RLPNC 18-11 Lighting Sales Data Analysis

FINAL

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SUBMITTED TO:
Massachusetts Electric Program Administrators
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Consultants

SUBMITTED BY:
NMR Group, Inc.

NMR Group, Inc.

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Executive Summary

This report describes recent screw-base light bulb market share, shipments, and prices in Massachusetts, in the entire United States, and in program and non-program states (defined below). The analyses draw on light bulb sales data compiled by the LightTracker Initiative of the Consortium for Residential Energy Efficiency Data (CREED), and shipment data reported by the National Electrical Manufacturers of America (NEMA).[1,2,3] This study is meant to provide information only and refrains from making recommendations or offering considerations.

Table 1 summarizes the topics explored in this report and their relevant data sources. LightTracker provided NMR with two different datasets: the full category lighting data and the Point of Sale (POS) data. The full category lighting data cover all retail channels (discount, dollar, drug, grocery, hardware, home improvement, mass merchandise, and membership stores). The POS data include only a subset of channels (discount, dollar, drug, grocery, mass merchandise, and some membership stores) that covers approximately 26% of the market in Massachusetts and 35% for the nation. Although the POS data exclude the hardware and home improvement channels, they have been available since 2009 (compared to 2015 for the full category data) and allow for more detailed analyses of bulb shape, ENERGY STAR qualification, and lumens. For most topics, we compared Massachusetts to three comparison areas: the nation, states with lighting programs, and states without lighting programs. For the full category, estimates for the entire US reflect extrapolations to the nation and not the sum of individual states. NEMA limits public shipment data to the national level, so our review necessarily occurred at the national level.

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

[2] Data presented include LightTracker calculations based in part on data reported by Nielsen through its Strategic Planner and Homescan Services for the lighting category for the 52-week period ending approximately on December 31, 2017, for the available state level markets and Expanded All Outlets Combined (xAOC) and Total Market Channels. Copyright © 2017, Nielsen.

[3] NEMA "Lamp Indices." Accessed on September 5, 2018, at http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx

Table 1: Study Topics and Data Sources

Topic	Years	Data Source[1]
Current market share (sales) by bulb type	2017	LightTracker full category
Market share (sales) overtime	2015 to 2017	LightTracker full category
Market share (sales) overtime	2009 to 2017	LightTracker POS
Market share (sales) by bulb shape, lumen bins, ENERGY STAR qualifications	2017	LightTracker POS
Market share (shipments)	2011 to 2018	NEMA
Bulb price analysis	2017	LightTracker full category

[1] Full category LightTracker data includes sales information for all retail channels and represents 100% of the lighting market. Point-of-sale (POS) data include discount, dollar, drug, grocery, mass merchandise, and some membership stores, representing 26% of lighting sales in Massachusetts and 35% nationally. POS data exclude hardware and home improvement stores.

OVERVIEW OF FINDINGS

The sales data analysis strongly suggests that the Massachusetts Residential Lighting Core Initiative (the Program) continued to have a positive impact on the energy-efficient bulb market in 2017. The year ushered in a sea change for LEDs in Massachusetts, including the following:

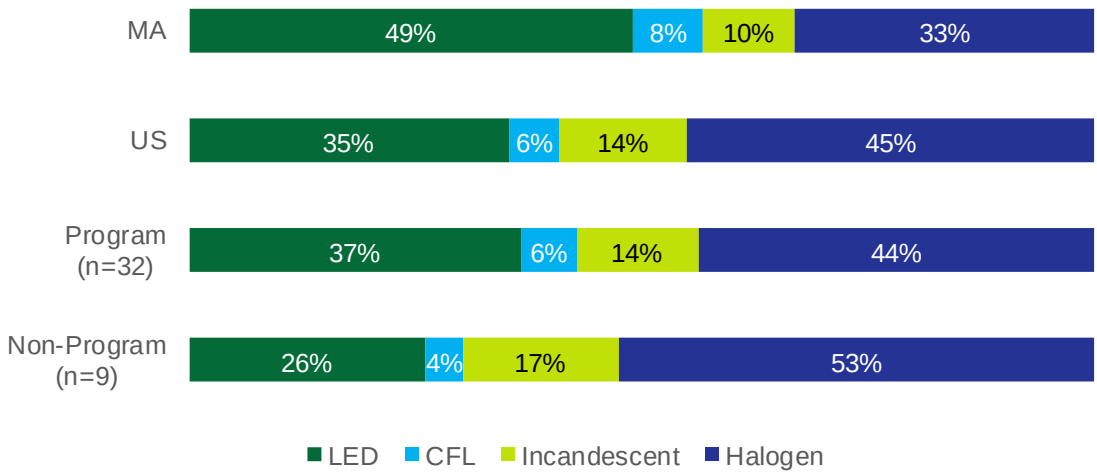
- The PAs stopped supporting CFLs and increased support for LEDs
- ENERGY STAR Specification 2.0 expanded the number, characteristics, and price points of qualified LEDs, so the PAs, which incent only ENERGY STAR qualified bulbs, could increase the diversity and price points of bulbs supported by the program
- The natural price point of LEDs continued to decline
- Retailers expanded the number and diversity of LEDS – both ENERGY STAR and non-ENERGY STAR – on their shelves

These factors culminated in LED market shares overall and for ENERGY STAR qualified bulbs in Massachusetts that were higher than in non-program states, the nation, and even most other program states. In fact, while the combined market share of energy-efficient bulbs (LEDs and CFLs) in the nation remained stable between 2015 and 2017, the efficient bulb market share in Massachusetts increased. The LED incentive per bulb in Massachusetts was the second highest in the nation, and the state's LED market share was the sixth highest in the nation. The aggressive incentives in Massachusetts help explain why LED prices in the state, including both ENERGY STAR and non-ENERGY STAR models, fell below those of not only of non-program states and the nation, but also other program states as well.

FINDINGS

Massachusetts had the highest market share of efficient lamps (LEDs and CFLs) in 2017 compared to the US, average program states, and average non-program states. Figure 1 shows that energy-efficient bulbs (LEDs and CFLs) accounted for a larger share of the market in Massachusetts (57%) than in the US overall (41%), as well as in both program (43%) and non-program states (30%).

Figure 1: 2017 Market Share in Massachusetts and Comparison Areas[1,2]

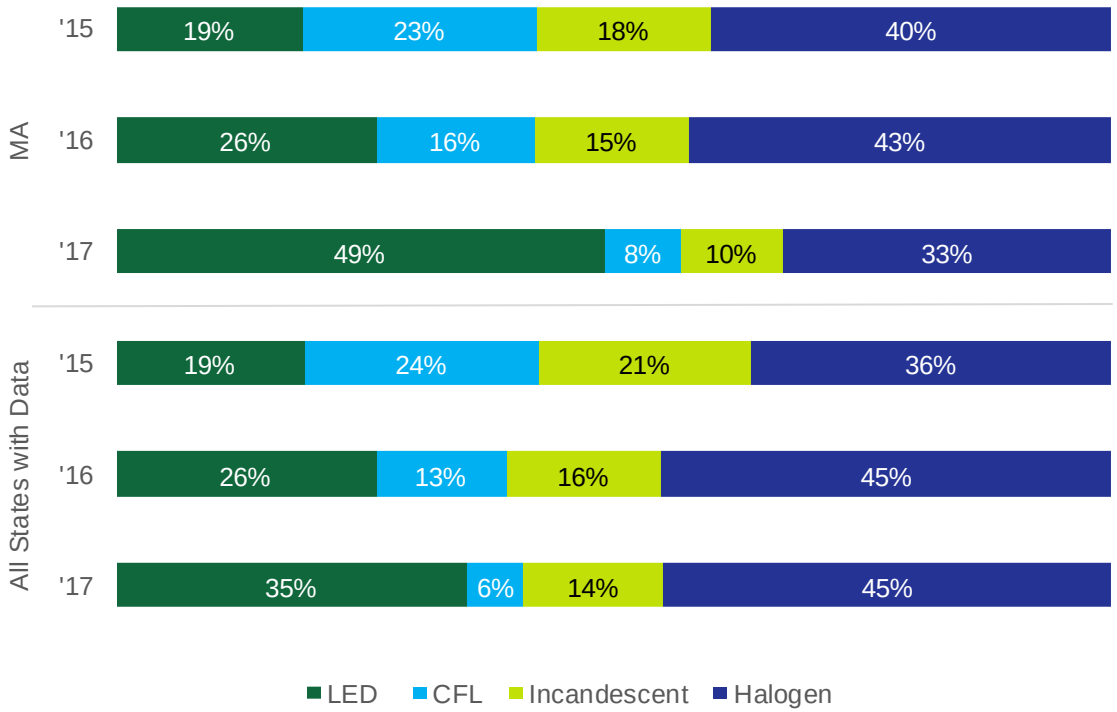


[1] All retail channels

[2] CREED adjusted LED sales in states (including Massachusetts) for better alignment with program sales data. Prior to the adjustment 2017 LED market share in Massachusetts was 44%. See Section 1.2.1 for more detail.

The combined market share in Massachusetts for LEDs and CFLs increased by over ten percentage points between 2016 and 2017, while the efficient share remained virtually the same nationwide. In both Massachusetts and the nation, CFL market share shifted to LEDs, but in Massachusetts LEDs have also cut into halogen market share (Figure 2). The figure also confirms the continued trend of market shift away from incandescents and CFLs and towards LEDs and halogens. LEDs had the largest year-over-year increase in Massachusetts, from only 19% in 2015 to 49% in 2017.

Figure 2: Massachusetts and US Market Share by Bulb Technology 2015-2017[1,2]



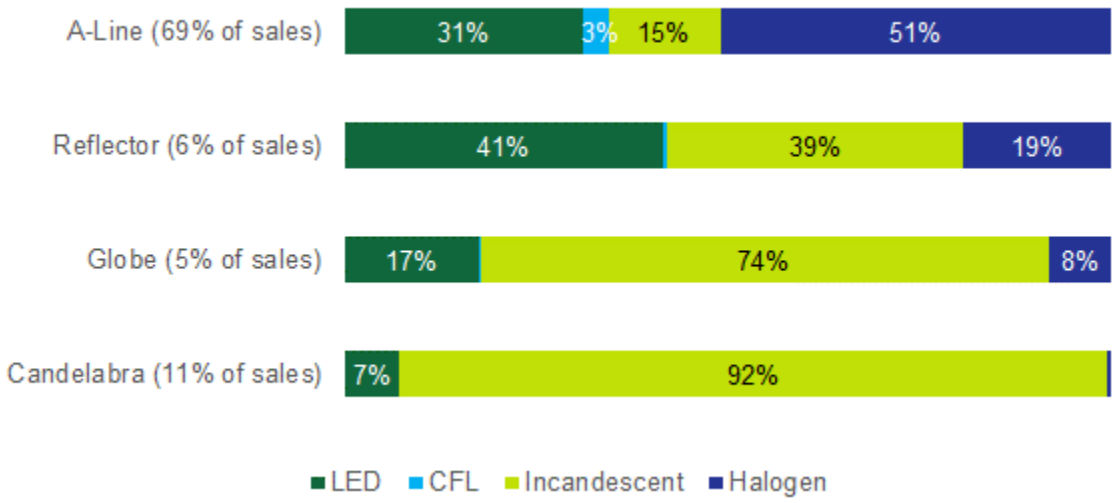
[1] All retail channels.

[2] In 2017, CREED adjusted LED sales in states (including Massachusetts) for better alignment with program sales data. Prior to the adjustment 2017 LED market share in Massachusetts was 44%, still a substantial increase over the comparable value of 26% in 2016. See Section 1.2.1 for more detail.

Massachusetts LED market share in 2017 was highest among reflector and A-line bulbs. Incandescent bulbs continued to dominate specialty bulbs.

In discount, dollar, drug, grocery, mass merchandise, and some membership stores, the LightTracker POS data suggest that LEDs have made the greatest inroads into the A-line and reflector bulb markets. LEDs made up 31% of A-line and 41% of reflector market shares (Figure 3). LEDs accounted for 17% of globes and 7% of candelabras, whereas incandescents continued to account for the large majority of sales of these two shapes.

