It's Déjà Vu All Over Again: More Revelations from a Lighting Panel Study

Kiersten von Trapp, NMR Group, Inc., Somerville, MA
Melissa Meek, NMR Group, Inc., Somerville, MA
Scott Walker, NMR Group, Inc., Somerville, MA
David Barclay, NMR Group, Inc., Jacksonville, FL
Lisa Wilson-Wright, NMR Group, Inc., Somerville, MA

ABSTRACT

In the past, program administrators have relied primarily on changes in lighting saturation over time, self-reported data from customer surveys, or store intercepts to help understand consumer lighting purchases and use. These approaches, however, have failed to reveal what types of bulbs are actually replaced when newly purchased bulbs are installed. Previous studies have tried to capture this through self-reported data, asking customers what types of bulb had been installed prior to the current CFL or LED. However, other work comparing telephone survey results with actual observed data has shown self-reported lighting data to be notoriously inaccurate.

This paper will describe the results of an ongoing approach to studying residential lighting: a panel study involving repeat visits to the same homes over multiple years in two states – one that has program support for energy-efficient bulbs, and a comparison state that has phased out program support for such bulbs. This panel study allows us to look at what types of bulbs customers choose to replace those that burn out or are removed, and what types of bulbs are replacing CFLs. With it we can assess trends in the two states by income, home type, and education level.

Background

This paper reports on a lighting panel study established in 2013. The authors presented findings from the first two waves of the panel study as part of IEPEC 2015. Since that time, we have completed an additional two waves and have added a substantial number of homes to the panel.

Things were not always so rosy for the panel study. The authors first attempted to convene a lighting panel study in 2010, but lack of consistent on-site data collection protocols made it difficult to tell whether differences were based on changes within homes or data collection errors. This early attempt led to a careful examination of on-site protocols used and areas for improvement; these issues are explored in-depth in a 2011 IEPEC paper (Filiberto et al.).

Armed with new protocols and a deeper understanding of panel issues, we have now successfully completed four waves of panel visits in Massachusetts and two waves of panel visits in New York (Figure 1).[1] The Massachusetts panel began in 2013 with 150 new on-site visits.

- *Massachusetts Panel Wave One:* In 2014, we returned to 111 of the homes first visited in 2013 and visited an additional 150 homes for the first time.
- *Massachusetts Panel Wave Two:* In 2015, we returned to 203 homes—89 that were first visited in 2013 and 114 that were first visited in 2014—and visited an additional 151 homes for the first time.

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[1] For an overview of on-site protocol improvements and findings, we presented a comprehensive review of enhancements to on-site data collection processes and protocols in an IEPEC 2015 poster session titled: ***Fifteen Secret Tips That Will Change Everything You Know about On-site Data Collection***.

- *Massachusetts Panel Wave Three:* In 2016, we returned to 270 homes—77 that were first visited in 2013, 98 that were first visited in 2014, and 95 that were first visited in 2015—and visited an additional 150 homes for the first time.
- *Massachusetts Panel Wave Four:* In 2017, we returned to 315 homes—65 that were first visited in 2013, 83 that were first visited in 2014, 72 that were first visited in 2015, and 95 that were first visited in 2016—and visited an additional 150 homes for the first time.

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

- *New York Panel Wave One:* In 2016, we returned to 80 of the homes first visited in 2015 and visited an additional 70 homes for the first time.
- *New York Panel Wave Two:* In 2017, we returned to 105 homes—44 that were first visited in 2015 and 61 that were first visited in 2016—and visited an additional 150 homes for the first time.

A fifth wave of Massachusetts visits, drawing on the 465 visits completed in 2017, as well as a third wave of New York visits, drawing on the 255 visits completed in 2017, are planned for the fall of 2017.

