



R1615 Light Emitting Diode (LED) Net-to-Gross Evaluation

FINAL REPORT FOR CONNECTICUT EEB

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Abstract

The *R1615 Light Emitting Diode (LED) Net-to-Gross (NTG) Study* estimated NTG ratios for LEDs in 2015 and predicted prospective ratios through 2020 for the Retail Products Program. It also characterized the market to lay the groundwork for the *R1616/R1708 Residential Lighting Impact Saturation Study* to be conducted in 2017 and 2018. Lighting is part of the Retail Products Program and has historically been the largest savings contributor for the residential sector. The NTG ratios are a key element of the PSD used to estimate and assess program savings for program planning and evaluation. Updated NTG values are needed to reflect fast-moving market changes in this end-use and assure Connecticut program dollars are well-spent.

The study's recommendations were based on three primary research activities (sales data and demand elasticity modeling and supplier interviews) and the responses of a consensus panel.¹ The key findings of the study include the following:

- LED NTG ratios have fallen since the completion of the 2014/2015 *R86 Lighting NTG Study* and are expected to continue falling through 2021.
- The lighting market remains volatile and marked by considerable uncertainty. Some of the factors that contribute to this situation include the following:
 - If and when LEDs will overtake halogens as the dominant standard light bulb in the market
 - If the current federal administration will rollback or fail to enforce higher lighting efficiency standards set to take effect in January 2020
 - Whether the market momentum for LEDs is sufficient to overcome federal action (or inaction) on lighting standards
 - Role played by non-ENERGY STAR-qualified LEDs in the market, and their impact on consumer acceptance and program sales of ENERGY STAR-qualified models
- Despite the uncertainty, **the study recommends the following LED NTG ratios for 2018 to 2020 to be used in PSD updates for 2018 and program planning for 2019 and 2020:**
 - *Standard and specialty LEDs*: 40% for 2018, 36% for 2019, and 33% for 2020.
 - *Standard and specialty LEDs sold through hard-to-reach (HTR) channels*: 60% for 2018, 56% for 2019, and 53% for 2020.

Other study recommendations include the following:

- The program should continue to support LEDs through 2018 as planned, but the EEB should monitor federal and state policy decisions and market trends to determine whether to fund an upstream lighting program in the 2019 to 2021 cycle.
- Further targeting HTR channels has the potential to increase the program's cost effectiveness, particularly by focusing incentives on lower-priced ENERGY STAR-qualified LEDs.
- Improving the level of detail in the tracking of in-store merchandising displays (ideally product model number or brand and bulb type) would increase the likelihood of identifying the impact this program component has on program sales.

¹ The study was led by NMR with its subcontractors DNV GL and Cadmus.

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Executive Summary

The *R1615 Light Emitting Diode (LED) Net-to-Gross (NTG) Study* estimated NTG ratios for LEDs in 2015 and predicted prospective ratios through 2018 and beyond for the Retail Products Program. This study also laid the groundwork for an upcoming lighting study, *R1616/R1708 Residential Lighting Impact Saturation Study*.²

RESULTS

The study undertook five research activities: in-depth interviews with suppliers and program staff, sales data modeling, demand elasticity modeling, benchmarking, and a consensus panel. These efforts were carried out between August 2016 and February 2017—a time of political uncertainty, with implications for lighting efficiency standards and programs. Some of the findings presented in this report may depend on federal rulemaking, political appointments, and funding of public agencies. This report attempts to note if the certainty of results is particularly tenuous given the political climate and if they should be interpreted with caution.

Recommended Prospective Net-to-Gross Estimates

Based on results from the five research tasks the R1615 study makes the following recommendations for the Retail Products Program:³

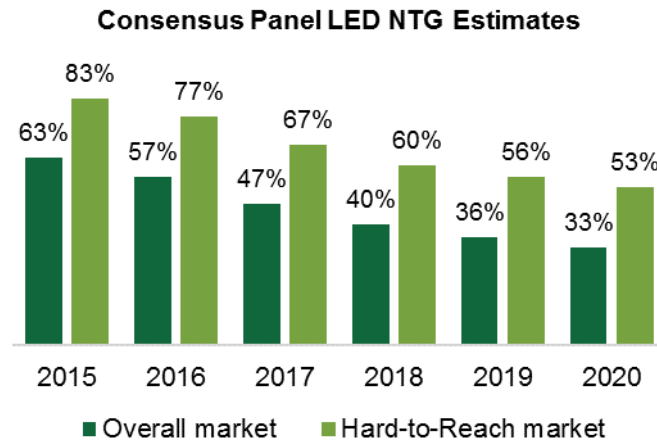
- **Update the Program Savings Document (PSD) LED NTG ratios to 40% for 2018 (as the 2017 PSD is already finalized and approved by the EEB).**
- **Plan for future LED NTG ratios of 36% for 2019 and 33% for 2020.**
- **Add to the PSD HTR channel-specific LED NTG ratios of 60% for 2018, 56% for 2019, and 53% for 2020.**

The calculations in the PSD require the use of individual freeridership and spillover rates, as Connecticut uses a *Net Realization Rate* that incorporates not only freeridership and spillover but also an installation rate (97.5% for LEDs in the 2017 PSD). The study's analysis did not specifically parse out these two values separately, but following the current practice in the PSD, it should be updated to list freeridership as one minus the NTG ratio listed above. **This would yield freeridership of 60% in 2018, 64% in 2019, and 67% in 2020 for all non-HTR LEDs and 40% in 2018, 44% in 2019, and 47% in 2020 for HTR LEDs.** See Footnote 6 and the [Introduction](#) to the main body of the report for more information about PSD calculations.