Figure 3: 2017 Massachusetts Market Share by Bulb Shape[1,2]

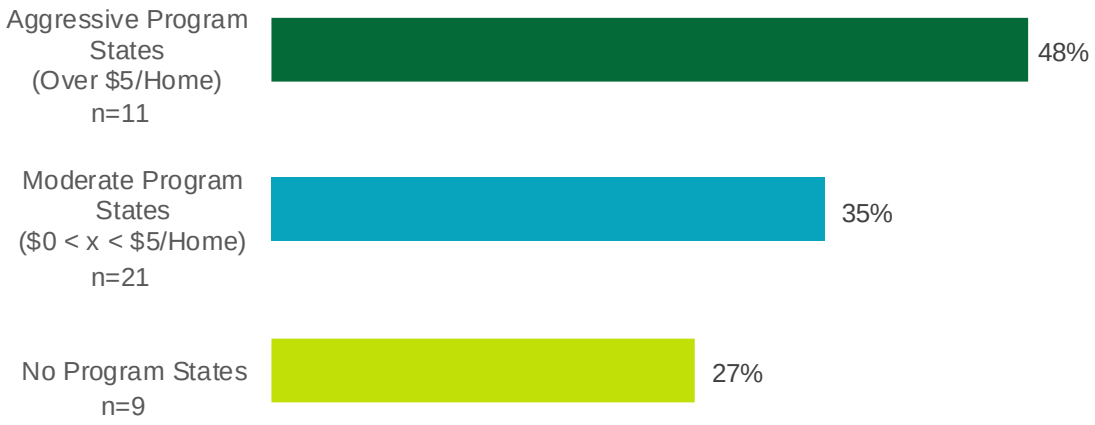


[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores, and represents approximately 26% of the Massachusetts market.

[2] Data labels removed for sales percentages less than 2%; percentage of sales excludes other bulb types (8% of sales); all results subject to rounding error.

Program spending was associated with higher LED market share. Figure 4 shows the general relationship between state-level, per-household program spending (including incentives, marketing, and administration), and average market share of LED bulbs per state. States with greater program spending per household tended to have greater LED market adoption. Massachusetts total program spending was over $5 per household in 2017. LED incentives were about $3.46 per LED, which was the second highest level of support in the nation. LED market share in Massachusetts was the sixth highest in the nation, up from 23th in 2016 (see Section 2.1.3 for more details).[4]

Figure 4: 2017 Program Spending and LED Market Share[1]

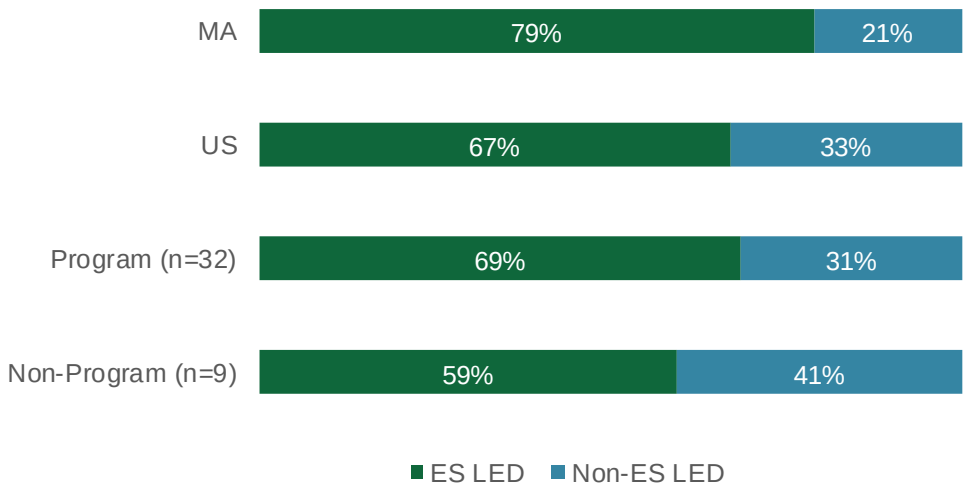


[1] All retail channels.

[4] The lower LED market share in 2016 likely reflected two things: 1) Massachusetts's continued support for CFLs (most other states did not support CFLs in 2016), and 2) the existing strong socket saturation of long-life CFLs and LEDs that limited consumers' need to buy new bulbs. While the saturation issue likely remains, the cessation of CFL support in 2017 coupled with increased incentives and efforts to promote LEDs appears to have boosted LED market share in Massachusetts to a greater extent than in other states and previous years.

A greater portion of LED bulbs sold in Massachusetts in 2017 were ENERGY STAR qualified compared to the comparison areas. Nearly four out of five LEDs (79%) sold in Massachusetts in discount, dollar, drug, grocery, mass merchandise, and some membership stores qualified for the ENERGY STAR label (Figure 5). All other areas examined were ten-percentage points or lower on the same indicator; non-program states were 20 percentage points lower.

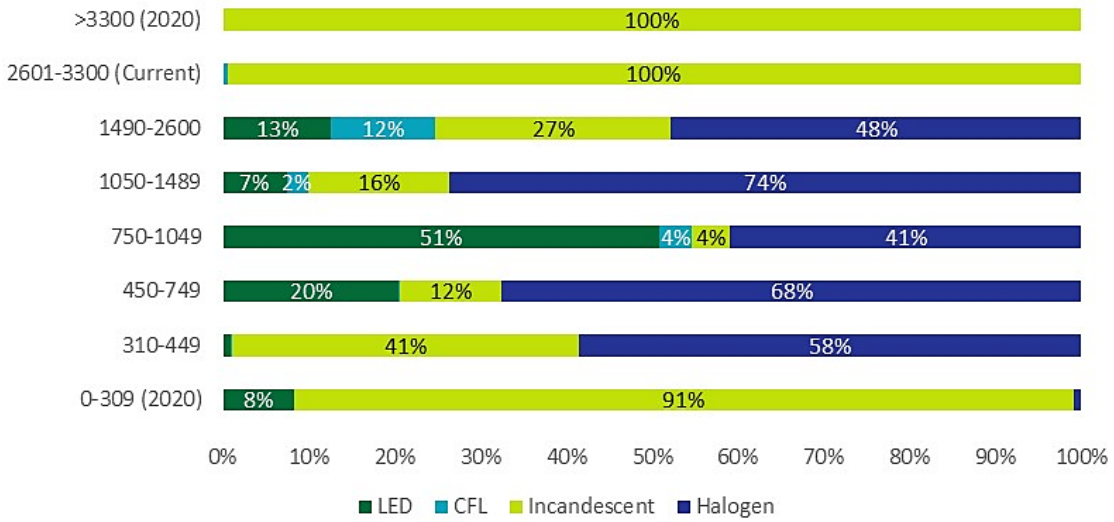
Figure 5: 2017 LED ENERGY STAR Status in Massachusetts and Comparison Areas[1]



[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores. Represents approximately 26% of the Massachusetts market, 35% of the US, 33% of program states, and 46% of non-program states. Excludes hardware and home improvement stores.

LEDs garnered the majority of the A-line bulbs market in only the 60-watt equivalent range (750 to 1,049 lumens), while incandescents dominated lumen bins that are currently EISA exempt. Figure 6 shows market share by technology type within each lumen bin in discount, dollar, drug, grocery, mass merchandise, and some membership stores. Table 2 provides a crosswalk between lumen bins and incandescent equivalence as well as the percentage of sales in each lumen bin. While they were a majority (51%) in the 750 to 1,049 lumen bin (i.e., the bin that accounts for one-half of all A-line bulb sales) LEDs still had significant growth potential in all other lumen bins. Halogens had the largest market share in four of the five lumen bins currently subject to EISA (bins subject to EISA span 310 to 2,600 lumens, and halogens had he majority in all but the 750 to 1,049 bin), while incandescents dominated all EISA-exempt lumen bins.

Figure 6: 2017 Massachusetts A-line Market Share by Lumen Bin[1,2,3]



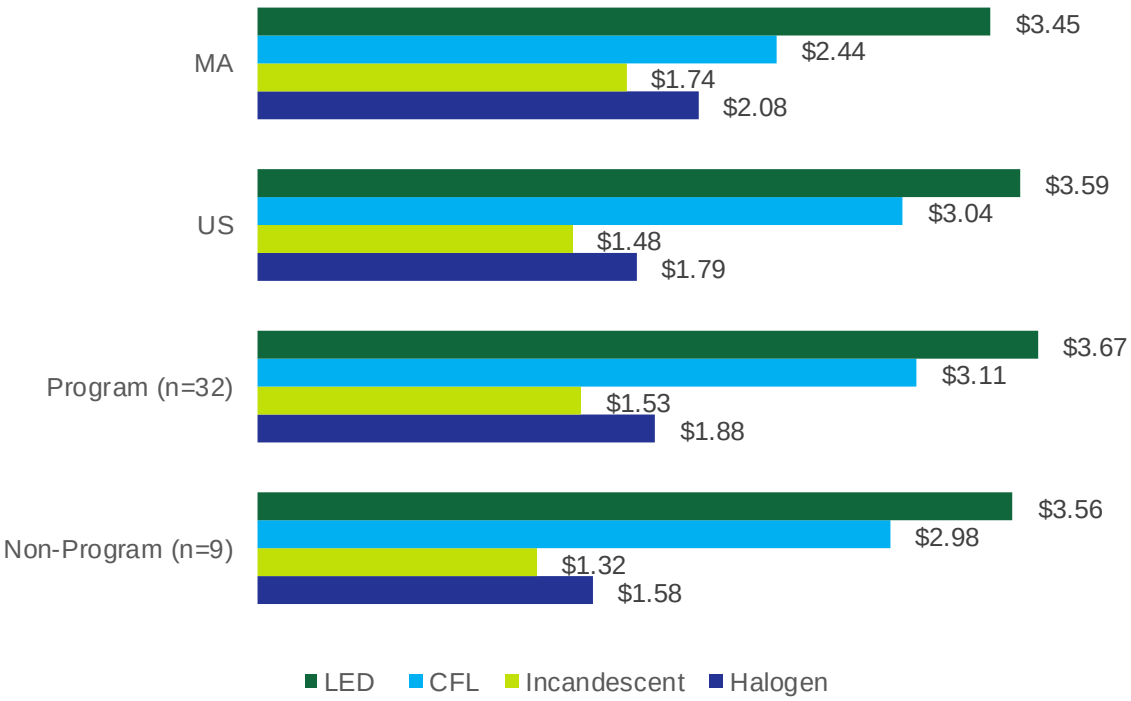
[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores, and represents approximately 26% of the Massachusetts market.
[2] Bins currently EISA Exempt: less than 310, above 2,600; bins subject to EISA 2020 (if implemented): less than 310, above 3,300.
[3] Small sample sizes of lumen bins less than 310 and above 2,600, while still in the thousands, are much smaller than the hundreds of thousands of bulbs in the 450 to 2,600 lumen bins.

Table 2: Lumen Bin Description

Lumen Bin	EISA Exemption	Approximate A-line Incandescent Wattage	Percentage of 2017 Bulb Sales
0-309	Current and 2020	Below 40 Watts	2%
310-449	Not exempt	40 Watts	7%
450-749	Not exempt	40 Watts	22%
750-1049	Not exempt	60 Watts	48%
1050-1489	Not exempt	75 Watts	11%
1490-2600	Not exempt	100 Watts	10%
2601-3300	Current	150 Watts	<0%
>3300	Current and 2020	Above 150 Watts	<0%

LED and CFL prices were higher than incandescents and halogens in all regions examined – but prices for efficient bulbs were lowest in Massachusetts. The average shelf prices shown in Figure 7 include program incentives and suggest that, on average, LEDs remained the most expensive technology ($3.45 in Massachusetts) at the point of purchase. Massachusetts had the lowest average prices for both LEDs and CFLs, despite having a higher proportion of ENERGY STAR LEDs than the comparison areas. The substantial program incentives in Massachusetts certainly help explain the lower average LED price. Likewise, although Massachusetts ceased supporting CFLs in 2017, the low average CFL price in Massachusetts ($2.44) relative to the comparison areas could reflect legacy program CFLs on shelves or in warehouses at the beginning of 2017.