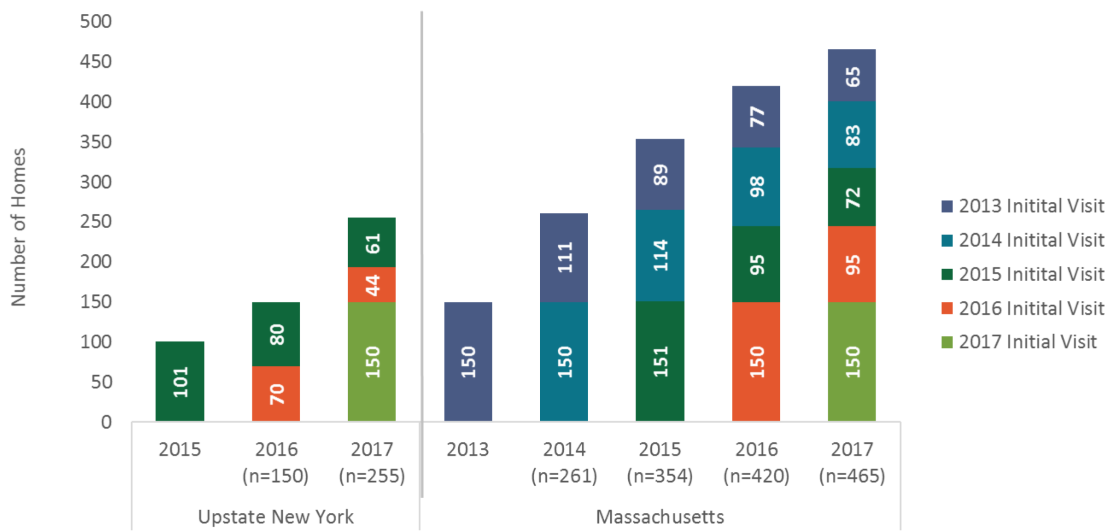

Figure 1. On-site lighting visits by year and type

All data from the panel visits are based on changes observed by technicians while on-site. Technicians used a data collection program on a tablet to collect comprehensive lighting inventory data comparing observed bulbs to those found during previous lighting inventories. To distinguish new bulbs from existing bulbs, technicians mark all bulbs (both installed and in storage). This makes new bulbs easy to identify due to the lack of such markings. Bulbs found in storage were marked with a different color, making it easy to identify bulbs installed from storage between visits.

Results and Analysis

Bulb Replacements

Sockets where the customer had replaced the bulb (or had installed a bulb in an empty socket) since the previous visit were of special interest in the panel visits, especially sockets with a newly installed CFL or LED.

Table 1 shows information on the panel visits in Massachusetts and New York and the bulb replacements in these homes. Between the 2014 and 2015 visits, Massachusetts panelists replaced roughly 0.9 bulbs per home per month, and between the 2015 and 2016 and the 2016 and 2017 visits, these panelists replaced roughly 0.6 bulbs per month. The difference in bulbs replaced per month may be due in part to the fact that Wave 2 covered only five months, whereas Wave 1 covered slightly more than a full year. In 2017, New York panelists replaced 4.7 bulbs per household, less than Massachusetts Wave 4 panelists (7.3 bulbs per household).

Table 1. Panel replacement bulb summary (unweighted)

Panel year	MA 2014 (Wave 1)	MA 2015 (Wave 2)	MA 2016 (Wave 3)	MA 2017 (Wave 4)	NY 2016 (Wave 1)	NY 2017 (Wave 2)
Homes	*111*	*203*	*270*	*315*	*80*	*105*
Baseline	May – June 2014	Dec. – Jan. 2015	Dec. 2015 – Feb. 2016	Oct. 2016 – Jan 2017	Jan. – Feb. 2015	Oct. 2016 – Jan 2017
Months	13	5	12	12	12	12
Total sockets	6,200	10,930	15,413	19,321	6,289	7,163
Sockets with replacement bulbs	834 (13%)	941 (9%)	2,004 (13%)	2,375 (12%)	434 (7%)	439 (6%)
Replacements/Home	7.5	4.6[a]	7.4	7.3	5.4	4.7
Replacements/Month	0.6	0.9	0.6	0.6	0.45	0.4
Homes replacing	103 (93%)	169 (83%)	245 (90%)	285 (90%)	65 (81%)[a]	79 (75%)[a]

[a] Significantly different from MA Wave 1 and Wave 3 at the 90% confidence level.