² The Connecticut Energy Efficiency Board (EEB) contracted NMR Group and its subcontractors, DNV GL and the Cadmus Group to carry out this study.

³ The research and recommendations do not apply to the Home Energy Solutions and Home Energy Solutions-Income Eligible Programs' direct install LEDs.

The recommendations derive from the project's well-rounded efforts to collect primary data, interview stakeholders, assess results from other locations, and augment the analysis with input from a consensus panel composed of lighting experts. These experts reviewed the data collected during R1615 primary- and secondary-research tasks and their knowledge of the industry and developed estimates of NTG values.⁴ They later participated in a consensus building process to refine estimates and develop recommendations for NTG values.



The panel took place a couple of months after the presidential election but in the early days of the new administration (January and February 2017). The panel specifically considered the possible impacts of the various industry and market sources of uncertainty. These factors included uncertainty about the future of the market and if and how the new administration might respond to previously legislated increases for lighting efficiency standards.⁵ The panel developed recommendations of prospective estimates of NTG for integration into planning efforts. This report reviewed the input values, analyses, consensus process, and results from other locations, and chose these recommended values.

The non-HTR recommended NTG estimates are lower than the current value assumed in the 2016 PSD (in effect when this study was conducted). The PSD assumed no freeridership or spillover for LEDs but assigned a net realization rate of 82% (listed as the installation rate). The PSD net realization rate value matches that recommended for NTG in the R86 lighting NTG study, *Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall*, conducted in 2014 and 2015.^{6,7} The analysts and consensus panel considered the changes in the market. They concluded that **the lighting market has changed substantially enough since the completion of that study to warrant an adjustment to future PSDs to reflect the newly recommended prospective NTG ratios.**

⁴ For more information on the consensus panel members, see Section 2.5.2.

⁵ These standards include the next phase of the Energy Independence and Security Act (EISA) due to take effect in 2020 and a 2017 Department of Energy (DOE) ruling to expand the general service lamps to include reflectors and other bulb types.

⁶ The PSD lists the following equation for *net realization rate*: $Net\ Realization = (Gross\ realization\ \%) \times (installation\ rate\ \%) \times (100\% - Freeridership\ \% + Spillover\ \%)$. Thus, by setting freeridership and spillover at zero and the installation rate at 82%, the equation yields a net realization rate of 82%.

⁷ The evaluation team could not locate the 2016 PSD on-line but has a copy of it provided by the EA Team. The 2017 PSD has updated LED net realization rate, placing the installation rate at 97.5%, freeridership at 24.3%, and the net realization rate at 73.8%. This document can be found at

https://www.energizect.com/sites/default/files/2017%20CT%20Program%20Savings%20Document_Final.pdf.

The study from which the 2016 net realization rate value is derived is NMR Group, Cadmus Group, and DNV GL. 2015.

http://www.energizect.com/sites/default/files/CT%20Residential%20LED%20Lighting%20Market%20Assessment%20and%20Lighting%20NTG%20%28R86%29_Final%20Report_06.19.15.pdf.

The HTR channels, such as discount stores, are more price sensitive, and therefore demonstrate higher NTG ratios. Separate NTG ratios were not developed for reflector bulbs for three reasons. There is considerable market uncertainty about adoption of EISA, the expanded definition of general service lamps, and consensus panelists' annual estimates only demonstrated differences of five percentage points or less.⁸ The study determined that the evidence does not support separate reflector NTG ratios.

Evaluated Net-to-Gross Estimates

The study relied on three empirical approaches to estimate LED NTG ratios, which, together with the results of the benchmarking exploration described below, fed into the consensus panel process. These included supplier interviews (n=16), sales data modeling (based on 17 states with varying levels of LED program activity), and demand elasticity modeling (drawing on program data from the Retail Products Program). Table 1 presents the results of the R1615 efforts.

While Connecticut does not apply retrospective NTG values, R1615 estimated NTG ratios for 2015 with the understanding that they would serve as anchors for estimating prospective NTG ratios, in part, because retrospective NTG is measurable whereas prospective NTG is somewhat speculative. Moreover, retrospective estimates illustrate how program influence and NTG ratios change over time (e.g., predicted values from the prior evaluation that have been incorporated into the PSD vs. the evaluated values based on actual market conditions). These considerations informed the consensus panelists' prospective estimates and the conclusions and recommendations of this study.

Table 1: Estimated and Recommended LED NTG Estimates

Source	Retrospective ¹		Prospective ²				
	2015	2016	2017	2018	2019	2020	2021
% of CT Lighting Strategy 2015 Program Bulbs	100%	100%	-	-	-	-	-
2016 to 2018 PSD	82%	82%	82%	82%	-	-	-
In-depth supplier interviews	61%	61%	40%		38%		35%
Sales data modeling	70%	70%	-	-	-	-	-
Demand elasticity modeling ³	61%	61%	-	-	-	-	-
Consensus panel / Recommended	63%	57%	47%	40%	36%	33%	-

¹ The in-depth interviews addressed 2015-2016 estimates together, while the sales data and demand elasticity modeling addressed only 2015. The consensus panel recommended separate estimates for 2015 and 2016.