Figure 7: 2017 Average Shelf Price per Bulb[1,2]



1

All retail channels.

[2] Does not include private label bulbs sold at specific retailers, so the prices reported here are likely somewhat higher than actual prices.

Section 1 Introduction

This report describes recent light bulb market share, sales, and shipment trends in Massachusetts, program states, non-program states (defined below), and the entire United States. It is based on analyses of light bulb sales data compiled by the LightTracker Initiative of the Consortium for Residential Energy Efficiency Data.[5,6,7] This study also presents updated shipment data from the Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA).[8] Finally, it examines trends in light bulb shelf prices.

1.1 Study Objectives and Research Questions

The residential lighting market and the nature of PA program support changed considerably in 2017. Some of the key changes included the following:

- The PAs stopped supporting CFLs (because most did not qualify for ENERGY STAR Specification 2.0) and increased the number of supported LEDs (from about 5 million LEDs in 2016 to over 10 million LEDs in 2017)[9]
- ENERGY STAR Specification 2.0 expanded the number, characteristics, and price points of qualified LEDs, enabling the program, which incents only ENERGY STAR qualified bulbs, to support a greater diversity and price points of bulbs
- The natural (non-incented) price point of LEDs continued to decline
- Retailers expanded the number and diversity of LEDS – both ENERGY STAR and non-ENERGY STAR – on their shelves

This study examines bulb market share and prices in 2017 and over time in an effort to understand the continuing impact of Massachusetts program support on the residential lighting market, particularly given the tremendous market and program change in 2017.

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[5] CREED serves as a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker, CREED's first initiative, is focused on acquiring full category lighting data, including incandescent, halogen, CFL, and LED bulb types for all distribution channels in the entire United States. As a consortium, CREED speaks as one voice for program administrators nationwide as they request, collect, and report on the sales data needed by the energy efficiency community (https://www.creedlighttracker.com).

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[7] Data presented include LightTracker calculations based in part on data reported by Nielsen through its Strategic Planner and Homescan Services for the lighting category for the 52-week period ending approximately on December 31, 2017, for the available state level markets and Expanded All Outlets Combined (xAOC) and Total Market Channels. Copyright © 2017, Nielsen.

[8] NEMA "Lamp Indices." Accessed on September 5, 2018, at http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx.

[9] See 2016 and 2017 Residential Lighting Results for LEDs on http://masssavedata.com/Public/MeasuresDetails.

The study objectives included the following:

- Examine current market share in Massachusetts, states with lighting programs, states without lighting programs, and the entire nation
- Provide breakdowns of market share by bulb type (i.e., LEDs, CFLs, halogens, and incandescents), shape (A-line, reflector, and all other), and ENERGY STAR status
- Explore trends in bulb market and shipment share based on LightTracker and NEMA data
- Assess market share in very low (<310) and very high (>3,300) lumen bins, which roughly coincide with ranges that will remain exempt when Phase 2 of the Energy Independence and Security Act (EISA) goes into effect in 2020
- Compare average prices of LEDs to other bulb types

The study aimed to achieve these objectives by exploring the following research questions:

- What is the size of the LED market overall and for specific subgroups and bulbs?
- Does the current LED share of bulbs in very high and very low lumen bins suggest any future program opportunities?
- What is the bulb price of LEDs compared to other bulb types, in Massachusetts and non-program states?
- What are the likely connections between the current nature of the light bulb market and PA program activity in Massachusetts?

1.2 DATA SOURCES

The Lighting Sales Data study draws on two data sources: LightTracker Initiative Sales Data and NEMA shipment data. Table 3 summarizes the topics examined and the sources of data. This section provides an overview of the data sources, while Appendix A provides a detailed discussion, including addressing variations in data provided by the LightTracker Initiative.

1.2.1 Lighting Sales Data

CREED generates the LightTracker dataset from two data sources: point-of-sale (POS) state sales data as scanned *at the register* and National Consumer Panel (NCP) state sales data. CREED purchases the data from third-party vendors, and the LightTracker team cleans, processes, and calibrates the data for analysis. Both the POS and the NCP datasets provide national level estimates of bulb sales. They also provide state-level data for individual states with sufficient sales and/or panel participation.

The POS dataset represents discount, dollar, drug, grocery, mass merchandise, and some membership stores. It accounts for about 26% of market share in Massachusetts and 35% for the nation.[10] The NCP represents a panel of approximately 100,000 residential households that are

[10] Calculated as the number of bulb sales per area included in the POS dataset divided by the number of bulb sales per area in the full category dataset.

provided a handheld scanner for their home and instructed to scan in every purchase they make that has a bar code. For Massachusetts, the NCP included approximately 1,300 households in 2017. The use of a scanner avoids potential recall bias, which is prevalent in self-report methods that ask about lighting purchases. While the NCP dataset includes sales from all retail channels, to avoid double counting sales when combining the two data sources to create the full category LightTracker dataset, CREED uses only those sales from home improvement, hardware, online, and the remaining membership stores.

It is important to note that the full category data for the entire US represents an extrapolation to the nation and not the sum of available states. In contrast, the analyses for program states and non-program states do represent the sum of available states in each category.

Each year CREED improves its data cleaning and vetting procedures. This year, they instituted a process to align full category total LED sales with known program-supported sales in the state. In situations in which program-supported sales (which are almost universally ENERGY STAR-qualified across the nation) exceeded or rivaled total LED sales (comprising both ENERGY STAR and non-ENERGY STAR sales) they adjusted LED sales upwards so that program-supported sales accounted for 90% of ENERGY STAR sales.

They made this change only to the full category data and not POS data (since the latter include only part of the market). Prior to this adjustment LED market share in Massachusetts was 44%; after this adjustment it was 49%. This change should be kept in mind when comparing full category market share over time. See Section 2.1 for more detail on market share.

The Massachusetts PAs and EEAC Consultants also desired longitudinal analyses of market and shipment share. Therefore, NMR supplemented the full category LightTracker data for 2015 to 2017 with POS data from 2009 to 2017 (obtained from CREED).

The **key strengths and weaknesses** of the LightTracker dataset include the following:

- **Strengths**:
    - Full category sales reflect the entire market, comprising program and non-program sales as well as all retail channels
    - Comparable data is available for most states in the nation
    - Includes characteristics such as lumens, bulb shape, and pricing
- **Weaknesses**:
    - POS data cover only a portion of the market, notably missing the important hardware and home improvement changes
    - Raw sales data do not always align with program or shipment data, leading CREED to make adjustments that force alignment
    - Reliability is reduced with small sample sizes (e.g., market share by bulb technology for lumen bins with low sales volumes)

Table 3: Study Topics and Data Sources

Topic	Years	Areas Examined	Data Source[1]	Market Coverage
Current market share (sales) by bulb type	2017	MA, US, program states, non-program states	LightTracker full category	100% for all areas
Market share (sales) over time	2015 to 2017	MA, US, program states, non-program states	LightTracker full category	100% for all areas
Market share (sales) over time	2009 to 2017	MA, US, program states, non-program states	LightTracker POS	~26% of MA and 35% of national markets
Market share (sales) by bulb shape, lumen bin, ENERGY STAR qualification	2017	MA, US, program states, non-program states	LightTracker POS	~26% of MA and 35% of national markets
Market share (shipments)	2011 to 2018	Entire US only	NEMA	100% for reporting manufacturers
Bulb price analysis	2017	MA, US, program states, non-program states	LightTracker full category	100% for all areas

[1] Full category LightTracker data include sales information for all retail channels and represent 100% of the lighting market. Point-of-sale (POS) data include discount, dollar, drug, grocery, mass merchandise, and some membership stores, representing 26% of lighting sales in Massachusetts and 35% nationally. POS data exclude hardware and home improvement stores.

1.2.2 Shipment Data

We also examined quarterly NEMA A-line bulb shipment data for 2011 to 2017.[11] NEMA derives shipment share estimates from a survey of NEMA members, and the data may suffer from non-response bias as some members may not respond to the organization's survey. If non-response varies by the types of bulbs manufactured, it could affect estimates of shipment share. NEMA shipments and LightTracker sales data should be expected to be somewhat out of sync, as shipments precede sales and could end up being stockpiled in retailer warehouses.

The **key strengths and weaknesses** of the NEMA Shipment data include the following:

- **Strengths**:
  - Data reflect shipments from manufacturers based on a survey of NEMA members
- **Weaknesses**:
  - NEMA provides estimates for A-line bulb shipments only
  - Survey response is voluntary and NEMA does not discuss potential bias based on which manufacturers respond
  - Results are reported publicly at the national level only
  - Shipments and sales capture similar but not identical concepts and sales lag shipments

1.3 PROGRAM ACTIVITY

Many of the analyses in this report assess market share and price by the presence and level of upstream lighting program activity. To determine program activity, the LightTracker team conducted a literature review of publicly available reports found on the internet or provided by program administrators or their evaluators.[12] The team contacted local utilities in areas for which reports with the relevant information were not available. Additionally, the team accessed DSM Insights, an E Source product that provides a detailed breakdown of program-level spending, including incentives, marketing, and delivery for over 100 program administrators around the country.[13] All states with at least some program activity in 2017 were designated *program states;* the remaining states were designated *non-program states*.

[11] http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx
[12] Specifically, the team began by searching the ENERGY STAR Summary of Lighting Programs website https://www.energystar.gov/ia/partners/downloads/2017%20ENERGY%20STAR%20Summary%20of%20Lighting%20Programs.pdf and referenced the Database of State Incentives for Renewables & Efficiency (www.dsireusa.org).
[13] E Source. "DSM Insights." April 2018.

1.4 APPROACHES

NMR and LightTracker Initiative analysts performed the following descriptive analyses of light bulb market share, sales, shipments, and prices:

- Compared 2017 market share by bulb type (Section 2.1.1) and bulb shape (Section 2.1.2) from the full LightTracker database for Massachusetts, states with lighting programs (program states), states without lighting programs (non-program states), and the US
- Described trends in market share in Massachusetts for 2009 to 2017, as reported in the POS data, and for 2015 to 2017, as reported in the full category data (Section 2.1.1)
- Examined 2011 to 2017 national NEMA shipment market share (Section 2.1.1)
- Explored general (not statistical) relationships between program spending and per-household bulb sales (Section 2.1.3)
- Examined the proportion of LED sales in Massachusetts, other program states, non-program states, and the nation that are ENERGY STAR qualified (Section 2.1.4)
- Analyzed market share by lumen bin for Massachusetts and non-program states to assess the distribution of bulb sales by current and future EISA exemption (Section 2.1.5)
- Reviewed prices for all light bulbs in Massachusetts and non-program states for 2016 and 2017 (Section 2.2)

Section 2 Data Examination

The team examined trends in market share, ENERGY STAR market share for LEDs, and bulb prices using the LightTracker and NEMA shipment data. Table 3 above summarizes the data sources and their coverage, and the bullets below serve as a reminder (we also footnote coverage in each figure):

- **Full category**: used for 2017 market share and represents all retail channels, including hardware and home improvement; estimates for the entire US reflect extrapolations to the nation and not the sum of individual states
- **Discount, dollar, drug, grocery, mass merchandise, and some membership club retail channels:** used for analysis of market share back to 2009 and market share by ENERGY STAR qualification; data reflect 26% of the Massachusetts market, 35% of the US, 33% of program states, and 46% of non-program states
- **Shipments:** used for assessment of A-line shipment share back to 2011; represent 100% of A-line shipments from reporting retailers, but coverage is unknown

The results generally describe market share and bulb prices in Massachusetts, program states, non-program states, and the nation. The NEMA shipment review in Section 2.1.1 covers national shipments only, while the program activity review in Section 2.1.3 considers all available states.