Figure 2 shows overall bulb replacement behavior for Massachusetts and New York for the most recent wave. Replaced bulbs are bulbs that were recorded in the 2016 visit but were removed from the sockets when techs returned for the 2017 visit. Replacement bulbs are those bulbs installed in sockets in 2017 from which the "replaced bulbs" were removed.

In 2017, LEDs were the most common replacement bulb type (47%) in Massachusetts and the second most common replacement bulb type in New York (28%). CFLs were the third most common replacement bulb type in both states and were chosen at similar rates in both states (19% in Massachusetts; 17% in New York). Incandescent bulbs were the second most common choice among Massachusetts households (22%) and the most common choice among New York households (34%).

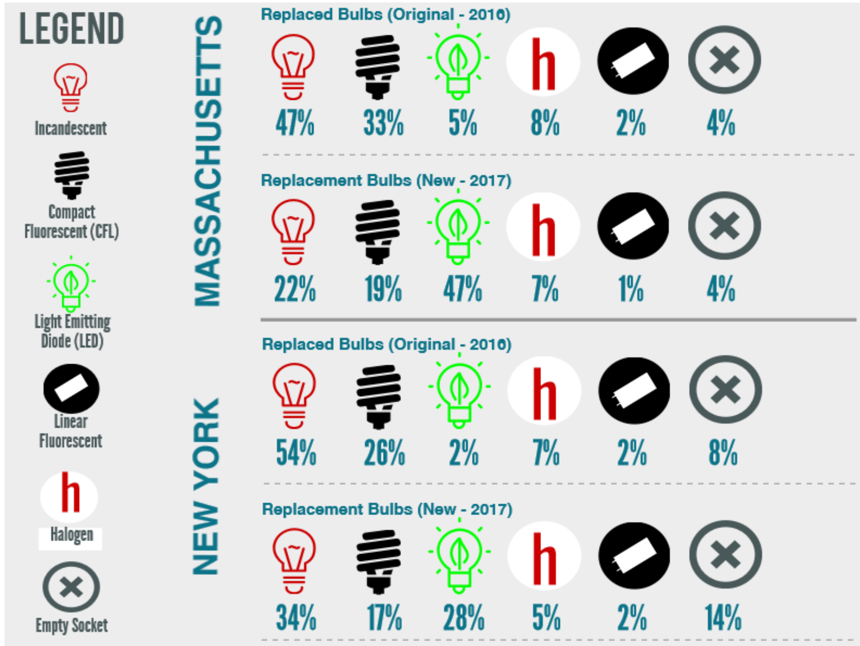

Figure 2. Overall bulb replacements, Massachusetts and New York 2017

Impact of Bulb Replacements (Delta Watts)

Examining the wattage of replaced (before) bulbs and replacement (after) bulbs shows a large drop in the observed wattage in those same sockets—not surprising given the shift from inefficient to efficient alternatives. However, when viewed graphically the shift in wattage is dramatic. When we look at all bulbs replaced among panel households between 2016 and 2017, the average wattage in those sockets before replacement was 40.1W. After replacement, the average wattage dropped to 20.5W (delta watt of 19.6). Figure 3 provides a graphic overview of the change in the distribution of wattage between 2016 and 2017 for replaced bulbs.