² Note that the PSD prospective estimates beyond 2018 have not yet been released; other empty cells indicate that the related task did not estimate NTG for the corresponding year.

³ Because the model includes only program data, the estimate is net-of-freeriders, which excludes spillover.

⁸ For example, their 2015 estimate for standard LEDs was 66% and their estimate for reflector LEDs was 62%.

Retrospective NTG. Supplier interviews yielded a retrospective NTG ratio of 61% for the last half of 2015 and the first half of 2016, demand elasticity modeling estimated a net-of-freeridership (which excludes spillover) of 61% for 2015, and sales data modeling resulted in the highest NTG ratio of 70% for 2015. The study relied more heavily on the consensus panel recommendations and supplier interview and demand elasticity modeling results, acknowledging some concerns about the level of robustness methodology of the sales data modeling.

The reader will observe that the recommended 2016 NTG ratio (57%) is lower than those associated with the empirical research methods. Two primary factors play into this result. First, given that the demand elasticity and sales data modeling did not incorporate 2016 data, the consensus panel gave less weight to those results when setting the 2016 NTG estimate. Second, suppliers' estimates spanned the second half of 2015 and the first half of 2016. Noting that NTG ratios would diminish year-over-year, the consensus panel considered 2015 to be an anchor year, and as such, the 2016 NTG ratio should represent a decrease from that value.

Prospective NTG. Suppliers expected program rebates would continue to be valuable in the future because they provide first cost decreases. They also emphasized that the rapidly increasing sales of LEDs independent of the program would make the program less influential. Suppliers estimated steadily decreasing prospective NTG ratios of 40% in 2017, 38% in 2019, and 35% in 2021. The consensus panel recommended somewhat similar estimates, steadily decreasing from 47% in 2017 to 33% in 2020, and the report concurs.

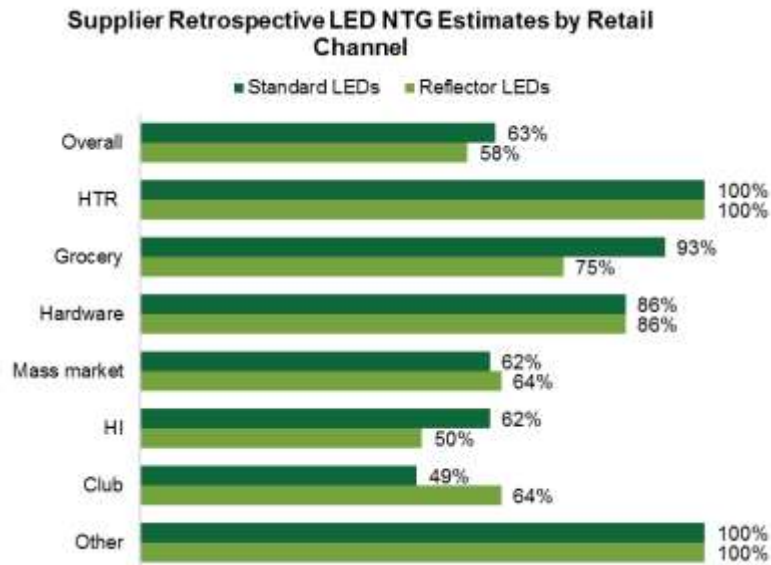
Bulb type. Suppliers and demand elasticity modeling estimated lower retrospective NTG ratios for reflector LEDs than standard LEDs. Suppliers predicted the opposite relationship in 2017 and 2019, but ultimately attributed a higher prospective NTG ratio for standard LEDs than reflector LEDs in 2021.⁹ NTG ratios may be lower for reflector and specialty LEDs than for standard LEDs possibly because the affinity between LEDs and the characteristics of reflectors (such as long life and, for many, dimmability), poor reflector CFL and halogen performance, greater length of time reflector LEDs have been on the market compared to standard LEDs, and near price parity between reflector LEDs and halogens. The lack of specific evidence supporting these explanations, the small differences in standard and reflector NTG estimates (5% or less), and that reflector LEDs only represented 13% of program bulb sales in 2015, led the panel to recommend using the same NTG for standard and reflector bulbs.

⁹ The consensus panel, supplier interviews, and sales data modeling did not address specialty (i.e., anything other than an A-line and reflectors) LEDs given that they only represented 5% of program bulb sales.

Retail channel. Suppliers estimated higher NTG ratios for HTR channels than other channels. The study, therefore, recommends consistently higher HTR NTG estimates. Demand elasticity modeling also made estimates by retail channel, but sample sizes for HTR channels were too small to isolate for analysis.

Comparison to Other Net-to-Gross Ratio Estimates

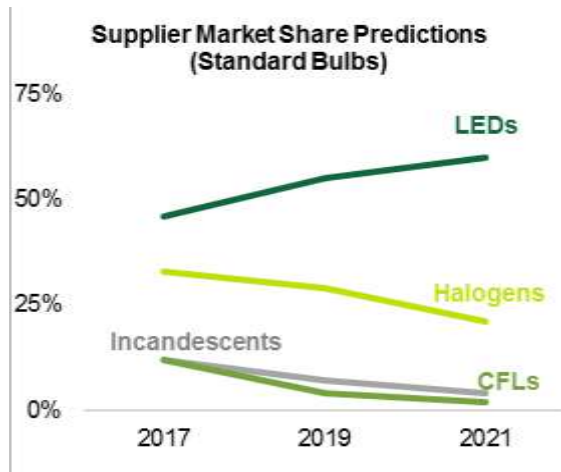
R1615's benchmarking effort revealed that research for comparable programs have resulted in retrospective LED NTG ratios ranging from 73% to 100% (with a median value of 85%) for the years of 2012 to 2015. The data from other jurisdictions do not display a clear pattern of increase or decrease over time. The study concurs with the consensus panel's determination that all benchmarking studies were too dated or geographically distant to strongly factor into their considerations.