2.1 Market Share

NMR assessed market share in Massachusetts, program states, non-program states, and the nation in various ways, as summarized in Table 4. We note the percentage of the market covered under each figure in the discussion that follows.

Table 4: Summary of Market Share Analyses

Type of Analysis	Dataset	Year(s) Addressed	Retail Channels
Annual	LightTracker Full Category	2017	All
Longitudinal	LightTracker Full Category	2015 to 2017	All
Longitudinal by Lumen Bin by ENERGY STAR	LightTracker POS	2009 to 2017, 2017	Discount, dollar, drug, grocery, mass merchandise, some membership clubs
Longitudinal	NEMA	2011 to 2017[1]	All

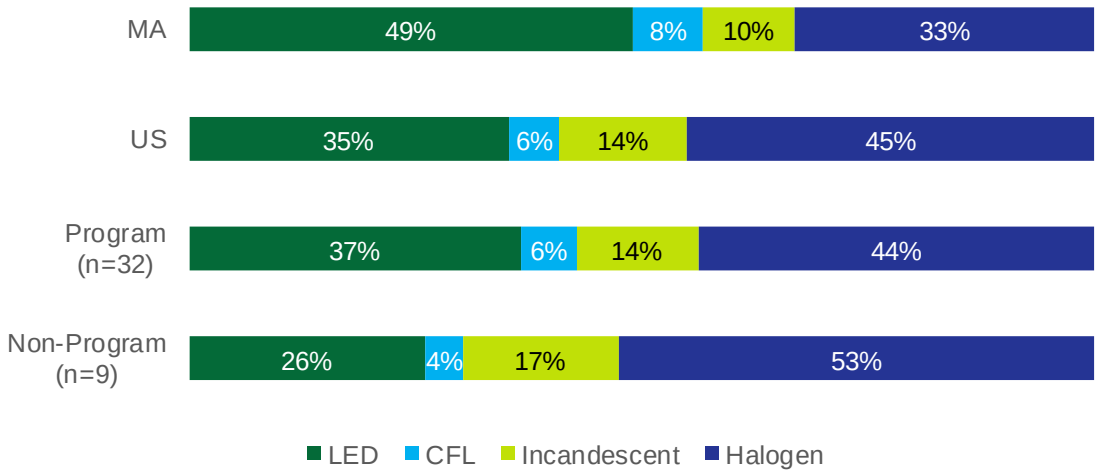
[1] Quarterly data from 2011 to December 2017.

2.1.1 Market Share by Bulb Technology

Massachusetts had a far higher market share of efficient bulbs (LEDs and CFLs) in 2017 compared to the US average, program states average, and non-program states average.

The market share of energy-efficient bulbs (LEDs and CFLs) was higher in Massachusetts (about 57%) than for the US overall (about 41%), program states (about 43%), and non-program states (31%) (Figure 8). LED market share in Massachusetts was nearly double the LED market share in non-program states (49% versus 26%). Conversely, inefficient bulbs (halogens and incandescents) took the majority of the market in the US, other program states, and non-program states. In fact, halogens alone accounted for 53% of market share in non-program states.

Figure 8: 2017 Market Share in Massachusetts and Comparison Areas[1,2]



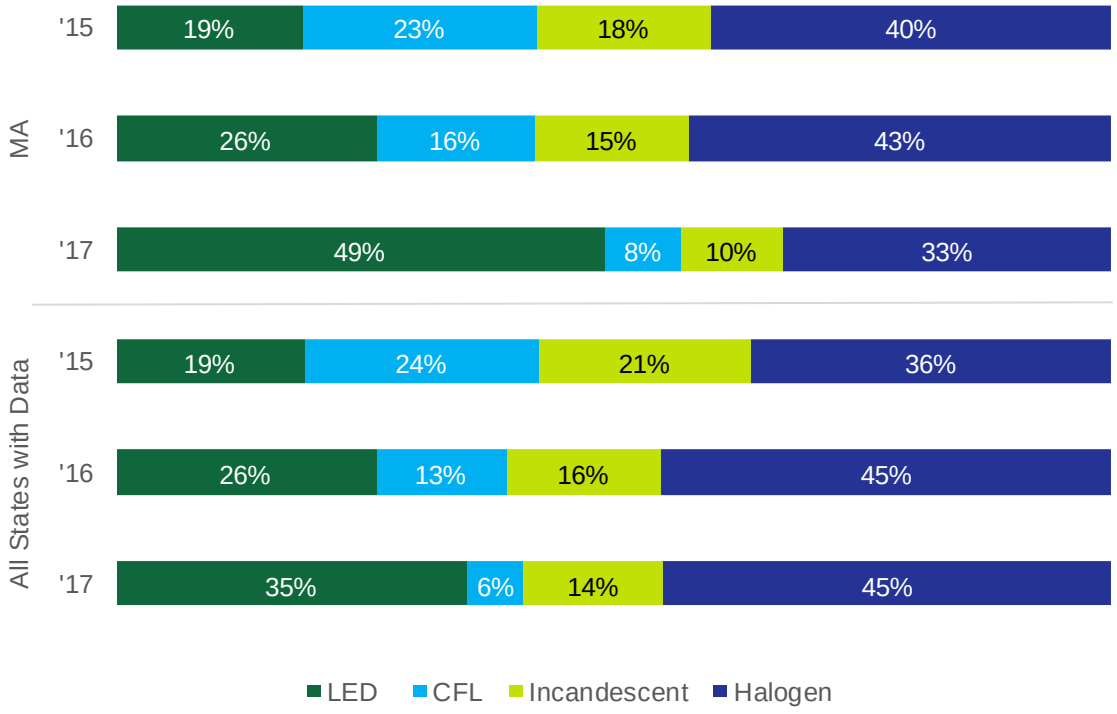
[1] All retail channels.

[2] CREED adjusted LED sales in states (including Massachusetts) for better alignment with program sales data. Prior to the adjustment 2017 LED market share in Massachusetts was 44%. Therefore, prior to the adjustment, Massachusetts's LED market share still exceeds that of the nation. See Section 1.2.1 for more detail.

The combined market share in Massachusetts for LEDs and CFLs increased by over ten percentage points between 2016 and 2017, while the efficient share remained virtually the same nationwide. The market continued to shift towards LEDs and halogens and away from CFLs and incandescents.

Figure 9 and Figure 10 display market share over time. Figure 9 reports 2015 to 2017 full category market share for all channels, including hardware and home improvement, for Massachusetts and the US. Figure 10 presents 2009 to 2017 market share Massachusetts for a subset of channels, discount, drug, dollar, grocery, mass merchandise, and some membership stores. Both datasets suggest that Massachusetts saw a greater increase in LED market share between 2016 and 2017 than the US. According to the full category dataset, LED market share in Massachusetts increased from 26% in 2016 to 49% in 2017. Meanwhile, national LED market share increased from 26% in 2016 to 35% in 2017. The point-of-sale data suggest similar trends over time, again pointing to a large increase in LED market share in 2017 (doubling from 15% to 30%). The aggressive program support for LEDs in Massachusetts (see more in Section 2.1.3) likely contributed to this greater increase.

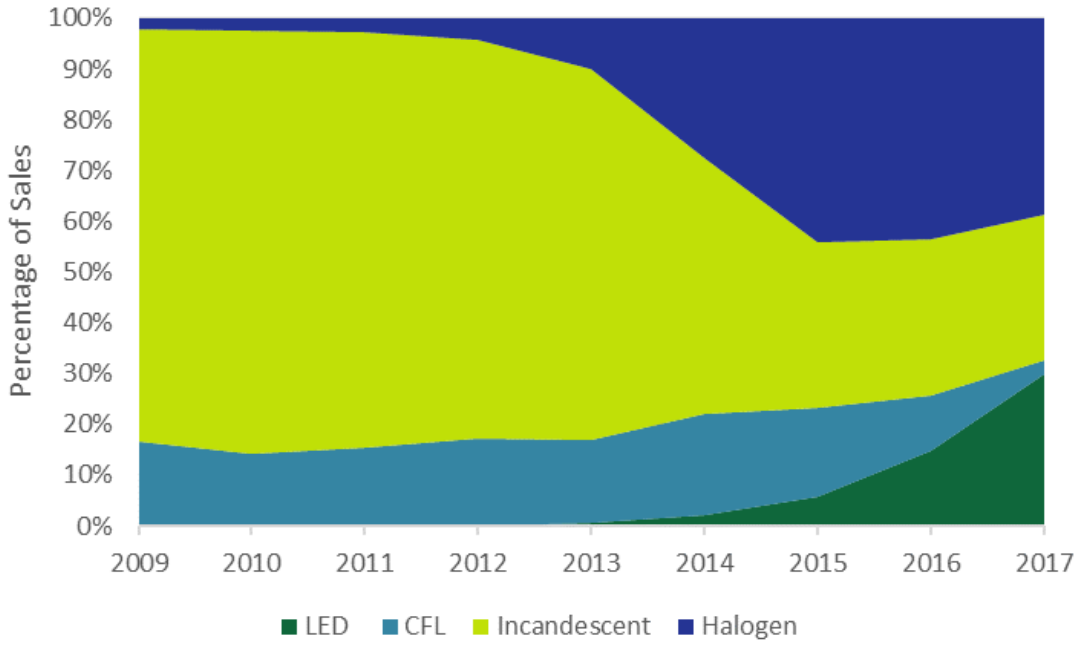
Figure 9: Massachusetts and US Market Share by Bulb Technology 2015-2017[1,2]



[1] All retail channels.

[2] In 2017, CREED adjusted LED sales in states (including Massachusetts) for better alignment with program sales data. Prior to the adjustment 2017 LED market share in Massachusetts was 44%, still a substantial increase over the comparable value of 26% in 2016. See Section 1.2.1 for more detail.

Figure 10: Massachusetts Market Share for Subset of Channels, 2009-2017[1]

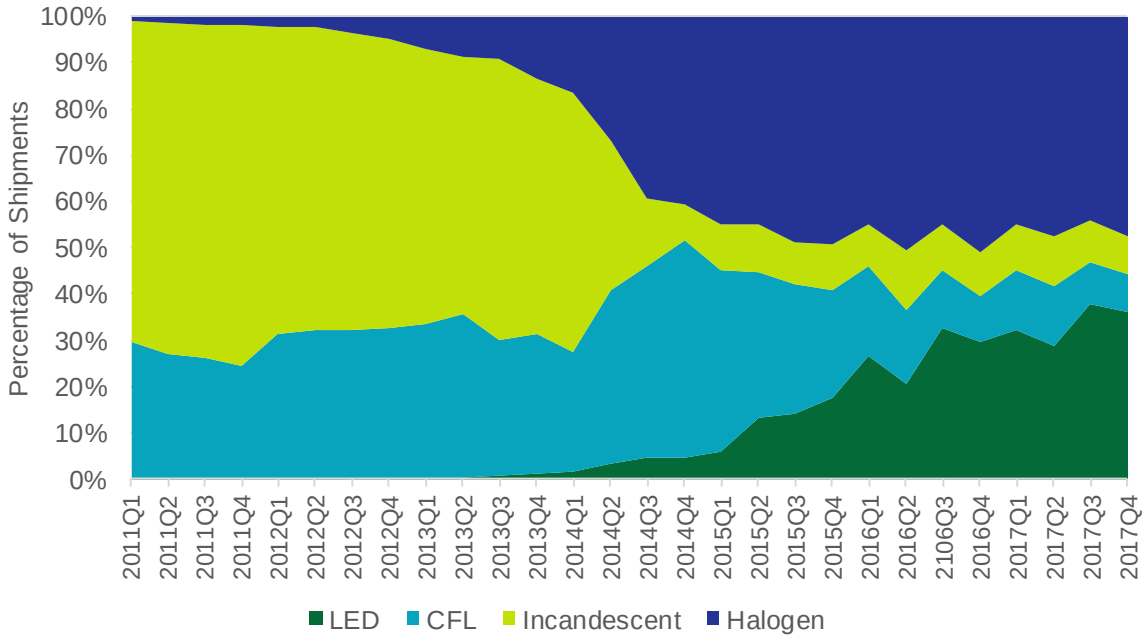


[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores, and represents approximately 26% of the Massachusetts market and 35% of the national market.

