RI2311 National Grid Rhode Island Lighting Market Assessment

FINAL

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SUBMITTED TO:
National Grid Rhode Island

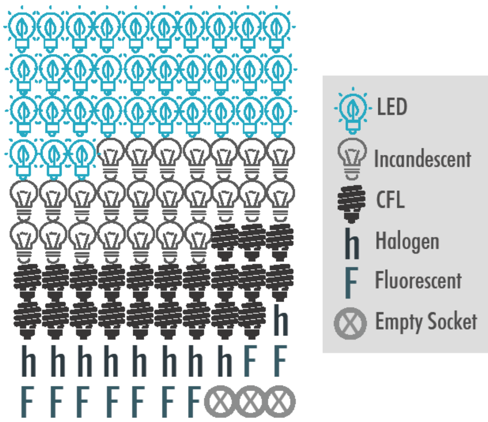
SUBMITTED BY:
NMR Group, Inc.

Rhode Island Residential Lighting Market Assessment

This study updated estimates of lighting saturation and assessed the lighting market in Rhode Island. NMR visited 75 homes in April and May of 2018 to collect data on lighting use, storage, and purchasing behavior. The results show that National Grid programs have had a strong impact on LED adoption. LED saturation and penetration rates in the comparison area (New York) continued to lag behind the rates measured in Rhode Island. In addition, ENERGY STAR LEDs (the only LEDs supported by the programs) accounted for the majority of the difference in LED saturation between the states. There were nearly five times as many ENERGY STAR LEDs in use in Rhode Island compared to New York.*

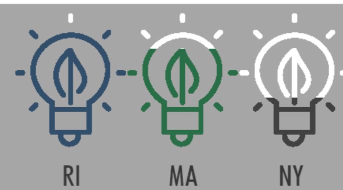
2018 Saturation Rates

Saturation is the percentage of sockets filled by a specific bulb type.



In Rhode Island, 33% of all installed bulbs were LED, followed by incandescent (24%), CFL (22%), halogen (9%), and fluorescent (9%). 3% of sockets were empty. Total efficient bulb saturation was 64%.

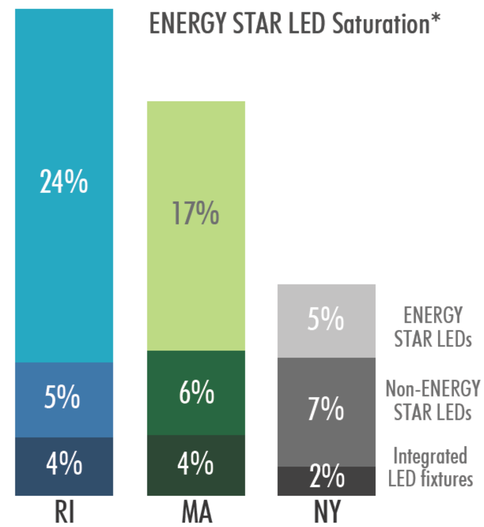
In Rhode Island, 86% of all LEDs purchased or received in the previous year were ENERGY STAR, compared to 74% in Massachusetts and 37% in New York.*



Saturation of ENERGY STAR LEDs in Rhode Island (24%) was nearly five times the rate observed in New York (5%).

Massachusetts, which also has program support, has 17% ENERGY STAR LED saturation.*

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

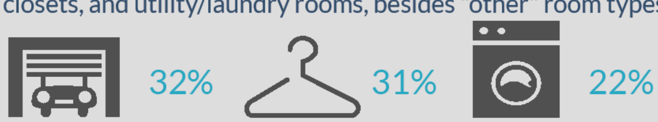


*Data collection in Rhode Island took place nearly 6 months after Massachusetts and New York.

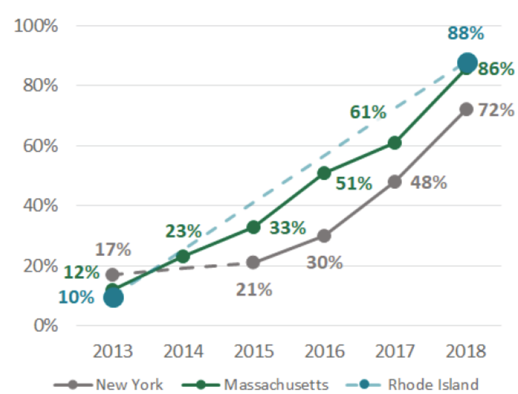
In Rhode Island, LEDs are installed in all room types; even the rooms with the lowest penetration still had some LEDs.

The rooms with the highest LED penetration were offices, dining rooms, and bedrooms.

The rooms with the lowest LED penetration were garages, closets, and utility/laundry rooms, besides "other" room types.



LED Penetration Rates



Rhode Island Prospective NTG

Net-to-gross (NTG) is a ratio that indicates how much of a program's savings the program is actually responsible for.

Standard
2019: 35%
2020: 30%

Reflector
2019: 45%
2020: 40%

Specialty
2019: 45%
2020: 40%

All LEDs
2019: 39%
2020: 34%

Table of Contents

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Executive Summary

In this report, NMR Group, Inc. (henceforth NMR) presents the results of the 2018 Rhode Island residential lighting market assessment. The study was designed to estimate lighting saturation and other critical market indicators in Rhode Island. The data for this study came from on-site lighting inventories of homes in Rhode Island completed in April and May of 2018. NMR presents the data alongside recent results of a similar study conducted between October and December 2017 on behalf of the Massachusetts Program Administrators. This study included data collection in Massachusetts, another program state, and a comparison area (portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse, as well as all of Westchester County – referred to as *New York* in this report).[1] The Massachusetts Program Administrators chose to use portions of New York as a comparison area because they present a unique opportunity to understand how the residential lighting market has responded to the cessation of standard spiral CFL incentives in 2012 and essentially all upstream incentives in 2014.[2] Both Massachusetts and New York are good comparison areas because the demographic profile in both areas are similar to that of Rhode Island.

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

This executive summary begins with an overall assessment followed by key findings. In the remaining body of the report we present more detailed findings from these efforts.

Overall Assessment

Evidence from this study suggests that the Rhode Island programs have had a strong impact on saturation and penetration of LEDs in Rhode Island homes. While consumers in the New York comparison area were also adopting LEDs, LED saturation and penetration rates lagged those measured in Rhode Island. ***LED saturation was 33% in Rhode Island compared to only 14% in New York. LED penetration was 88% in Rhode Island compared to 72% in New York.***

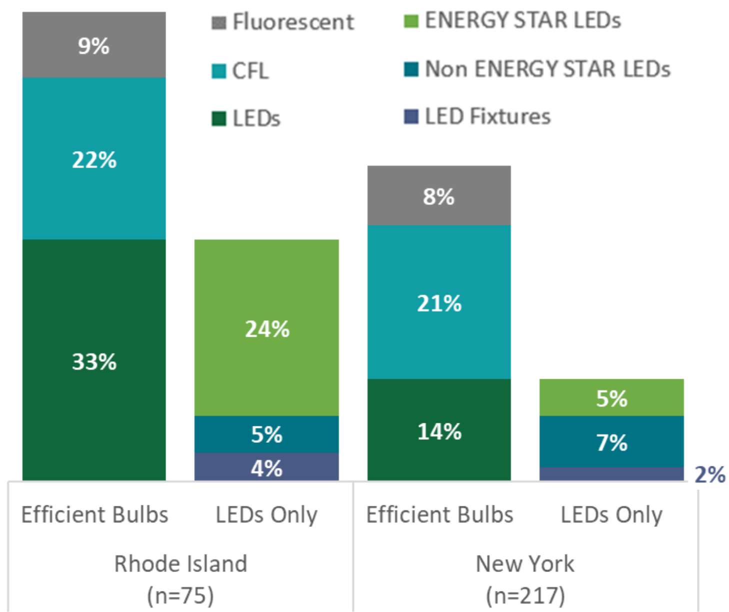
Further, ***ENERGY STAR® LEDs (the only type of LEDs supported by Rhode Island program efforts) accounted for the entire difference in LED saturation between the two areas***, providing strong evidence that the Rhode Island programs have had a profound impact on the market. While householders in Rhode Island reported high overall satisfaction rates with over 90% of installed LEDs, they were significantly more likely to indicate they were "very satisfied" with ENERGY STAR LEDS (83%) compared to non-ENERGY STAR LEDs (65%).

[1] Note: Massachusetts collected the Massachusetts and New York data; this was partially sponsored by National Grid – Massachusetts.

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

Figure 1 also shows that saturation for all efficient bulb types combined – LEDs, CFLs and fluorescent bulbs – was significantly higher in Rhode Island (64%) than in New York (43%) in 2018.

Figure 1: Efficient Bulbs and LED Saturation 2018 (RI & NY)



We found the Rhode Island lighting market in 2018 to be similar to the market in Massachusetts, which had 27% LED saturation at the end of 2017. We predicted that LED saturation in Massachusetts would be 33% if study timing had aligned with the recent data collection effort in Rhode Island. Approximately one-quarter of stored bulbs in Rhode Island (25%) and Massachusetts (22%) were LEDs and one-half of stored bulbs in both states were incandescents (51%).

Upstream Impact Factors

As part of this study, NMR prepared updated estimates of residential upstream lighting hours of use (HOU) based on the results of the 2014 Northeast Residential Lighting Hours-of-Use Study[3] and changes in saturation over time. The HOU values are for residential applications and do not include any adjustments for cross-sector sales.[4] NMR also provided updated discounted lifetime in-service rates (ISRs) for LEDs distributed through the upstream program. These updated values are provided for application to the upstream lighting program and should not be applied to any direct install programs. Impact factors are provided in Table 1. Details on the methods used to

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

[4] Rhode Island currently assumes 7% of lamps sold through the residential upstream lighting program are ultimately installed in commercial sockets. Rhode Island assumes an average daily HOU of 8.5 for cross-sector sales. Combining residential and cross-sector HOU yields an estimate of 3.5 HOU per day (3.1 * 93%) + (8.5 * 7%).

update HOU can be found in Section 2.2. Details on the methods used to update ISR can be found in Section 5.

Table 1: Updated Upstream Impact Factors

Factor	2018 TRM Values	Updated Value
LED Daily HOU	**3.0**	**3.1**
LED Discounted Lifetime ISR		
A-line ISR[1]	**93%**	**93%**
Reflector ISR[2]	**94%**	**94%**
Specialty ISR[2]	**Varies[3]**	**94%**

[1] Assumes a sunset year of 2022; sunset years are defined as points in time past which savings are no longer claimed, based on the assumption that consumers are unlikely to find non-LED lamps available to purchase.
[2] Assumes a sunset year of 2023.

[3] The 2018 TRM provides values for two EISA exempt categories with ISR of 95% and 97% based on estimated useful lives of 15,000 or 25,000 hours. Neither category is directly comparable to the specialty ISR developed.

Prospective NTG

Typically, NMR recommends that program administrators establish NTG values based on a triangulation approach that relies on several methods of estimating NTG rather than relying on a single method. In addition, for prospective estimates, NMR recommends the use of a panel of knowledgeable industry experts who can examine available data and provide an informed prospective estimate.