Market Trends and Predictions

The study also gathered information on market trends that may affect NTG ratios through 2021, including past market share trends and predictions of future market share, the ENERGY STAR 2.0 specification, and the program decision to phase out CFLs by early 2017.

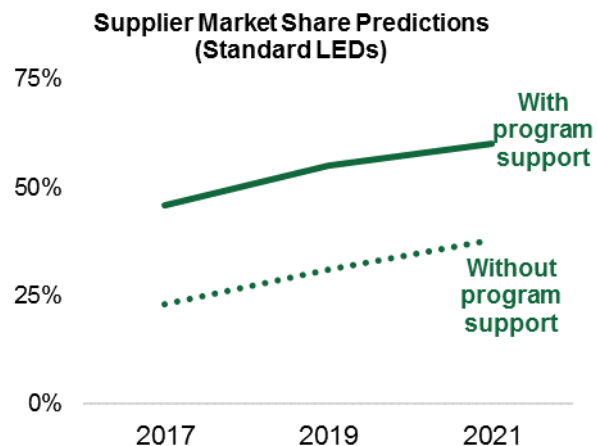
Aggregated sales data and shipment data as reported by North American Electrical Manufacturers Association (NEMA) show that halogens and CFLs dominated the residential market in 2015, yet LED market share has been on the rise. The sales data also suggest that Connecticut residents were most likely to have purchased halogen bulbs in 2015. Connecticut's sales of LEDs among a subset of retailers sharply increased in recent years, which is in line with national and neighboring state sales. Shipments of A-line bulbs reported by NEMA point to slightly different trends than the sales data: while NEMA data also suggest a steep decrease in incandescent sales, they indicate a more rapid decline of CFL shipments and sharp increases of halogens and LEDS shipments. By 2016, NEMA data showed that LEDs had overtaken CFLs as the second most commonly shipped bulb type. Suppliers projected that LEDs would represent 60% of the standard bulb market and 54% of the reflector bulb market regionally in 2021. Meanwhile, they anticipated that all other bulb types would decrease in market share.



When it came to speculating on the impacts of non-program factors, suppliers expected that EISA 2020 would usher the decrease in halogen sales and increase in LED sales. They anticipated that ENERGY STAR 2.0 would 1) cause CFL sales to gradually decrease because the specification excludes most CFLs which, in part, has slowed manufacturers' production of them, and 2) stimulate LED sales to increase, with LEDs and halogens—already encroaching on CFL market share—both filling in the CFL market share gap created by the new specification. Additionally, they predicted

that ENERGY STAR 2.0 coupled with EISA 2020 would greatly curtail CFL sales and significantly decrease CFL market share.

Nonetheless, suppliers emphasized that program support in the next several years would remain vital to LEDs' steadily increasing dominance in the regional market. For example, they hypothesized that, LEDs would only account for 38% of the standard bulb market in 2021 without program support (versus 60% with program support). Suppliers did not believe that the program's phase-out of CFLs would make their sales decline faster than they already were, but suppliers did recognize that the decline in CFLs would create a potential gap in the market for a low-price, energy efficient alternative to incandescents and halogens. They speculated that program support for LEDs would increase the likelihood that consumers would choose LEDs over halogens and incandescents in the absence of CFLs.



A variety of non-ENERGY STAR-qualified LEDs had been around for a few years, but the shelf space devoted to them skyrocketed over the months leading up to the evaluation. Some lighting and energy-efficiency experts fear that these less expensive LED models, often called *value-line* LEDs, may suffer from poor quality (premature failure, lack of omnidirectionality, limited durability, and questionable light quality) due to a rapid increase in manufacturing that may sacrifice quality control to meet customer demand. Program staff, suppliers, and consensus panelists acknowledged the complex dynamics that value-line LEDs¹⁰ might yield—either driving LED sales independent of program support or, conversely, averting customers from the technology. The latter might happen if value-line models prove unreliable, driving consumers away from LEDs altogether.

¹⁰ Defined in Section 1.1.

CONCLUSIONS AND RECOMMENDATIONS

Retrospective and Prospective Net-to-Gross

The study estimated NTG values based on its primary and secondary-research tasks and the recommendations of the consensus panel. Based on predictions that the future LED market would grow independent of program support, the study determined that NTG will steadily decline from 2015 to 2020. HTR channels are more price sensitive, and therefore will consistently demonstrate higher NTG ratios.

- **Recommendation.** The study recommends using the NTG ratios resulting from the consensus panel. For non-HTR LEDs overall (inclusive of standard [A-line], reflector, and other specialty bulbs), 40% for 2018, 36% for 2019, and 33% for 2020. The consensus panel suggests setting the HTR channel NTG by adding 20 percentage points annually to the non-HTR estimates: 60% for 2018, 56% for 2019, and 53% for 2020. The study does not recommend changes to the 2017 PSD, as it has been finalized and approved by the EEB. However, annual reports from Eversource and UI should include a note about the differences between the 73.8% listed in the 2017 PSD and the consensus panel recommendation of 67% (made after the PSD was approved but before the panel had access to it).

