading to consumers, many of whom may not understand that halogens will now be among the least efficient bulbs they can buy to replace phased-out incandescents.

Recommendation 4: Continue efforts to educate consumers about their bulb choices post-EISA, helping them to make the most efficient choices possible for their lighting needs. This recommendation echoes those made in the consumer survey report, but its importance is highlighted by the fact that consumers currently have little awareness of A-shaped halogens but are fairly aware of CFLs. The opportunity now exists to help them understand the benefits of using CFLs and LEDs over halogens in most applications in the home. A-shaped CFLs offer a unique opportunity, as they resemble incandescents and can be used with clip-on lampshades, unlike standard CFLs. Related to this recommendation is the suggestion to consider the cessation of promotions of CFLs and LEDs that do not perform at levels consumers desire; dimmable, three-way, and candelabra CFLs and LEDs are among the products the PAs should consider not supporting until the technology improves to standards desired by consumers. The PAs should review performance data for all types of specialty CFLs and LEDs to determine which ones have the quality to justify promotion.

1 Background and Methodology

This report presents the findings of research conducted to understand use, saturation, and purchases of lighting products in Massachusetts in support of the Massachusetts ENERGY STAR® Lighting Program (the Program). The findings are based on the results of an onsite socket inventory of 150 households in Massachusetts conducted between February and April 2012. NMR Group, Inc., and its subcontractor DNV KEMA performed the research and are collectively referred to as "the team" throughout the report. The inventory sought not only to understand residential lighting use and purchase behavior, but also to establish baseline conditions at the earliest stages of implementation of the lighting efficiency standards resulting from the Energy Independence and Security Act (EISA) of 2007 that went into effect in January 2012. By comparing the current results with those of previous lighting inventories in 2009 and 2010,[12] the team could also search for any changes in residential lighting that could indicate early impacts of these new standards. An additional inventory will be performed in early 2013, which will enhance our ability to understand the impact of EISA on residential lighting.

1.1 Methodology

The team identified households for inclusion in the onsite lighting inventory through the Lighting Consumer Survey performed in December 2011 and January 2012.[13] After completing the telephone survey, each survey respondent was offered a $150 incentive to participate in an onsite visit to their home. DNV KEMA randomly selected among all survey respondents voicing interest and called to set up an onsite visit. The visits were conducted between February and April of 2012. The team successfully completed the desired 150 onsite visits and also inventoried the second home of one of the participants, for a total of 150 independent onsite respondents and 151 homes. This sample size achieves a 10% sampling error at the 90% confidence level for all households in Massachusetts. Note that throughout this report, we refer to the 2011 telephone survey respondents and the 2012 onsite households; however, the 2012 onsite households are a subset of the 2011 telephone survey respondents.

During the onsite visits, a trained technician gathered detailed information on each socket in the home. This information included:

- Bulb type
- Wattage
- Application

[12] NMR, "Results of the Massachusetts and Pennington County, South Dakota, Telephone and Onsite Compact Fluorescent Lamp Survey," in *Massachusetts ENERGY STAR Lighting Program 2010 Annual Report.* Delivered to the Massachusetts Program Administrators on June 13, 2011.

[13] NMR, *Massachusetts Consumer Survey Results*. Delivered to the Massachusetts Program Administrators on April 16, 2012. Appendix A compares the responses of the onsite subsample to all telephone survey respondents on key indicators of CFL awareness, familiarity, and use as well as demographic indicators in an effort to identify potential sources of bias.

- Socket type
- Room location
- Specialty features
- Date and store type where compact fluorescent lamps (CFLs) and light-emitting diodes (LEDs) were purchased
- Manufacturer and model number of each CFL and LED, when these could be determined

The team also collected data on *all* bulbs found in storage; in previous onsite inventories, we had only included CFLs in our storage assessment. However, given concerns about the potential for incandescent stockpiling due to EISA and the increased program support offered for LEDs, the Program Administrators (PAs), Energy Efficiency Advisory Council (EEAC) consultants, and the NMR team decided to include all bulbs in the storage assessment to provide more information on these issues.

A typical onsite visit proceeded as follows: A trained technician arrived at the home at a pre-scheduled time, introduced him- or herself, and asked for the contact person who had been identified when scheduling the visit. The respondent and the technician walked through each room of the home, examining all lighting sockets to see if they contained a bulb and, if so, the type of lighting technology in use, the switch type, and the base type. If the product was a CFL or LED, the technician noted its manufacturer and model number and any specialty features. The technician also asked the respondent to estimate when he or she purchased that particular CFL. The technician and householder also examined all light bulbs in storage, again noting similar detailed information on stored LEDs and CFLs and asking the householder the specific reason why he or she bought the stored bulbs. The lighting portion of the visits typically took less than two hours, but the average time spent in each home was greater due to data collection on consumer electronics and plug load, to be reported separately.

The weighting scheme adjusted for householder education and home ownership/renter status as estimated by the United States Bureau of the Census's 2006 to 2010 *American Community Survey*.[14] The team uses this proportionate weighting scheme when describing results for households and the population weighting scheme—which extrapolates to all households in the state—when describing results for sockets. These schemes mirror those used in the 2009 and 2010 report (Table 1-1).[15]

Table 1-1: Population, Sample Sizes, and Weights for Onsite Survey

	Households	Sample Size	Proportionate Weight	Population Weight
Massachusetts Total	*2,512,552*	*150**	*n/a*	*n/a*
Owner-occupied, High School degree or less	474,060	13	2.13	36,466
Owner-occupied, some College, Associate's Degree, Bachelor's degree or higher	1,134,414	108	0.61	10,504
Renter-occupied, High School degree or less	407,684	4	5.96	101,921
Renter-occupied, some College, Associate's Degree, Bachelor's degree or higher	496,394	22	1.32	23,563
Refused**	n/a	3	1.00	Excluded

* Sample size sums to 150 and not 151 because one respondent had two homes visited during the onsite and we did not want to double weight this individual.

** Respondents refused to answer either the home ownership or the education question, or both, so could not be assigned a weight.

[14] United States Bureau of the Census. *2006-2010 American Community Survey 5-Year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_5YR_B25013&prodType=table Accessed April 25, 2012.

[15] NMR, Results of the Massachusetts and Pennington County, 2011.

2 Use and Saturation

The team estimated CFL use and saturation (both interior and exterior sockets) largely through the onsite saturation survey, although we supplemented these data with pertinent information from the telephone survey. We note the source of the data for all tables.

2.1 Use of CFLs and LEDs

In order to determine if the onsite sample systematically differed from the telephone sample regarding CFL use, we compared their responses to the telephone survey question asking respondents if they had ever had CFLs installed in their home. While 61% of telephone survey respondents reported having had a CFL installed at some point, 68% of the onsite subset of respondents said they had used a CFL; however, these results do not differ statistically from one other (Table 2-1). Therefore, the results do not indicate a systematic bias between the onsite and telephone survey sample, although there appears to be a slight tendency for onsite households to be slightly more open to using CFLs. See Appendix A of this report for additional comparisons between all telephone survey respondents and the subset of onsite respondents.

Table 2-1: CFLs Ever Installed in Home

(Base: All telephone and onsite respondents, reflecting their telephone survey response)

Have Ever Used a CFL	2011 Telephone Survey	2012 Onsite Sample
Sample size	*582*	*151*
Yes	61%	68%
No	20%	16%
Don't know/Refused	6%	4%
Not aware of / familiar with CFLs	13%	12%

A comparison of self-reported current CFL use between 2009 and 2011 as reported in the telephone survey suggested that CFL use had declined.[16] While this raised concerns about trends in CFL use, NMR suggested waiting until the results of the onsite study were available before assuming that CFL use had, in fact, declined. In fact, the onsite inventories for the past three years show that the percentage of households using at least one CFL (i.e., penetration) has steadily increased, from 88% in 2009 to 96% in 2012 (Table 2-2). This lends credence to the idea discussed in the telephone survey report that changing opinions about CFLs may explain altered self-reported usage, but also that self-reported use is not always in line with actual behavior.

We also collected data on LED penetration, but only in 2012; 7% of respondents had at least one LED installed at the time of the onsites, but this includes all LEDs, not just A-shaped ones.

Table 2-2: CFL and LED Penetration

(Base: All onsite respondents)

Currently Have CFLs or LEDs Installed	2009	2010	2012	2012, LED
Sample Size	*100*	*150*	*151*	*151*
Yes	88%	92%	96%*	7%
No	11%	8%	4%*	93%

* Significantly different from 2009 at the 90% confidence level

[16] NMR, *Massachusetts Consumer Survey Results*, 2012.

The number of CFLs in use in homes has also increased over the past three years. In 2009, 53% of households used six or more CFLs (Table 2-3). In 2010, 61% of homes used six or more CFLs, and in 2012, 65% of homes did. Although gains have been made in the number of standard CFLs in use, the increase in use of specialty CFLs has been even more pronounced. In 2009, only 25% of households used specialty CFLs, but this percentage increased significantly to 57% in 2010 and remained steady at 58% in 2012.[17] The percentage of households with large numbers of specialty bulbs has also increased, with only 10% of households using six or more specialty bulbs in 2009 compared to 19% in 2010 and 22% in 2012. Importantly, the PAs revised the Program in 2010 to focus more on specialty bulbs, and this strategy appears to have resulted in increased use of specialty CFLs in respondents' homes.

Table 2-3: Current Use of CFLs by Type and Households

(Base: All onsite respondents)

	2009	2010	2012
Sample Size	*100*	*150*	*151*
All CFLs			
Zero	12%	8%	4%*
One to five	35%	31%	32%
Six to fifteen	34%	35%	40%
Sixteen or more	19%	26%	25%
Standard CFLs			
Zero	14%	12%	7%*
One to five	37%	39%	46%
Six to fifteen	36%	32%	32%
Sixteen or more	13%	18%	16%
Specialty CFLs			
Zero	75%	43%*	42%*
One to five	16%	39%*	37%*
Six to fifteen	9%	14%	18%*
Sixteen or more	1%	5%*	4%

* Significantly different from 2009 at the 90% confidence level

[17] Specialty CFLs identified include: dimmable, three-way, A-shaped, flood/spot, candelabra, circline, globe, tubes/bent tubes, and bullet/torpedo CFLs.

Table 2-4 shows that the average number of CFLs increased a great deal between 2009 and 2010, but remained steady between 2010 and 2012. In 2009, the average household used 9.4 CFLs, but this increased to 11.7 in 2010 and remained steady at 11.6 in 2012 (although the median increased from seven to nine between 2010 and 2012). Results for standard and specialty CFLs mimic those for all CFLs, with gains in use between 2009 and 2010 but with use remaining steady between 2010 and 2012. The difference between the median and mean numbers of CFLs is because many of the CFLs in use are accounted for by relatively few households, as displayed in Table 2-5.

Table 2-4: Current Use of CFLs

(Base: All onsite respondents)

	2009	2010	2012
Sample Size	*100*	*150*	*151*
All CFLs			
Total CFLs in use	953	1,765	1,754
Mean number of CFLs in use	9.4	11.7	11.6
Median number of CFLs in use*	n/a	7	9
% of all CFLs in use	100%	100%	100%
Standard CFLs			
Total CFLs in use	820	1,259	1,247
Mean number of CFLs in use	8.1	8.4	8.3
Median number of CFLs in use*	n/a	5	5
% of all CFLs in use	86%	71%	71%
Specialty CFLs			
Total CFLs in use	133	506	507
Mean number of CFLs in use	1.3	3.4	3.4
Median number of CFLs in use*	n/a	1	1
% of all CFLs in use	14%	29%	29%

* Median not reported in 2009

The majority of CFLs in use tended to be concentrated in homes with sixteen or more CFLs installed; two-thirds (66%) of all installed CFLs in the 2010 onsite homes and more than one-half in the 2009 (52%) and 2012 (55%) onsite homes were found in homes with at least sixteen CFLs (Table 2-5). Likewise, more than one-half of the standard CFLs were concentrated in homes with sixteen or more CFLs in 2010 (53%), while the percentage was 40% in 2009 and 45% in 2012. Specialty CFLs for the 2010 respondents were concentrated in the households that had sixteen or more CFLs (40%), while those onsite homes in 2009 and 2012 that had six to fifteen specialty CFLs (55% and 47%, respectively) comprised the largest percentage of CFLs installed. In the 2010 onsite sample, the 40% of specialty CFLs found in homes with 16 or more CFLs was driven largely by a single respondent with numerous exterior flood lights.

Table 2-5: Current Use of CFLs by Percentage of CFLs Installed

(Base: All installed CFLs)

	2009	2010	2012
Sample Size	*953*	*1,765*	*1,754*
All CFLs			
One to five	10%	8%	8%
Six to fifteen	38%	27%	38%
Sixteen or more	52%	66%	55%
Standard CFLs			
Sample Size	*820*	*1,259*	*1,247*
One to five	13%	11%	16%
Six to fifteen	47%	36%	39%
Sixteen or more	40%	53%	45%
Specialty CFLs			
Sample Size	*133*	*506*	*507*
One to five	24%	27%	28%
Six to fifteen	55%	32%	47%
Sixteen or more	21%	40%	25%

The number of LEDs in use in homes was considerably lower than that of CFLs (Table 2-6). Only 7% of homes were observed to contain a total of 92 LEDs, and the mean number of LEDs was 0.6 for all households. One household accounted for 29 of the 92 LEDs (32%).