Unfortunately, triangulation of NTG and consensus processes are time consuming and expensive.. Therefore, NMR designed this study to allow Rhode Island to leverage the prospective NTG consensus process recently completed in Massachusetts,[5] which relied on a variety of methods.[6]

In this document, NMR outlines similarities between the residential lighting markets in Rhode Island and Massachusetts, ultimately concluding that the two markets are substantially similar; therefore, Rhode Island can likely use the results from the recently completed NTG study in Massachusetts. The main items we considered in this comparison were current LED saturation, the current level of stored LEDs, and historical upstream program support. A high-level examination of historical program activity found that the overall level of support between 2013 and 2017 was comparable. NMR used Massachusetts to help fill in gaps in annual saturation and storage values for Rhode Island to assess historical NTG values based on a single saturation-based approach.

Finally, NMR explored prospective values used for planning purposes in Rhode Island and those adopted in Massachusetts (based on a consensus approach). NMR is recommending that the Rhode Island consensus group, consisting of National Grid, the C-Team, and NMR, consider

[5] The Massachusetts NTG consensus process was funded in part by National Grid – Massachusetts.
[6] http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_1711_LEDNTGConsensus_30JUNE2018_final.pdf

adopting the Massachusetts values for 2019 and tentatively as a placeholder for 2020, in the absence of additional research. These values are presented in Table 2 for consideration by National Grid and the C-Team.

Table 2: Rhode Island Prospective NTG Values

Program Year	Standard	Reflector	Specialty	All LEDs
2019	35%	45%	45%	39%
2020	30%	40%	40%	34%

[1] Rhode Island planning values for 2019 were 43% for all LEDs and 63% for hard-to-reach LEDs. Planning values for 2020 were 36% for all LEDs and 56% for hard-to-reach LEDs.

1

Section 1 Introduction

1.1 Study Objectives

In this study, we updated estimates of lighting saturation and assessed the lighting market in Rhode Island. We used these study data to examine socket saturation, penetration, LEDs purchased or obtained by customers through direct-install programs, bulbs in storage, and LED satisfaction. We also estimated a saturation-based NTG ratio based on changes in saturation in Rhode Island and the non-program comparison area.

1.2 Methodology

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

1.2.1 Weighting Scheme

We weighted the Rhode Island on-site survey data to reflect the population proportions for tenure and heating fuel type in Rhode Island based on the American Community Survey (ACS) 5-Year Estimates. Delivered fuel type is based on customer data provided by National Grid and represents the types of fuels National Grid provides customers; it does not speak to customers who may receive fuel from other suppliers (fuel oil, propane, etc.) nor the type of fuel the home may use for heating. Note: values for Massachusetts and New York presented in this report have not been weighted to the demographics of Rhode Island and are taken directly from reports available through http://ma-eeac.org/.

Table 3: Rhode Island On-Site Visit Weight Scheme

Tenure by National Grid Delivered Fuels	Households	Sample Size	Proportionate Weight
Total	*323,636*	*75*	
Own	193,080	50	
Electric	88,109	24	0.85
Gas/Electric	104,972	26	0.94
Rent	130,556	25	
Electric	49,155	11	1.04
Gas/Electric	81,401	14	1.34

In Table 4, we show weighted and unweighted saturation side-by-side. Weighting had a minimal effect on saturation. See Appendix A for a comparison of the unweighted sample to the ACS 5-year estimates.

Table 4: Rhode Island Weighted and Unweighted Saturation Comparison

Bulb Type	Weighted	Unweighted
Total	*3,635*	*3,892*
LED	33%	33%
Incandescent	24%	24%
CFL	22%	22%
Halogen	9%	10%
Fluorescent	9%	9%
Empty Socket	3%	2%
DK/Other	0%	0%

Table 5 provides the weighted estimates of total saturation by bulb type as well as the mean and median saturation at the household level. The greater the difference between the mean and median per household, the greater the discrepancy between households with a lot of that bulb type installed versus those with few. This difference was largest for LEDs, likely demonstrating that there are some households committed to LEDs while others are not. This may indicate that there are still households that can be influenced by a lighting program.

Table 5: Saturation by Socket and Mean and Median Saturation by Household, Rhode Island (n=75)

Bulb Type	Saturation	Mean	Median
LEDs	33%	28%	20%
Incandescent	24%	25%	21%
CFLs	22%	27%	21%
Halogen	9%	8%	5%
Fluorescent	9%	7%	5%

1.2.2 On-site Lighting Inventories

NMR visited 75 homes to collect data on their lighting use, storage, and purchasing behavior. NMR conducted the visits in April and May 2018. Participants were recruited through a web-based survey on appliances that asked if respondents were interested in the on-site portion of the study. NMR contacted those interested to schedule a visit. Among the 900 respondents who completed the web survey, 56% indicated they would be willing to complete the on-site portion of the study for an additional incentive ($150).

While on site, the technician examined all sockets in the home by room type, gathering data on fixture type, bulb type, bulb shapes, socket type, wattage, and specialty characteristics for all installed lighting products, as well as LED model numbers and brands. The technician collected similar information for all lighting products found in storage. The technician also asked where the household had purchased or received all recently obtained LEDs (installed and in storage).

1.2.2.1 Previous On-Site Visits

Prior to 2018, National Grid last conducted an on-site lighting inventory for Rhode Island as part of the Northeast Residential Lighting Hours-of-Use Study. As part of that effort, NMR visited a total of 41 households in Rhode Island in November 2012.

1.2.2.2 Comparison Areas

This primary data collection conducted as part of this study, on behalf of National Grid Rhode Island, has been supplemented by recent results of a similar study (RLPNC 17-9) conducted between October and December 2017 on behalf of the Massachusetts Program Administrators. The RLPNC 17-9 study included data collection in Massachusetts, another program state, and a comparison area (portions of New York, namely a 40-mile radius around the cities of Albany, Buffalo, Rochester, and Syracuse, as well as all of Westchester County – referred to as *New York* in this report).[7] NMR relied on data from these two comparison areas to provide context to the saturation values observed for Rhode Island:

- **Massachusetts.** We chose Massachusetts since it is a neighboring program state with a similar portfolio of residential lighting programs and a history of conducting nearly annual on-site lighting inventory studies. Thus, Massachusetts provides additional insights into year-to-year changes in saturation lacking in Rhode Island. For more details on how Massachusetts and Rhode Island program activity compares, please see Section 7.1.
- **Portions of Upstate New York**[8]. In 2014, the Massachusetts Program Administrators chose portions of Upstate New York as a comparison area because they presented a unique opportunity to understand how the residential lighting market has responded in the absence of upstream residential lighting program support. In 2012, NYSERDA [9] discontinued upstream support for standard spiral CFLs incentives and nearly all upstream incentives (including LEDs) in 2014. The decision to exit the market was made by the New York Department of Public Service, operating under the hypothesis that the residential lighting market would continue to transform without further intervention from NYSERDA.

While NYSERDA no longer offers upstream programs in Upstate New York, in the intervening years, utilities in these portions of New York have continued to provide varying levels of support for LEDs through a variety of program offerings, including direct install programs, energy efficiency kits, and online marketplaces/portals. In addition, in 2017, Con Edison began to support LEDs through traditional upstream channels in their service area (including Westchester County, which is one-fifth of the total number of households included in the comparison area panel). It is NMR's understanding that Con Edison upstream program activity was low in 2017 but has ramped up in 2018. NMR detected no differences in LED saturation among Westchester County

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[7] Note: Massachusetts collected the Massachusetts and New York data; this was partially sponsored by National Grid – Massachusetts.

[8] Comprising Westchester County and 40-mile radiuses around the cities of Albany, Buffalo, Rochester, and Syracuse.

[9] New York State Energy Research and Development Authority.

households and households in other portions of the comparison area. This leads NMR to believe the new upstream program activity has had little or no impact on saturation for the overall New York comparison area, but we still acknowledge this as a potential threat to validity for using New York as a non-program comparison area.

2

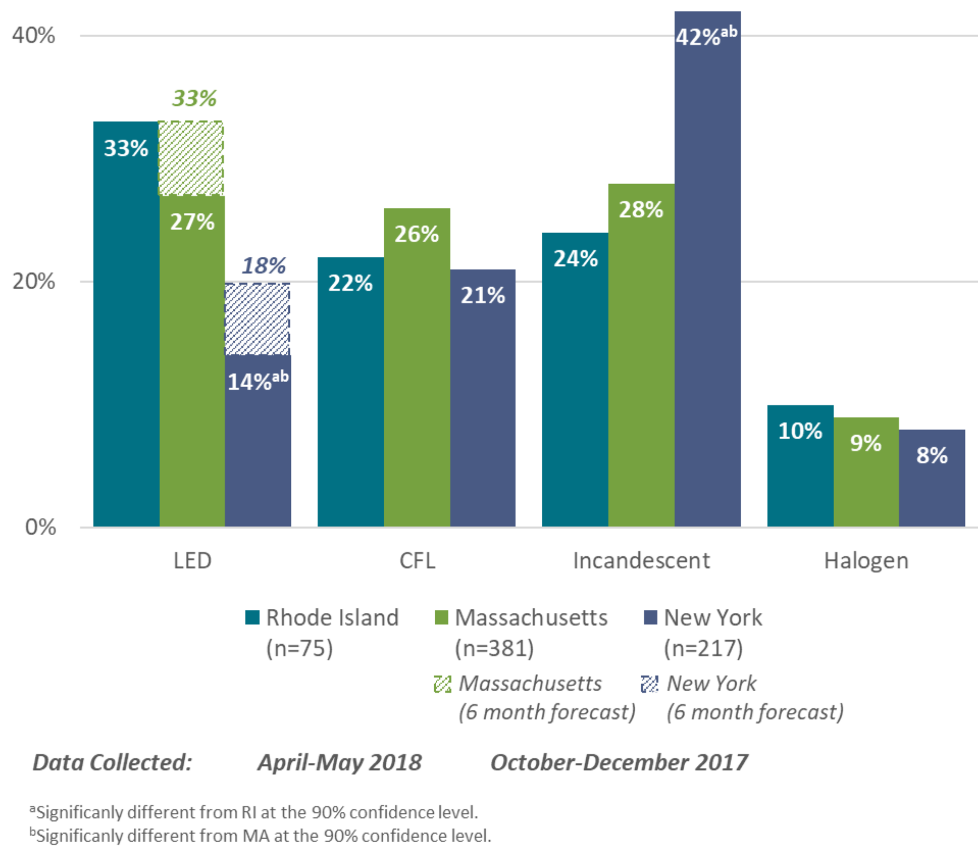
Section 2 Socket Saturation

In this section, we explore trends in socket saturation in Rhode Island, Massachusetts, and the comparison area of New York.

2.1 Saturation by Household

Figure 2 shows saturation for LEDs, CFLs, incandescent bulbs, and halogen bulbs in 2018 in Rhode Island, Massachusetts, and New York.[10] We observed significantly higher LED saturation in both Rhode Island (33%) and Massachusetts (27%) compared to New York (14%). Not surprisingly, incandescent saturation was significantly lower in both Rhode Island (24%) and Massachusetts (28%) compared to New York (42%). The figure also shows predicted LED saturation in Massachusetts and New York if data had been collected in those states during the same time frame as the Rhode Island study.[11]

Figure 2: Saturation 2018 (RI, MA & NY)



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[10] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.
[11] NMR predicted LED saturation in Massachusetts and New York based on an LED adoption curve, described in Appendix B.