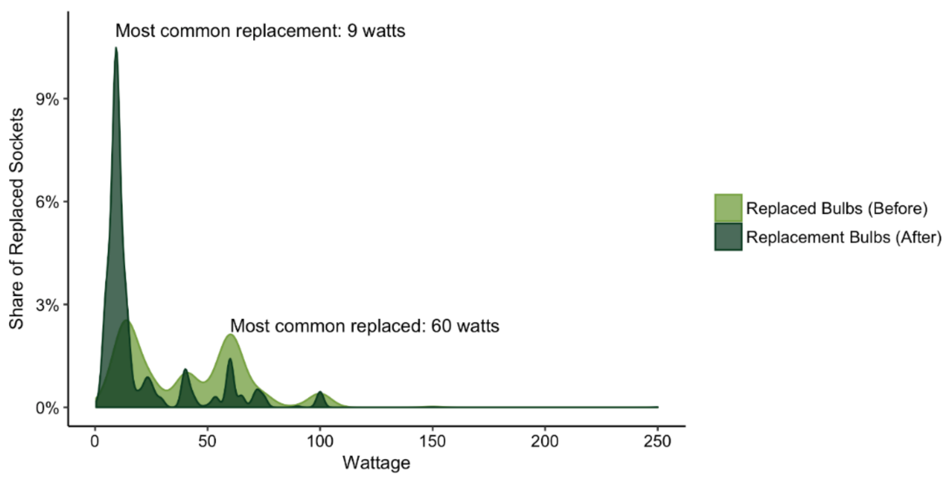

Figure 3. Wattage distribution of replaced and replacement bulbs[2,3]

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

Replacement Drivers

In Table 2, we look at the reasons panelists gave for replacing inefficient bulbs (incandescent or halogen) with LEDs and CFLs, and efficient bulbs (LED or CFL) with incandescent or halogen bulbs. In both states, over four in five replacement LEDs were installed because the householder wanted to use a more energy-efficient bulb. One in three CFLs (30%) were installed to replace inefficient bulbs in Massachusetts, and this was primarily due to their availability in storage, compared to 9% of CFLs replacing inefficient bulbs in New York. Massachusetts householders who replaced efficient bulbs with incandescents or halogens said they did so because of dissatisfaction with the function, light quality, or appearance (35%) of CFLs, or because of the ready availability of incandescent bulbs in storage (25%).

Table 2: Reasons for bulb type change (Base: Replacement bulbs in 2017 panel homes that were a different type than the bulb they replaced; bulbs self-reported to be DI excluded)

	Massachusetts			New York		
Reasons why…	*Inefficient bulbs replaced with:*		*Efficient bulbs replaced with:*	*Inefficient bulbs replaced with:*		*Efficient bulbs replaced with:*
Reasons for replacing	LED	CFL	Incan+ Halo	LED	CFL	Incan+ Halo (count)
Households (n)	*82*	*59*	*52*	*32*	*19*	*17*
Replaced bulb count[b]	*340*	*111*	*92*	*99*	*29*	*29*
Wanted to use a more energy-efficient bulb	86%	37%	3%	80%	67%[a]	1
Did not like function and/or appearance of previous bulb	3%	15%	35%	5%	10%	3
Available in storage	2%	30%	25%	2%	9%[a]	10
Wanted new bulbs/bulbs in fixtures to match	--	4%	4%	--	--	4
Don't know/Other	8%	15%	28%	13%	12%	6

[a] Significantly different from Massachusetts at the 90% confidence level.
[b] Unweighted count; weighted count for column values.

Panel Trends by Key Demographics

We further explored replacement behavior by income, home type, and tenure to determine if replacement behavior varied by demographic characteristics. While there were no demographic differences in CFL replacement behavior, non-low-income householders, homeowners, and householders in single-family dwellings were more likely than others to install replacement LEDs (Figure 4). This pattern held true in both Massachusetts and New York, which is explored in more detail in the companion paper, *Keep Calm and Carry On: Why Upstream Lighting Programs Are Still Important*, Barclay, et al.