Table 2-6: Current Use of LEDs

(Base: All onsite respondents and installed LEDs)

LEDs	**Massachusetts Onsite Sample 2010**	
Sample Size	*151*	
Number of Bulbs	*92*	
Zero	% of Households	93%
	% of LEDs	0%
One to five	% of Households	5%
	% of LEDs	13%
Six to fifteen	% of Households	1%
	% of LEDs	12%
Sixteen or more	% of Households	1%
	% of LEDs	75%
Mean number of LEDs in use	0.6	
Median number of LEDs in use	*1*	

2.2 Socket Saturations

The percentage of sockets filled with CFLs has remained relatively stable over the past three years. In both 2009 and 2010, just over one-fourth of the sockets in onsite homes (26%) contained CFLs, and the percentage increased just slightly (and not significantly) to 27% in 2012 (Table 2-7). If one also considers LEDs, saturation is 28%, and adding traditional fluorescent bulbs increases saturation of all energy-efficient bulb types to 36%. The percentage of sockets filled with incandescent bulbs decreased from 2009 to 2012 (62% to 53%) but was offset by increases in regular fluorescent tubes and halogen bulbs, and to a small extent LEDs, rather than CFLs. Saturations of specialty bulbs of any type changed little from 2009 to 2010 (30% to 31%) but increased to 48% in 2012, largely due to an increase in the number of flood- and candelabra-shaped bulbs found in homes.[18] Saturations of specialty CFLs increased from 4% in 2009 to 7% in 2010 and 8% in 2012. Such increases provide further evidence that the new program focus on specialty CFLs may be having the desired effect of boosting use of specialty CFLs, but that boost seems to have occurred between 2009 and 2010, with a leveling off in 2012. A-shaped CFLs represent a small percentage of specialty CFLs found in the 2012 sample (1% of all sockets, and about 12% of all specialty CFLs), although these are the CFLs that most resemble the majority of incandescent bulbs and could help alleviate concerns about fit with fixtures and lamp shades as well as the aesthetic shape of the bulb.

Table 2-7: Socket Saturations

(Base: All onsite respondents)

Sockets Containing	**2009**	**2010**	**2012**
Sample Size	*100*	*150*	*151*
Total Sockets	**3,709**	**6,741**	**6,565**
Incandescent bulbs	62%	57%	53%
CFLs	26%	26%	27%
Fluorescent	6%	9%	8%
Halogen	5%	7%	11%
LEDs	<1%	<1%	1%
Other	<1%	1%	-
*Any specialty bulb**	30%	31%	48%**
*Any specialty CFL**	4%	7%	8%
Any specialty CFL (not including A-shaped CFLs)	-	-	7%

*Specialty bulbs and specialty CFLs also fall within shape categories and therefore are not additive.

**The number of candelabra and flood-shaped bulbs increased substantially between 2010 and 2012; we are examining possible explanations for this increase.

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

The increase in CFL saturation from 26% in 2009 to only 27% in 2012 seems small compared to CFL sales of approximately 10.8 million bulbs across the same time period. Previous studies performed by the team suggested that socket saturation varied by home size, and we considered the possibility that the sizes of homes in our sample could differ from those in Massachusetts overall. In other words, we thought that perhaps our study had more homes of the size that use fewer CFLs, thus "hiding" some of those purchased through the program. Table 2-8 summarizes the results of this analysis. In the column "Massachusetts Census," the table shows the distribution of homes by the number of rooms in the home, while the second column, "Massachusetts Onsite Visits 2012," shows the same for the onsite participants. The third column shares the average number of sockets found in homes of that size, while the final column shows the average, unweighted saturation. These data show that the onsite sample was, in fact, slightly biased toward larger homes than are typically found in Massachusetts, and this has likely served to *lower* the saturation estimate somewhat, as smaller homes tend to have higher saturation than larger homes. In fact, the combined saturation for homes with five or six rooms—the median home in Massachusetts has 5.5 rooms—is 31% (not shown in the table). Taking into consideration the slightly larger home size in the onsite sample and the saturation rate of median size homes, the team concludes that actual CFL saturation is likely between 27% and 30%.[19] Although we believe that the assumed CFL saturation rate could safely be adjusted to 30%, one of the purposes of this analysis is to assess *change* in saturation, and by the same logic the saturation could have been 29% or even 30% in 2010. To maintain consistency and comparability between years, therefore, for the remainder of this analysis we still use a CFL saturation rate of 27%, a CFL and LED saturation rate of 28%, and an overall efficient bulb rate of 36% because these are the numbers found in the study and the numbers that provide for a direct analysis of the results. We further explore the issue of where program-supported CFLs may have gone in Section 3.1 and Appendix B.

[19] We do not say 31% because homes that differ from the median still have saturation rates that are lower, and their sockets factor into the actual saturation rate for the state.

Table 2-8: Analysis of Saturation by Home Size

(Base: All onsite respondents, data are unweighted)

Total Rooms	Massachusetts Census	Massachusetts Onsite Visits 2012	Total Bulbs Installed	CFL Saturation
Sample size	*2,520,419**	*151*	*151*	*151*
1	2%	2%	21	20%
2	3%	1%	10	45%
3	10%	6%	30	32%
4	15%	9%	29	43%
5	18%	10%	35	27%
6	18%	22%	40	33%
7	13%	10%	58	26%
8	10%	17%	58	25%
9	12%**	8%	70	26%
10 or more		13%	84	18%
Don't know/Refused	-	2%	118	24%

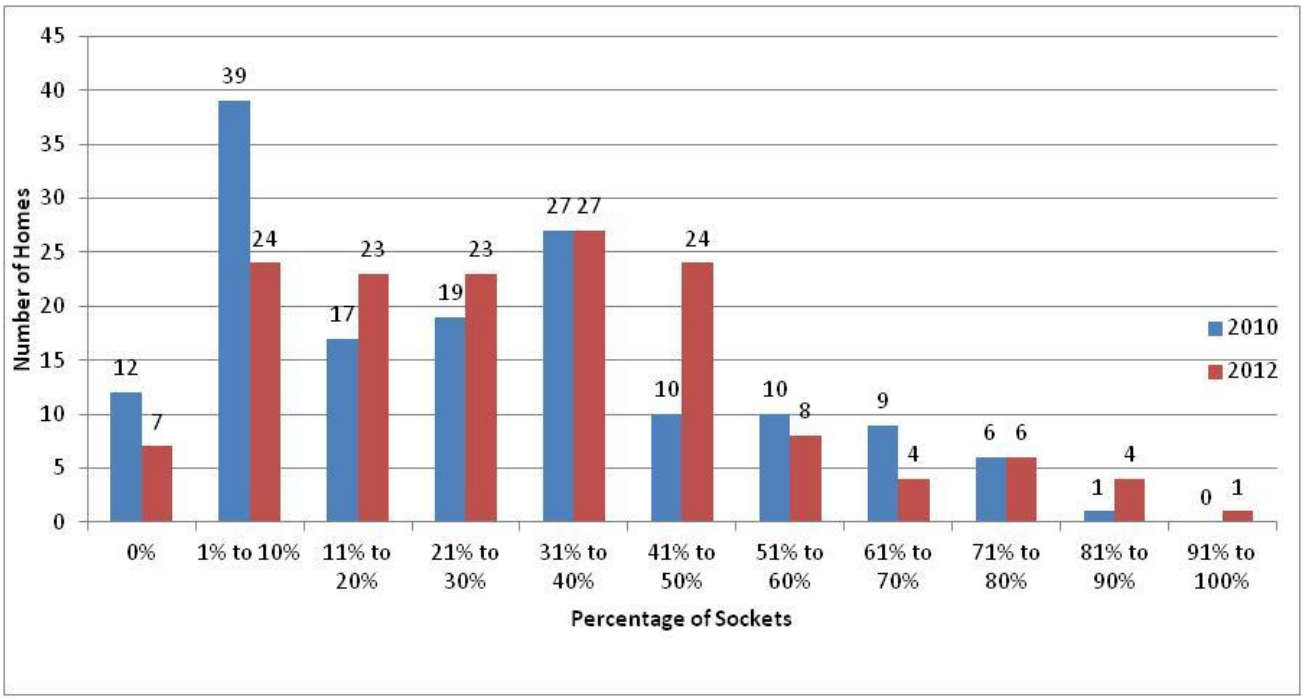
*Total occupied housing units

Using the unadjusted estimate of energy-efficient bulb saturation (i.e., 36%), optimistically, if each incandescent and halogen bulb were converted to a CFL, approximately 64% of sockets in the 2012 sample could still be converted to screw-in CFLs or LEDs. Specialty sockets (based on non-A-line bulb shape as well as fixture controls) account for 60% of the potential (or 38% of all potential sockets in the home). The actual potential for CFLs and LEDs is likely less because fixture shape, the nature of various applications, and the preferences of householders will limit the number of sockets that will be converted to CFLs or LEDs. As a result, the realizable potential will be lower than 64%, but the data do not allow us to estimate by how much.

Figure 2-1 displays the 2010 and current distributions of CFL saturation across homes—that is, the saturation *for each individual onsite home* rather than across all sockets in the state, as reported in Table 2-7. The data for both years point to a right-skewed distribution, as the mass of the distribution is concentrated on the left of the figure. Importantly, though, the skew is less pronounced in 2012, meaning saturation in individual homes is increasing even though the overall saturation across all homes has only crept slightly higher.[20] Specifically, the 2012 data indicate a peak of saturation in homes (27 homes) that contain between 31% and 40% of CFLs installed. A total of 23 onsite homes in 2012 had more than one-half of their sockets filled with CFLs, and one home had a saturation rate above 90% (but even this home did not have 100% CFL saturation). The data also show that 74 households had moderate levels of saturation (between 21% and 50%) in 2012 compared to 56 in 2010. Moreover, 68 households in 2010 had saturation rates below 21% compared to 54 in 2012. However, the number of homes with more than 50% saturation was fairly equal across the two samples (26 in 2010 and 23 in 2012). In short, the data suggest that saturation is becoming more homogenous across homes.

Figure 2-1: CFL Saturation per Household

(All onsite households, 2010 and 2012; data are unweighted)



[20] The reason for the difference between the data in Figure 2-1 and those reported earlier for overall saturation reflect the method of calculation. In Figure 2-1, we find the saturation for each home and then average the results; the overall saturation rate looks across all sockets and across all homes. For example, a small home with 25 sockets and 10 CFLs has saturation of 40%; a large home with 100 sockets and 20 CFLs has a saturation of 20%. The average of these two individual saturation rates is 30%, but the saturation rate calculated across all sockets is 24%.

Saturation of CFLs remained consistent or showed slight variation from 2009 to 2012 in most room types (Table 2-9). Notable gains in CFL saturation over time were achieved in kitchens, bedrooms, family rooms, home offices, and foyers. Decreased usage was evident in basements and garages. The table reveals slight to moderate volatility of CFL saturation in several room types over time (e.g., exterior, bathroom, dining rooms)—but, on the whole, saturation was mostly stable. Of note, in rooms or areas where CFL usage was not considerable (i.e., home exteriors and dining rooms), the behavior of one individual could significantly influence CFL saturation in the sample. For example, in the 2010 sample, the high saturation rate of 27% in large part reflected the behavior of one household with numerous exterior flood CFLs, while the higher saturation rate in dining rooms in 2012 was accounted for by one home installing nearly four times the number of CFLs in the dining room than the next closest respondent.

Table 2-9: CFL Socket Saturation by Room Type

(Base: All onsite respondents)

Sockets Containing	2009	2010	2012	Average Total Sockets 2012*
Sample Size	*100*	*150*	*151*	*151*
Living Room	33%	35%	32%	5.3
Kitchen	30%	28%	35%	5.4
Bedroom	26%	28%	31%	8.1
Hall	28%	28%	31%	2.7
Exterior	19%	27%	18%	2.6
Bathroom	18%	27%	23%	5.4
Basement	34%	26%	23%	3.8
Family Room	15%	25%	27%	1.6
Office	23%	24%	31%	1.1
Foyer	16%	21%	21%	1.1
Utility/Laundry	0%	19%	10%	0.7
Garage	38%	12%	13%	0.6
Dining Room	20%	10%	17%	3.3
Other	0%	14%	21%	1.8

* Average number of sockets across all rooms of this type in all homes in the study. Note that some homes do not have all room types, hence averages that fall below one.

In all three samples from 2009 to 2012, CFLs were most commonly found in portable fixtures such as floor lamps and table lamps (73% in 2009, 76% in 2010, and 81% in 2012) (Table 2-10). Use of CFLs in ceiling fans and recessed fixtures increased each year from 2009 to 2012. A net increase of CFL saturation occurred in floor lamps, table lamps, and ceiling flush mounts despite the volatility in saturation from 2009 to 2012. Across the three years, CFL saturation declined only in wall mount fixtures (from 21% to 20%) and pendant fixtures (16% to 15%), although these decreases are not statistically significant. CFL use in track lighting and under cabinet lighting remained relatively stable from 2009 to 2012.

Table 2-10: CFL Socket Saturation by Fixture Type

(Base: All onsite respondents)

Sockets Containing	2009	2010	2012	Average Total Sockets 2012*
Sample Size	*100*	*150*	*151*	*151*
Floor Lamp	38%	35%	44%	2.1
Table Lamp	35%	41%	37%	5.1
Ceiling Fan	28%	30%	33%	2.5
Ceiling Flush Mount	29%	24%	32%	11.7
Wall Mount	21%	27%	20%	7.1
Recessed	17%	23%	23%	7.2
Pendant	16%	18%	15%	5.4
Track	8%	9%	8%	1.1
Night Light	0%	<1%	0%	0
Under Cabinet	0%	3%	3%	0.5
Other	0%	10%	22%	0.3

* Average number of sockets across all fixtures of a given type in all homes in the study. Note that some homes do not have all fixture types, hence averages that fall below one.

Looking only at fixtures with CFLs installed in them, we found that, unsurprisingly, CFL saturation was greatest in the type of fixtures most prevalent in the 2012 onsite sample (flush mount, recessed, and wall mount fixtures). Thirty-two percent of CFLs were installed in ceiling flush mount fixtures, with table lamp fixtures following at 18% (Table 2-11). Track and under-cabinet lighting represented the lowest percentage of total CFL fixture types installed (1% and 0%, respectively).