Shipment data provide additional evidence that efficient and inefficient market share appear to have stabilized even as halogens and LEDs continued to fill the gaps left by dwindling incandescent and CFL shipments.

NEMA A-line lamp indices and shipments provide another data source for tracking the lighting market by technology type.[14] Figure 11 presents those data as an area graph that sums to represent the full market. This presentation shows that the combined efficient (LED + CFL) and inefficient (incandescent + halogen) shipment shares have remained steady since the beginning of 2016, similar to the 2015 to 2017 national market share stability conveyed in Figure 9 and Figure 10. Figure 11 also illustrates the dramatic market changes precipitated by EISA starting in 2014, when incandescent and CFL shipment shares rapidly declined. Halogens have largely captured the incandescent shipment share, while LEDs have filled the CFL shipment share gap. At the end of 2017, LEDs were second only to halogens in shipment share (36% versus 48%). LED market share continued to climb while halogen share appears to have stabilized.

Figure 11: A-line Shipment Market Share Q1 2011 to Q4 2017, Area Graph[1]



[1] All retail channels.

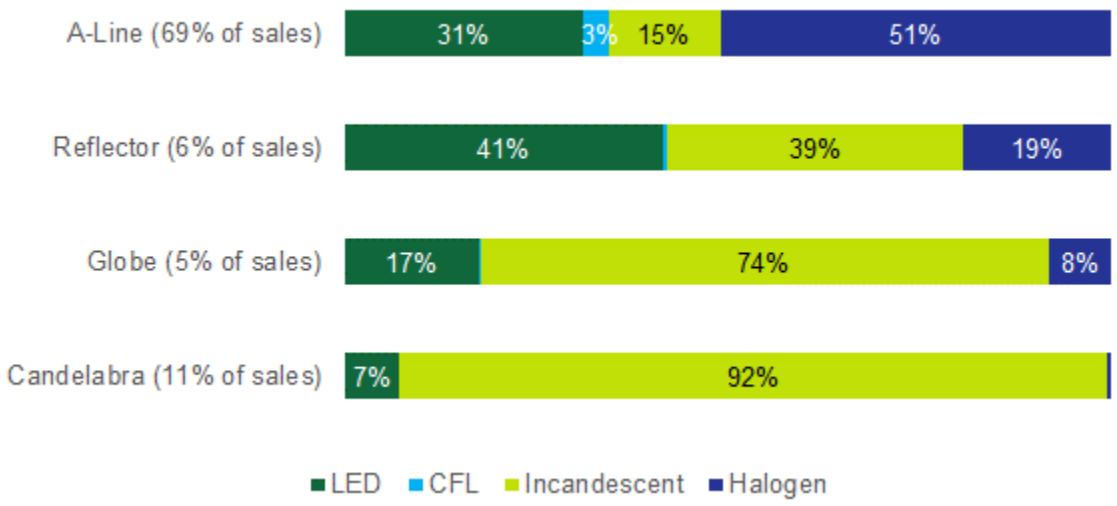
[14] Unlike the other data sources, NEMA only reports A-line bulbs (but would include bulbs such as rough service). NEMA explains that the shipment data are based on surveys of its members; but, as with every survey, not everyone responds. This means that we do not know the percentage of the market covered by NEMA nor the nature of the nonresponse bias (i.e., how respondents differ from non-respondents and its impact on shipment estimates).

2.1.2 Market Share by Bulb Shape

LEDs exhibited their highest market share among reflector and A-line bulbs (among the subset of retail channels for which this information is available). Incandescent bulbs – at least among this subset of channels – continued to dominate globes and candelabras.

LightTracker POS data allow for an assessment of market share by bulb shape. These data, which include discount, dollar, drug, grocery, mass merchandise, and some membership stores, suggest that LEDs have made the greatest inroads into the A-line and reflector bulb markets. Figure 12 breaks down 2017 market share by bulb shape. The values in parentheses on the vertical axis describe the percentage each bulb shape represents of total bulb sales, while the values within the bars represent the market share of each technology for a given bulb shape. Together, A-line and reflector bulb shapes accounted for about 75% of the market. LEDs made up 31% of A-line and 41% of reflector sales. Among candelabras (representing 11% of the market), LEDs made up only 7% of sales, with incandescents accounting for almost the entire balance. Among globes (representing 5% of the market), LEDs accounted for 17% of bulbs, incandescents for 74%, and halogens for the remaining 8%. The full category dataset does not allow for an assessment of sales by bulb type in home improvement and hardware channels.

Figure 12: 2017 Massachusetts Market Share by Bulb Shape[1,2]



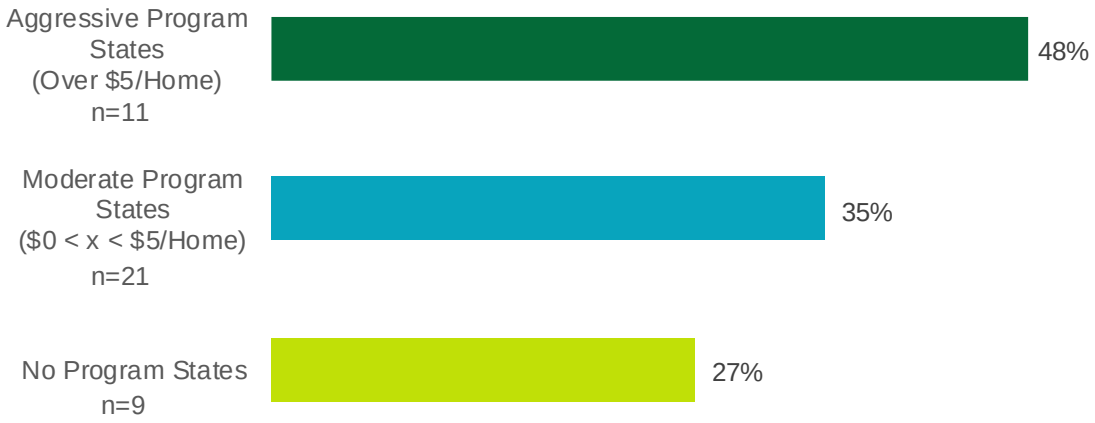
[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores, and represents approximately 26% of the Massachusetts market.
[2] Data labels removed for sales percentages less than 2%; percentage of sales excludes other bulb types (8% of sales); all results subject to rounding error.

2.1.3 Market Share by Program Activity Analysis

States with more aggressive program spending per household and LED spending per bulb have higher LED market shares than non-program states as well as states with moderate program spending.

Figure 13 presents LED market share as a function of program spending (including incentives, marketing, and administration), and exhibits a clear increase in LED share as program spending increases.[15] Nine states did not run an upstream lighting program. The average LED market share among these non-program states in 2017 was 27%.[16] States with aggressive program activity (including Massachusetts) spent over $5 per household on upstream lighting programs. The average LED market share among these states was 48%. Moderate activity states fell in between, with LEDs garnering 35% of the market share.

Figure 13: 2017 Program Spending and LED Market Share[1]



[1] All retail channels.

[15] State-level spending varies for three primary reasons. First, unlike in Massachusetts, in some states not all PAs support upstream lighting. Second, the level of program intensity can vary among active PAs within other states. That is, in contrast to the coordinated program delivery in Massachusetts, in many other states, some PAs promote LEDs more aggressively than others. Finally, the non-incentive costs (e.g., marketing and outreach, allocation of admin) can also vary by PA, which could affect both program spending per household and program incentive per LED.

[16] See Appendix A for details on which states are included. Some states lacked sufficient program activity information to be included in this analysis.

Similarly, Figure 14 shows Massachusetts' LED market share relative to other states with sufficient data. States denoted in dark green had aggressive programs (program spending more than $5 per household) in 2017. Lime green bars represent non-program states, and teal bars represent states with spending between zero and five dollars per household. LED market share in Massachusetts placed at the median of other aggressive program states. As expected, LED market share tended to be low for most states lacking upstream lighting programs. LED market share in states with moderate spending varied considerably.

The LightTracker team was able to obtain LED incentive dollars for 24 of the program states.[17] A simple calculation of LED incentive dollars (a portion of total spending) divided by program LEDs yielded average LED incentives per state. As shown below in Figure 15, per-bulb LED incentives in 2017 ranged from $1 to nearly $5; the average LED incentive was $2.08. Massachusetts ranked near the top of per-bulb incentives, offering $3.46 per LED in the upstream lighting program.

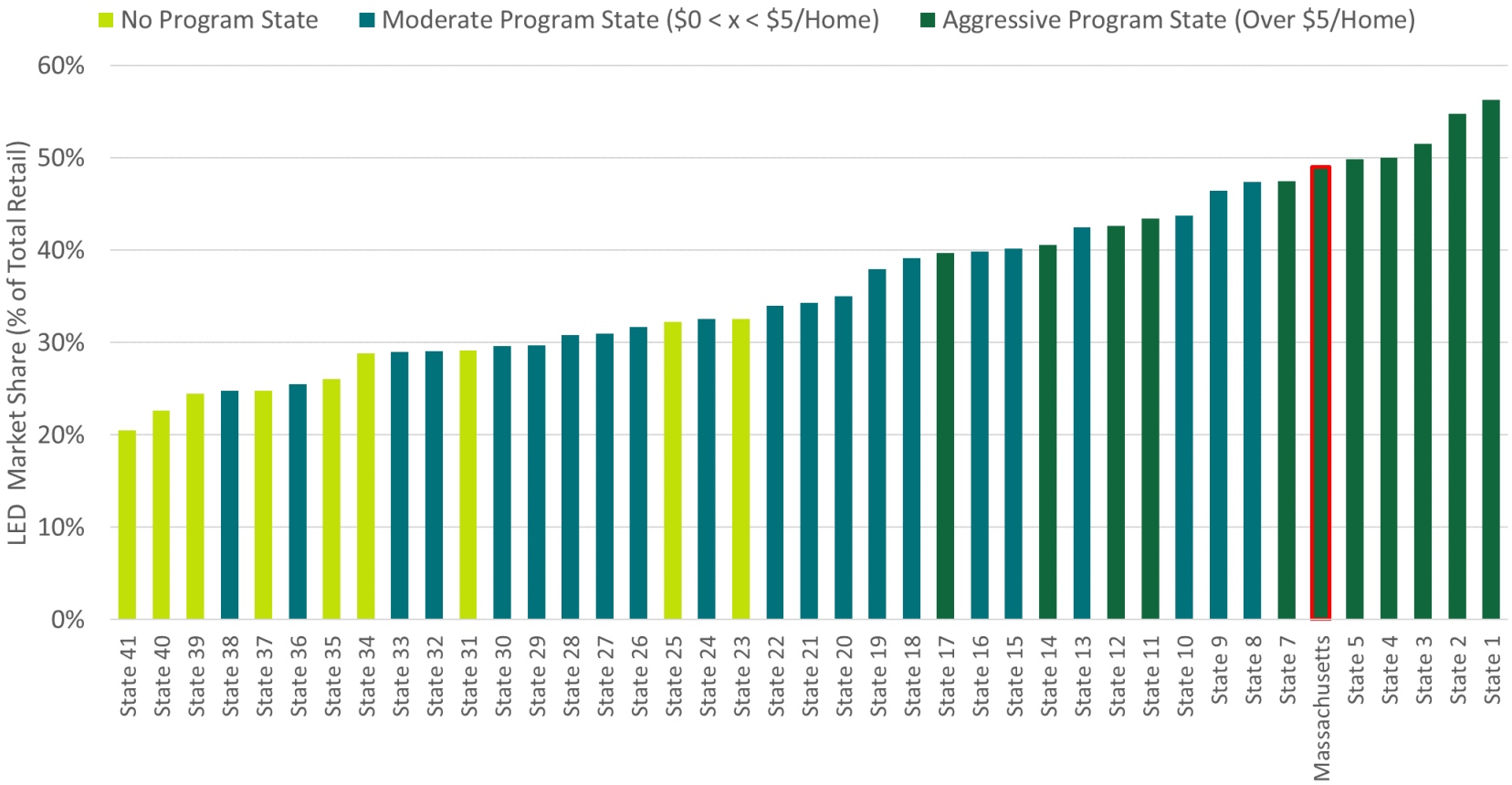
Reviewers of an earlier draft of this report have asked "Given the level of support (Figure 15), why isn't Massachusetts's market share ranking (Figure 14) even higher"? NMR and the LightTracker analysts believe that Massachusetts's continued support of CFLs through 2016 suppressed purchases of LEDs. In 2016, Massachusetts had a combined energy-efficient market share of 42%, ranking it 17th in the nation (Table 5). This reflected a rank of sixth place for CFLs and 23rd for LEDs. In 2017, the PAs stopped supporting CFLs and ramped up their support for LEDs, and the national LED market experienced numerous other changes (see Section 1.1). The combined CFL and LED market share in the state jumped to 57%, the third highest in the nation. Massachusetts had the sixth highest market share of both LEDs and CFLs.[18] Thus, it appears that, prior to 2016, the support for ENERGY STAR qualified CFLs may have suppressed LED sales, but the combination of programmatic and market changes in 2017 favored LEDs, leading to the large increases in LED market share in Massachusetts.[19]