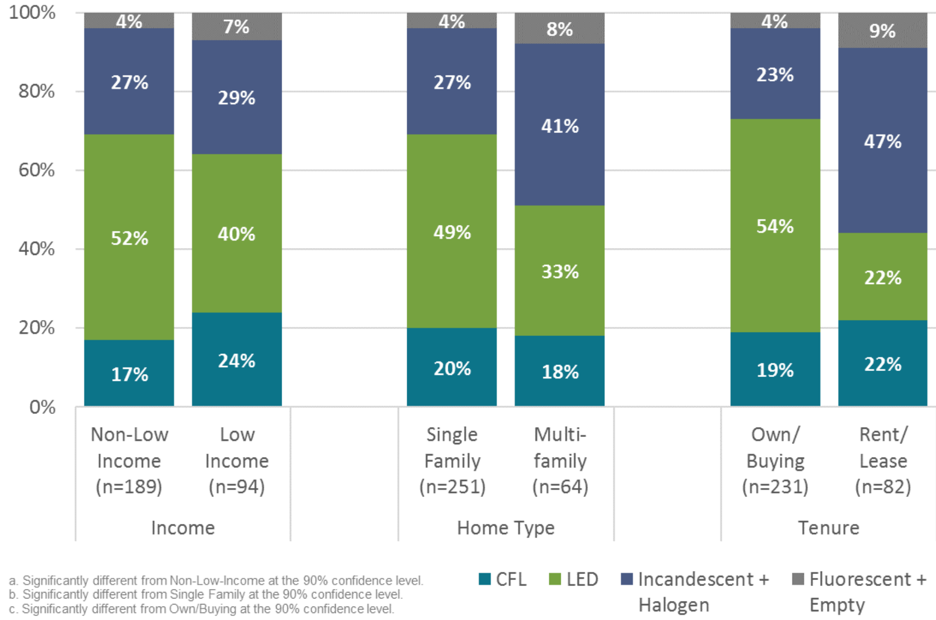

Figure 4. Replacement bulbs by demographic

Storage Behavior

In panel sites, the team was able to track stored bulb status from the 2016 visit to the 2017 visit. There were 6,337 bulbs still in storage in Massachusetts panel homes in 2017 and 1,739 that had been in storage in 2016 that were no longer in storage in 2017. New York panel homes had 2,531 bulbs in storage in 2017 and 361 that had been in storage in 2016 that were no longer in storage in 2017. As Table 3 shows, most bulbs that had been in storage in 2016 were still in storage in 2017 (62% in Massachusetts; 70% in New York). Notably,

- One out of every ten (10%) incandescent bulbs that had been in storage in 2016 in Massachusetts was thrown out between the 2016 visit and the 2017 visits, while only 3% were thrown out in New York.
- In Massachusetts, 7% of LEDs that had been in storage in 2016 were installed in 2017; in New York, 3% were installed by the 2017 visit. In both states, nearly one-half of stored LEDs were newly purchased (47% in Massachusetts, 49% in New York).

Table 3: Stored bulb status

Bulb Status 2017	Massachusetts					
	CFL	Fluorescent	Halogen	Incandescent	LED	All
# of Bulbs	2,039	157	696	4,436	748	8,076
Same	58%	59%	57%	68%	34%	62%
New	8%	4%	20%	7%	47%	11%
Thrown out/Recycled	12%	24%	2%	10%	1%	10%
Installed in fixture	9%	1%	9%	5%	7%	7%
Previously Installed	6%	8%	4%	4%	5%	5%
Don't know/Other	7%	4%	8%	6%	6%	6%
Bulb Status 2017	New York					
	CFL	Fluorescent	Halogen	Incandescent	LED	Total
# of Bulbs	487	116	370	1,735	184	2,892
Same	73%	77%	57%	75%	41%	70%
New	13%	18%	25%	13%	49%	16%
Thrown out/Recycled	1%	0%	5%	3%	1%	3%
Installed in fixture	4%	3%	1%	2%	3%	2%
Previously Installed	2%	0%	0%	<1%	0%	1%
Don't know/Other	7%	2%	12%	7%	6%	8%

Methods

At the initial visit, trained technicians collected detailed lighting inventory data and marked each bulb found installed or in storage with a temperature-safe marker. During subsequent panel visits, technicians compared lighting data from the previous visit with the current lighting inventory. Marks on bulbs helped to identify bulbs that were new or moved from stored to installed. In general, lighting inventory visits lasted about two hours.