Table 6 shows that saturation for all efficient bulb types – LEDs, CFLs and fluorescent bulbs – was significantly higher in Rhode Island (64%) than in New York (43%) in 2018.

Table 6: Efficient Bulb Saturation by Area 2018

Bulb Types	Rhode Island	Massachusetts	New York
LEDs + CFLs	55%	53%	35%[ab]
LEDs, CFLs + Fluorescents	64%	60%	43%[ab]

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

Table 7 shows socket saturation for all bulb types in Rhode Island in 2013 and 2018. In 2018, one-third (33%) of all sockets in Rhode Island were filled with an LED. In 2018, efficient bulbs – LEDs, CFLs and Fluorescents combined – filled nearly two-thirds (64%) of all sockets, up from 43% in 2013. Conversely, inefficient bulbs – incandescents and halogens combined – filled only one-third (34%) of all sockets in 2018, down from 55% in 2013.

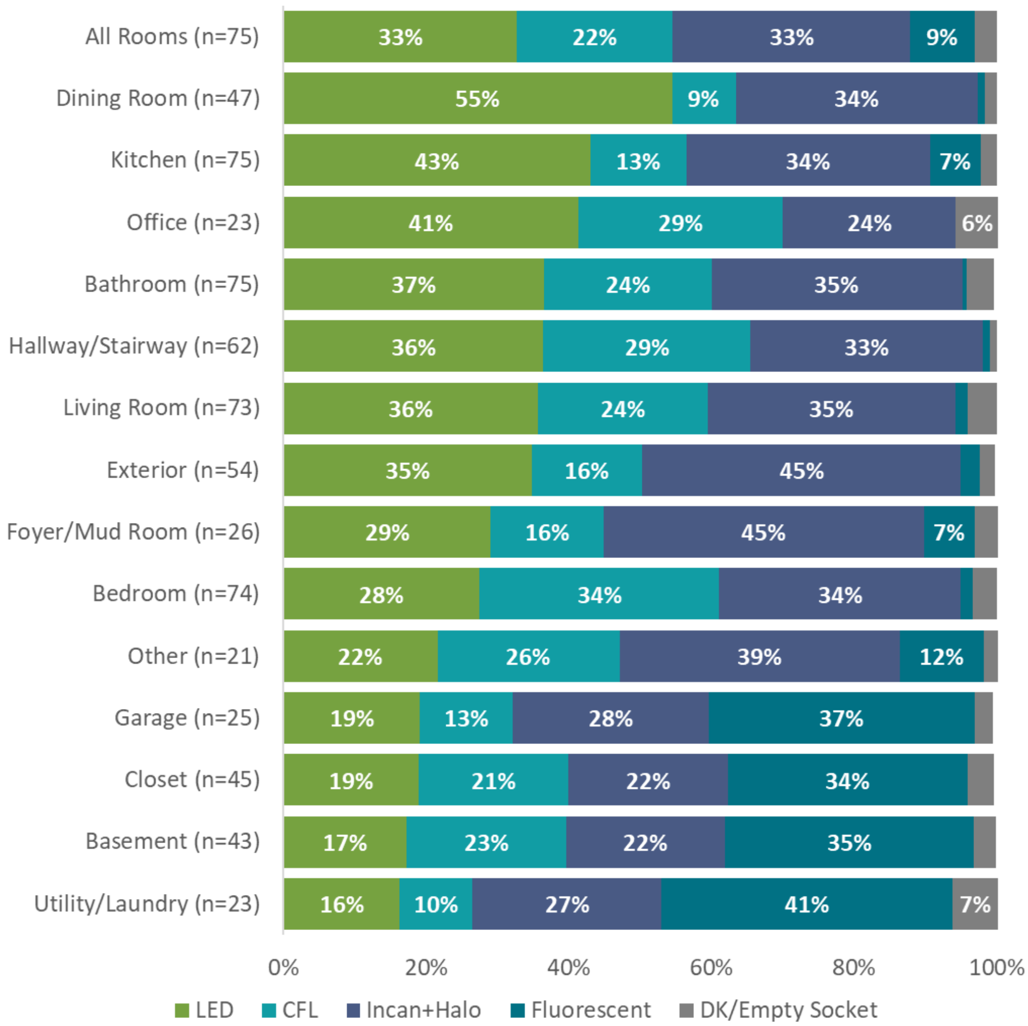
Table 7: Rhode Island Socket Saturation, 2013 & 2018

Bulb Type	2013	2018
Sample Size	*41*	*75*
# of installed bulbs	*1,776*	*3,635*
LED	1%	33%
Incandescent	48%	24%
CFL	27%	22%
Halogen	7%	9%
Fluorescent	15%	9%
Other/Don't know	<1%	<1%
Empty Socket	1%	3%

2.1.1 Room-by-Room Saturation

In this section we explore saturation by room type in Rhode Island in 2018 (Figure 3). Across all room types combined, LED saturation was 33%. Dining rooms (55%), kitchens (43%), and offices (41%) were the room types with the highest levels of LED saturation. This was similar to the most recent study in Massachusetts, which had the highest LED saturation in kitchens (37%), living spaces (32%), and dining rooms (31%). The room types with the lowest levels of LED saturation were utility/laundry rooms (16%), basements (17%), closets (19%), and garages (19%). Not surprisingly, these room types also had the highest levels of fluorescent saturation. The rise of linear LEDs in the market may increase LED saturation in these room types in the future. Technicians observed only three linear LEDs as part of the 2018 Rhode Island visits.

Figure 3: Saturation by Room Type



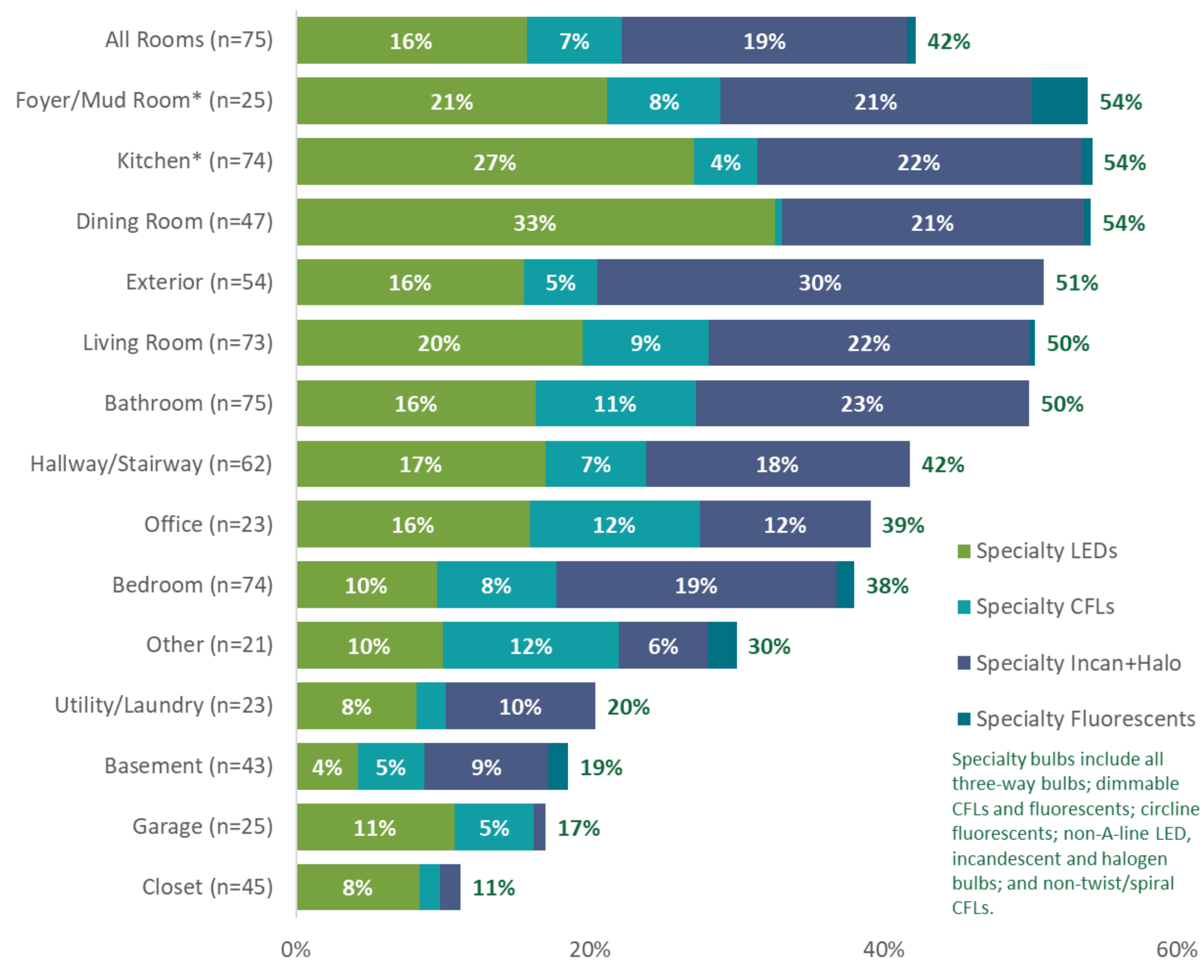
Values under 5% not labeled.

Next, we explore the proportion of sockets occupied by a specialty bulb by room type and bulb type and focus on the proportion of sockets occupied by a specialty LED. An important consideration when examining saturation by room type is the proportion of specialty sockets present in each room type. This is important because CFL and LED specialty bulbs are generally more expensive.

As Figure 4 shows, specialty sockets – including three-way bulbs of any kind; dimmable CFLs and fluorescents; circline fluorescents; non-A-line LED, incandescent, and halogen bulbs; and non-twist/spiral CFLs – comprised just over two-fifths (42%) of all bulbs in Rhode Island households in 2018. Specialty sockets comprised just over one-half of all sockets in dining rooms (54%), kitchens (54%), foyer/mud rooms (54%), and exteriors (51%). Closets (11%), garages (17%), and basements (19%) had the lowest specialty bulb saturation in 2018. Specialty trends by room type were similar in Massachusetts.

Specialty LEDs filled one-fifth (20%) of all sockets or less in most room types. However, when compared to the proportion of sockets occupied by a specialty bulb overall, exteriors, bathrooms and foyer/mud rooms had the highest remaining potential to fill specialty sockets with LEDs.

Figure 4: Specialty Bulb Saturation and Specialty LED Saturation by Room Type, Rhode Island 2018



* These room types each had one outlier removed from the analysis.
Note: Values under 4% not labeled.