Market Trends and External Factors

Halogens and CFLs currently dominate the residential market, but LED market share has been sharply on the rise. Suppliers expected that EISA 2020 would usher the decrease in halogen sales and increase in LED sales. They anticipated that ENERGY STAR 2.0 and EISA 2020 would cause CFL sales to decrease and further stimulate LED sales to increase. Program staff, suppliers, and consensus panelists also acknowledged the complex dynamics that value-line LEDs might yield—either driving LED sales independent of program support or, conversely, averting customers from the technology. The latter might happen if value-line models prove unreliable, driving consumers away from LEDs altogether. Nonetheless, suppliers emphasized that program support in the next several years would remain vital to LEDs' steadily increasing dominance in the regional market. The consensus panel agreed that program support remains critical.

- **Recommendation.** The program should continue to support LEDs as planned through the remainder of the current 2016 to 2018 program cycle. However, the EEB should monitor federal rulemakings and other relevant policy decisions, especially surrounding EISA 2020 and the definition of general service lamps, to determine if and for how long continued support is cost effective into the 2019 to 2021 cycle. The EEB should also monitor available information on the document quality of value-line LEDs and their impact on customer perceptions of LEDs.

Retail Channels

Big box stores¹¹ (including home improvement (HI), mass market, and club stores) composed 88% of program LED sales from 2015 to 2016 so the relatively high freeridership estimated by suppliers drove their relatively low NTG estimates. The consensus panel results aligned with supplier interview results that higher NTG ratios should be associated with the HTR channels, yet HTR channels composed a small share of program sales.

- **Recommendation.** Further targeting the HTR channel has the potential to increase the program's cost effectiveness. The program should continue incentivizing lower-priced ENERGY STAR-qualified LEDs at HTR retailers, assuming doing so passes cost effectiveness tests.

Program Implementation

The demand elasticity data relied on data detailing in-store promotional events and merchandising displays. Field staff collected these data when visiting stores to ensure compliance with retailer contractual agreements by: 1) verifying prices and shelf signs that indicated products were included as part of the program and 2) tracking off-shelf merchandising displays of program bulbs (e.g., clip strips, end caps, pallet displays).

- **Recommendation.** Improving the level of detail in the tracking of in-store merchandising displays (ideally product model number or brand and bulb type) would increase the likelihood of identifying the impact this program component has on program sales.

¹¹ Big box stores are retailers with a large volume of floor space, often part of a chain, and offer a wide variety of products.

1

Section 1 Introduction

The Connecticut EEB contracted the evaluation team to estimate retrospective and prospective LED NTG ratios from 2015 through 2018 and beyond for the Retail Products Program, which largely supports light bulbs and light fixtures. The study, known as R1615, produced LED net-to-gross (NTG) estimates for 2015 through 2020.

1.1 BACKGROUND

The EEB completed a lighting NTG study in 2014 and 2015 (R86), which provided estimates of NTG or net-of-freerider ratios for standard and specialty compact fluorescent lamps (CFLs) and LEDs (treated as one category) for 2013 and 2014.¹² The R86 study recommended applying a CFL NTG of 51% and LED NTG of 82% for 2013 and 2014. The *Connecticut Program Savings Documentation* does not list NTG ratios, but instead uses a net realization rate. The PSD adheres to the following equation for *net realization rate*: $Net\ Realization = (Gross\ realization\ \%) \times (installation\ rate\ \%) \times (100\% - Freeridership\ \% + Spillover\ \%)$. Because most retail lighting NTG approaches either rely on a market-level estimate (that incorporates freeridership and spillover) or are unable to estimate spillover, the developers of the PSD adjusted inputs to achieve net realization rates that equaled recommended NTG ratios for 2016, the edition in effect for this evaluation. They have updated these values in the 2017 PSD. Table 2 lists the CFL and LED inputs in both PSD editions. The updated installation rates reflect recommendation from the *R154 Connecticut LED Lighting Study*, but the source of the updated freeridership is unclear.¹³

Table 2: Comparison of PSD Net Realization Rate Inputs

Measure	PSD	Installation Rate	Freeridership	Spillover	Net Realization Rate
CFL	2016	63.0%	19.0%	0.0%	51.0%
CFL ¹	2017	88.0%	47.9%	0.0%	45.9%
LED	2016	82.0%	0.0%	0.0%	82.0%
LED	2017	97.5%	24.3%	73.8%	0.0%

¹ The program will cease offering CFLs early in 2017.

Since the completion of the R86 Lighting NTG study, Eversource and the United Illuminating Company (UI) released the *2016-2018 Electric and Natural Gas Conservation & Load Management Plan* (2016 to 2018 CL&M Plan). The plan called for the continued phasing out of CFLs from program offerings through 2018, while shifting support to both

¹² NMR, Cadmus, DNV GL. *R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall*. 2015.

http://www.energizect.com/sites/default/files/CT%20Residential%20LED%20Lighting%20Market%20Assessment%20and%20Lighting%20NTG%20%28R86%29_Final%20Report_06.19.15.pdf.