To ensure a representative sample, we set quotas for multifamily and single-family and low-income and non-low-income homes as well as by first visit year with the goal of achieving an equal number of visits with each group. Sponsors offered incentives and set aggressive goals to convert those who agreed to on-site visits in order to reduce potential non-response bias and panel attrition.[4]

Panel Recruitment

Panelists were initially recruited using computer-assisted telephone interviews (CATI). To generate a sample, the authors obtained customer names, telephone numbers, and addresses from a list of utility customers. Prior to calling, potential respondents were sent advance letters informing them about the study. While response rates varied, they were high in general for initial recruitment in 2013 (17%), 2014 (20%), 2015 (27%), 2016 (32%), and 2017 (27%). The take rate—those respondents who also agreed to an on-site visit—was also high for all five years (about 50%).

Each year since the initial wave of panel visits in Massachusetts in 2014, we have compared the sample of potential panelists to the actual panelists to see if they differ in any ways that would point to non-response bias. For the 2017 visits, we had 420 sites to draw upon for the sample—270 panelists and 150 new visits from the 2016 wave.

[4] In 2017, panelists in Massachusetts received an incentive of $225 for each visit conducted; panelists in New York received an incentive of $200 for each visit conducted.

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

Table 4 shows that we continue to have a robust response rate among previous panelists. We again completed visits at three-quarters of the available sites, as in 2014, 2015, and 2016. The share of sites that did not respond was at its highest level this year (12%), though that rate is similar to 2015.

Importantly, in 2016 the panel visits were completed prior to beginning the new visits, which created some differences in saturation because LED saturation was growing so rapidly (about 1% every two months). This was corrected in 2017 by ensuring panel and new visits were carried out concurrently (as they had been in 2015).

Table 4: Massachusetts panel disposition

	2014		2015		2016		2017	
Disposition	Count	%	Count	%	Count	%	Count	%
Complete	111	74%	203	78%	270	77%	315	75%
No response	9	6%	29	11%	15	4%	51	12%
Did not contact	4	3%	6	2%	37	11%	20	5%
Ineligible	24	16%	16	6%	21	6%	22	5%
Wait list	--	--	6	2%	3	1%	6	1%
Visit cancelled	--	--	--	--	4	1%	5	1%
Refused	2	1%	1	<1%	1	<1%	2	<1%
Total	150	100%	261	100%	351	100%	420	100%

The demographic characteristics of the 2017 completed panel visits were again quite similar to the overall respondent pool (Table 5). The share of single-family homes increased slightly from 2016 after increasing 8% for the sample overall and 6% among the completed visits between 2015 and 2016. The share of low-income homes is 6% smaller for the 2017 visits than for 2016, though the difference is in the increase of refusals rather than in identified non-low-income homes. In tenure, we find the largest divergence between the 2017 sample and actual visits: there were 4% more homeowners among the sites visited compared to the available pool of respondents. This difference is still relatively small, and smaller than the 7% difference in the same figure for 2014.

Table 5: Massachusetts panel demographics

Demographics	2014 All (n=150)	2014 Comp. (n=111)	2015 All (n=261)	2015 Comp. (n=203)	2016 All (n=351)	2016 Comp. (n=270)	2017 All (n=420)	2017 Comp. (n=315)
Home type								
Single family	66%	67%	66%	67%	74%	73%	76%	75%
Multifamily	34%	33%	34%	33%	27%	27%	25%	25%
Education								
Graduate degree	38%	38%	36%	36%	33%	32%	33%	33%
Bachelor's degree	20%	21%	26%	29%	28%	28%	31%	29%
Some college/ Associate's degree	27%	29%	25%	24%	25%	27%	23%	25%
High school/GED	13%	11%	11%	9%	10%	9%	9%	10%
Less than high school	2%	2%	1%	1%	2%	2%	2%	2%
DK/Ref	--	--	1%	1%	2%	2%	2%	2%
Income								
Low-income	31%	27%	31%	31%	29%	30%	24%	24%
Non-low-income	69%	73%	63%	63%	63%	62%	63%	63%
DK/Ref	--	--	6%	6%	9%	8%	13%	13%
Tenure								
Own/Buying	65%	72%	66%	67%	69%	70%	69%	73%