Table 2-11: CFL Fixture Type Saturation by CFL Total Fixtures

(Base: All onsite respondents)

Sockets Containing	2012
Sample Size	*151*
Number of CFL Fixtures	**1,754**
Ceiling Flush Mount	32%
Table Lamp	18%
Recessed	14%
Wall Mount	12%
Floor Lamp	8%
Ceiling Fan	7%
Pendant	7%
Track	1%
Under Cabinet	0%
Other	1%

The saturation of screw-base sockets remained stable at approximately 30% across all three samples (28%, 28%, and 29%, respectively) (Table 2-12). However, the saturation of pin-base sockets decreased slightly from 2009 to 2010 (11% to 7%), but then increased to 15% overall in the 2012 sample, a pattern driven by traditional fluorescent lighting, which is also pin-base (Table 2-7). Given that they are made for CFLs, all GU base socket types are filled with CFLs; the 2009 sample did not include any GU bases.

Table 2-12: CFL Socket Saturation by Socket Base Type

(Base: All onsite respondents)

Sockets Containing	2009	2010	2012
Sample Size	*100*	*150*	*151*
Screw base (small/medium)	28%	28%	29%
Pin base	11%	7%	15%
GU Base	0%	100%	100%
Other/Unknown	0%	<1%	100%

Again looking only at sockets with CFLs, 91% of CFLs were installed in screw-base socket types (small/medium types), and the other eight percent were pin-base (Table 2-13). GU base sockets represent a very small percentage of CFLs installed in the 2012 sample (<1%).

Table 2-13: CFL Socket Base Saturation by Total CFL Socket Base

(Base: All onsite respondents)

Sockets Containing	2012
Sample Size	*151*
Number of CFL Sockets	**1,754**
Screw base (small/medium)	91%
Pin base	8%
GU Base	<1%
Other/Unknown	<1%

Despite the increased use of specialty CFLs, they still had not been adopted in great numbers at the time of the onsites. Looking first at shape, one-fifth (21%) of tube-shaped bulbs were CFLs, and 13% of flood or spot lamps were CFLs (Table 2-14).[21] Only three percent of A-shaped bulbs—the most common bulb shape found in homes—were CFLs, largely reflecting the fact that the spiral CFL is meant to replace an A-shaped incandescent bulb. Looking at specialty controls, the saturation of three-way bulbs that are CFLs had a net increase from 2009 to 2012 (6%), while dimmable bulbs experienced a net decrease (3%) during the same time period. Importantly, poor CFL dimmability remained a persistent complaint in the telephone survey. The team believes that mislabeling of the lighting technology for certain bulb types (i.e., globes, dimmable, and circline bulbs) may have occurred in either 2009 or 2010 as it is unlikely that their saturations changed this significantly in one year.

Table 2-14: CFL Socket Saturation by Bulb Features

(Base: All onsite respondents)

Sockets Containing	2009	2010	2012
Sample Size	*100*	*150*	*151*
Globe**	11%	40%	8%
Flood/Spot	10%	17%	13%
Tube	14%	14%	21%
Circline**	44%	2%	5%
A-Bulb*	3%	2%	3%
Candelabra	1%	1%	8%
*Dimmable****	9%	19%	6%
*Three-way****	17%	27%	23%

*A-shaped bulbs are the typical shape for standard incandescent bulbs. A-shaped CFLs are made to look and feel like traditional incandescent bulbs.

** Differences in the pictures provided to identify CFLs may have influenced whether technicians classified these products as CFLs or other types of lighting. Moreover, sample sizes for circline bulbs are small.

***Dimmable and three-way bulbs also fall within shape categories and therefore are not additive.

[21] We have not shown all bulb types here, as some are found in fewer than 5% of homes and small variations in use by just one or two households can greatly alter the reported percentages.

The spiral-shaped CFL bulb—the standard bulb—represented the largest number of CFL bulbs installed (71%) in 2012 (Table 2-15). Tube and flood/spot bulb-shaped CFLs had notable levels of saturation at 10% and 9%, respectively.

Table 2-15 CFL Feature Saturation by Total CFL Feature Sockets

(Base: All onsite respondents)

Sockets Containing	**2012**
Sample Size	*151*
Number of CFL Sockets	***1,754***
Spiral	71%
Tube	10%
Flood/Spot	9%
Candelabra	4%
A-Bulb	3%
Globe	2%
Bug Light	0%
Bullet/Torpedo	0%
Circline	0%
Other	0%
Dimmable	2%
Three-way	2%

The remaining tables in this section (Table 2-16 to Table 2-23) provide detail on saturation for all bulb types and estimate the remaining potential for CFLs and LEDs. The results for potential are presented in a subsequent table as both percentages and the number of bulbs (sockets). It is important to note that the stated potential serves as a best case scenario. Actual potential will be lower due to limitations in fixture shape, lighting application, and the preferences of the householder.

As illustrated in Table 2-16, bedrooms and bathrooms had the largest number of bulbs of all types installed in the 2012 sample. CFLs and incandescent bulbs accounted for 88% of installed bulbs in bedrooms and 91% of bulbs in bathrooms. Halogen bulbs were mostly installed in exterior spaces, family rooms, and kitchens. Fluorescent bulbs represented almost one-half of bulbs installed in basements, garages, and utility or laundry rooms. The remaining potential to install a CFL or LED where it was less likely to be found was highest in dining rooms (83%) and exterior spaces (81%).[22] LEDs have only begun to gain adoption in kitchens (5% of bulbs) and living rooms (4% of bulbs) and these tend to be under-cabinet lights and spot lamps, not A-shaped LEDs; the majority of rooms did not have LEDs installed.

[22] Remaining potential is calculated as the number of incandescent and halogen bulbs which can be replaced with CFLs or LEDs.

Table 2-16: Socket Saturation – Room Types by Percent of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets	CFL	Fluorescent	Halogen	Incandescent	LED	Potential for CFLs or LEDs
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Total Sockets	**112,260,136**	**30,023,458**	**9,200,959**	**12,221,317**	**59,226,089**	**1,588,313**	**71,447,406**
Bedroom	19%	31%	1%	11%	57%	0%	68%
Bathroom	13%	23%	2%	6%	68%	0%	74%
Kitchen	12%	35%	9%	17%	34%	5%	51%
Basement	9%	23%	45%	4%	28%	0%	31%
Living Room	12%	32%	1%	10%	52%	4%	63%
Exterior	6%	18%	1%	21%	60%	0%	81%
Dining Room	8%	17%	0%	8%	75%	0%	83%
Hall	6%	31%	2%	13%	54%	0%	66%
Garage	1%	13%	46%	4%	37%	0%	41%
Family Room	4%	27%	2%	19%	52%	0%	71%
Foyer	3%	21%	0%	6%	73%	0%	79%
Office	3%	31%	6%	11%	51%	2%	61%
Utility or Laundry Room	2%	10%	42%	8%	39%	2%	47%
Other	4%	21%	23%	9%	48%	0%	57%
Sockets per Household	44.7	11.9	3.7	4.9	23.6	.6	28.4

When extrapolating all the bulbs found in the 2010 and 2012 samples to the larger population of households in Massachusetts, we find that households added about 2.4 million sockets in their homes between 2010 and 2012, which is consistent with the findings reported by Navigant Consulting in a recent study drawing on onsite saturation data from across the nation (Table 2-17 on the next page).[23] The number of CFLs installed increased by about 1.9 million, but we cannot conclude that CFLs accounted for 79% (i.e., 1.9 million divided by 2.4 million) of the new sockets, because potential also increased by 1.3 million sockets (i.e., 1.9 million plus 1.3 million = 3.2 million, which is greater than 2.4 million). Instead, Massachusetts households converted some sockets to CFLs and used CFLs in some new sockets, but they also added new non-CFL sockets and converted some CFL sockets to other bulb types (e.g., decreased saturation in bathrooms and exterior spaces). Taken together, these behaviors help to explain why the number of CFLs installed increased more than saturation.

[23] Navigant Consulting. *Lighting Market Characterization*. US Department of Energy, Energy Efficiency and Renewable Energy Division. 2012. This study uses data collected in numerous onsite studies conducted in recent years, including some data from Massachusetts.

Table 2-17: Room Types by Number of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets 2010	CFL 2010	Potential for CFLs or LEDs 2010	All Sockets 2012	CFL 2012	Potential for CFLs or LEDs 2012
Sample Size	*150*	*150*	*150*	*151*	*151*	*151*
Total Sockets (in millions)	**109.9**	**28.1**	**70.1**	**112.3**	**30.0**	**71.4**
Bedroom	19.3	5.4	12.5	20.8	6.4	14.1
Bathroom	13.3	3.5	9.3	14.1	3.3	10.4
Kitchen	13.7	3.8	7.3	13.9	4.9	7.1
Basement	12.5	3.3	5.7	9.8	2.3	3.1
Living Room	10.6	3.7	6.7	13.6	4.4	8.5
Exterior	8.7	2.3	6.4	6.7	1.2	5.5
Dining Room	6.5	.6	5.8	8.5	1.5	7.1
Hall	6.2	1.8	4.4	7.0	2.2	4.6
Garage	2.8	.3	1.2	1.5	.2	.6
Family Room	4.0	1.0	2.7	4.2	1.2	3.0
Foyer	3.6	.7	2.7	2.9	.6	2.2
Office	1.9	.5	1.2	2.9	.9	1.8
Utility or Laundry Room	1.5	.3	.8	1.9	.2	.9
Other	5.2	.7	3.4	4.5	.9	2.6
Sockets per Household	43.7	11.2	27.9	44.7	11.9	28.4

As illustrated in Table 2-18, flush-mount and recessed fixture types represented the most prevalent fixture types found in the 2012 sample of onsite homes (27% and 17%, respectively). Pendant, ceiling fan, and wall mount type fixtures tended to be primarily filled with incandescent bulbs. One-quarter of flush mount type fixtures were filled with fluorescents, as were one out of five under-cabinet type fixtures. Under-cabinet and track lighting were filled with a notable amount of LEDs—32% and 20%, respectively. Halogen bulbs tended to fill almost half (49%) of the track lighting fixtures and two out of five (40%) of the under-cabinet fixtures. Incandescent bulbs were prevalent throughout all fixture types and were greatest in pendant type fixtures (77%). The only exception was under-cabinet lighting (6%). The potential to replace incandescent and halogen bulbs with CFLs or LEDs was greatest in pendant (81%), wall mount (77%), and recessed (74%) type fixtures.

Table 2-18: Socket Saturation – Fixture Types by Number of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets	CFL	Fluorescent	Halogen	Incandescent	LED	Potential for CFLs or LEDs
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Total Sockets	**112,260,136**	**30,023,458**	**9,200,959**	**12,221,317**	**59,226,089**	**1,588,313**	**71,447,406**
Flush Mount	27%	32%	25%	1%	42%	0%	27%
Wall Mount	16%	20%	3%	12%	65%	1%	77%
Table Lamp	13%	37%	1%	1%	60%	<1%	61%
Recessed	17%	23%	1%	35%	39%	2%	74%
Pendant	12%	15%	3%	5%	77%	<1%	81%
Floor Lamp	5%	44%	2%	5%	48%	<1%	53%
Track	3%	8%	0%	49%	22%	20%	72%
Ceiling Fan	6%	33%	1%	0%	66%	1%	66%
Under Cabinet	1%	3%	20%	40%	6%	32%	46%
Night Light	<1%	0%	0%	0%	100%	0%	100%
Other	1%	23%	0%	3%	74%	0%	77%
Sockets per Household	44.7	11.9	3.7	4.9	23.6	.6	28.4

When extrapolating all the fixture types found in the 2010 and 2012 samples to the larger population of households in Massachusetts, the flush and wall mount types of fixtures represented approximately 49 million sockets, or almost half the total sockets counted in each year (Table 2-19). The greatest potential for CFLs or LEDs in 2012 was also found in the flush mount type sockets (9.6 million) as well as table lamp fixtures (5.3 million).

Table 2-19: Socket Saturation by Fixture Types – Number of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets 2010	CFL 2010	Potential for CFLs or LEDs 2010	All Sockets 2012	CFL 2012	Potential for CFLs or LEDs 2012
Sample Size	*150*	*150*	*150*	*151*	*151*	*151*
Total Sockets (in millions)	**109.9**	**28.1**	**70.1**	**112.3**	**30.0**	**71.4**
Flush Mount	27.1	6.4	13.4	30.0	9.6	12.9
Wall Mount	22.1	6.0	14.8	18.5	3.7	14.2
Pendant	13.8	5.6	12.3	13.9	2.1	11.3
Ceiling Fan	13.1	3.0	4.9	6.6	2.2	4.3
Table Lamp	16.3	2.9	8.0	14.1	5.3	8.6
Recessed	4.7	1.6	10.0	18.8	4.3	14.0
Floor Lamp	1.8	.2	2.9	5.4	2.4	2.9
Track	7.0	2.1	1.6	2.9	.2	2.1
Under Cabinet	1.7	.06	.8	1.4	0	.6
Night Light	.02	-	0	0	0	0
Other	2.3	.2	1.2	.7	.2	.6
Sockets per Household	43.7	11.2	27.9	44.7	11.9	28.4

As illustrated in Table 2-20, the socket saturation of screw-base type sockets in 2012 was 85%. Any GU base sockets were CFLs, while all incandescent bulbs were screw-base types. More than half of the pin-base type sockets were fluorescent bulbs (54%), while halogen bulbs represented another 29%. Since the majority of socket types were screw-base, the greatest potential for CFLs and LEDs was with these types of sockets, at 70%.