2.1.2 Saturation by Bulb Shape

Table 8 shows overall saturation by bulb shape per state while

Bulb Shape	Rhode Island	Massachusetts	New York
Sample Size	*75*	*381*	*217*
A-line	50%	55%	61%
Spot/Reflector/Flood	22%	18%	15%
Other	28%	27%	24%

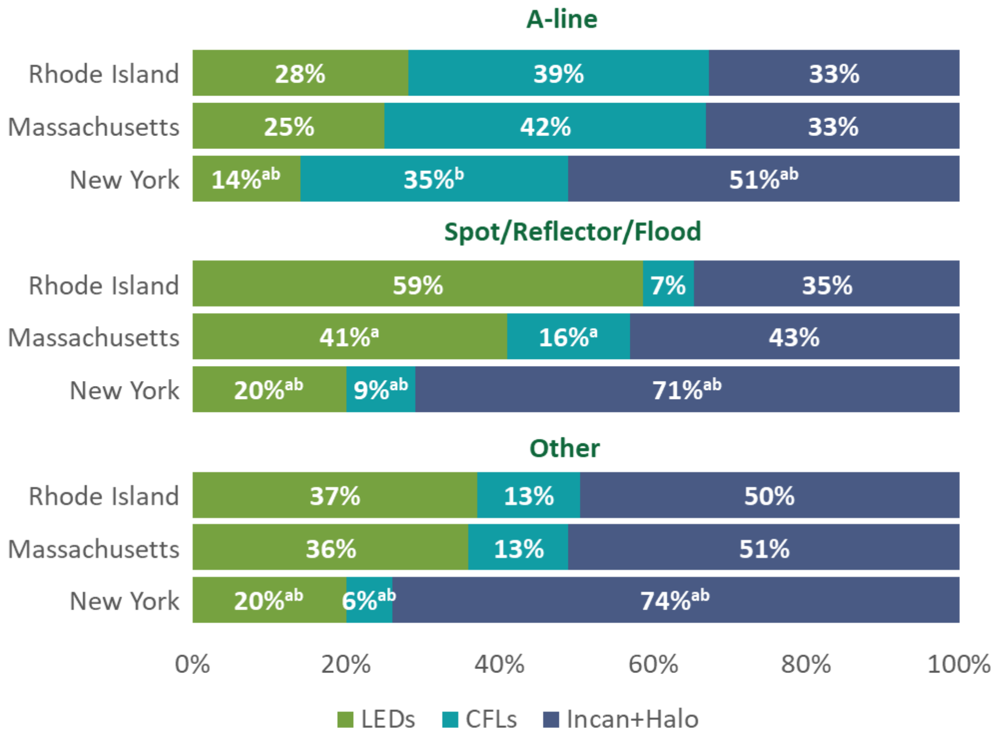
Figure 5 shows saturation by bulb shape and bulb type in each state.[12] Among common bulb shapes, LED saturation was highest for spot/reflector/flood bulbs. In Rhode Island, LEDs were installed in more than one-half (59%) of all sockets with spot/reflector/flood bulbs. Among A-line bulbs, CFLs continued to dominate the socket share. In New York, a state that lacks program support for LEDs, incandescent bulbs were the most commonly installed bulb regardless of bulb shape.

[12] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.

Table 8: Proportion of Bulbs by Shape 2018 (RI, MA & NY)

Bulb Shape	Rhode Island	Massachusetts	New York
Sample Size	*75*	*381*	*217*
A-line	50%	55%	61%
Spot/Reflector/Flood	22%	18%	15%
Other	28%	27%	24%

Figure 5: Saturation by Bulb Shape and Type



[a]Significanly different from RI at the 90% confidence level.
[b]Significanly different from MA at the 90% confidence level.

2.1.3 ENERGY STAR® LED Saturation

While on site, technicians collected model numbers for all screw-base LED bulbs (we did not collect model numbers for integrated LED fixtures). Using these model numbers and the list of ENERGY STAR®-qualified LED bulbs, we determined ENERGY STAR status for each LED bulb. Figure 6 provides the results of this analysis for Rhode Island, Massachusetts and New York in 2018.[13] We separated LED saturation into three distinct categories:

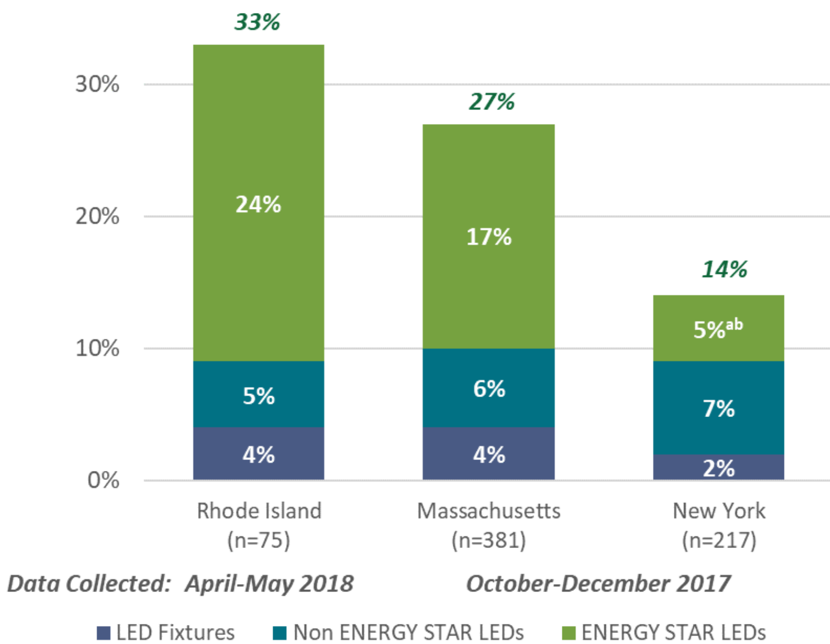
- ENERGY STAR qualified

[13] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.

- Non-ENERGY STAR qualified
- Integrated LED fixtures

As the data show, ENERGY STAR LED saturation was significantly higher in both Rhode Island households (24%) and Massachusetts households (17%), than in New York households (5%). Interestingly, all three states had nearly the same saturation levels for non-ENERGY STAR LEDs (5% in Rhode Island, 6% in Massachusetts, and 7% in New York) and integrated LED fixtures (4% in Rhode Island, 4% in Massachusetts, and 2% in New York). Since the National Grid Rhode Island's programs only provide incentives for ENERGY STAR LEDs (as do the programs in Massachusetts) this is compelling evidence that the programs are directly leading to increased adoption of ENERGY STAR LEDs.

Figure 6: Energy Star LED Saturation 2018 (RI, MA and NY)



[a]Significanly different from RI at the 90% confidence level.
[b]Significanly different from MA at the 90% confidence level.

2.1.4 Saturation by Special Feature

Technicians observed 71 **3-Way bulbs** as part of the 2018 Rhode Island on-site visits. Among these, 46% were inefficient (halogen or incandescent), 26% were CFLs, and 21% were LEDs.

Technicians observed 205 **dimmable bulbs**[14] installed in dimming fixtures as part of the 2018 Rhode Island on-site visits. Among these, 65% were LEDs, 32% were inefficient (halogen or incandescent), and only 3% were CFLs.

Technicians observed only three connected (WiFi) LEDs out of 1,189 LEDs observed on-site in Rhode Island (less than 1%).

[14] Note: We determining dimmability, a lamp must be both capable of dimming and installed in a dimming fixture.

Table 9: Saturation by Special Feature 2018, Rhode Island

Special Feature	3-Way	Dimmable
# of Bulbs	*71*	*205*
LEDs	21%	65%
CFLs	26%	3%
Incans+Halos	46%	32%
Other	7%	0%

2.2 Hours of Use

The 2014 Northeast Residential Lighting Hours-of-Use Study[15] was designed to allow sponsors in the Northeast to update hours-of-use (HOU) estimates based on room-by-room saturation collected as part of regular saturation studies. In this section, we explore socket saturation as it relates to HOU to prepare updated HOU estimates for the upstream lighting program. This update is only applicable to upstream programs.

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

Formula:

$$\text{Proportion of bulbs per room} = \frac{(\text{Room Saturation in 2018}) * (\text{2018 Socket Count})}{(\text{Total LED Socket Count})}$$

As an example, we provide the calculations for LEDs for bathrooms here. Note that 1,189 represents the number of LEDs across all room types. The calculations for other room types were carried out similarly. As the calculations show, LEDs in bathrooms accounted for 14% of all LEDs installed in 2018.

Bathroom: *37% * 467 (LED saturation times socket count in bathrooms) = 159 (LED count in bathrooms)*

171 / 1,189 (LED count in bathrooms divided by LED count in all room types) = 14% (proportion of all LEDs that are in bathrooms)

Table 10 provides the results of these calculations for each room type, as well as the snapback-adjusted efficient HOU by room type and the resulting household efficient HOU estimate.[16] To calculate a household HOU estimate, we simply multiplied the snapback-adjusted HOU for each

[15] http://ma-eeac.org/wordpress/wp-content/uploads/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf

[16] The Northeast HOU study provided HOU found significant differences in HOU for efficient and inefficient lamps. The authors speculated that there were three competing theories to explain the difference: differential socket selection, shifting usage, and snapback (increased usage). The authors suggested assuming the difference in HOU was caused equally be all three theories and recommended that program administrators reduce savings by one-third the difference between the efficient and all bulb HOU. They termed this the snapback adjusted HOU. More details can be found in the Northeast HOU report: http://ma-eeac.org/wordpress/wp-content/uploads/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf

room by the proportion of bulb gains and summed the results. This provided us with a weighted average HOU for installed bulbs.

Table 10: Proportion of Bulbs by Room and Type

Room Type	2018 Socket Count	2018 LED Saturation	2018 LED Socket Count	2018 Proportion of LEDs	Snapback Adjusted HOU	HOU Times Proportion of LEDs
Dining Room	189	55%	103	8.7%	3.0	0.26
Kitchen	464	43%	200	16.8%	4.2	0.71
Bathroom	467	37%	171	14.4%	2.0	0.29
Living Space	487	36%	174	14.6%	3.5	0.51
Exterior	341	35%	119	10.0%	5.8	0.58
Bedroom	593	28%	163	13.7%	2.3	0.32
Other	1,093	24%	259	21.8%	1.9	0.41
Household	**3,635**	**33%**	**1,189**	**100%**	**2.9**	**3.1**

2.2.1 Cross-sector Sales

The HOU estimates provided in this report do not factor into account any cross-sector sales (upstream lamps installed in commercial settings) which may have higher HOUs. It is NMR's understanding that Rhode Island currently assumes 7% cross-sector sales (i.e. 7% of residential upstream lamps are ultimately installed in commercial sockets). Rhode Island assumes an average daily HOU of 8.5 for cross-sector sales. Combining residential and cross-sector HOU yields an estimate of 3.5 HOU per day (3.1 * 93%) + (8.5 * 7%).

Section 3 Penetration

In this section, we explore trends in penetration (i.e., the percentage of homes using at least one of a particular bulb type). The analysis here examines penetration rates for LEDs and halogens as well as a room-by-room LED penetration analysis over time. Penetration is an extremely important indicator of LED program success early on in the market adoption process. Penetration shows that the market is advancing and that the program is getting people to try LEDs. As more households purchase LEDs and expand the number and diversity of sockets in which LEDs are installed, higher saturation rates will follow suit. Similarly, awareness of and satisfaction with LEDs are important market indicators for LED programs.