Socket saturation is the most important comparison for this study to identify any non-response bias. As in every previous wave, there are no lamp types that exhibit a saturation difference of greater than 1% for the completed sites versus the sample of potential panelists in 2017 (Table 6).

Table 6: Massachusetts Saturation Comparison*

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

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

We also analyzed the New York panelists for non-response bias. As in Massachusetts, we find little to no indication of non-response bias for the panelists in New York. For more details on non-response bias, please see the full 2016-17 Market Assessment report (NMR 2017).

Weighting

The on-site survey data were weighted to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on census data from the 2015 American Community Survey (ACS) five-year estimates. The guiding principles behind the schemes are:

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

Examination of Potential Study Effects

As discussed in the 2015 IEPEC paper (Barclay et al.), the authors compared key data for variables from Wave 1, Wave 2, Wave 3 and Wave 4 panelists to data from new visits in the same year. The purpose of this analysis was to identify any systematic differences between the two on-site samples in order to assess whether any reactive or Hawthorne[5] effects were occurring among panelists. The analysis found that the panel and new visits showed very similar or identical levels of penetration, saturation, and purchase behavior. The similarity of the data between the pool of potential panelists and the panelists in each wave suggests that there are few or no reactive effects or Hawthorne-type effects on panel saturation rates.

Conclusions

A successful panel study requires careful attention to data collection protocols and technician training. Others wishing to establish panels should learn from past efforts and look for opportunities to examine existing longitudinal data while preparing data collection protocols. In addition, the inclusion of additional new sample serves both to combat attrition and serves as a control group for the panel to help identify potential study effects.

The authors offer a word of caution to others wishing to use results from this study. Massachusetts has a long history of uninterrupted residential lighting programs supporting CFLs and LEDs. Households in other areas without similarly high levels of program activity may exhibit different behavior. Still, the results do offer insights into customer behavior that may translate to other jurisdictions, as will lessons learned regarding panel design and implementation.

Key Takeaways

- In Massachusetts, LEDs were the most common replacement bulb type (47%), followed by incandescent bulbs (22%). In New York, incandescents were the most common replacement bulb type (34%), followed by LEDs (28%).
- Nearly one-quarter (23%) of all replacement bulbs in Massachusetts came from storage (23%); notably, nearly one-half (47%) of replacement incandescent bulbs in Massachusetts came from storage in 2017, an increase from 2016 when only two-fifths of replacement incandescents came from storage.
- CFL replacement rates declined in both states. CFLs are the third most common replacement bulb type, and we observed net decreases in CFLs among replaced sockets in both Massachusetts (-14%) and New York (-9%).

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

- Massachusetts households replaced significantly more incandescent bulbs with LEDs (44%) than New York households (24%). Nearly one-quarter (23%) of all replacement bulbs in Massachusetts came from storage (23%); notably, nearly one-half (47%) of replacement incandescent bulbs in Massachusetts came from storage in 2017, an increase from 2016 when only two-fifths of replacement incandescents came from storage.
- We observed backsliding (efficient bulbs being replaced with inefficient) in households in both states. In Massachusetts, 21% of replaced LEDs and 12% of replaced CFLs were replaced with halogens or incandescents. In New York, 25% of replaced LEDs and 20% of replaced CFLs were replaced with halogens or incandescents.
- Replacement behavior in Massachusetts differed significantly based on the key demographic characteristics of income, home type, and tenure. Similar trends were observed in New York. Differences in LED replacement were especially pronounced.
- Despite differences in replacement behavior among demographic groups, LED replacement trends in Massachusetts are increasing overall.

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