Table 2-20: Socket Saturation – Socket Types by Percent of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets	CFL	Fluorescent	Halogen	Incandescent	LED	Potential for CFLs or LEDs
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Total Sockets	**112,260,136**	**30,023,458**	**9,200,959**	**12,221,317**	**59,226,089**	**1,588,313**	**71,447,406**
Screw-base (small/medium)	85%	29%	<1%	8%	62%	1%	70%
Pin-base	15%	15%	54%	29%	0%	3%	29%
GU base	<1%	100%	0%	0%	0%	0%	0%
Other / Unknown	<1%	100%	0%	0%	0%	0%	0%
Sockets per Household	44.7	11.9	3.7	4.9	23.6	.6	28.4

When extrapolating from all the socket types found in the 2010 and 2012 samples to the larger population of households in Massachusetts, the use of screw-base and pin-base sockets has increased over time from over 94 million sockets in 2010 to 95 million in 2012 for screw-base, and from over 15 million in 2010 to over 17 million in 2012 for pin-base (Table 2-21). The overall potential for CFLs and LEDs is increasing because more pin-base sockets were installed and most likely filled with halogen.

Table 2-21: Socket Saturation by Socket Types – Number of Sockets

(Base: All onsite respondents, weighted to the population of households in the state)

Socket Type	All Sockets 2010	CFL 2010	Potential for CFLs or LEDs 2010	All Sockets 2012	CFL 2012	Potential for CFLs or LEDs 2012
Sample Size	*150*	*150*	*150*	*151*	*151*	*151*
Total Sockets	**109.9**	**28.1**	**70.1**	**112.3**	**30.0**	**71.4**
Screw-base (small/medium)	94.2	27.0	67.2	95.0	27.4	66.5
Pin-base	15.2	1.1	2.9	17.1	2.5	5.0
GU base	.3	.3	0	.1	.1	0
Other / Unknown	.3	0	0	0	0	0
Sockets per Household	43.7	11.2	27.9	44.7	11.9	28.4

As illustrated in Table 2-22, the most prevalent bulb shape for all sockets observed in the 2012 onsite surveys was the A-shaped bulb (29%). Spiral- and flood/spot-shaped bulbs each comprised another 19% of the total bulbs observed. Unsurprisingly, all spiral-shaped bulbs were CFLs, while the majority of incandescent bulbs were A-shaped bulbs (96%), with most of the remainder being CFLs. Bulbs located on dimmable circuits tended to be primarily incandescent (57%) or halogen bulbs (33%), while three-way bulbs tended to be incandescent (77%) or CFLs (23%). Specialty bulbs were primarily incandescent. Globe-shaped (92%) and candelabra types (91%) were almost all incandescent bulbs. More than three-fourths (76%) of circline bulbs tended to be fluorescent. Given that the large majority of A-shaped bulbs were incandescent, the greatest potential for CFLs and LEDs lies in replacement of this bulb shape (97%). Candelabra and globe-shaped bulbs also had high potential replacement with CFLs and LEDs at 92% each.

Table 2-22: Socket Saturation – Bulb Features by Percent of Sockets

(Base: All 2012 onsite respondents, weighted to the population of households in the state)

Sockets Containing	All Sockets	CFL	Fluorescent	Halogen	Incandescent	LED	Potential for CFLs or LEDs
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Total Sockets	**112,260,136**	**30,023,458**	**9,200,959**	**12,221,317**	**59,226,089**	**1,588,313**	**71,447,406**
A-Bulb	29%	3%	<1%	<1%	96%	<1%	97%
Spiral	19%	100%	0%	0%	<1%	0%	<1%
Tube	13%	21%	58%	17%	1%	3%	18%
Flood/Spot	19%	13%	0%	44%	39%	5%	83%
Candelabra	13%	8%	0%	<1%	91%	<1%	92%
Globe	6%	8%	0%	0%	92%	0%	92%
Circline	1%	5%	76%	0%	10%	0%	19%
Bullet/Torpedo	<1%	86%	0%	14%	0%	0%	14%
Bug Light	0%	0%	0%	0%	0%	0%	0%
Other	<1%	42%	8%	0%	51%	0%	51%
*Dimmable***	10%	6%	0%	33%	57%	4%	90%
*Three-way***	2%	23%	0%	0%	77%	0%	77%
Sockets per Household	44.7	11.9	3.7	4.9	23.6	.6	28.4

*A-shaped bulbs are the typical shape for standard incandescent bulbs. A-shaped CFLs are made to look and feel like traditional incandescent bulbs.
**Dimmable and three-way bulbs also fall within shape categories and therefore are not additive; for non-CFL bulbs types, dimmability was determined by the control type, not by the bulb type.

When extrapolating all the bulb shapes and features found in the 2010 and 2012 samples to the larger population of households in Massachusetts, we noted that the A-shaped bulb was declining from almost 45 million sockets in 2010 to less than 33 million in 2012 (Table 2-23). Flood/spot and candelabra shapes were increasing over time, from 14.9 million in 2010 to 21.8 million in 2012 for flood/spot, and from 4.9 million in 2010 to 14 million in 2012 for candelabra; the team expects that measurement error—specifically, inconsistent notation of bulb shape across years—explains this change. Fewer than one million sockets were filled with a dimmable CFL bulb in 2010, decreasing slightly to 0.7 million in 2012. One-half million three-way bulbs were in sockets in 2010 and in 2012. With the increase in flood/spot and candelabra type bulbs, the greatest potential for CFLs or LEDs existed with these types.

Table 2-23: Socket Saturation by Bulb Features – Number of Sockets

(Base: All onsite respondents, weighted to the population of households in the state)

Sockets Containing	All Sockets 2010	CFL 2010	Potential for CFLs or LEDs 2010	All Sockets 2012	CFL 2012	Potential for CFLs or LEDs 2012
Sample Size	*150*	*150*	*150*	*151*	*151*	*151*
Total Sockets (in millions)	**109.9**	**28.1**	**70.1**	**112.3**	**30.0**	**71.4**
A-Bulb*	44.8	.9	43.9	32.8	1.0	31.7
Spiral	21.5	21.5	.8	21.3	21.3	0
Tube	13.6	2.0	1.5	14.6	3.1	2.6
Flood/Spot	14.9	2.5	12.4	21.8	2.7	18.1
Candelabra	4.9	.05	4.9	14.0	1.1	12.9
Globe	4.1	1.6	2.4	6.3	.5	5.8
Circline	1.2	.02	0	1.0	.1	.2
Bullet/Torpedo	.06	.03	0	0.2	.1	0
Bug Light	.04	.03	0	0.0	0	0
Other	4.8	.3	4.2	0.3	.1	.1
*Dimmable***	5.1	.9	4.2	11.7	.7	10.6
*Three-way***	2.0	.5	1.5	2.2	.5	1.7
Sockets per Household	43.7	11.2	27.9	44.7	11.9	28.4

*A-shaped bulbs are the typical shape for standard incandescent bulbs. A-shaped CFLs are made to look and feel like traditional incandescent bulbs.
**Dimmable and three-way bulbs also fall within shape categories and therefore are not additive; for non-CFL bulbs types, dimmability was determined by the control type, not by the bulb type.

2.3 Current Storage of CFLs[24]

During onsite visits, technicians also counted the CFLs found in storage. The top of Table 2-24 shows that a greater percentage of homes in 2010 and 2012 stored CFLs than in 2009; while in 2009 about one-fourth of households stored CFLs, about one-third did so in 2010 and 2012. Most households stored just one to five CFLs; only 11% of households in 2009 and 13% in 2010 and 2012 stored six or more CFLs. The mean number of CFLs in storage fluctuated between 1.4 in 2009 and 2.5 in 2010, with 1.6 in storage in 2012.

Table 2-24: Current Storage of CFLs by Households

(Base: All onsite respondents)

All CFLs	2009	2010	2012
Sample Size	*100*	*150*	*151*
Zero	72%	63%	62%
One to five	18%	24%	25%
Six to fifteen	9%	9%	12%
Sixteen or more	2%	4%	1%
CFL Storage			
Total number of households	*100*	*150*	*151*
Total CFLs in storage	139	380	247
Mean number of CFLs in storage	1.4	2.5	1.6

Table 2-25 shows a great deal of fluctuation in the percentage of stored CFLs found in homes that store the bulbs. In 2009 and 2010, the majority of stored CFLs were found in homes that stored six to fifteen CFLs, while in 2012, the majority were in homes that stored sixteen or more CFLs. In combination with the results shown in Table 2-24, these findings suggest that a few outliers from the 2010 sample are likely responsible for the different CFL storage patterns apparent in that year compared to 2009 and 2012.

Table 2-25: Current Storage of CFLs by Percentage of CFLs in Storage

(Base: All onsite respondents)

All CFLs	2009	2010	2012
Sample Size	*100*	*150*	*151*
Number of CFLs in storage	**139**	**380**	**247**
One to five	28%	21%	36%
Six to fifteen	50%	28%	55%
Sixteen or more	22%	51%	9%

[24] We include a discussion of incandescent storage in Section 3.4.

Only one respondent in the 2012 onsite sample stored three LEDs. Incandescent bulb storage and stockpiling is considered in Section 3.4.

2.4 Satisfaction with Installed CFLs

The 2011 telephone survey results demonstrated a persistent decrease in CFL satisfaction between 2009 and 2011 and raised the concern that this could translate into lower CFL use.[25] In order to determine if satisfaction had an effect on CFL use and saturation as well as purchases (discussed in more detail in Section 3), the team compared these key indicators between people who said they were "somewhat satisfied" or "very satisfied" with CFLs to those who were less satisfied or did not know their level of satisfaction. The 85 respondents who noted they were satisfied with CFLs had an average of 14.1 CFLs installed compared to 12.3 CFLs among those who were less satisfied (Table 2-26), although this difference was not statistically significant. However, we did find statistically different saturation rates and numbers of bulbs purchased; satisfied onsite households had 35% of their sockets filled with CFLs and purchased 3.6 CFLs in 2012, while less satisfied households displayed a saturation rate of only 22% and bought just 1.3 CFLs in 2012. In themselves, these results are not unexpected—consumers are not going to use a product as often if they are dissatisfied with it—but they take on greater importance when considered in the context of reported decreases in CFL satisfaction. If more consumers are dissatisfied with CFLs, CFL use may go down, particularly if consumers opt for halogens to replace incandescent bulbs instead of CFLs or LEDs in the post-EISA lighting environment. This underscores the need to explore reasons for changes in satisfaction in more detail, which the team will do in Wave 2 of the telephone consumer survey being fielded in July of 2012.

Table 2-26: Satisfaction with CFLs Compared to Those Installed CFLs

(Base: telephone survey current or past CFL users, onsite respondents)

Satisfaction	Average # of CFLs Installed	Average Saturation Rate	Average 2012 CFL Purchases
Satisfied n = 85	14.1	35%	3.6
Everyone else n = 30	12.3	22%*	1.3*

* Statistically different from satisfied at the 90% confidence level

[25] NMR, *Massachusetts Consumer Survey Results*, 2012.

3 Purchases of Lighting Products

In order to ascertain lighting purchase behavior, 2012 onsite respondents indicated when they had obtained any of the CFLs found installed or stored in their homes. Time periods included early 2012 (January 1 through the date of the onsite visit), the second half of 2011, the first half of 2011, and prior to 2011, but here we report the results for the entire 2011 year and for 2012. Due to concerns about the reliability of self-reported purchases, we do not compare the results presented here to those from earlier inventories. The time periods in question overlap, but recall error means the results should not be compared directly. For example, estimates of purchases in the first half of 2010 are available from both the current and 2010 analysis, but the results point to different purchase rates, as would be expected because of recall error.

3.1 Number and Type of CFLs and LEDs Purchased

Table 3-1 summarizes the number of CFLs 2012 onsite households recalled purchasing in 2011 and early 2012. Approximately one out of three onsite respondents (30%) reported obtaining one or more CFLs in 2011, while only 9% of households purchased one or more CFLs in early 2012. Households buying CFLs in 2011 and 2012 usually purchased 15 or fewer CFLs. Most of the CFLs purchased in 2011 and 2012 were standard CFLs; 15% of households bought specialty CFLs in 2011, and 5% purchased specialty CFLs in early 2012; in both years, purchasers typically bought fewer than five specialty bulbs.

Table 3-1: CFLs Purchased by Household and Type in 2011 and 2012

(Base: All onsite respondents)

	Onsite	
	2011	**Early 2012**
Sample Size	*151*	*151*
All CFLs		
Zero	70%	91%
One to five	13%	5%
Six to fifteen	13%	3%
Sixteen or more	4%	1%
Standard CFLs		
Zero	74%	92%
One to five	13%	5%
Six to fifteen	9%	2%
Sixteen or more	6%	1%
Specialty CFLs		
Zero	85%	95%
One to five	12%	3%
Six to fifteen	3%	2%
Sixteen or more	1%	0%

Onsite respondents purchased an average of 2.9 CFLs in 2011 and 0.6 CFLs in early 2012 (Table 3-2). Standard CFLs accounted for 78% of the 2011 purchases and 69% of the early 2012 purchases.

Table 3-2: Number of CFLs Purchased in 2011 and 2012 by Type

(Base: All onsite respondents)

	Onsite	
	2011	**Early 2012**
Sample Size	*151*	*151*
All CFLs		
Total CFLs purchased	439	83
Mean number of CFLs purchased	2.9	0.6
% of all CFLs purchased	100%	100%
Standard CFLs		
Total CFLs purchased	341	57
Mean number of CFLs purchased	2.3	0.4
% of all CFLs purchased	78%	69%
Specialty CFLs		
Total CFLs purchased	98	26
Mean number of CFLs purchased	0.6	0.2
% of all CFLs purchased	22%	31%

In order to extrapolate these purchases to all households in Massachusetts, the team weighted the purchases of CFLs to the population of all households in the state. This extrapolation suggests that onsite households purchased a total of 6.6 million CFLs in 2011 and 1.3 million CFLs in early 2012 (Table 3-3). Standard spiral CFLs accounted for 4.9 million of the CFLs purchased in 2011 and 0.9 million of the CFLs purchased in early 2012. Households purchased a total of 1.7 million specialty CFLs in 2011 and about 0.5 million in early 2012.[26]

Table 3-3: Estimates of all CFLs Purchased in Massachusetts

(Base: All onsite respondents)

Products	2011	Early 2012
Total CFLs Purchased	*6,611,870*	*1,345,426*
Standard CFLs		
Total CFLs Purchased	4,895,434	884,427
% of All CFLs Purchased	74%	66%
Specialty CFLs		
Total CFLs Purchased	1,716,436	460,999
% of All CFLs Purchased	26%	34%

The number of LEDs purchased in 2011 and early 2012 was significantly less than that of CFL purchases in the same time period. Only 86 LEDs were purchased by onsite respondents in 2011, and just three LEDs were purchased in early 2012. The sample sizes are too small to extrapolate the results to the population, as doing so would exaggerate potential bias in the estimates.