¹³ NMR Group, Inc. 2016. *Connecticut LED Lighting Study Report (R154)*. Available at *Connecticut LED Lighting Study*.

standard and specialty LEDs. However, after the Connecticut Department of Energy and Environmental Protection (DEEP) approved the plan, ENERGY STAR® released Lamp Specification 2.0. Because very few CFLs meet the criteria,¹⁴ the Companies adjusted their Lighting Strategy to phase out CFLs by early 2017, coinciding with the implementation of the ENERGY STAR implementation date.

The C&LM plan also called for supporting lighting products in multiple retail channels, including those considered as serving HTR consumers who are less likely to purchase or use energy-efficient bulbs mostly due to cost barriers.

Table 3 lists the unit and saving goals for the Retail Products Program, as well as the percentage of all residential savings represented by the program. The plan does not indicate the number of CFLs and LEDs, specialty and standard products, or retail channels to be supported in each year, though it does specify a minimum number of LEDs expected to be supported. The table makes clear that the Companies will still rely heavily on the Retail Products Program to achieve a significant share of residential savings over the 2016 to 2018 program cycle, but they anticipate the savings falling precipitously in 2018.

The reason for the decline stems from multiple factors and assumptions:

- At the time the plan was written, it was assumed that the next phase of the Energy Independence and Security Act (EISA), to be implemented in January 2020, would essentially make LED bulbs the new baseline.
- The continued LED price decreases would lead to a higher natural adoption rate prior to 2020.
- The global lighting industry has committed to supporting LEDs because they believe CFLs are inferior products to LEDs for many applications.
- A reduction in claimed Delta Watts, which is the result of the introduction of lower wattage general service halogens and a greater number of CFL to CFL and CFL to LED replacements (rather than assuming all CFLs and LEDs replace incandescent or halogen bulbs).

Together, these assumptions have implications on the *current* bulb lifetime the Companies can claim for bulbs sold. If the assumed baseline wattage for 2020 approached that of the program bulbs being offered, then the amount of savings the program could claim and factor into cost-effectiveness tests would be greatly reduced post-2019. Stressing that nothing is certain in this dynamic market, it is possible, if not likely, that market changes may lead to the cessation of a retail-based residential lighting program in the next program cycle. The impact of regulatory and legislative requirements on this phase-out remain uncertain, as discussed more below. However, they could serve to accelerate this phase out.

¹⁴ As of June 2017, a CFL search on the [ENERGY STAR product database](#), returns a list of 23 models out of the over 1,450 models currently included.

Table 3: Retail Products Unit and Savings Goals 2015 to 2018
(2016 to 2018 CL&M Plan)

Company	2015	2016	2017	2018
Units				
Eversource	2,211,792	2,684,921	2,631,667	2,435,933
UI	605,963	671,181	670,385	601,615
Total	2,817,755	3,356,102	3,302,052	3,037,548
Annual MWh Savings				
Eversource	51,420	67,192	62,020	53,967
UI	13,648	16,539	15,794	13,304
Total	65,068	83,731	77,814	67,271
Percentage of Residential Annual Savings				
Eversource	40%	58%	53%	42%
UI	65%	60%	59%	51%
Total	43%	58%	54%	44%
Lifetime MWh Savings				
Eversource	524,925	587,271	526,435	432,452
UI	127,161	145,661	134,025	106,572
Total	652,086	732,932	660,460	539,024
Percentage of Residential Lifetime Savings				
Eversource	53%	59%	54%	47%
UI	63%	70%	67%	59%
Total	55%	61%	56%	49%

The evaluation began with the supposition that four important developments in the lighting market since the approval of the three-year C&LM plan may have an impact on the Companies' residential retail lighting plans for the 2016 to 2018 cycle. Knowledge of these developments informs the interpretation of the NTG and market share trends discussed in this report, but the study focuses greatest attention on the ENERGY STAR Lamp 2.0 specification due to its immediate effect on program offerings and market trends.

- ENERGY STAR Lamp 2.0 Specification:**¹⁵ As mentioned earlier, ENERGY STAR released its final Lamp 2.0 Specification, which has important implications for ENERGY STAR qualification for both CFLs and LEDs. The specification adjusts measure life and efficacy requirements, among other factors, but the most important implications are that very few CFLs will meet the new standard as of January 2017, and some low-cost LEDs (see more below) now qualify for ENERGY STAR. The Department of Energy (DOE) allowed LEDs qualified under the new specification to

¹⁵ During the drafting of this report, the administration's proposed budget called for the elimination of ENERGY STAR (see <https://www.bloomberg.com/graphics/2017-trump-budget/>). The subsequent appropriations bill funded ENERGY STAR through September 2017, but the proposed 2018 budget still zeros the budget for ENERGY STAR starting in October 2017. Congress is currently holding hearings on the budget, and there appears to be support in favor of funding ENERGY STAR. In short, ENERGY STAR's future remains unclear, but signs are pointing to its continuation in 2018. For more information see Ungar, L. 2017. Available at <http://aceee.org/blog/2017/05/making-america-inefficient-budget-s> as well as personal communication.

be labeled and sold as ENERGY STAR starting in Summer 2016. During in-depth interviews in November and December of 2016, program staff reported that they had added these newly qualified LEDs to the product mix and were phasing CFLs out of the program, with very few CFL sales anticipated for 2017 (all 2017 CFL sales resulting from existing MOUs set to expire early in the year).