Table 5: Massachusetts 2016 and 2017 Efficient Bulb Market Share and Ranking (out of 44 states)

	2016		2017	
	%	rank	%	rank
CFL	16%	8	8%	6
LED	26%	23	49%	6
CFL+LED	42%	17	57%	3

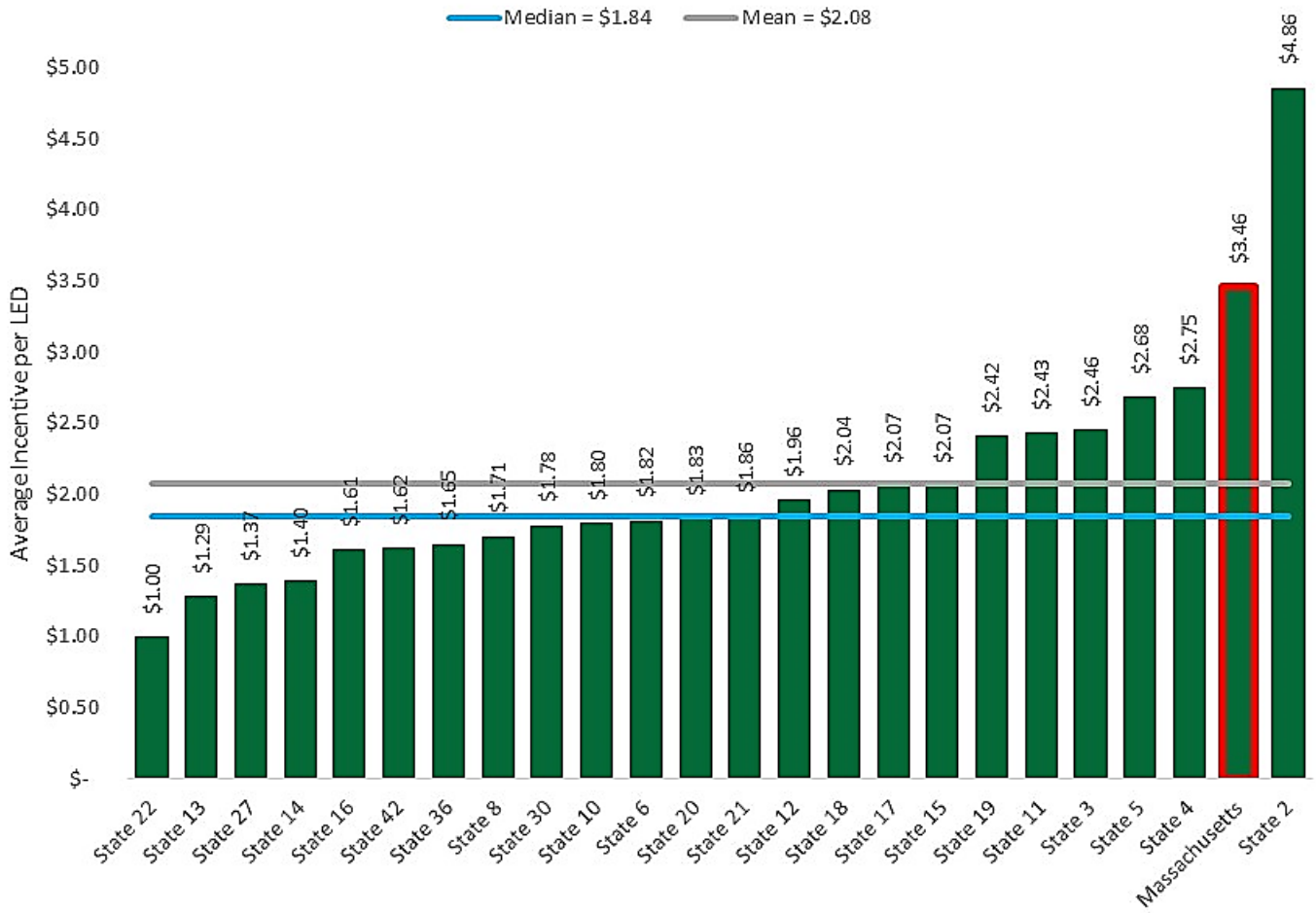
[17] Note that this analysis focuses solely on incentive dollars, while Figure 13 and Figure 14 include all program spending.
[18] Only one state – another New England state – saw superior improvement in LED and combined energy-efficient market share rankings between 2016 and 2017. It also had the highest incentive per LED and the second highest program spending per household of all states in the nation.
[19] Other research confirms that the strategy of supporting CFLs helped increase energy-efficient bulb saturation for a wider range of Massachusetts households at a time when even program-supported LEDs remained out of reach for some consumers. Yet, it does appear that one unintended consequence was to suppress LED sales. See NMR. 2016. *2015-16 Lighting Market Assessment Consumer Survey and On-site Saturation Study.* http://ma-eeac.org/wordpress/wp-content/uploads/MA-2015-16-Lighting-Market-Assessment-Final-Report-08August2016.pdf.

Figure 14: 2017 LED Market Share Across States by Program Spending[1]



[1] All retail channels.

Figure 15: Average 2017 Upstream Incentive per LED (Program States)[1,2]



[1] All retail channels.

[2] LightTracker was able to isolate LED spending for only 24 states. Therefore, some states – for example, State1, State7, and others – listed in Figure 14 do not appear in Figure 15.

2.1.4 LED Market Share by ENERGY STAR Qualification

The LightTracker Initiative identified ENERGY STAR qualification (under any prior specification) for LEDs in the POS database using a mixture of information, including:

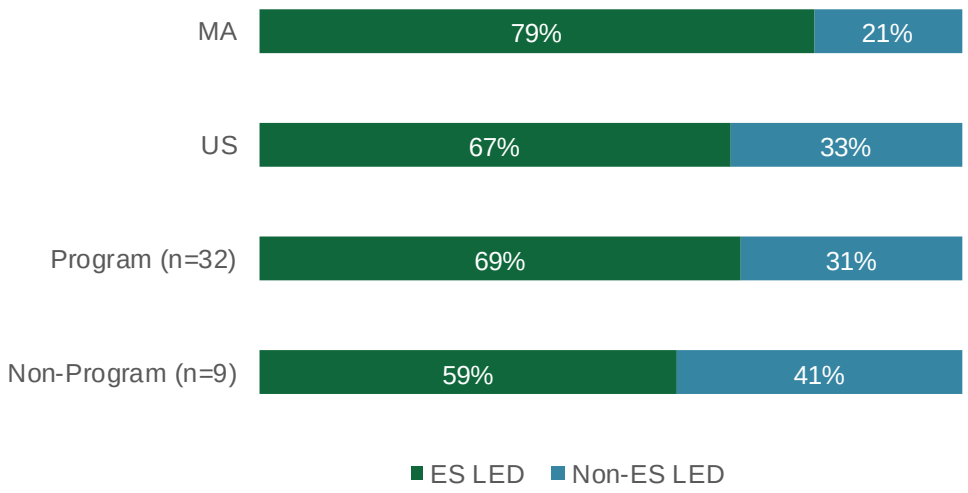
- Rated lifetime of the bulbs
- Web scraping and shelf-stocking of stores in Massachusetts and New York conducted for the RLPNC 16-6 Shelf Stocking study
- Web scraping conducted by LightTracker analysts
- Reviews of ENERGY STAR qualification lists (current and prior) that had previously been downloaded and saved by NMR and other LightTracker analysts
- Supplemental internet searches

The team was able to ascribe ENERGY STAR status (yes or no) for 99% of 2017 LED sales in Massachusetts, 98% in the US, 97% in program states, and 96% in non-program states. These identified ENERGY STAR bulbs are from the POS data, meaning that they represent about 26% of the Massachusetts lighting market and exclude big box stores.

Market share of ENERGY STAR qualified LEDs in Massachusetts exceeded that of other areas.

Among LEDs of verified status in the subset of retail channels, 79% were ENERGY STAR-qualified in Massachusetts in 2017. This is higher than in the US (67%), program states (69%), and non-program states (59%) (Figure 16).

Figure 16: ENERGY STAR Status of 2017 LED Sales in Massachusetts and Comparison Areas[1]



[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores. Represents approximately 26% of the Massachusetts, 35% of the US market, 33% of the program state market, and 46% of the non-program state market.

2.1.5 Market Share by Lumen Bin

The Energy Independence and Security Act (EISA) of 2007 originally allowed many bulbs to be exempt from increased efficiency standards. Specialty bulbs, such as two-way, three-way, reflector,[20] globe, and candelabra bulbs accounted for many of the exempt bulbs. The list of exemptions also included rough service and other A-line bulb types that function almost identically to general service bulbs. Some argued that these exemptions created loopholes through which consumers could continue to purchase and use incandescent bulb technology instead of switching to more efficient bulbs. To close these loopholes, the December 29, 2016 Department of Energy (DOE) Rulemaking expanded the definition of general service bulbs to include many of these previously exempt categories, including not only rough service and similar bulb types, but also reflectors, globes, candelabras, and other specialty products (e.g., two- and three-way, colored bulbs) that are included in the Massachusetts Lighting Core Initiative. The status of this expanded definition – and of EISA Phase 2 – remains uncertain. However, for the sake of discussion, the analysis below draws distinctions between current EISA exemptions and EISA

[20] While exempt from the first phase of EISA, reflector bulbs must adhere to their own set of efficiency standards that vary by size and shape. See https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=23.

2020 exemptions, even though we recognize that EISA Phase 2 and the expanded definition of general service lamps may not go into effect in January 2020.

The original phase of EISA prohibited the manufacture and import of bulbs that do not comply with EISA, yet some of these remain on store shelves. This could reflect retailers and manufacturers selling through large stockpiles of incandescent bulbs manufactured or imported prior to the enactment of EISA. It may also reflect illegal importation of non-compliant incandescents, since Congress has opted not to allocate funds to enforce EISA.