When taken together, the number of market-level sales presented above and the increase in saturation of about 1.9 million CFLs shown in Section 2 do not seem to add up. Moreover, data provided by program data tracking vendors suggest that the program accounted for 4.8 million of the 6.6 million CFLs sold in Massachusetts in 2011. This raises the question: if the number of CFLs installed in homes increased by only 1.9 million between 2010 and 2011, what happened to the other 4.7 million CFLs, many of which were likely program-supported CFLs? To answer this question, the team performed a number of quality assurance and data checking procedures discussed in Section 2 and Appendix B. Here, we present three analyses involving trends in CFL use, storage, and purchases to explore this question.

The first analysis compared estimates of program-level sales, market-level sales, national CFL shipments, and CFLs found installed or in storage in homes for 2005 through early 2012 (Figure 3-1; CFL use estimates for 2006 and 2008 are extrapolated, hence the use of non-filled markers on the trendline). The data suggest that the number of CFLs found in homes and estimates of market-level sales in Massachusetts tend to mirror trends in national shipments, while program-supported sales follow a separate trend. The different trendline for program-supported sales is to

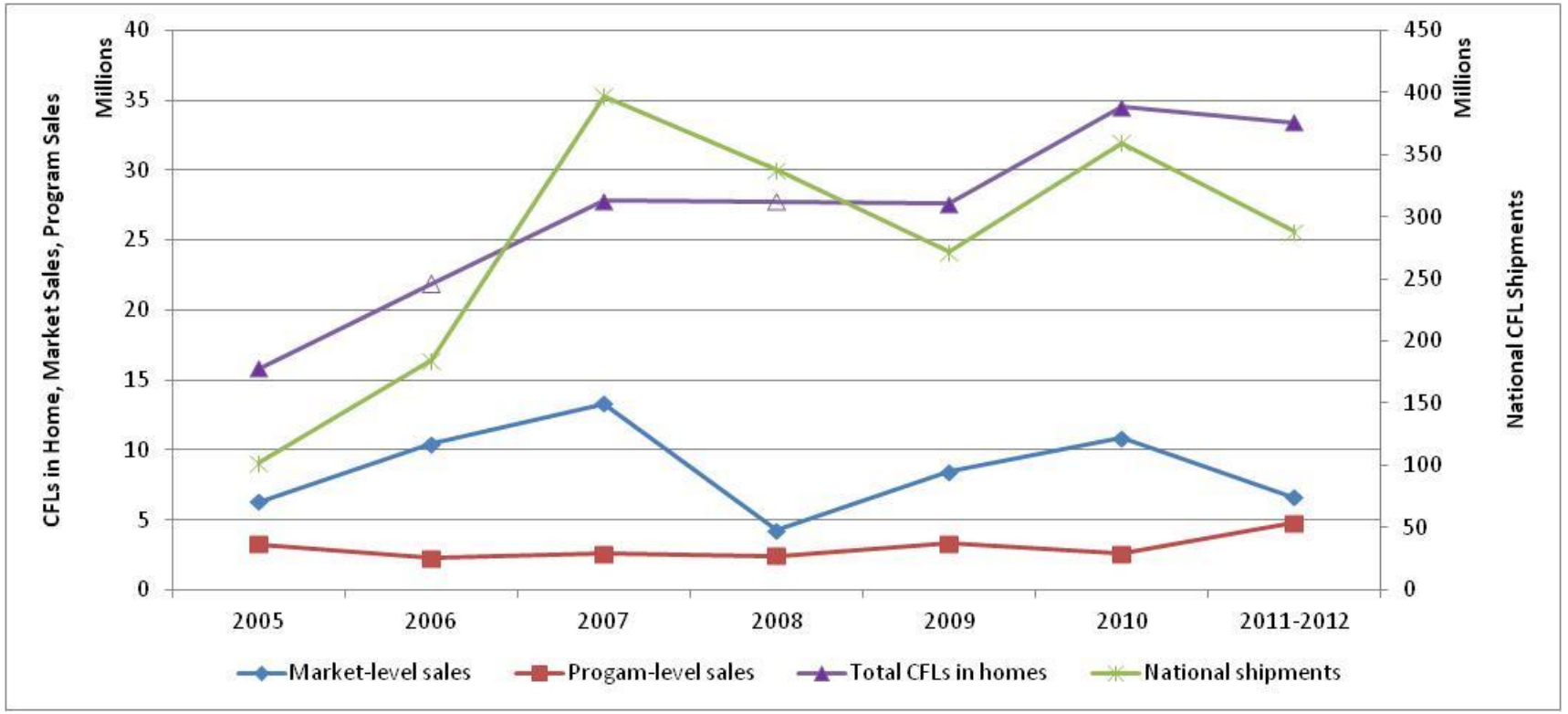
[26] The percentage differences between Table 3-2 and Table 3-3 reflect the different weighting schemes and rounding errors.

be expected, as the memoranda of understanding (MOUs) between program partners and PAs have placed limits on program-supported sales.

We also examined the *change* in the number of CFLs across years in terms of market- and program-level sales as well as CFLs installed and in storage in homes (Figure 3-2).[27] This analysis also suggests that the change in the number of program-supported bulbs does not mirror the change in the number of CFLs found in homes. In fact, in years when program-supported sales were higher, the total number of CFLs tended to decrease, and vice versa. Another important observation relates to CFLs in storage: they tend to cycle, with increases in prior time periods being offset fairly closely by decreases in subsequent time cycles; moreover, the installation of stored CFLs has tended to be associated with an overall *decrease* in the number of CFLs in the home, suggesting that at least some of these stored bulbs have been replacing previously installed CFLs.

[27] Note that some of the periods cover two years due to the availability of data and our desire not to distort results by using the extrapolated estimates shown in Figure 3-1 above.

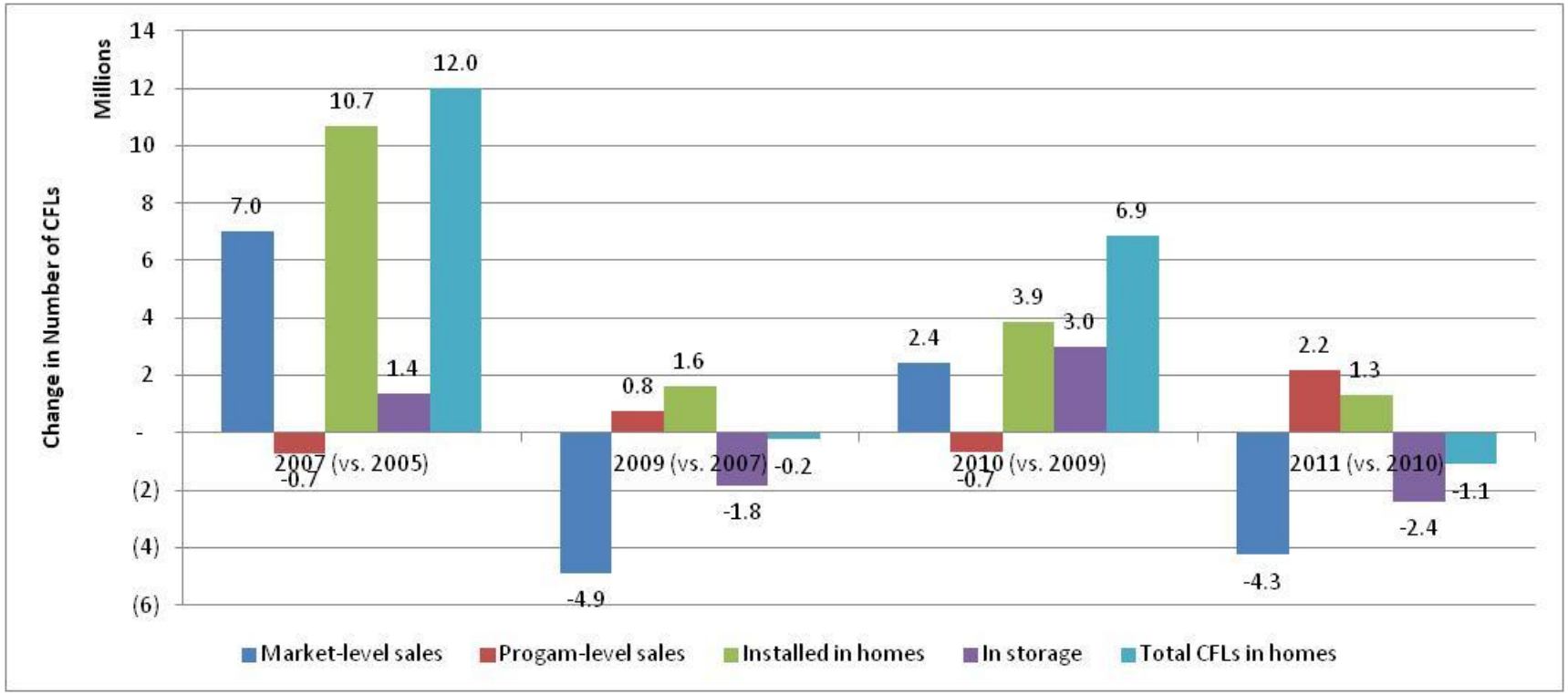
Figure 3-1: CFL Use, Sales, and Shipment Estimates 2005 to Early 2012



Sources: Total CFLs in homes, market-level sales, and program-level sales for 2005 to 2010 as compiled for the 2010 Delphi Panel.[28] Total CFLs in homes and market-level sales for 2011 and early 2012 from the current onsite visits. Program-level sales in 2011 and early 2012 from EFI and Helgeson data. National shipment data as compiled from the Department of Commerce.

[28] NMR. "Estimating the Net-to-Gross Ratio for the 2009-2010 Massachusetts ENERGY STAR Lighting Program: Delphi Panelist Response Summary." Appendix G in *Massachusetts ENERGY STAR Lighting Program 2010 Annual Report*. Delivered June 16, 2011.

Figure 3-2: Change in CFLs Sales and CFLs Found in Homes 2005 to Early 2012



The third analysis—relying on three separate approaches—examined the possibility that CFLs purchased in 2011 and 2012 could have replaced other CFLs that had burned out. The first approach, summarized in Table 3-4, involved adding the total number of CFLs found in homes in Massachusetts in 2010 to the estimated market-level sales from 2011. We then subtracted the total number of CFLs found in Massachusetts homes in early 2012. This approach suggests that 7.7 million bulbs may have burned out in 2011, and that many of them may have been replaced by newly purchased CFLs and CFLs in storage. Note that this approach does not take installation rates into account, other than by including stored CFLs in the estimate of CFLs found in the homes in 2010 and 2012.

Table 3-4: Estimating CFL Failures in 2011 – Method 1

Measures Used in Estimate	Number of CFLs
A. CFLs in Homes 2010*	34,518,832
B. Market-level CFLs sales 2011	6,611,870
C. A + B	41,130,702
D. CFLs in Homes early 2012*	33,416,942
E. C - D Implied Replacements	7,713,760

* Includes installed and stored CFLs

The second approach relies on a similar logic as the first, but takes installation rates into account. As reported in the 2009 *Residential Lighting Markdown Study*,[29] the first-year installation rate for CFLs was estimated to be 77% and the lifetime rate 97%. For this analysis, NMR made the simplistic assumption for illustrative purchases that 10% of the bulbs were installed the second year after purchase, making the annual installation rates 77% (first year), 10% (second year), and 10% (third year and lifetime). We then computed the likely burnouts in 2011 in the manner described in Table 3-5, drawing on data from the current study, the two previous *Market for CFLs* studies, and the *Markdown Study*. This approach suggests that 5.7 million CFLs burned out in Massachusetts homes in 2011, which is lower than the first approach but still points to a substantial number of burnouts.