2. **Value-line LEDs:** A variety of non-ENERGY STAR qualified LEDs had been around for a few years, but the shelf space devoted to them skyrocketed over the months leading up to the evaluation. Some lighting and energy-efficiency experts fear that less expensive LED models, often called *value-line* LEDs, may suffer from poor quality (premature failure, lack of omnidirectionality, limited durability, and questionable light quality) stemming from a rapid increase in manufacturing that may sacrifice quality control in order to meet customer demand.¹⁶ While the new ENERGY STAR specification allowed some lower-cost models to qualify for the label,¹⁷ numerous others that still fail to meet the ENERGY STAR specifications remain on store shelves. These non-qualifying LEDs are the bulbs this study refers to as value-line. The persistent availability of value-line bulbs will likely have impacts on the lighting market. The impacts could be positive, such as leading to greater consumer adoption of all LEDs (including ENERGY STAR models); they could be negative, if value-line LEDs prove to be poorly performing and turn consumers off to all LEDs (including ENERGY STAR models); or they could be a mixture of the two.
3. **DOE Rulemaking on EISA 2020 Implementation:** As explained above, the original EISA legislation called for a second wave of standard increases to go into effect in January 2020. As written, the next wave of standards would bar the manufacturing, importation, and sale of bulbs that did not meet the 45 lumens/watt backstop included in the original EISA 2007 legislation. Yet, the legislation also allowed the DOE to issue a rule by January 1, 2017, that could alter certain aspects of the rule.¹⁸ In two rules dated December 29, 2016, and published January 18, 2017, the DOE expanded the definition of *general service lamp* to include many specialty bulbs that had previously been exempt from EISA. Although it remains to be seen whether EISA and these rules will be enacted or enforced by the new administration, as it now stands, on January 1, 2020, all general service lamps must meet a 45 lumens/watt standard and no longer be manufactured or imported into the United States.
4. **November 2016 Election:** In January 2017, the Republican party took control of both the Legislative and Executive branches of government. Members of the new administration have voiced skepticism about the role of human activity in climate change and are generally less supportive of energy-efficiency and renewable energy compared to fossil fuels.¹⁹ A prior failed legislative attempt to overturn the lighting

¹⁶ CFLs suffered a dip in quality in the mid-2000s, which permanently led some consumers to reject them. These commentators fear a similar fate if value-line LEDs prove to be of low quality.

¹⁸ The DOE had also considered increasing the lumens per watt standard for CFLs and LEDs but ultimately dropped that consideration.

¹⁹ See summaries of cabinet member positions at <http://www.nbcnews.com/feature/trump-cabinet>; accessed March 2017.

efficiency standards of EISA resulted in a budget rider that remains in effect, barring Congress from allocating funds towards its enforcement. As of March 2017, the new administration has not addressed the EISA legislation directly, but some commentators expect the law will not be enforced and may be overturned.

However, some market forces may stand unchanged in the face of these developments and regardless of federal action or inaction on lighting standards. As this study shows, LED sales and shipments have increased dramatically, and manufacturers and retailers believe they are a superior technology and will eventually take over the market. Individual states and nations outside of the United States have voiced continuing commitment to energy efficiency. In short, the momentum behind the LED market could be strong enough to withstand any potential federal attempts to roll back or fail to enforce existing standards.

The lighting market, then, challenges all efforts at predicting its future, which further challenges any attempts to estimate prospective NTG ratios. For this reason, this study takes advantage of the collective knowledge of lighting program administrators and implementers outside of Connecticut and evaluators with experience in Connecticut and beyond to review retrospective NTG estimates for Connecticut for 2015, recent NTG estimates from other jurisdictions, and the most recent residential lighting market intelligence available to estimate prospective NTG for Connecticut through 2021.

1.2 STUDY OUTCOME AND OBJECTIVES

The R1615 study outcomes included estimates of 2015 NTG ratios and predictions of 2016 to 2021 NTG ratios for LEDs. Where possible, results are reported separately for standard, reflector, and all other specialty LEDs (specialty bulbs are defined here as anything other than an A-line and reflector LEDs, such as globe, 3-way, and candelabra bulbs). Given that specialty LEDs only represent 5% of program sales, only the demand elasticity modeling effort provided an estimate of net-of-freeriders for this category of products.

The main study objectives included:

- Estimate 2015 NTG ratios overall and for standard and reflector LEDs (the most common specialty bulb). Compare these estimates to those developed in a prior study for 2013 and 2014²⁰ and to the assumptions included in the 2016-2018 C&LM Plan and 2015 and 2016 PSDs.
- Examine studies in other jurisdictions and stay apprised of changes in the lighting market in response to federal standards and ENERGY STAR specifications as well as changes in the availability of various bulb types.

²⁰ NMR, Cadmus, DNV GL. *R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall*. 2015.

<http://www.energizect.com/sites/default/files/CT%20Residential%20LED%20Lighting%20Market%20Assessment%20and%20Lighting%20NTG%20%28R86%29%20Final%20Report%2006.19.15.pdf>.

- Use the NTG estimates for 2013 and 2015, supplier and model-based predictions of future sales, and the information on NTG trends in other areas and on market changes to convene a panel of lighting experts to use a consensus-building approach to develop prospective (forward looking) NTG ratios for standard and reflector LEDs for 2016 to 2018, and possibly through 2021.

2

Section 2 Methodology

The R1615 study involved in-depth interviews with manufacturers and high-level buyers (referred to as *suppliers*) and program and evaluation staff, sales data modeling, and demand elasticity modeling. The study also included a benchmarking task that examined LED market trends and NTG in other areas. A team of experts then engaged in a process of examining the results of the various Connecticut and external studies and lighting market trends and using them in a consensus approach to develop recommended standard and reflector LED NTG estimates. Table 4 summarizes the research tasks and the key research questions each address—some of which provided market information that informed the NTG consensus process. The following section describes these tasks; Appendix A provides additional details.