The PAs and EEAC Consultants asked NMR to examine 2017 market share for A-line bulbs in the LightTracker sales data to assess the percentage of bulbs sold by type that are EISA exempt by the current and EISA 2020 definitions.[21] We used the following definitions:

- Currently exempt from EISA: bulbs of any shape that exceed 2,600 lumens or fall below 310 lumens
- Exempt from EISA 2020: bulbs of any shape that exceed 3,300 lumens or fall below 310 lumens

Table 6 lists the overall percentage of A-line bulb sales that fell into each lumen bin, including all technologies. It also indicates whether the lumen bin is currently EISA exempt and will remain so in 2020 (if implemented) and provides an imperfect crosswalk A-line incandescent wattage equivalents by lumen bin.[22] Assessing market share by lumens highlights the market share of incandescent bulbs that fall between 310 and 2,600 lumens. The dominance of sales in the 310 to 2,600 lumen ranges is expected, but the information helps explain some of the later findings. As mentioned earlier, it is possible that an (unknown) portion of 2017 bulb sales were sold from stockpiles or illegal importation. It is also possible that some remain exempt (e.g., rough service), though it is impossible to tell *which* bulbs in the data remain exempt.

Table 6: Lumen Bin Description

Lumen Bin	EISA Exemption	Approximate A-line Incandescent Wattage	Percentage of 2017 Bulb Sales
0-309	Current and 2020	Below 40 Watts	2%
310-449	Not exempt	40 Watts	7%
450-749	Not exempt	40 Watts	22%
750-1049	Not exempt	60 Watts	48%
1050-1489	Not exempt	75 Watts	11%
1490-2600	Not exempt	100 Watts	10%
2601-3300	Current	150 Watts	<0%
>3300	Current and 2020	Above 150 Watts	<0%

[21] A prior report included all bulb shapes in this analysis, but LightTracker analysts expressed concerns about the reliability of the data due to small sample sizes. Therefore, this report focuses solely on A-line bulbs.
[22] Wattage equivalents vary considerably by bulb shape and manufacturer, so these are approximations only.

Figure 17 presents market share by lumen bin for A-line bulbs in Massachusetts and non-program states in the grocery, drug, dollar, discount, merchandise, and some membership channels.

Incandescent and halogen bulbs made up nearly all A-line bulb sales in current and future EISA-exempt lumen bins.

Manufacturers and retailers may have embraced halogens and LEDs in the lumen ranges subject to EISA, but they remained committed to incandescents in the currently exempt lumen ranges (less than 310 and greater than 2,600, Figure 17). Additionally, the 310 to 449 lumen range almost exclusively comprised incandescents and halogens. This finding suggests that low and high lumen bulbs may offer current and future program opportunity, although they account for a very small portion of overall sales. However, this finding falls short of a recommendation since the future program opportunity will also depend on the PAs' assessments of cost effectiveness given agreed-upon prospective net-to-gross ratios.

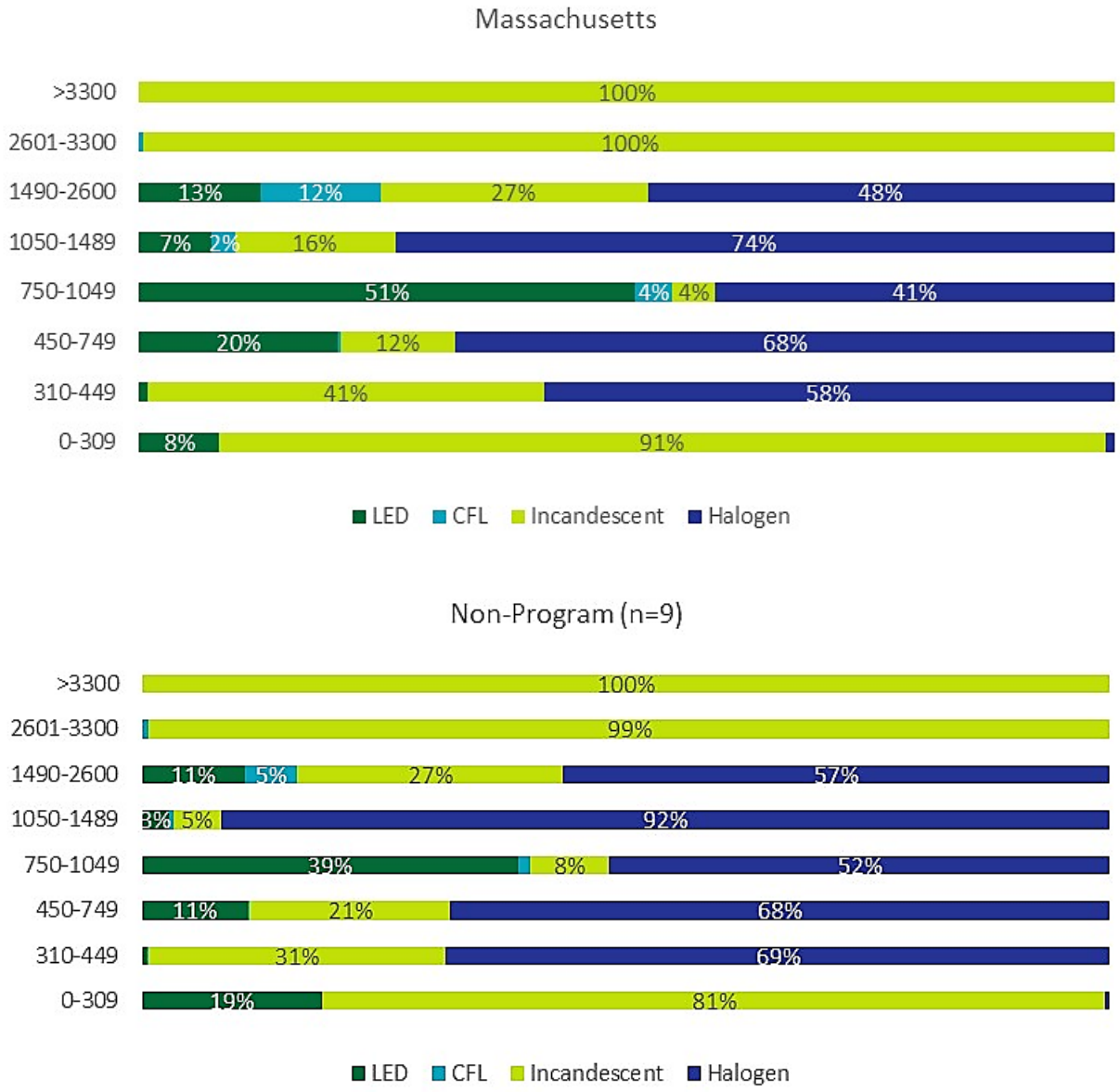
Incandescents accounted for relatively few sales in the 750 to 1,049 lumen range; however, their sales in the 1,050 to 2,600 lumen range exceeded those of CFLs and LEDs combined.

The search for incandescents sold from stockpile, illegal importation, or loophole exemptions suggests the biggest concern rests in the higher and lower lumen categories currently subject to EISA. Incandescents were fairly scarce (4% of sales) in the 750 to 1,049 lumen bin in Massachusetts (Figure 17). This bin is most associated with 60-Watt incandescents and accounted for almost one-half of all A-line sales. Incandescents made up larger portions of sales in the 1,050 to 1,489 lumen bin (16% in Massachusetts), as well as in the brighter 1,490 to 2,600 lumen bin (27% in Massachusetts). Likewise, in the lower ranges, incandescents made up 41% of sales in the 310 to 449 bin in Massachusetts, and 12% in the 450 to 749 lumen bin.

Market share of LED A-line bulbs in the 450 to 1,489 lumen range was higher in Massachusetts than in non-program states. This range is most closely associated with the 40-Watt to 100-Watt incandescent bulbs currently subject to EISA.

LED market share in Massachusetts in the 450 to 1,489 lumen range exceeded the share in non-program states. This offers further evidence of a positive program impact on LED sales. In contrast, LED market share was similar between Massachusetts and non-program states in most of the bins not currently subject to EISA, again suggesting program potential for bulbs in these lumen ranges. The one exception is the lowest lumen bin (0 to 310), in which non-program states had higher market share of A-line LEDs than Massachusetts. This lumen bin accounted for only 1.4% of total A-line sales in non-program states and 2.0% in Massachusetts.

Figure 17: 2017 A-line Bulb Market Share by Lumen Bin[1,2,3]



[1] Includes discount, dollar, drug, grocery, mass merchandise, and some membership stores, and represents approximately 26% of the Massachusetts market and 46% of non-program states. Labels for subtotals less than 2% are omitted for aesthetic purposes.

[2] Bins currently EISA Exempt: less than 310, above 2,600; bins subject to EISA 2020 (if implemented): less than 310, above 3,300.

[3] As shows in Table 6, the percentages of sales represented in the lumen bins below 310 and above 2,600 are very small. Likewise, small sample sizes of bulbs in these bins, while still in the thousands, are much smaller than the hundreds of thousands of bulbs in the 450 to 2,600 lumen bins.

2.2 BULB PRICE ANALYSIS

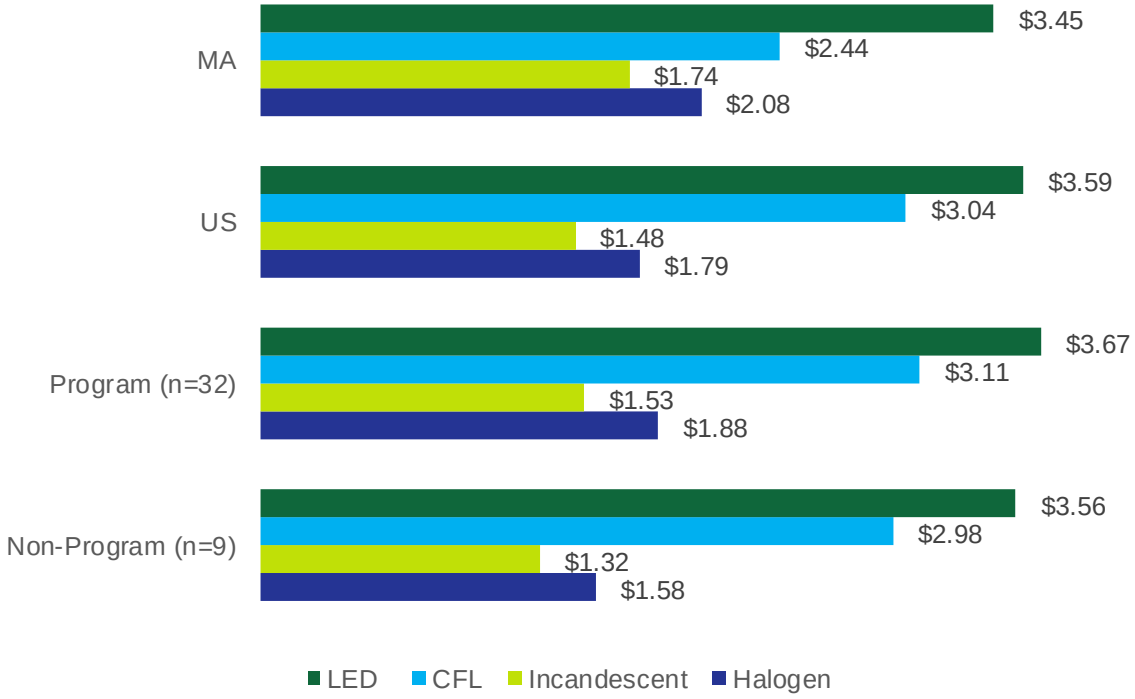
NMR conducted a bulb price analysis using the full category lighting data comparing the average price of different groups of light bulbs sold in Massachusetts, non-program states, and the entire US. We present pricing data for all bulb shapes because LightTracker can only provide detailed break-outs (e.g., by bulb shape) for discount, dollar, drug, grocery, mass merchandise, and some membership stores. Small sample sizes for many breakouts among the subset of channels limit generalizability and create concerns about bias, so we opted to focus on full category data by technology only.

The prices in the LightTracker dataset reflect the application of program incentives. However, the third-party sources do not report prices for private label bulbs (also known as store brands). Store brands usually sell for less than brand name models, so the prices reported in this section should be considered on the high end of what consumers pay at the register.

LEDs remained the most expensive bulb on shelves, even with program price supports.