Table 3-5: Estimating CFL Failures in 2011 – Method 2

Measures Used in Estimate	Assumptions/Sources	Number of CFLs
A. Previous Year Installed	From *2010 Market for CFLs*	28,098,169
B. Market-level CFLs sales, 2011	From current study	6,611,870
C. Market-level CFLs sales, 2010	From *2010 Market for CFLs*	10,870,314
D. Market-level CFL sales, 2009	From *2009 Market for CFLs*	8,447,382
E. B x 77%	First year installations; *Markdown Study*	5,091,140
F. C x 10%	Second year installations, derived from *Markdown Study*	1,087,031
G. D x 10%	Third year installations, derived from *Markdown Study*	844,738
H. A + E + F + G	Total should be installed	35,121,078
I. Observed installed	From current study	29,396,859
J. H – I	Possible burnouts	5,724,219

The third and most complicated approach is shown in Table 3-6. It considers not only the installation rates but also the failure rates of CFLs as estimated in the 2008 *Residential Lighting Measure Life Study*, covering the years 2005 to 2010, and extrapolates failure rates for the seventh through fourteenth years based on the previous rates of failure (see Table 3-6; in this table, cells with empirically observed or derived data are shown in white, and cells with extrapolated data are shaded gray).[30] Moreover, this approach takes the history of market-level CFL purchases in Massachusetts between 1998 and 2011 into account, with purchase data for 2005 to 2011 reported in prior studies delivered to the PAs[31] and data for 1998 extrapolated from program-level sales relative to national shipment trends (see Table 3-6). At this point having both installation and failure rates, we estimated the total number of bulbs installed by year as described in Table 3-6. We applied the failure rates to those installations, allowing us to estimate

[29] NMR and KEMA. "Residential Lighting Markdown Impact Evaluation Study." Final delivered Markdown and Buydown Program Sponsors in Connecticut, Massachusetts, Rhode Island, and Vermont. January 20, 2009.
[30] NMR and RLW. *Residential Lighting Measure Life Study*. Delivered to the New England Residential Lighting Program Sponsors, June 10, 2008.
[31] Nexus Market Research (now NMR), RLW Analytics, Inc. (now KEMA), and Dorothy Conant. *Market Progress and Evaluation Report (MPER) for the 2007 Massachusetts ENERGY STAR® Lighting Program.* Delivered to the Program Administrators on July 1, 2008. NMR. *Market for CFLs*. 2009. NMR. *Market for CFLs*. 2010.

the burnouts per year. This third method estimates 2011 CFL burnouts to be about 5.6 million, similar to the results of Method 2. Moreover, this method suggests that a total of 26.6 million CFLs have burned out since the start of the PAs' lighting programs in 1998, suggesting that the replacement of burned out CFLs with newly obtained ones has been occurring for quite some time.

It is also worth noting that subtracting the estimated 2011 CFL burnouts (5.6 million) from the estimated 2011 CFL installations (7.0 million) yields an estimate of 1.4 million additional CFLs installed in homes, meaning CFLs that did not replace existing CFLs. This is very close to the 1.9 million new CFLs observed during the onsite visits (see discussion above Table 2-17).

These results from different methods, a form of triangulation, suggest that between 5.6 million and 7.7 million CFLs could have failed in 2011, and it is NMR's opinion that the actual number of burnouts is likely closer to the bottom of that range. The CFLs that burned out in 2011 could have been replaced by CFLs or by other bulb types, but the saturation data presented above strongly suggest that most replacements were not incandescent bulbs, whose saturation decreased during that period. Moreover, while the saturation of halogen bulbs did increase, this is largely due to flood-shaped and not A-line bulbs. It therefore appears very likely that many, if not most, of these failed CFLs have been replaced with other CFLs. If we consider that perhaps another 10.5% to 15% of CFLs (700,000 to 1,000,000) have been obtained for commercial purposes,[32] the approach potentially explains the disposition of at least 6.3 million CFLs that had been obtained by or removed from storage in households in 2011 and early 2012. Another 1.9 million CFLs were newly added to homes in 2011 and early 2012, bringing the total number of bulbs potentially accounted for to 8.2 million. Thus, in just over one year, the analysis potentially accounts for the whereabouts of 75% of the CFLs (10.8 million) supported by the program *over the past three years*. Considering leakage, returns, disposals, and measurement error (see Appendix B), NMR believes that this approach provides a feasible explanation of "where the CFLs have gone" even if it does not entirely prove the disposition of the program- and non-program CFLs obtained by Massachusetts households in 2011.

[32] These percentages of commercial leakage are estimates used or reported in various sources, not all of which are publically available. However, they were discussed in communications regarding this study.

Table 3-6: Estimating CFLs Replacing Other CFLs – Method 3

Year after Purchase	Failure Rate*	Year	Market Level Purchases	Newly Installed in Given Year**	Burned out in a Given Year
First	4%	1998	305,216	235,016	9,039
Second	9%	1999	554,077	457,161	38,674
Third	8%	2000	530,006	494,034	79,202
Fourth	15%	2001	979,811	862,863	149,326
Fifth	10%	2002	892,859	838,483	241,637
Sixth	8%	2003	3,565,495	2,932,698	397,649
Seventh	10%	2004	4,565,862	3,961,549	722,209
Eight	5%	2005	6,308,402	5,670,605	1,123,553
Ninth	5%	2006	10,426,466	9,115,805	1,854,475
Tenth	4%	2007	13,330,771	11,938,180	2,836,906
Eleventh	3%	2008	4,248,761	5,647,270	3,692,280
Twelfth	3%	2009	8,447,382	8,262,437	4,462,733
Thirteenth	2%	2010	10,870,314	9,639,756	5,389,633
Fourteenth	2%	2011	6,611,870	7,022,909	**5,617,062**
Cumulative			71,637,292	67,078,766	26,614,379

* Derived from NMR and RLW. *Residential Lighting Measure Life Study*. 2008. This column does not correlate with the columns to the right of the table, but factors into the burn-out rate for each year; we show the failure rates in this table in order to have all the components of the calculations in one place.

** Sum of 77% of the current year market-level purchases and 10% of each of the two previous years' market-level purchases.

*** Sum of the burnouts occurring in that year based on all installations occurring prior to that year. To use a simple example, the number of burned out CFLs in 2000 includes 4% of the CFLs obtained in 2000 plus 9% of the CFLs obtained in 1999 and 8% of the CFLs obtained in 1998.

3.2 Manufacturers of CFLs and LEDs Obtained in 2011 and 2012

The team also collected information on the manufacturers of the CFLs and LEDs obtained in 2011 and early 2012. Table 3-7 lists the number of standard CFLs, specialty CFLs, and LEDs purchased for each manufacturer. The unweighted number of bulbs purchased is reported because of the relatively small sample sizes of purchases for each manufacturer. General Electric accounted for the largest number of CFLs that respondents reported purchasing in 2011 (64 total CFLs) and early 2012 (15 total CFLs). Ecosmart (54 total CFLs; the current Home Depot brand name) and Philips (40 total CFLs) were the second and third largest manufacturers, respectively. Additionally, N:Vision (a previous Home Depot brand name) accounted for 18 total CFLs, and Commercial Electric (another previous Home Depot brand name) accounted for an additional 8 total CFLs. Combined, the 90 CFLs purchased through Home Depot labels make this retailer the fourth largest "manufacturer" of CFLs, even though, in reality, the bulbs are manufactured by another company and simply sold under the Home Depot labels.

When reviewing the purchase of LEDs in 2011, FEIT Electric is the leading manufacturer of LEDs at 29 bulbs purchased or 35% of the total, although the manufacturer could not be determined for 40 of the LEDs. Likewise, Earthmate led the number of specialty CFLs purchased in 2011 at 12 bulbs. Only General Electric (7 specialty CFLs), Philips (1 specialty CFL), and Earthmate sold specialty CFLs to the onsite respondents in 2011. The reported manufacturers of CFLs purchased in early 2012 are narrower, as only three manufacturers (General Electric, Ecosmart, and TCP) accounted for 62% of the total CFLs purchased. No specialty CFLs were purchased in early 2012 and only one LED was purchased, but the manufacturer could not be identified. It is important to note that the *self-reported* date of purchase is subject to respondent error, and the date of actual purchase may differ. However, the onsite technician determines manufacturer by looking at the actual bulb; therefore, the manufacture data are more reliable than the date of purchase.

Table 3-7: Total Purchases by Manufacturer

Manufacturer	2011				Early 2012			
	Specialty	Standard	LED	Total	Specialty	Standard	LED	Total
Number of Bulbs								
General Electric	7	57	1	65	0	15	0	15
Ecosmart	0	54	0	54	0	11	0	11
Philips	1	39	1	41	0	3	0	3
Sylvania	0	25	8	33	0	0	0	0
FEIT	1	20	29	50	0	0	0	0
N:Vision	0	18	0	18	0	0	0	0
TCP	0	16	0	16	0	13	0	13
Earthmate	12	1	0	13	0	0	0	0
Harmony	0	10	0	10	0	4	0	4
Commercial Electric	0	8	0	8	0	0	0	0
Maxlite	0	8	0	8	0	1	0	1
Lights of America	0	5	2	8	0	0	0	0
Bright Effects	0	5	0	5	0	0	0	0
Broada	0	5	0	5	0	0	0	0
Spring Light	0	4	0	4	0	0	0	0
Greenlite	0	2	0	2	0	0	0	0
Conserv Energy	0	1	0	1	0	4	0	4
Fresh	0	1	0	1	0	0	0	0
Hampton Bay	0	0	1	1	0	0	0	0
Globe	0	0	0	0	0	4	0	4
Westinghouse	0	0	0	0	0	4	0	4
Utilitech	0	0	0	0	0	2	0	2
Not Available	0	2	40	42	0	1	1	2

3.3 Types of Stores where Respondents Shop for Light Bulbs

The onsite respondents were asked the date and location that they had purchased the CFLs installed in their homes. CFL bulb counts were then extrapolated to the larger Massachusetts population to provide an estimate of likely bulb sales statewide. As Table 3-8 demonstrates, 45% of the CFLs purchased in 2011 (174 bulbs) were bought at home improvement stores. Significantly smaller quantities were purchased at warehouse stores, bargain stores, hardware stores, grocery stores or supermarkets, and drugstores.

Another major source of CFL purchases in 2011 was mass merchandise or discount stores. These establishments sold 24% (93 bulbs) of the total CFLs for the year. Based on respondent self-reports, the PAs also supplied 45 bulbs or 12% of the CFLs to the sample of respondents through direct install programs. Notably, bargain stores (e.g., dollar stores) and drugstores were a negligible source of CFL purchases. Combined, these two types of stores sold only 4 CFLs to onsite respondents in 2011.

In early 2012, the majority of CFLs were purchased or acquired through home improvement stores, mass merchandise or discount stores, and PA programs (Table 3-9). However, home

improvement stores and mass merchandise or discount stores sold almost equal amounts of CFLs in early 2012 at 22 (27%) and 24 (29%) bulbs, respectively. Additionally, PAs provided the largest significant number of CFLs in early 2012 at 20, or 24%, of the CFLs in the sample, indicating that at least one participant had likely taken part in a direct-installation program.

Table 3-8: Types of Stores where Bulbs Were Purchased

(Base: All onsite respondents)

Store Type	2011								
	Home improvement	Warehouse	Bargain	Mass merchandise/ discount	Hardware	Grocery/supe rmarket	Drugstore	PA program	Other
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Number of CFLs Purchased*	**174**	**15**	**4**	**93**	**30**	**10**	**0**	**45**	**15**
Bright Effects	5	0	0	0	0	0	0	2	0
Commercial Electric	8	0	0	0	0	0	0	0	0
Conserv Energy	0	0	0	1	0	0	0	0	0
Earthmate	5	0	0	1	0	0	0	7	1
Ecosmart	71	0	0	0	0	0	0	2	0
Feit	10	0	0	15	7	0	0	1	0
Fresh	1	0	0	0	0	0	0	0	0
Full Spectrum	0	0	2	0	0	0	0	0	0
General Electric	11	0	0	38	11	6	0	7	2
Globe	5	0	0	0	0	0	0	0	0
Greenlite	0	0	2	0	0	1	0	1	0
Harmony	7	0	0	1	0	0	0	2	0
Lights of America	5	0	0	0	0	0	0	1	0
Maxlite	5	4	0	0	1	0	0	1	10
N:Vision	14	0	0	0	0	0	0	4	0
Not Available	0	0	0	1	0	0	0	1	0
Philips	14	0	0	30	4	0	0	1	0
Spring Light	0	0	0	0	0	0	0	4	0
Sylvania	12	11	0	1	0	3	0	2	0
TCP	1	0	0	4	0	0	0	9	3
Westpointe	0	0	0	0	7	0	0	0	0

Table 3-9: Types of Stores where Bulbs Were Purchased

(Base: All onsite respondents)

Store Type	Early 2012								
	Home improvement	Warehouse	Bargain	Mass merchandise/ discount	Hardware	Grocery/supe rmarket	Drugstore	PA program	Other
Sample Size	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*
Number of CFLs Purchased*	**22**	**0**	**13**	**24**	**2**	**0**	**1**	**20**	**0**
Ecosmart	12	0	0	0	0	0	0	0	0
GE	0	0	0	18	1	0	1	1	0
Globe	4	0	0	0	0	0	0	0	0
Greenlite	0	0	13	0	0	0	0	0	0
Harmony	0	0	0	0	0	0	0	4	0
Maxlite	0	0	0	0	1	0	0	0	0
Philips	0	0	0	0	0	0	0	3	0
TCP	5	0	0	0	0	0	0	8	0
Utilitech	2	0	0	0	0	0	0	0	0
Westinghouse	0	0	0	7	0	0	0	0	0

* Results subject to rounding error

3.4 EISA and Possible Stockpiling

As mentioned earlier, EISA included new efficiency standards for lighting products, and the legislation began to be implemented in January 2012 when 100-Watt incandescent bulbs could no longer be manufactured or imported into the United States. EISA has raised some concerns about the stockpiling of incandescent bulbs. Incandescent stockpiling was documented in the United Kingdom,[33] and German sources report that sales of incandescent bulbs jumped by 34% during the first half of 2009 in anticipation of the incandescent restrictions in that country.[34] In the United States, evidence of stockpiling ahead of the phase-out has also been reported.[35] According to information reported by the National Electrical Manufacturers Association (NEMA), in 2011, "Shipments of CFLs decreased by 6.6% compared to 2010. Conversely, incandescent lamp shipments rose 16.4% during 2011. A preponderance—62.1%—of the increase over last year occurred during [the fourth quarter]."[36] The earlier telephone survey results suggested that approximately 23% of respondents were likely to stockpile 100-Watt incandescent bulbs; moreover, respondents likely to stockpile also indicated that they had bought more 100-Watt incandescents in the months preceding the survey than those who were not likely to stockpile.[37] Given the concern about stockpiling and the self-reported tendency of some telephone survey respondents to stockpile, an important aspect of the onsite inventory was to search for evidence of actual stockpiling of incandescent bulbs.