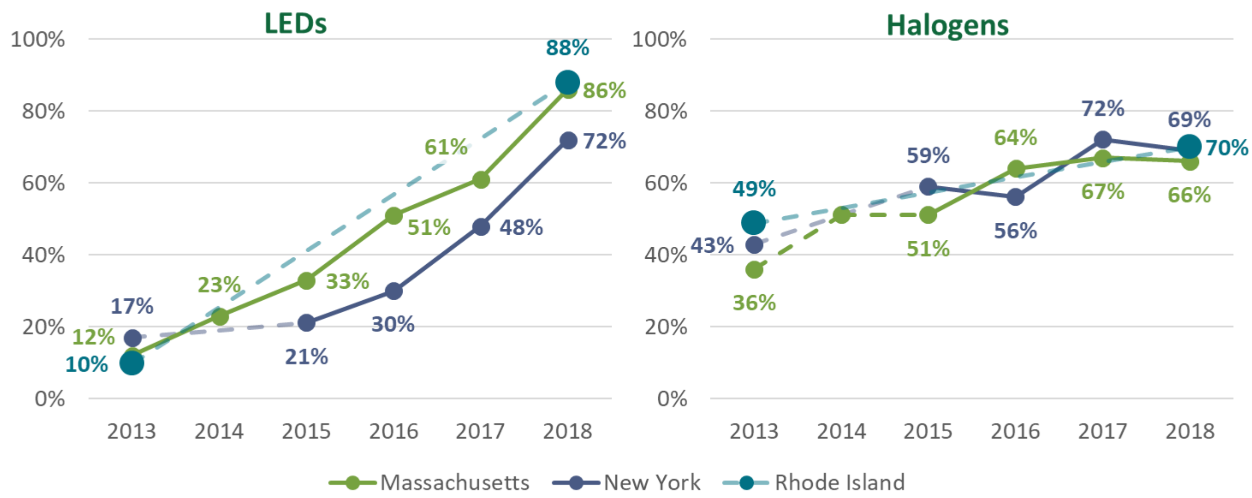
3.1 Bulb Penetration

Figure 7 shows penetration for LED and halogen bulbs from 2013 to 2018 in Rhode Island, Massachusetts, and New York.[17] These two bulb types are shown as they are the two technologies that have displayed notable changes in penetration over time. For years in which there was no study (Rhode Island from 2014 to 2017, and New York in 2014), penetration was estimated using straight-line interpolation and displayed with a dashed line.

- LED penetration in Rhode Island increased from 10% in 2013 to 88% in 2018. In Massachusetts, LED penetration increased from 12% to 86%. New York LED penetration, while still increasing, was lower (72%) than both Massachusetts and Rhode Island, which have lighting programs.
- Halogen penetration has increased in all three states since 2013 but appears to have plateaued in recent years. In 2018, halogen penetration was similar in Rhode Island (70%), Massachusetts (69%), and New York (66%).

[17] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.

Figure 7: LED and Halogen Bulb Penetration (RI, MA, & NY)

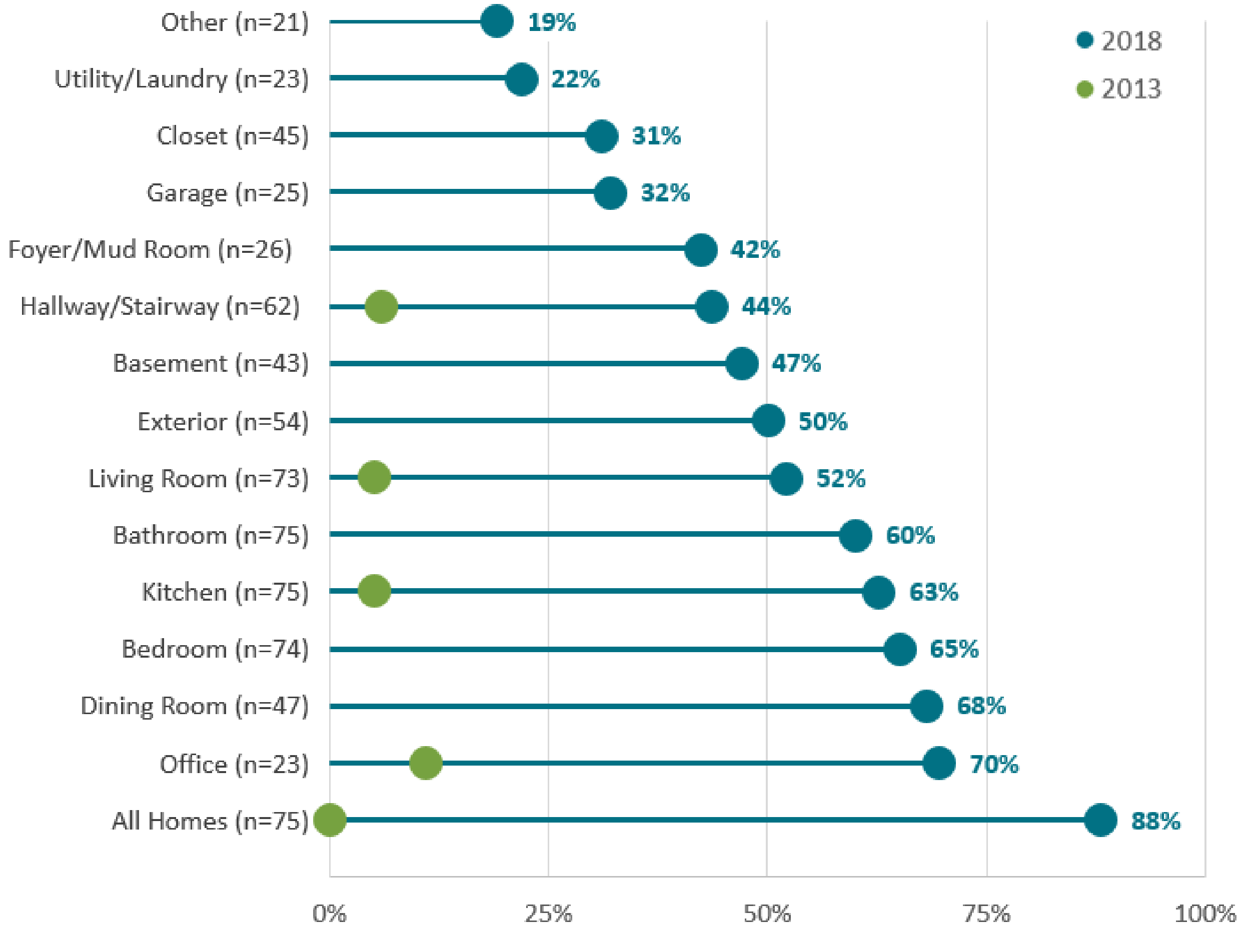


3.2 Room-by-Room Analysis

Figure 8 shows LED penetration by room type. When calculating penetration by room type, we included only homes that had rooms of that type. For example, in 2018, 43 homes had basements, and 20 of those homes had at least one LED installed in basements, which calculates to a 47% penetration rate.

Overall, there was at least one LED bulb or integrated LED fixture observed in 88% of Rhode Island homes. In 2018, home offices had the highest penetration of LEDs (70%), followed by dining rooms (68%), bedrooms (66%) and kitchens (63%). In 2013, the only rooms that had at least one LED installed were offices, kitchens, living rooms, and hallways/stairways.

Figure 8: Rhode Island LED Penetration by Room Type, 2013 vs. 2018



Section 4 LED Purchases

In this section, we examine LEDs that were obtained in the past year. In addition to exploring counts of newly obtained LEDs, we also examine the sources of the newly-acquired LEDs and their ENERGY STAR status.

4.1 Sources of Newly-acquired LEDs

NMR technicians not only asked respondents when they had bought the LEDs found in their homes, but also asked them to recall where they had obtained the bulbs they had acquired within the past year. This section looks at recent purchases by channel. Note that while panel data in Massachusetts and Rhode Island provided an additional layer of confirmation that an LED was new to the home, purchase date and bulb source in all three areas is based on self-reported responses to questions posed by the technician.. Self-reported data is inherently less reliable than direct observation.

In all three studies highlighted in Table 11, householders were surveyed about installed and stored LEDs acquired in the past year.[18]

Home Improvement stores (e.g., Home Depot and Lowe's) were the most common source of LED bulbs in Rhode Island (47%) as well as in Massachusetts (31%) and New York (54%). The next most common source was from National Grid direct-install programs (32%), with 29% of those bulbs installed in households verified as program participants. Three percent of bulbs in Rhode Island were also provided by National Grid at energy efficiency outreach events, such as fairs or other community events. It is important to note that while NYSERDA discontinued upstream residential lighting support, individual utilities continued to offer various levels of support for lighting through direct-install programs. NMR was unable to measure and compare the level of direct-install support in New York to either Rhode Island or Massachusetts.

[18] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.

Table 11: Sources of Obtained Bulbs (2018)

Bulb Type	RI	MA	NY
Sample Size	*75*	*381*	*217*
Homes with new LEDs	*28*	*186*	*85*
Bulbs Obtained	**311**	**1,654**	**503**
Avg. # Obtained	**11.1**	**9.5**	**6.6**
Home Improvement	47%[a]	31%[b]	54%
Program (DI Verified)*	29%[a]	1%	--
Program (DI Unconfirmed)*	3%[a]	24%	--
Discount	4%	6%[b]	<1%
Hardware	3%	6%[b]	2%
EE Fair/Pop-up[19]	3%	2%	--
Mass Merchandise	2%[ab]	7%[b]	22%
Online	2%	3%	5%
Grocery	<1%[a]	3%[b]	1%
Lighting & Electronics	0%[a]	3%[b]	0%
Membership Club	0%[ab]	2%	2%
Electrician	0%[a]	2%	1%
Other	1%	2%	3%
Don't know	7%	9%	9%

[a] Significantly different from MA at the 90% confidence level.
[b] Significantly different from NY at the 90% confidence level.
* Verified direct install participants have been confirmed as program participants based on program records provided by PAs in Massachusetts and Rhode Islands; Unconfirmed direct install participants self-reported having participated when asked during the on-site visit but were not found in program records. In Massachusetts in 2018, only two of the on-site participants who reported participating in a direct install program were found in program records.

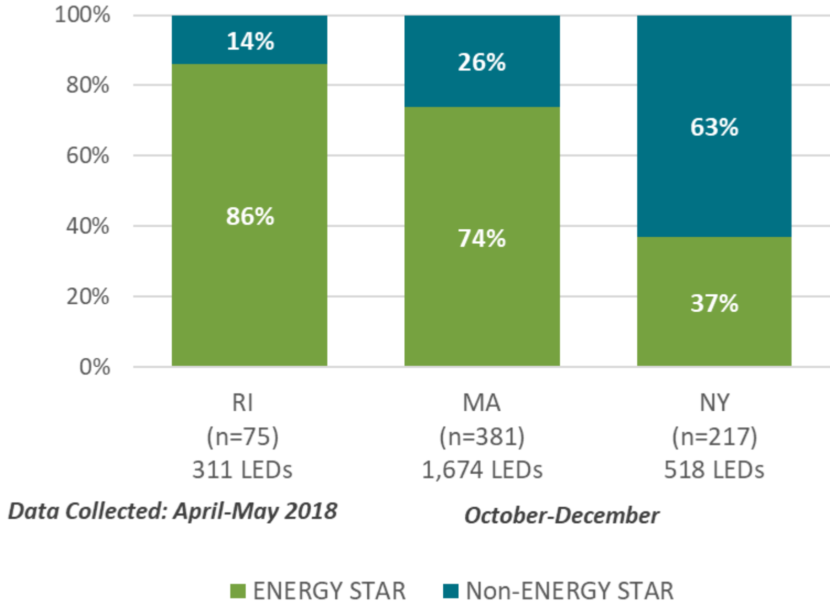
4.2 Purchases by ENERGY STAR Status

In Rhode Island, 86% of LEDs obtained within the last year were ENERGY STAR-qualified (Figure 9). In Massachusetts, where LEDs are also program-supported, 74% of LEDs were ENERGY STAR-qualified, compared to 37% in New York. Much of the difference in ENERGY STAR LEDs between Rhode Island and Massachusetts was most likely attributable to the six-month lag in data collection periods.[20]

[19] Householders reported purchasing bulbs at National Grid kiosks at community events and /or "pop-up" stores.
[20] See "Saturation Comparison" in Appendix B for additional information on saturation adjustments to account for the difference in study timing.