In 2017, LEDs continued to be the most expensive bulb type. The average LED bulb price from all channels was $3.59 nationally, $3.45 in Massachusetts, and $3.67 among program states (Figure 18). These prices include both ENERGY STAR and non-ENERGY STAR LEDs, and the analysis presented in Section 2.1.4 makes clear that Massachusetts consumers bought a greater proportion of ENERGY STAR LEDs than consumers in non-program areas. Similarly, the average LED price among non-program states was ($3.56). This price is higher than program states ($3.67) but the latter had a higher percentage of ENERGY STAR LEDs, and not every program state supported ENERGY STAR LEDs as aggressively as Massachusetts did. CFLs were the next most expensive bulb, with average bulb prices between $2.44 and $3.11. The lower average CFL price in Massachusetts may reflect the sell-through of supported bulbs obtained by retailers prior to 2017. Average bulb prices were lowest for halogens and incandescents.

Figure 18: 2017 Average Price per Bulb in Massachusetts and Comparison Areas[1,2]



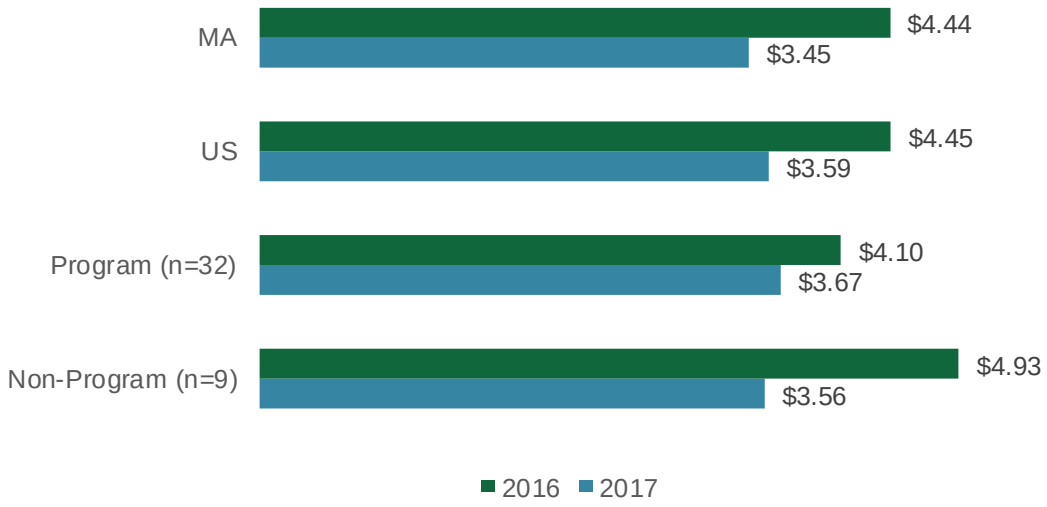
[1] All retail channels.

[2] Does not include private label bulbs sold at specific retailers, so the prices reported here are likely somewhat higher than actual prices.

The average LED bulb price decreased by about a dollar in Massachusetts between 2016 and 2017.

Figure 19 shows a comparison of 2016 and 2017 average LED bulb prices. Average LED bulb prices declined in Massachusetts and all three comparison areas. In 2016 the average LED bulb cost more in Massachusetts ($4.44) than in program states ($4.10), a pattern that reversed in 2017 ($3.45 compared to $3.67, respectively). In fact, the average LED bulb price in Massachusetts was lower than all comparison areas in 2017. Between 2016 and 2017, the average LED bulb price declined by about 22% in Massachusetts, 19% in the US, 10% in program states, and 27% in non-program states. Again, we note that Massachusetts aggressively supported ENERGY STAR LEDs in 2017, both in terms of the number of bulbs and the amount of the incentive.

Figure 19: 2016 and 2017 Average Price per LED Bulb in Massachusetts and Comparison Areas[1,2]



[1] All retail channels.
[2] Does not include private label bulbs sold at specific retailers, so the prices reported here are likely somewhat higher than actual prices.

Appendix A Data Sources and Data cleaning

This appendix provides a detailed discussion of data sources, data cleaning, and the strengths and weaknesses of each source.

A.1 Lighting Sales Data

On behalf of the PAs, NMR Group purchased the LightTracker Initiative dataset compiled by CREED. These data fill a gap in the availability of market-level lighting sales data. While many program partners readily share program sales data, they are reluctant to share non-program sales data. Non-program retailers and manufacturers also rarely share sales data with program administrators or evaluators. Prior to the LightTracker Initiative, PAs and evaluators relied on various sources of data to estimate market-level sales, including on-site panelists, bulb replacement behavior, self-reported customer purchases (on-site, web, phone), and the NEMA lamp shipment data. LightTracker offered a new source of market level information. While not perfect, it offers improved estimates of market-level sales for all retail channels and most states. LightTracker provides data for 45 of the 50 United States (see Table 7 for a listing of states).

CREED generates sales data from two sources: point-of-sale (POS) state sales data as scanned at the register and National Consumer Panel (NCP) state sales data (representing home improvement, hardware, online, and selected membership stores). Both the POS and the NCP datasets provide national level estimates of bulb sales. They also provide state-level data for individual states with sufficient sales and/or panel participation.

The 2017 POS dataset represents sales from grocery, drug, dollar, discount, mass merchandise, and the remaining membership club stores. The dataset accounts for about 26% of market share in Massachusetts and 35% for the nation. CREED purchases the data from third-party vendors, and the LightTracker team cleans, processes, and calibrates the data for analysis.

The NCP represents a panel of approximately 100,000 residential households that are provided a handheld scanner for their home and instructed to scan in every purchase they make that has a bar code. For Massachusetts, the NCP included approximately 1,300 households in 2017. The use of a scanner avoids potential recall bias, which is prevalent in self-report methods that ask about lighting purchases.

Each year CREED improves its data cleaning and vetting procedures. In prior years, comparisons of program-supported sales and full category LightTracker data have suggested that LightTracker undercounted LED sales in Massachusetts and some other states with aggressive upstream lighting programs. This year, CREED instituted a process to align full category total LED sales with known program-supported sales in each state. In situations in which program-supported sales (which are almost universally ENERGY STAR qualified across the nation) exceeded or rivaled total LED sales (comprising both ENERGY STAR and non-ENERGY STAR sales) they adjusted LED sales upwards so that program-supported sales accounted for 90% of ENERGY STAR sales. They made this change only to the full category data and not POS data (since the

latter include only part of the market). Prior to this adjustment LED market share in Massachusetts was 44%. After this adjustment, it was 49%. This change should be kept in mind when comparing full category market share over time.

Table 7: Program Strength and Data Quality Confidence

Program States[1]	Non-Program States	Unable to Categorize[2]	Excluded from LightTracker[3]
Arizona*	Alabama	Nevada	Alaska
Arkansas*	Delaware	Oklahoma	Hawaii
California*	Kansas	Utah	Iowa*,[3]
Colorado*	Kentucky	Wyoming	Montana
Connecticut*	Louisiana		North Dakota
Florida	Mississippi		
Georgia	Nebraska		
Idaho	Tennessee		
Illinois*	Virginia		
Indiana*			
Maine*			
Maryland*			
Massachusetts*			
Michigan*			
Minnesota*			
Missouri*			
New Hampshire*			
New Jersey			
New Mexico*			
New York			
North Carolina			
Ohio*			
Oregon*			
Pennsylvania*			
Rhode Island*			
South Carolina			
South Dakota*			
Texas*			
Vermont			
Washington*			
West Virginia			
Wisconsin*			

* States with an asterisk included in Figure 14.

[1] LightTracker was unable to assign program status to these states.

[2] The states lacked sales data or LightTracker.

[3] CREED was able to obtain program data for Iowa, but the state's representation in the POS and NCP data used to create the LightTracker dataset is too small to allow for estimation of bulb sales and market share.

Though the dataset CREED received included detailed records of lighting data purchases, the data required a considerable effort to ensure data integrity and inclusion of all the necessary bulb

attributes. For example, some records did not have critical variables populated, such as bulb type, shape, or wattage. In addition, some records had clearly erroneous values (e.g., 60-watt LEDs). After thorough review and quality control of the dataset, CREED re-classified and standardized the data. CREED also populated missing records, created additional variables, and performed general enhancements to the data. To populate missing records, validate existing records, and include additional bulb attributes, CREED created a proprietary Universal Product Code (UPC) database with approximately 36,000 bulbs from the following five sources:

- Manufacturer product databases provided to LightTracker
- Product catalogs downloaded from manufacturer web sites via web scraping
- Product offerings downloaded from retailer web sites
- Automated lookups of online UPC databases, such as www.upcitemdb.com
- ENERGY STAR databases available online at https://www.energystar.gov/productfinder/product/certified-light-bulbs

CREED then merged the bulb database with the POS/Panel data, populating fields based on a hierarchy of data sources believed to be most reliable. Prioritization was typically in the following order: manufacturer specifications, UPC lookups, original data provider (IRI and Nielsen) database values. The team also conducted manual web lookups on individual bulbs to determine final assignments.

In addition, CREED investigated the bulb assignment and the quantity of bulbs per package by examining the average price per unit and by identifying outliers in terms of per bulb prices. This process helped identify misclassification of certain bulb types (e.g., bulbs that were flagged as low cost LEDs but were really LED nightlights, so they needed to be moved under the *other* category), and misclassification of bulb counts that represented box shipments (e.g., a package identified as having 36 bulbs was really a six-pack of CFLs that was shipped with six packages per box).

Key aspects of the final lighting dataset include:

- 2017 sales volume and pricing for CFLs, LEDs, halogens, and incandescent bulbs for all channels combined, and broken out by the POS and non-POS channels
- Data reporting by state (with 45 states included) and bulb type
- Inclusion of all bulb shapes (e.g., candelabra, globe, etc.) and controls (e.g., three-way, dimmers, etc.)

A.2 LONGITUDINAL SALES AND SHIPMENT DATA

The Massachusetts PAs and EEAC Consultants also desired longitudinal analyses of bulb sales and shipments. Therefore, NMR supplemented the full category LightTracker data for 2015 to 2017 with POS data from 2009 to 2017 (obtained from CREED), which captured about 26% of

the residential lighting bulb sales.[23] We also examined quarterly NEMA bulb shipment data, derived from a survey of NEMA members, which provided information for January 2011 to December 2017.[24] NEMA data may suffer from non-response bias as some members may not respond to the organization's survey. If non-response varies by the types of bulbs manufactured, it could affect estimates of shipment share. NEMA shipments and LightTracker sales data should also be expected to be somewhat out of sync, as shipments precede sales and could end up being stockpiled in retailer warehouses.

A.3 PROGRAM ACTIVITY

To research program activity, the LightTracker team used internal resources and conducted a literature review of publicly available reports that were found on the internet or provided by program administrators or their evaluators.[25] The team contacted local utilities in each given area when reports with the relevant information were not available. Additionally, the team accessed DSM Insights, an E Source product that provides a detailed breakdown of program-level spending, including incentives, marketing, and delivery for over 100 program administrators around the country.[26]

The program data collection activity included:

- Total number of claimed LED upstream program bulbs reported by each program
- Upstream LED incentives
- Total upstream program budget

Where available, the team used actual program data; in other cases, it turned to DSM Insights, ENERGY STAR reported expenditures, or planning values as proxies.[27]

All states with at least some program activity in 2017 were designated *program states; the* remaining states were designated *non-program states*, as shown above in Table 7.

[23] The POS data cover the grocery, drug, dollar, discount, and merchandise stores, and represents approximately 26% of the Massachusetts market, 35% of the US market, 33%of program states markets, and 46% of the non-program states market.
[24] http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx
[25] Specifically, the team began by searching the ENERGY STAR Summary of Lighting Programs website https://www.energystar.gov/ia/partners/downloads/2017%20ENERGY%20STAR%20Summary%20of%20Lighting%20Programs.pdf and referenced the Database of State Incentives for Renewables & Efficiency (www.dsireusa.org).
[26] E Source. "DSM Insights." April 2018.
[27] Note that because the ENERGY STAR report only included expenditure ranges, the midpoints of the ranges were used to represent the expenditures.