[33] Stockpiling of incandescent bulbs by both retailers and consumers happened in the United Kingdom after the government asked retailers voluntarily to stop selling 75-Watt and 100-Watt CFLs in advance of their legal banning in 2012. See http://www.nytimes.com/2009/04/24/world/europe/24bulbs.html?ref=earth.
[34] Europe's Ban on Old-Style Bulbs Begins. New York Times. August 31, 2009. http://www.nytimes.com/2009/09/01/business/energy-environment/01iht-bulb.html
[35] There is evidence of stockpiling from designers to homeowners over the uncertain future of incandescent bulbs. See http://www.nytimes.com/2011/05/26/garden/fearing-the-phase-out-of-incandescent-bulbs.html?pagewanted=all
[36] See http://www.nema.org/News/Pages/Shipments-of-Incandescent-Lamps-Illuminate-at-the-Close-of-2011.aspx.
[37] NMR, *Massachusetts Consumer Survey Results*, 2012.

During the onsite visit, the team searched for stored incandescent bulbs and explored whether self-reported likelihood to stockpile related to actual stockpiling behavior verified onsite. We found approximately four incandescent bulbs between 40 Watts and 100 Watts in storage in onsite homes on average; 0.6 of these were 100-Watt bulbs, which are currently being phased out (Table 3-10). Because we found so few 100-Watt incandescents in storage, we expanded the analysis of potential stockpiling beyond these bulbs; it was likely that most consumers did not fully understand the phase-out implementation of EISA. The results indicated that the households that reported being most likely to stockpile incandescent bulbs had more incandescent bulbs in storage than those households that said they were less likely to stockpile. The findings indicated that there is suggestive evidence that those likely to stockpile are indeed storing more incandescent bulbs than those who are not. However, because we have not tracked storage of incandescent bulbs in prior onsite studies, we cannot conclude with certainty that the pattern displayed in Table 3-10 results from EISA.

Table 3-10: Likelihood of Buying and Saving Extra 40- to 100-Watt Incandescent Bulbs for Use after 2012

(Base: All Respondents)

Level of likelihood	Sample Size (unweighted)	Average of all 40- to 100-Watt Stored Incandescent	All Incandescent Stored Bulb Count (weighted)
Overall	151	3.96	594
Very likely	8% (10)	8.6	98
Somewhat likely	14% (20)	4.6	93
Somewhat unlikely	17% (24)	3.5	87
Very unlikely	58% (95)	3.6	316
Don’t know/refused	4% (2)	--	--

In an attempt to address this possibility that EISA was driving incandescent storage, however, the technician asked all households storing 100-Watt incandescent bulbs why they were doing so. The most popular response, cited by seven out of the 18 respondents, was to have the bulbs as a back-up for when another 100-Watt incandescent burned out. The second most popular response, cited by four respondents, was that they simply liked to have extra 100-Watt incandescents. Only one respondent indicated purchasing and storing 100-Watt incandescents specifically because the bulbs would stop being made. All responses are shown in Table 3-11.

Table 3-11: Why Respondents Purchased and Stored 100-Watt Incandescents

(Base: Respondents with 100-Watt Incandescents in Storage)

Reason	Sample Size
Total	*18*
As a back-up/to replace burned out 100 Watt bulbs	7
I like to have extras	4
For the wattage	1
They were there when we moved in	1
Because they will stop being made/EISA	1
Other	1
Don't know/no reason	3

4 Conclusions and Recommendations

Based on the onsite analysis, the team concludes that most households in Massachusetts use CFLs, even if some of them are dissatisfied with the products or are not aware that they are using them. Despite high rates of penetration (i.e., households using CFLs), the number of CFLs in use and the percentage of sockets in which they are installed appears to have leveled over the past two years, and there is evidence that recently purchased CFLs are largely being used to replace installed CFLs that have burned out. Between 2009 and 2010, statistically significant gains were made in increasing the number of specialty CFLs in homes, but this increase was not repeated between 2010 and 2012. LEDs remain an emerging technology in Massachusetts, with very few homes using any LEDs bulbs; most of the LED bulbs in use do not adhere to the A-shaped profile and are installed in track lighting or under cabinets. Most sockets in the state could still be converted to CFLs and LEDs using bulb shapes and sizes already available—and often program supported—at stores where consumers buy most light bulbs.

Use of incandescent bulbs has also decreased, but this trend started well before the January 1, 2012, implementation of the first phase of EISA. The rate at which sockets are being converted *away* from incandescents will likely accelerate with later stages of EISA, particularly the 2014 implementation of the 60-Watt phase-out. The question remains: what bulbs will consumers adopt in place of incandescent bulbs? The saturation results suggest that, even while CFL saturation has stagnated, households have increased the number and proportion of sockets filled with halogens, although virtually none of those found in onsite homes were the more recently introduced A-shaped variety; instead, consumers used pin-base and flood-shaped halogens. Yet, the team expects that the use of A-shaped halogen bulbs will increase as incandescents become scarce simply because they look so much like traditional incandescent bulbs; consumers may not even realize that they are buying halogens. Continued incentives for all types of CFLs and LEDs and increased education focusing on A-shaped CFLs could help offset consumers' move toward the less efficient A-shaped halogen.[38] Whether increasing the saturation of energy-efficient lighting remains a challenge for the program will depend on how consumers respond to EISA over the next few years. Therefore, continuation of incentives for all types of CFLs and LEDs should be paired with continued regular tracking of saturation to understand if and how saturation shifts in the coming years.

Finally, we found some evidence of incandescent stockpiling in the households who self-report being likely to stockpile, as those homes actually had more incandescents in storage than households who said they were not likely to stockpile. Overall, though, the onsite households are storing about four incandescents per household, the size of one typical pack of these bulbs. In short, stockpiling is occurring and may increase with the impending 2014 phase-out of the

[38] Focus groups held in Connecticut in fall 2011 suggested that consumers wary of CFLs for certain applications enjoyed the shape and light quality of A-shaped CFLs that were included in a light bulb demonstration. See NMR Group, Inc. 2011. *Connecticut Lighting Focus Groups: Exploration of Changes in the Lighting Market and Reactions to Various Efficient Lighting Choices*. Delivered to the Energy Efficiency Board in December 2011.

popular 60-Watt bulb, but, for now, it appears that stockpiling rates are likely to remain low and confined to a small but important subset of consumers.

Based on the results of the onsite inventory, the team makes the following four recommendations; these are in addition to those made previously in the Wave 1 telephone survey report:

Recommendation 1: Consider revisions to program design to reinvigorate adoption of standard and specialty CFLs. These revisions should include updated marketing strategies to boost use of energy-efficient bulbs in standard and specialty applications. A high-volume program would need to continue with the PAs' current upstream approach. Even so, the slowing saturation calls for other creative approaches. NMR understands that the PAs will soon pilot a market lift strategy to promote CFLs and LEDs, and the program design incorporates an evaluation strategy that will facilitate determining program impact. The results of the pilot evaluation, together with those from the second and third waves of the telephone survey and the 2013 onsite saturation study will help to clarify if any changes in CFL use, saturation, and purchase rates have resulted from the pilot and from the first full year of EISA implementation. It may be worth considering some new approaches in addition to market lift—perhaps some approaches that are untried and could be explored. NMR does not have evidence of the efficacy of these approaches; they are offered simply for PAs' consideration. It may be worthwhile to explore the feasibility of some of the following approaches, perhaps in the form of pilots:

- Although the CFL potential for non-converted sockets is greater for specialty shaped bulbs than standard A-line bulbs, the likely high rate of newly purchased CFLs replacing burned out CFLs suggests that the program may want to promote a higher ratio of standard CFLs and A-line CFLs.[39] This will work to keep the saturation rate of CFLs steady, while still offering consumers the opportunity to convert remaining specialty and standard sockets to CFLs and LEDs.
- Bulb buyback programs – Either buying working incandescents back at slightly below their retail value or offering to replace incandescents with CFLs. This could be accomplished at store kiosks or another central location.
- Ending "get them while you can" incandescent promotions at program retailer stores – Last September (prior to the 100-Watt phase-out), a team member noted that some program retailers had displays of incandescents in or near lighting aisles and even at the check-out lanes with signs urging consumers to "get them while you can." To the extent that this is still occurring or may occur again prior to the phase out of 40-Watt to 75-Watt incandescents, the PAs may want to exert pressure to stop the practice,

[39] The A-line CFL is currently considered a specialty bulb because of its higher price and non-spiral shape. However, the profile mimics that of the most common A-line incandescent shapes, meaning that the A-line CFL is meant to fill standard sockets, not specialty ones (as are, for example, candelabra or flood-shaped CFLs).

perhaps by negotiating a "cease fire" among some of the major retail partners to stop promoting incandescents at the very least, and preferably to phase them out early.

- Neighborhood swarm light bulb replacement – The PAs would pick an area and then have representatives knock on doors and offer to change a specified number of inefficient bulbs in homes with CFLs and LEDs.

Recommendation 2: Continue working with the residential retail products and other residential evaluation teams as well as program implementers to understand the dynamics of consumer satisfaction with CFLs and LEDs more fully. The telephone survey demonstrated that respondents who say they are satisfied with CFLs often have similar concerns about the technology as those who are dissatisfied with CFLs. The onsite analysis suggested that dissatisfied households used and purchased fewer CFLs, on average, than did those that were satisfied with CFLs. Yet, despite these findings, we still do not have a clear understanding of what makes one person decide not to use CFLs; for example, one person may decline to use them because he or she takes a while to warm up and another person may shrug this concern off as unimportant when compared to the things he or she likes about CFLs. The Wave 2 consumer survey will explore reasons for satisfaction and dissatisfaction with CFLs—including the role of media attention—in more depth. However, additional strategies, such as more in-depth questioning during onsite inventories or focus groups, may be needed to understand these dynamics more fully and could reveal steps the PAs could take to increase satisfaction among consumers.

Recommendation 3: Work with manufacturers, perhaps through national organizations like CEE or manufacturers' association, to try to persuade them to remove the phrase "energy-efficient" from A-line halogen bulbs. A-line halogen bulbs will be the new standard bulb when the lumen-equivalent incandescent bulbs are phased out. Labeling them as "energy-efficient" is misleading to consumers, many of whom may not understand that halogens will now be among the least efficient bulbs they can buy to replace phased-out incandescents.

Recommendation 4: Continue efforts to educate consumers about their bulb choices post-EISA, helping them to make the most efficient choices possible for their lighting needs. This recommendation echoes those made in the consumer survey report, but its importance is highlighted by the fact that consumers currently have little awareness of A-shaped halogens but are fairly aware of CFLs. The opportunity exists now to help them understand the benefits of using CFLs and LEDs over halogens in most applications in the home. A-shaped CFLs offer a unique opportunity, as they resemble incandescents and can be used with clip-on lampshades, unlike standard CFLs. Related to this recommendation is the suggestion to consider the cessation of promotions of CFLs and LEDs that do not perform at levels consumers desire; dimmable, three-way, and candelabra CFLs and LEDs are among the products the PAs should consider not supporting until the technology improves to standards desired by consumers. The PAs should review performance data for all types of specialty CFLs and LEDs to determine which ones have the quality to justify promotion.

Appendix A Onsite Respondents' Characteristics

In order to determine any potential sources of bias, the team also examined how closely onsite households resembled those responding to the telephone survey as well as the state population. Key indicators examined included awareness and familiarity with energy-saving light bulbs, housing characteristics, and social attributes.

A.1 Awareness of and Familiarity with Energy-Efficient Bulbs

The current sample of onsite respondents closely resembled the telephone survey respondents in reported CFL awareness (Table A-1). Likewise, the team identified very few statistically significant differences in reported familiarity with CFLs, LEDs, and halogen bulbs between the onsite households and all telephone survey respondents (Table A-2).

Table A-1: Awareness of CFLs

(Base: All respondents)

Awareness	2012 Onsite Sample	2011 Telephone Survey
Sample size	*150*	*582*
Yes	94%	93%
No	6%	8%
Don't know/refused	0%	0%

* Significantly different at the 90% confidence level

Table A-2: Familiarity with Energy-Saving Bulb Types 2011

(Base: All respondents)

Familiarity with CFLs	**2012 Onsite Sample**	**2011 Telephone Survey**
Sample size	*150*	*582*
Very familiar	34%	29%
Somewhat familiar	38%	40%
Not too familiar	16%	17%
Not at all familiar	6%	6%
Not aware of CFLs	6%	8%
Don't know / refused	0%	<1%
Familiarity - LEDs	**2012 Onsite Sample**	**2011 Telephone Survey**
Sample size	*150*	*582*
Very familiar	14%	16%
Somewhat familiar	30%	24%
Not too familiar	23%	25%
Not at all familiar	33%	34%
Don't know / refused	1%	<1%
Familiarity – Halogen Bulbs	**2012 Onsite Sample**	**2011 Telephone Survey**
Sample size	*150*	*582*
Very familiar	38%	32%
Somewhat familiar	40%	37%
Not too familiar	11%	12%
Not at all familiar	10%	19%*
Don't know / refused	0%	<1%

* Significantly different at the 90% confidence level

A.2 Housing Characteristics

Telephone survey respondents, including the subset that took part in the onsite visits, were more likely to live in single-family detached or attached homes and less likely to live in an apartment building than were all Massachusetts residents, but we observed no statistically significant differences between the telephone survey respondents and the onsite households in the types of homes in which respondents lived (Table A-3).

Table A-3: Type of Home

(Base: All Respondents)

Type of home	Massachusetts Census	2012 Onsite Sample	2011 Telephone Survey
Sample size	*2,512,552**	*150*	*582*
Single-family detached house	52%	55%	54%
Single-family attached house (townhouse, row house, or duplex)	5%	12%	16%
Apartment building with 2-4 units	21%	19%	13%
Apartment building with 5 or more units	21%	13%	14%
Mobile home or house trailer	1%	0%	<1%
Other	0%	2%	1%
Don't know/Refused	-	0%	<1%

* Total occupied housing units

About three out of five onsite respondents (64%) reported that their homes were smaller than 2,000 square feet, compared to 68% among all telephone survey respondents, but the differences were not statistically significant (Table A-4).