Figure 9: ENERGY STAR LEDs

(LEDs obtained in the past year)



Section 5 Storage Behavior

In this section, we present a brief analysis of bulbs found in storage in on-site households in Rhode Island in 2013 and 2018 and in Massachusetts and New York in 2018 only.[21] In Rhode Island in 2018, 51 out of 75 households (68%) had at least one bulb in storage, averaging 9.2 stored bulbs per home – enough to fill one-fifth (20%) of the sockets in an average home. Incandescent bulbs made up the majority (51%) of stored bulbs in Rhode Island households. While respondents reported that only one-third (34%) of incandescents were being stored for future use, they did not plan to use or planned to throw out/recycle the majority of incandescents in storage (60%).

LEDs made up one-quarter (25%) of all bulbs in storage; notably, nearly all (99%) of the LEDs in storage were being stored for future use. Not surprisingly, the percentage of LEDs in storage made the biggest jump since 2013, increasing nearly twenty-five percentage points (virtually the entirely of LEDs in storage in 2018). Storage patterns were similar in all three states for incandescents, LEDs, and CFLs and reflect the changing market share of each product. (Table 12)

Table 12: Stored Bulbs by Bulb Type

	Rhode Island		Massachusetts	New York
Bulb Type	**2013**	**2018**	**2018**	**2018**
Sample Size	*41*	*75*	*381*	*217*
Avg # of Stored Bulbs/Home	**10.0**	**9.2**	**14.5**	**12.1**
Incandescent	57%	51%	51%	58%
LEDs	<1%	25%	22%	19%
CFLs	29%	17%	9%	8%
Halogen	4%	7%	2%	3%
Fluorescent	10%	1%	16%	12%
Other*	0%	0%	<1%	0%

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

5.1 First Year In-service Rate

In-service rate (ISR) represents the percent of program bulbs that program participants have obtained and installed in a given period of time. **First-year ISR** is a measure of how many LEDs

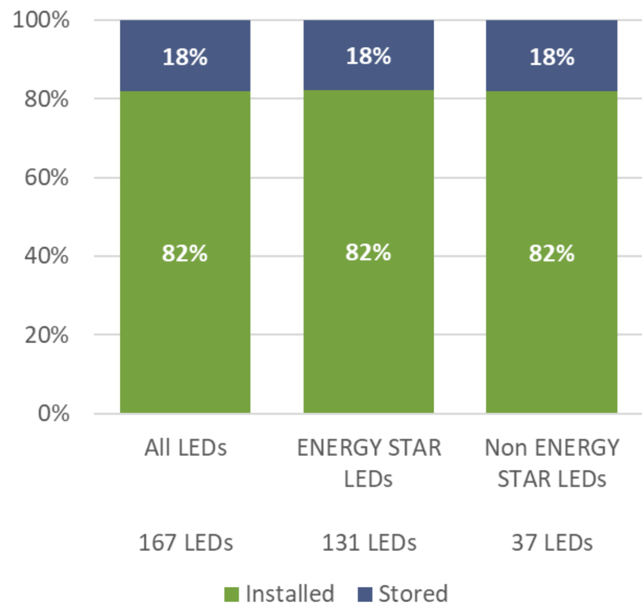
[21] Note: data collection in Rhode Island took place nearly six months after Massachusetts and New York.

are installed within the first year after acquisition. It is common for first-year ISRs for upstream lighting programs to be well below 100%. Per the Uniform Methods Project Residential Lighting Protocol (UMP),[22] three factors lead to lower first-year ISRs:

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

For this report, we identified all the new LEDs reported (installed or in storage). That is, any LEDs that respondents reported as having been purchased in the twelve months prior to participation. We then divided the number of new LEDs found installed by the total number of new LEDs. We excluded any bulbs identified as having been obtained through a direct-install program. The majority (82%) of LEDs – and the majority of both ENERGY STAR LEDs (82%) and non-ENERGY STAR LEDs (82%) – were installed within a year of purchase. (Figure 10)

Figure 10: First Year ISR – Rhode Island 2018



5.2 Lifetime In-service Rate

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

[22] https://www.nrel.gov/docs/fy17osti/68562.pdf

Lifetime ISR for LEDs is difficult and expensive to measure. Fortunately, as part of the recently completed 2017-18 Market Assessment Study in Massachusetts, NMR explored multi-year in-service rates for LEDs. Based on a panel of households, NMR observed first-, second-, and third-year ISRs. While three years is far short of the time frame during which customers will install stored LEDs, the data provided a means by which to extrapolate lifetime in-service rates. Ultimately, NMR concluded that 32% of stored LEDs would be installed in the second year and 18% of remaining stored LEDs would be installed from storage in each subsequent year. (Table 13)

Table 13: In-Service Rate Extrapolation

Year	Incremental Install from Storage	Storage	ISR
1 – 2018	n/a	18%	82%
2 – 2019	32%	12%	88%
3 – 2020	18%	10%	90%
4 – 2021	18%	8%	92%
5 – 2022	18%	7%	93%
6 – 2023	18%	6%	94%
7 – 2024	18%	5%	95%
8 – 2025	18%	4%	96%
9 – 2026	18%	3%	97%

To determine how many years out to extrapolate ISR to achieve a lifetime estimate, the Massachusetts study suggested using estimated useful lives to establish sunset years. Massachusetts defined sunset years as points in time past which the Massachusetts PAs will no longer claim energy savings for a lamp–determined by the date which consumers are unlikely to find non-LED bulbs available for purchase. For Massachusetts, sunset years were set to 2022 for A-line LEDs and 2023 for reflector and specialty LEDs. Using these sunset years, we have calculated lifetime ISR by bulb type as included in Table 14.

Table 14: Estimated Lifetime LED In-Service Rate

Year	A-Line	Reflector	Specialty
1 – 2018	82%	82%	82%
2 – 2019	88%	88%	88%
3 – 2020	90%	90%	90%
4 – 2021	92%	92%	92%
5 – 2022	**93%**	93%	93%
6 – 2023		**94%**	**94%**

Section 6 LED Satisfaction

While respondents were significantly more likely to report that they were "very satisfied" with ENERGY STAR-qualified LEDs (83%) compared to non-ENERGY STAR-qualified LEDs (65%), overall satisfaction ("very satisfied" or "somewhat satisfied") was similar (93% and 95%, respectively). We observed similar levels of LED satisfaction (over 90% overall) in Massachusetts and New York, but did not observe a significant difference in satisfaction between ENERGY STAR-qualified and non-ENERGY STAR-qualified LEDs in those areas. While it appears respondents in Rhode Island were more satisfied overall with non-ENERGY STAR bulbs, it is important to note that there were only 148 non-qualified LEDs in our sample, compared to 791 ENERGY STAR-qualified LEDs. (Table 15)

Table 15: LED Satisfaction

Level of Satisfaction	ENERGY STAR LEDS	Non-ENERGY STAR LEDS	All LEDs
Households	*52*	*41*	*63*
Number of Bulbs	*819*	*159*	*979*
Very Satisfied	83%[a]	65%	80%
Somewhat Satisfied	10%[a]	30%	13%
Neither Satisfied or Dissatisfied	2%	4%	2%
Somewhat Dissatisfied	4%	0%	3%
Very Dissatisfied	0%	0%	0%
Don't Know	1%	1%	1%

[a] Significantly different from Non-ENERGY STAR at the 90% confidence level.

If a householder indicated they were dissatisfied with their LED (3% of all installed LEDs), we asked them why (Table 16). The most common reason was that the bulb was "too bright" (58%).

Table 16: Reason for Dissatisfaction

(Households = 5; Number of LEDs = 32)

Reason	LEDs
Too Bright	58%
Dislike color	20%
Not bright enough	12%
Other	10%

Section 7 LED Net-to-Gross

In this section, we summarize the changes in LED saturation since the last on-site lighting inventory, compare historical and prospective NTG values for the residential lighting program, and provide a detailed comparison to Massachusetts.

7.1 Rhode Island and Massachusetts Detailed Comparison

This section outlines key data used to help assess similarities and differences between Rhode Island, Massachusetts, and New York. The purpose of this section is to assess whether Rhode Island is sufficiently similar to Massachusetts to allow for the use of Massachusetts as a proxy for Rhode Island. This was done because Massachusetts has conducted nearly annual lighting saturation visits since 2012.

7.1.1 Historical LED Saturation and Program Support

Prior to 2018, National Grid last collected on-site lighting inventory for Rhode Island as part of the Northeast Residential Lighting Hours-of-Use Study. As part of that effort, NMR visited a total of 41 households in Rhode Island in November 2012. For the 2018 effort, NMR visited a sample of 75 homes in April and May 2018.

In 2012, LEDs were present in only 1% of all sockets and no LEDs were found in storage. In 2018, LEDs were present in 33% of sockets (an average increase of 17.3 LEDs per home) and an average of 2.7 LEDs were found in storage. Based on a population of 410,240 households in Rhode Island (ACS) and an average of 54 sockets per household, this level of saturation increase is equivalent to 7.1 million LEDs. The increase in LEDs in storage is equivalent to 1.1 million LEDs, bringing the total increase in LEDs in the market to 8.2 million.[23]

The increase in LED saturation corresponds with increasing levels of support for LEDs offered by National Grid in Rhode Island. Between 2013 and 2018, National Grid supported LEDs through its upstream and direct install programs. See Table 17 for a year-by-year breakdown of saturation and program supported LEDs. As the table shows, between 2013 and 2018 (year-to-date) National Grid has supported a total of 5.6 million LEDs through two primary channels (upstream and direct install) and three general program categories:

- Upstream (Residential Light)
- Direct Install
    - Market-rate Direct Install[24]
    - Income Eligible[25]

[23] Of course, given the relatively small sample size, there is a large confidence interval around each of the inputs. The confidence interval for saturation is 24% to 42% at the 90% confidence level.
[24] Includes: ENERGY STAR Homes and EnergyWise Single Family and Multifamily
[25] Includes: Income Eligible Multifamily and Low-Income Services 1-4 units

Looking just at upstream program support, over the past five and one-half years, National Grid has supported an average of 10.6 LEDs per household in Rhode Island. Including the direct-install channels, brings the average number of LEDs supported up to 13.9 per home.