Table A-4: Size of Home

(Base: All Respondents)

Square Feet	2012 Onsite Sample	2011 Telephone Survey
Sample size	*150*	*582*
Less than 1,400	40%	36%
1,400 – 1,999	24%	32%
2,000 –2,499	17%	15%
2,500 – 3,499	8%	11%
3,500 – 3,999	5%	3%
4,000 – 4,999	1%	1%
5,000 or more	4%	2%
Don't know/Refused (sample size)	31	185

A.3 Social Attributes

The onsite and telephone survey respondents were less likely to live in single-person households than Massachusetts residents overall, but family size was not statistically different between the onsite and telephone surveys (Table A-5).

Table A-5: Number of Persons Living in Home

(Base: All Respondents)

Number of household members	Massachusetts Census	2012 Onsite Sample	2011 Telephone Survey
Sample size	*2,512,552*	*150*	*582*
1	29%	18%	17%
2	32%	31%	35%
3	16%	24%	20%
4	14%	17%	16%
5	6%	6%	7%
6 or more	3%	3%	4%
Don't know/refused	-	1%	<1%

Among those who provided a usable response when asked about their household income, the onsite sample included a greater percentage of lower-income respondents than the state of Massachusetts as a whole. Although 42% of Massachusetts households make less than $50,000 a year, 49% of 2012 onsite survey respondents and 53% of 2011 telephone survey respondents had incomes of less than $50,000. The large number of respondents who refused to answer this item, however, makes comparability difficult (Table A-6).

Table A-6: Household Income

(Base: All Respondents)

Household Income	Massachusetts Census	2012 Onsite Sample	2011 Telephone Survey
Sample size	*2,512,552*	*150*	*582*
Less than $15,000	13%	8%	12%
$15,000 to less than $20,000	5%	9%	7%
$20,000 to less than $30,000	8%	14%	14%
$30,000 to less than $40,000	8%	11%	12%
$40,000 to less than $50,000	8%	7%	8%
$50,000 to less than $75,000	17%	13%	15%
$75,000 to less than $100,000	13%	13%	11%
$100,000 to less than $150,000	16%	14%	13%
$150,000 or more	13%	12%	9%
Don't know (sample size)	-	6	19
Refused (sample size)	-	11	69

Appendix B Where Have the CFLs Gone?

The results of the onsite saturation studies in 2009 to 2012 suggest that CFL saturation has increased by only about one percent over this three-year period; during the same three-year period, the total number of CFLs found in all homes in Massachusetts increased from about 23 million to 30 million. (However, as mentioned elsewhere in this report, combined CFL and LED saturation increased by 2%, from 26% to 28%, during the same period.) Based on data provided by EFI and Helgeson, NMR estimates that the program provided incentives for 10.8 million CFLs from 2009 to early 2012,[40] leaving 3.8 million program bulbs not accounted for, not to mention all the non-program bulbs sold in the state. This appendix provides an overall description of the steps the team took to attempt to account for these "missing" bulbs. These steps included considering quality control during onsite data collection and analysis and outlining other possible dispositions of program CFLs. Note that Section 2 and Section 3 provide detailed results for the most pertinent of these analyses—saturation by house size and estimating the number of CFLs that burned out in 2011. Quality control checks led the team to conclude that the data collection followed proper procedures and, with an exception about home size noted below, did not result in bias that could explain where all the CFLs have gone. Instead, additional analyses suggest a number of possible locations of the missing CFLs, which collectively could account for most of the missing bulbs. As shown in Section 3, we especially suspect that newly purchased CFLs have been replacing existing CFLs that have burned out, while below we discuss some other possible locations of the missing bulbs. We also suggest that the PAs and EEAC consultants pursue a study to explicitly track where CFLs go after they leave the store in order to understand the full range of customers who are buying program-supported bulbs and what they are doing with them after purchase. Importantly, this study should include commercial customers and contractors (maintenance companies, electricians, etc.), as they may buy products targeted for residential use and use them in non-residential situations. Such bulbs would not be captured in our residential-only study.

B.1 Onsite Quality Control

KEMA, a subcontractor to NMR, performed the onsite data collection. Its team followed these quality control procedures while collecting data:

- Held trainings with field staff
- Performed follow-up quality control calls
- Limited the number of technicians who performed onsite visits to reduce variability in data collection by technician

[40] NMR used dates provided in the files by both companies to avoid double counting bulbs; however, as shown in Figure 3-1, the estimate of program-supported bulbs for 2011 and early 2012 is 2.2 million more CFLs in 2010. If the PAs believe this number is in error, we request that they provide us with estimates from their own records.

- Strengthened efforts to look at all sockets, even those in enclosed fixtures or located on very high ceilings

In looking at the data for Massachusetts from 2009 to 2012 as well as data from other states evaluated by team members in the past few years, it is the team's opinion that **socket counts** might vary based on the types of quality control procedures in place for onsite visits, but **saturation percentages** do not change much based on those procedures. This is because the types of sockets technicians "find" or "miss" are not biased in terms of the types of bulbs found in them.

B.2 Alternative Weighting Scheme for 2012 Analysis

As discussed earlier (see Section 2.2), the team found that socket saturation varied by home size and that the size of homes visited in 2012 were slightly skewed to larger homes compared to the distribution of home size in Massachusetts. In order to make an apples to apples comparison between saturation in 2010 and 2012, the team performed an analysis of saturation in which we weighted the 2012 data back to the 2010 sample based on home size. Doing so increased saturation for 2012, but by only a very small amount, from 26.7% to 27.2%. The small change is due to the fact that the distribution of home size in 2010 is very similar to that of 2012; thus, any bias in saturation due to home size was present in both samples. This again supports the conclusion that CFL saturation has increased very little in the past few years.

B.3 Where Might the CFLs Have Gone?

The team, in conversation with the PAs and EEAC consultants, have identified five possible explanations for the location of the missing CFLs. We believe that each of these partially explains the disposition of the missing program and non-program CFLs sold between 2009 and 2012. Importantly, as summarized in Section 3.1, our analyses support the possibility that many of the CFLs purchased recently could very well be replacing CFLs that have burned out. While the analyses do not provide definitive proof that this is the case, they certainly provide a viable explanation of where most of the "missing" CFLs have gone. The five explanations are as follows:

1. *Sampling and measurement error*: Sampling error would mean that the sample of homes we visited is biased in some manner such that it does not accurately represent all households in Massachusetts; in particular, we found that the homes in the sample are slightly larger than homes in the state overall. Measurement error would involve not counting all the sockets or bulbs in storage in homes or misidentifying the types of bulbs found in the homes. We cannot quantify this error, but it is likely that some sockets and bulbs were missed during the onsite visits.
2. *Non-residential applications*: Program-supported bulbs may be installed in commercial applications, particularly small businesses or public areas of multifamily buildings. Using

an estimate of 10.5% to 15% of CFL sales being for commercial use (percentages used by various sources and noted in communications regarding this study) would place this number between 700,000 and 1,000,000 in 2011 and early 2012.

3. *Returns and early failures*: Unfortunately, not all customers are satisfied with CFLs and some CFLs fail early. Customers may have returned these bulbs to the store or disposed of them.
4. *Leakage outside of the state*: CFLs purchased in Massachusetts may be installed outside of the state; note that we have no evidence for this, but present it as a possibility.
5. *Replacement of many CFLs with other CFLs*: CFLs have a measure life of about seven years, meaning that many of the program-supported bulbs sold in the mid-2000s are now burning out. Customers who are satisfied with CFLs are likely replacing them with newly purchased CFLs. See Section 3 for more detail.

Appendix C Onsite Data Collection Form – Lighting

Massachusetts ENERGY STAR

Lighting and Consumer Electronics

On-Site Data Collection Form

Customer ID # **Customer Name:**

Inspector: **Date:** **Time:**

Utility:

Notes: «Notes»

I. Introduction

"Hello, my name is _____ with _____ working under contract to the Residential ENERGY STAR Products Program in Massachusetts [If respondent asks "Who are the sponsors?" Say: The group of sponsors includes **National Grid, NSTAR** [SAY "N-star"] **Electric, Cape Light Compact, Western Massachusetts Electric Company, and Unitil**.]. I'm here to meet with _____. As I mentioned on the phone, I'm here to walk through your home and record the types of lighting fixtures and bulbs installed in each socket. I'd also like to take a look at your water heater and some of your home electronics and power strips. [Customer should be expecting auditor]. During my visit I'll also be asking a few questions about your home's general characteristics, about lighting and about your use of some home electronics. In appreciation for your time, the sponsors of the ENERGY STAR Lighting Program in Massachusetts are offering you a payment of $150. Do you have any questions regarding my visit?"

II. Lighting Count

Record information on all interior and exterior lighting sockets on the attached sheets. Refer to bulb shape code list. Then ask:

"Now, I would like to see all light bulbs and fixtures that are not currently installed. This would include those you have bought and not yet installed as well as those that were installed and then removed."

Record information on all bulbs in storage on the attached sheet.

III. TVs, Set Top Boxes, and Power Strips

For each TV and set top box in the home, record all items indicated on the attached TV and Set Top Box Form.

Then, for each power strip in the home, record all items plugged into each type indicated on the attached Power Strip Form.

IV. Appliances and Home Office Equipment

Gather information for each as noted in the Appliance and Home Office Equipment form; including manufacturer, model #, counts, power source, etc.

Massachusetts Onsite Lighting Socket Inventory Report

Room	Fixture Type by Location				Num. of Fixtures	Num. of Sockets	Bulb Type	Bulb Shape	Socket Type	Watts	Dimmable?	3-Way?	For all bulbs Manufacturer	For CFLs & LEDs only Model Num.	Num. Bulbs	For & Pur
	Ceiling R=Recessed P=Pendant F=Flush mount T=Track CF=Ceiling Fan O=Other [Specify]	Wall W=Wall mount N=Night light O=Other [Specify]	Portable T=Table F=Floor O=Other [Specify]	Other/Outdoor U=Under cabinet [See Outdoor types under 'Rooms']	#	#	I=Incandescent CFL=CFL F=Fluorescent H=Halogen LED=LED O=Other [Specify]	T=Twist/Spiral G=Globe A=A-lamp B=Bullet/Torpedo Bug=Bug light S=Spot/Reflector/Flood C=Circline Tub=Tube Cap=Capsule,Post,Barrel Can=Candelabra O=Other [Specify]	S=Screw P=Pin G=GU O=Other [Specify]	#	Y=Yes N=No	Y=Yes N=No	Name	Name/#	#	1=J 2=J 3=Be
Living Room																
Dining Room																
ETC																

Data Collection Form for All Bulbs in Storage

Bulb Type I=Incandescent CFL=CFL F=Fluorescent H=Halogen LED=LED O=Other [Specify]	Bulb Shape T=Twist/Spiral G=Globe A=A-lamp B=Bullet/Torpedo Bug=Bug light S=Spot/Reflector/Flood C=Circline Tub=Tube O=Other [Specify]	Base Type S=Screw P=Pin G=GU Can=Candelabra O=Other [Specify]	Watts	Dimm-able?	3-way?	For all bulbs Manufacturer	For CFLs & LEDs only Model Num.	Number of Bulbs	For all CFL, LED and standard 100 W incandescent Bulbs: When Purchased? 1=Jul to Dec 2011, 2=Jan to Jun 2011 3=Before 2011	For all CFL, and LED Bulbs: What store were bulbs purchased at? Enter store name, or see types below	For all 100W bulbs: Did you purchase and store this particular wattage and type of bulb for any particular reason?

Store Types if respondent can't recall where each CFL purchased:

a. Grocery store or supermarket, such as Shaw's, Stop n Shop, or Whole Foods
b. Warehouse store, such as Sam's Club, BJ's, or Costco
c. Home improvement store, such as Home Depot or Lowe's
d. Hardware store, such as True Value or ACE Hardware
e. Mass merchandise/discount department store, such as Wal-Mart, Kohl's, K-Mart, or Target
f. Drugstore, such as Walgreen's or CVS
g. Convenience store, such as 7-Eleven, White Hen Pantry, or Cumberland Farms
h. Specialty lighting or electrical store
i. Home furnishing store, such as a Bed, Bath, and Beyond, or Pottery Barn
j. Mail order catalogs
k. Through the Internet
l. Bargain store, such as the Building 19, Dollar Store, or Family Dollar
m. Office supply store, such as Office Depot or Staples

Bulb Shape	Code	Image	Bulb Shape	Code	Image
1. Twister/Spiral	**T**		7. Circline	**C**	
2. Globe (e.g., for bathroom vanity fixtures)	**G**		8. Tube Style	**TUB**	
3. A-lamp (shaped like standard incandescent)	**A**		9. Candelabra (pointed top with a candelabra screw base)	**CAN**	
4. Bullet/ Torpedo (pointed top, standard screw base)	**B**		10. Post, Capsule, Barrel (round top, standard screw base)	**CAP**	

5. Bug light (yellow color)	**BUG**		11. Other (Describe to right of table)	**O**	
6. Spotlight/ reflector/flood	**S**		12. LED Globe	**LG**	
Bulb Style	**Code**	**Image**	**Bulb Style**	**Code**	**Image**
13. LED A-Bulb	**LA**		14. LED Bullet/Torpedo	**LB**	
15. LED Spotlight/ reflector/flood	**LS**		16. LED Circline	**LC**	
17. LED Tubes	**LTUB**		18. LED Candelabra	**LCAN**	
19. LED Capsule	**LCAP**		20. LED Rope	**LR**