Table 17: Rhode Island LED Saturation and Program Support

Program Year	Saturation (Year Ending)	Upstream LEDs	Direct Install Market Rate	Direct Install Income Eligible	Total
2012	1% (Nov. 2012)	n/a	n/a	n/a	**n/a**
2013	n/a	95,275	27,660	5,008	127,943
2014	n/a	279,191	95,352	13,320	387,863
2015	n/a	620,241	339,126	47,500	1,006,867
2016	n/a	1,048,400	287,864	79,964	1,416,228
2017	n/a	1,584,021	254,571	71,291	1,909,883
2018 (YTD)	33% (Jun. 2018)	737,361	80,282	17,698	835,341
Total	**32% (change)**	**4,364,489**	**1,084,855**	**234,781**	**5,684,125**
% of All Programs	**n/a**	**77%**	**19%**	**4%**	**100%**

7.1.2 Impact of Direct Install Participants

The random sample selected for the on-site visits included both self-reported and verified energy-efficiency program participants. When we removed both self-reported and verified program participants, LED saturation dropped from 33% to 31%.[26]

7.1.3 Comparison Areas

NMR relied on two comparison areas to provide context to the saturation values observed for Rhode Island:

- **Massachusetts.** We chose Massachusetts since it is a neighboring program state with a similar portfolio of residential lighting programs and a history of conducting nearly annual on-site lighting inventory studies and thus provides additional insights into year-to-year changes in saturation lacking in Rhode Island.
- **Portions of Upstate New York**[27]. In 2014, the Massachusetts Program Administrators chose portions of Upstate New York as a comparison area because they presented a unique opportunity to understand how the residential lighting market has responded in the absence of upstream residential lighting program support. In 2012, NYSERDA[28] discontinued upstream support for standard spiral CFLs incentives and nearly all upstream

[26] In Massachusetts, when direct install participants are removed, overall LED saturation also drops by 2%.
[27] Comprising Westchester County and 40-mile radiuses around the cities of Albany, Buffalo, Rochester, and Syracuse
[28] New York State Energy Research and Development Authority

incentives (including LEDs) in 2014. The decision to exit the market was made by the New York Department of Public Service, operating under the hypothesis that the residential lighting market would continue to transform without further intervention from NYSERDA.

While NYSERDA no longer offers upstream programs in Upstate New York, in the intervening years, utilities in these portions of New York have continued to provide varying levels of support for LEDs through a variety of program offerings including: direct install programs, energy efficiency kits, and online marketplaces/portals. In addition, in 2017, Con Edison began to support LEDs through traditional upstream channels in their service area (including Westchester County, which is one-fifth of the total number of households included in the comparison area panel). It is NMR's understanding that Con Edison upstream program activity was low in 2017 but has ramped up in 2018. NMR detected no differences in LED saturation among Westchester County households and households in other portions of the comparison area. This leads NMR to believe the new upstream program activity has had little or no impact on saturation for the overall New York comparison area—but must acknowledge this as a potential threat to validity for using New York as a non-program comparison area. (It is important to note that throughout this report saturation values for Massachusetts and New York are taken directly from publicly available reports (http://ma-eeac.org/) and have not been adjusted or weighted to reflect demographics of Rhode Island. NMR feels confident that this approach does not significantly impact the overall results, as historically, weighting has minimal impact on saturation values, typically changing saturation values by less than 1% (as shown in Table 18 in this report).

Table 18: Saturation by Area

	Saturation (Year Ending)		
Year End	Rhode Island	Massachusetts	New York
2012	1%	2%	1%
2013	n/a	3%	n/a
2014	n/a	6%	3%
2015	n/a	12%	7%
2016	n/a	18%	10%
2017	n/a	27%	14%
Mid-2018	33%	n/a	n/a

7.1.4 Filling the Gaps

Section 7.1.6 in the report provides an overview of saturation over time between the three areas: Rhode Island, Massachusetts, and New York. As the table reveals, the saturation values for Rhode Island and the comparison areas do not align due to the timing of the most recent visits and lack of visits in Rhode Island between 2013 and 2016. While knowing the current total saturation and historical 2012 saturation is helpful in understanding the current state of the market and gauging how far the market has advanced over the past six and one-half years, it does not provide sufficient detail to calculate annual NTG values or examine more subtle changes in market conditions that annual values would provide. To help fill in the missing years, NMR turned to the Massachusetts comparison area and its nearly annual lighting inventory data. NMR sought to leverage this information to help provide informed guesses regarding Rhode Island saturation values in the intervening years. Before attempting to adjust based on Massachusetts, it was important to ascertain if upstream program support and saturation levels in the two states were comparable.

7.1.5 Program Support Comparison

To help estimate relative level of program support, we divided total supported upstream LEDs by the number of households in each state (providing a comparison figure). As Table 19 shows, the general level of upstream LED program support in both states followed a similar pattern with increasing levels of support between 2013 and 2017 and both states supported a similar total number of LEDs over the full period (8.8 vs. 8.1 LEDs per household). While there are differences in LEDs supported on a per household basis in any given year, we feel the overall level of support is comparable. Note: some differences between the two areas are no doubt caused by reporting periods, program and funding cycles, and various program record vagaries between the two states. This analysis is meant as a high-level comparison in general program activity between the two areas.

Table 19: Upstream Support per Household

Program Year	Rhode Island	Massachusetts	% of Rhode Island
2013	0.23	0.36	157%
2014	0.68	0.68	100%
2015	1.51	1.08	71%
2016	2.56	1.71	67%
2017	3.86	4.31	112%
Total	8.84	8.14	92%

7.1.6 Saturation Comparison

NMR conducted the most recent wave of saturation visits in Massachusetts and New York between mid-October and December of 2017, approximately six months prior to the Rhode Island visits. Given the rapid adoption of LEDs, this six-month period makes direct comparisons of the most recent saturation values problematic. Therefore, it was necessary to extrapolate the values in Massachusetts and New York to approximate expected LED saturation in May 2018 (thus allowing for a more apples-to-apples comparison.)

Fortunately, the nearly annual saturation data collected in Massachusetts and New York allowed NMR to estimate socket saturation using a LED adoption curve. This adoption curve was prepared by NMR as part of a paper to be presented at the ACEEE Summer Study Conference.[29] The

[29] *It's Almost the End of the World and We Know It: An Examination of the Future of Residential Lighting Programs*.

adoption curve is based on observed changes in LED saturation and a simplified logistic function to forecast LED saturation for Massachusetts (assuming continued program support) and New York (assuming no program support).[30] We followed guidelines discussed in a paper by Robert Buskirk, *An Adoption Curve Fitting Method for Estimating Market Efficiency Improvement and Acceleration.*[31] For both forecasts, we used the following function:

$$f(t) = \frac{M}{1 + e^{-\alpha(t-T)}}$$

Where,

M = ***Maximum saturation,*** the maximum expected saturation for LEDs.

α = ***Alpha***, the rate at which efficiency is increasing over time. A lower alpha results in a flatter curve and a higher alpha results in a steeper curve.

T = ***half point,*** the point in time where we expect saturation to reach 50%

We assumed that LED saturation would reach a maximum (M) of 90% saturation – with 10% of sockets deemed to be ultimately out of reach either due to specialized features (shape or function) or requirements or lack of willingness on the part of customers to adopt LEDs. We used an iterative process to manipulate the alpha and half-way point such that the curves aligned with observed historical saturation levels. Figure 11 provides an overview of the final fitted curves. We found an alpha of 0.28 fit the data best in both Massachusetts and New York. The curve allows us to examine forecasts of saturation for both Massachusetts and New York at any point in time. For the purposes of this report, we were most interested in the mid-point of 2018, the same period when visits took place in Rhode Island.

Based on the LED adoption curves, we expect LED saturation in Massachusetts in May 2018 was 33% (the same as that observed in Rhode Island in May 2018). The estimated saturation in New York in May 2018 was 18%. Note: these estimated saturation values were calculated in March 2018, before the Rhode Island visits took place. While the accuracy of the adoption curves cannot be confirmed by this exercise, we believe this method of extrapolating saturation provides at least some reassurance that saturation levels between Massachusetts and Rhode Island are comparable.

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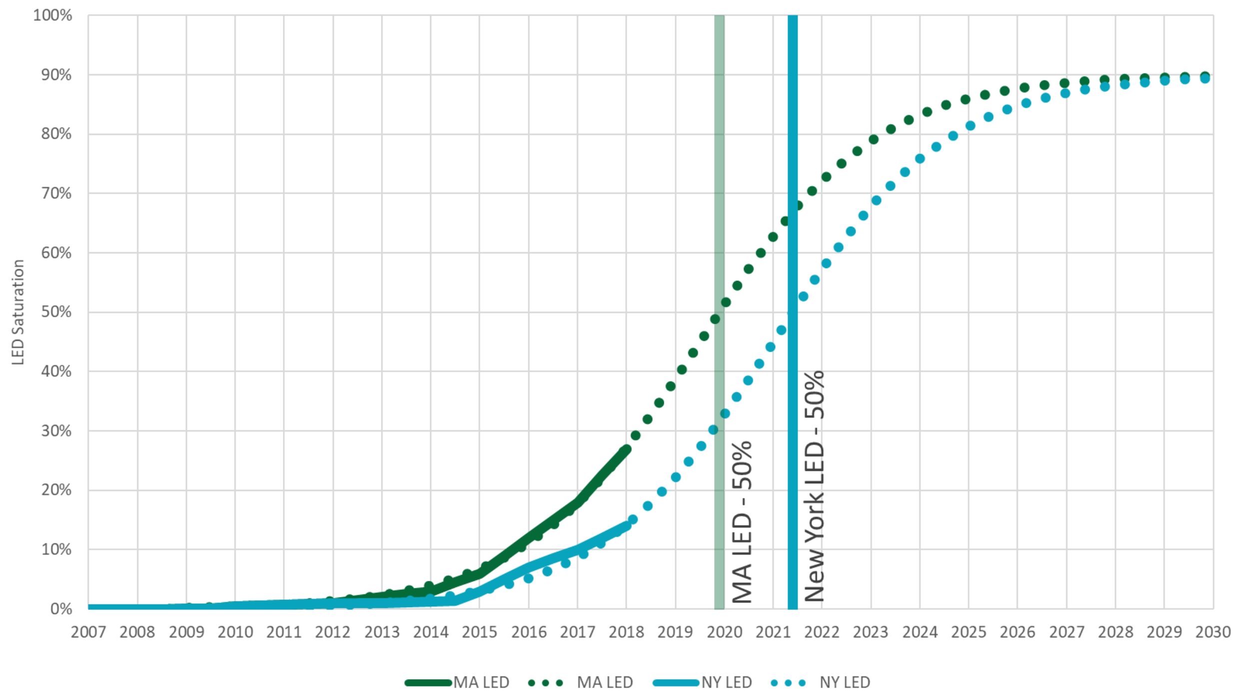
[30] It is worth noting that the market adoption curves presented in Figure 11 are based on extrapolation of historical market conditions and have not been adjusted to reflect possible impacts of pending lighting standards. The residential lighting market has been and will continue to be impacted by not just voluntary energy-efficiency incentive programs, but also by changes in federal regulations. The Energy Independence and Security Act (EISA) of 2007 has had, and will continue to have, a profound impact on the residential lighting market. EISA laid out initial standards to be implemented between 2012 and 2014 (Phase I) and a schedule of events that would lead to increased standards in 2020 (Phase II) and 2025 (Phase III). Since Phase II of EISA has yet to go into effect, the saturation-based adoption curves presented do not incorporate any influence it may have on the market. When Phase II goes into effect, it will likely lead to increases in LED saturation in both areas and will likely reduce the gap between Massachusetts and the New York comparison area at an earlier date.

[31] https://www.researchgate.net/profile/Robert_Van_Buskirk/publication/271859920_An_Adoption_Curve_Fitting_Method_for_Estimating_Market_Efficiency_Improvement_and_Acceleration/links/54d5b9960cf25013d02bae3f.pdf?inViewer=true&disableCoverPage=true&origin=publication_detail

Figure 11: LED Adoption Curve



7.1.7 Annual Saturation Values

Based on the above analysis, we believe we can use annual-observed saturation in Massachusetts as a proxy for saturation in Rhode Island. Table 20 provides saturation by year and area, using observed saturation in Massachusetts as a proxy for years not observed in Rhode Island, LED adoption curve values for mid-2018 for Massachusetts and New York, and a value for saturation in New York for 2013 (based on straight line interpolation).

Table 20: Saturation by Area (Filled In)

	Saturation (Year Ending)		
Year End	Rhode Island	Massachusetts	New York
2012	1%	2%	1%
2013	3%	3%	2%
2014	6%	6%	3%
2015	12%	12%	7%
2016	18%	18%	10%
2017	27%	27%	14%
Mid-2018	33%	33%	18%

7.1.8 Annual Stored LED Values

In both Massachusetts and New York, we observed a general increase in the number of LEDs in storage between 2012 and 2017, with higher levels of storage in Massachusetts compared to New York. Unfortunately, the growth is not uniform and does not appear to follow a general market adoption curve. This is perhaps not surprising given the nature of lamp storage. Most customers only purchase new lamps when an existing lamp needs replacing.[32] When purchasing LEDs, customers are increasingly purchasing multipacks,[33] and reserve extra LEDs to replace future burnouts. Stored LEDs may remain in storage for several years before being installed. This can lead to stored lamps increasing/decreasing on a per home basis at any given point in time. NMR speculates that increases in stored LEDs are driven in part by retailers increasingly offering larger multipacks of LEDs and in program areas, program administrators increasingly providing incentives for these larger multipacks. Based on this, we expect stored LEDs to increase in the near-term and then decrease over time. Given this, we can speculate that the number of LEDs found in storage in Rhode Island in May 2018 is a close approximation for the number we would expect to find in Massachusetts at a comparable time—but this is more of a leap of faith without any reliable way to predict storage behavior (Table 21).

Table 21: Average LEDs in Storage by Area

	Saturation (Year Ending)		
Year End	Rhode Island	Massachusetts	New York
2012	0	0.1	0.1
2013	n/a	0.3	n/a
2014	n/a	0.3	0.4
2015	n/a	0.9	0.4
2016	n/a	1.6	1.0
2017	n/a	2.3	1.5
Mid-2018	2.7	n/a	n/a

7.2 Net-to-Gross Calculations

We used annual-observed saturation in Massachusetts as a proxy for saturation and stored LED values in Rhode Island.[34] These values are used in the following analysis. In this section, we explore historical NTG values and then suggest an approach for estimating prospective NTG values.

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[32] MA RLPNC 17-9 Lighting Market Assessment
[33] MA RLPNC 17-12 Lighting Decision Making
[34] See Saturation Comparison in Appendix B.

7.2.1 Historical NTG Values

Examining historical NTG values can help provide useful context when seeking to establish prospective NTG values. To that end, based on the data explored in the Background Data, we calculated the change in LED saturation and storage in Rhode Island and New York (counterfactual or baseline) for each year 2013 – 2017, for 2018 through May, and for the entire period, 2013 through May 2018. To calculate net impacts, we must first establish a baseline or counterfactual scenario. In this case, the counterfactual is what would have happened if the upstream program had not existed—in other words, what the lighting market in Rhode Island would have done in the absence of the program. In this study, NMR used data collected in the New York comparison area (an areae with no upstream program) to represent the counterfactual.

Based on changes in saturation and storage in Rhode Island and the New York comparison area, we estimated separate market-level LED gains based on the assumed population of Rhode Island (410,240 households (ACS)) and the average number of sockets in Rhode Island households 48 sockets per home (% Saturation Gain * 410,240 households * 48 Sockets).[35] The results of this analysis are presented in Table 22, including NMR's estimate of installed and stored LEDs had the program not been in place (counterfactual).

Table 22: Rhode Island Annual LED Market Gains

	Rhode Island LEDs Gained[1]				Counterfactual* LEDs Gained[2]			
Program Year	**Sat.**	**Installed LEDs**	**Avg. Stored LEDs**	**Stored LEDs**	**Sat.**	**Installed LEDs**	**Avg. Stored LEDs**	**Stored LEDs**
2013	2%	393,830	0.3	123,072	1%	196,915	0.25	41,024
2014	3%	590,746	0.3	123,072	1%	196,915	0.4	102,560
2015	6%	1,181,491	0.9	369,216	4%	787,661	0.4	164,096
2016	6%	1,181,491	1.6	656,384	3%	590,746	1.0	164,096
2017	9%	1,772,237	2.3	943,552	4%	787,661	1.5	410,240
2018 (YTD)	6%	1,181,491	2.7	1,107,648	4%	787,661	1.8	615,360
Total	**32%**	6,301,286	**2.4**	**984,576**	**17%**	3,347,558	**1.4**	**574,336**

[1] Values shaded in gray are based on observed values from Massachusetts.
[2] Values shaded in gray are interpolated.

We calculated net LED gain by subtracting gain in New York from gain in Rhode Island, for example, to calculate 2018 net LEDs, we started with the LED gain in Rhode Island (1,181,491) and subtracted counterfactual LEDs gains (787,661) resulting in a net gain of 393,830 (as shown in Table 23). We did the same for stored LEDs (2018: 1,107,648 – 615,360 = 492,288). We did this separately for installed and stored LEDs. Using these values, we calculated upstream NTG

[35] LED gain is highly subject to assumptions regarding number of households and sockets. While the values are based on the best available data (Census & on-site saturation values), this is a potential threat to validity which bears enumerating.

estimates by dividing net LEDs gained by the number of LEDs supported through the Rhode Island upstream program. We calculated NTG values with and without stored LEDs. The results of this analysis are presented in Table 23. We did not adjust for direct-install program activity as utilities in New York also engage in direct-install program activity. As the data show, upstream NTG began at a very high level and decreased steadily over time. This makes intuitive sense as between 2013 and 2018, LEDs have become less expensive and more common across the country, including in areas without upstream program support. At the same time, traditional incandescent lamps have given way to halogens which are somewhat more expensive, further shrinking the incremental cost between an LED and the baseline. This naturally occurring market adoption has eroded program-induced savings resulting in falling NTG values. The inclusion of stored lamps in the numerator substantially increases NTG values.

Table 23: Rhode Island Annual LED Market Gains

Program Year	Rhode Island LEDs Gained vs. Counterfactual		Rhode Island Upstream LEDs	Upstream NTG (Installed Only)	Upstream NTG (Including Storage)
	Installed LEDs	Stored LEDs			
2013	196,915	82,048	95,275	207%	293%
2014	393,830	20,512	279,191	141%	148%
2015	393,830	205,120	620,241	63%	97%
2016	590,746	492,288	1,048,400	56%	103%
2017	984,576	533,312	1,584,021	62%	96%
2018 (YTD)	393,830	492,288	737,361	53%	120%
Total	2,953,728	410,240	4,364,489	68%	77%

7.2.2 Prospective NTG Values

While examining historical NTG values provides useful context, it is NMR's understanding that National Grid ultimately needs to establish prospective NTG for 2019 and is interested in potential placeholder values for 2020. For planning purposes, Rhode Island has been using the prospective NTG values shown in Table 24. Rhode Island separated LEDs into two categories: all LEDs and LEDs distributed through channels designated as hard-to-reach (HTR). [36]

[36] HTR customers are generally considered to have lower incomes or educational attainment, or to primarily speak a language other than English. The program currently operationalizes HTR through sales in discount stores, second-hand (thrift) shops, and certain grocery, convenience, and neighborhood stores.

Table 24: Rhode Island Planning Values

Program Year	All LEDs	HTR LEDs
2018	50%	70%
2019	43%	63%
2020	36%	56%

Typically, NMR recommends that program administrators establish NTG values based on a triangulation approach that relies on several methods of estimating NTG rather than relying on a single method. In addition, for prospective estimates, NMR recommends the use of a panel of knowledgeable industry experts who can examine available data and provide an informed prospective estimate.

Unfortunately, National Grid was unable to employ multiple methods of NTG estimation for this project. However, Massachusetts recently completed a LED NTG consensus process using data available from a variety of methods (including saturation-based estimates). The results of this effort will be presented in the final RLPNC 17-11 LED NTG Consensus Report (to be posted in July). Through that effort, Massachusetts stakeholders established NTG values for 2019 – 2021 for three categories of LEDs: standard, reflector, and other specialty shapes. The values established are presented in Table 25. The consensus panel discussed establishing separate NTG values for HTR distribution channels, but ultimately decided against setting values due to the lack of information on these categories.

Table 25: Massachusetts Consensus NTG Values

Program Year	Standard	Reflector	Specialty
2019	35%	45%	45%
2020	30%	40%	40%
2021	25%	35%	35%

In Section 7.1, we established that program activity, current levels of saturation, and current levels of storage in Rhode Island were comparable to those in Massachusetts. Given this, it may be possible for Rhode Island to adopt the Massachusetts consensus NTG values for 2019 and 2020. To help provide a comparison between the Rhode Island planning assumptions and the Massachusetts prospective NTG values (shown as all LED and HTR LED), we combined the Massachusetts estimates into all LEDs based on the current mix of lamp types distributed in Rhode Island. Based on 2018 program records, NMR estimates that approximately 31% of the LEDs supported in 2018 (YTD) were reflectors, 10% were specialty (EISA exempt), and the balance (59%) were standard LEDs. Based on this mix, NMR has calculated weighted average for all LED prospective NTG values to help provide context as the Rhode Island group considers adopting prospective NTG values. These values are presented in Table 26 for consideration by National Grid and the C-Team.

Table 26: Rhode Island Prospective NTG Values

Program Year	Standard	Reflector	Specialty	All LEDs
2019	35%	45%	45%	39%
2020	30%	40%	40%	34%

Appendix A Demographics

NMR collected demographic information through the web survey. Rhode Island census data came from the 2016 American Community Survey (ACS) five-year estimates. We tested for significant differences between the Rhode Island on-sites and ACS using a two-tailed t-test; significance is indicated in Figure 12. Tenure and income in the sample were similar to population estimates from the ACS. There were significantly fewer respondents with a high school degree or less in the study sample (11%) than the overall population (42%), and more respondents in the sample with a bachelor's degree or higher (51%) than in the population (31%). We also sampled fewer multi-family units (37%) than the overall population (60%).

Figure 12: Demographics

ª Significantly different from the ACS at the 90% confidence level.