Table 4: Summary of Research Methods

Task	Key Research Questions
Supplier Interviews (n=16 lighting manufacturers and high-level buyers) (n=2 program managers/evaluation staff)	<ul style="list-style-type: none"> Based on supplier estimates of the program impact on sales, what was the NTG ratio for standard and reflector LEDs and what might those ratios be in 2016-2021? What will be the likely market and program impacts of value-line LEDs, the ENERGY STAR Specification, and EISA 2020 regulations? What are their predictions for market penetration trends for standard and reflector LED products?
Demand Elasticity Modeling	<ul style="list-style-type: none"> What is the relationship of price and promotion to sales (elasticity)? What would LED sales be without the program's intervention (baseline sales); and What is the program freeridership rate?
Sales Data Modeling	<ul style="list-style-type: none"> What have been the trends in LED sales from 2009 to 2015 in states with programs and states without programs? What is the NTG ratio for LEDs in 2015?
Benchmarking	<ul style="list-style-type: none"> What have studies suggested are the recent and prospective LED NTG ratios in other jurisdictions?
Consensus NTG	<ul style="list-style-type: none"> Considering the results of Task 2 – Task 4, what do persons knowledgeable about the CT, regional, and national lighting programs and market predict NTG to be in 2016 to 2020?

2.1 IN-DEPTH INTERVIEWS – METHODOLOGY

As mentioned, the study included in-depth interviews with program and evaluation staff members (n=2) and lighting suppliers who participated in the program in 2015-2016 (n=16).²¹ The supplier interviewees included the following:

- Fifteen lighting manufacturers who together accounted for 88% of the Connecticut 2015-2016 sales in the program tracking database
- One high-level lighting buyer who accounted for 3% of the 2015-2016 program sales²²

The supplier interviews, which were completed from September through November 2016, covered the following primary topics:

- Program impacts to determine retrospective (2015 and 2016) and prospective (2017-2020) NTG ratios (R1615)^{23,24}
- The market impacts of ENERGY STAR Lamp 2.0 specification and EISA 2020 implementation (R1615 and R1616)
- Market penetration trends for LED products (R1615 and R1616)

In addition to these primary topics, other topics included reasons for selecting particular lighting products to sell through the program and for joining the Connecticut program.

Most of the supplier interviews were fielded prior to the 2016 presidential election. Some interviewees indicated that their responses may change based upon the results of the election, largely assuming a less optimistic future for LEDs under the new administration. If asked today, it is likely that at least some suppliers would provide higher prospective NTG ratios and lower LED market shares than reflected in the results presented here.

Program staff interviews were conducted in November and December 2016 and touched on many of the same topics above (but were not asked NTG-related questions). The interviews also focused on process-related questions such as outreach to HTR customers, program design, relationships with program implementers, and marketing. The results of these process-related questions are summarized in Appendix B and are in support of R1616.

2.1.1 Retrospective NTG

To estimate retrospective NTG ratios, interviewers asked suppliers a series of questions about what their sales of standard and reflector LEDs would have been in the absence of the program. Generally, if a respondent said they would not have sold any of each type of LED

²¹ A *high-level lighting buyer* refers to a purchaser of lighting products for a large chain retailer that participates in the Connecticut program. The data spanned the period of June 2015 through June 2016, which included a change in program cycles.

²² In addition to this retail lighting buyer interview, we also completed a second “proxy” interview with a high-level retail buyer. In this case, the high-level retail buyer elected to have their primary lighting supplier do the interview in their stead. This other retail buyer accounted for 16% of 2015-2016 program sales.

²³ While Connecticut does not apply retrospective NTG values, R1615 estimated NTG ratios for 2015 and 2016 (the program year in which the evaluation was conducted) with the understanding that they would serve as anchors for estimating prospective NTG ratios because retrospective NTG is measurable whereas prospective NTG is essentially speculative.

²⁴ Estimates for 2017 were prospective at the time this research was conducted. The study recognizes that the 2017 net realization rates have been finalized, so it does not make recommendations to revise NTG for 2017.

in Connecticut without the program, the sales from this respondent were assigned a NTG ratio of 100%. If the respondent would have sold LEDs, they were asked a series of questions to estimate their anticipated sales in the absence of the program. If a respondent sold both types of LEDs, they answered each series of questions separately for the two types of bulbs. The following formula was used to calculate the retrospective NTG ratios for both bulb types:

$$NTG = \frac{(\text{Supplier reported total sales} - \text{Supplier reported sales without program})}{\text{Total program sales (actual)}}$$

Using the ratio of standard to reflector LED program sales, the study calculated an average weighted NTG ratio for LEDs overall. See the interview instrument in [Appendix C](#) for further context.

Manufacturers were also asked the questions separately for each retail channel through which they offered program-supported bulbs, although to limit the survey's length, the study prioritized obtaining NTG estimates from retail channels with the greatest program sales volumes for manufacturers working through several channels.

The quantity of bulbs that each respondent sold through the program was used to weight the NTG ratios provided by individual respondents (within a given type of market actor) up to a retail channel level.

This method does have weaknesses stemming largely from three potential sources of bias, as explained below.

1. **The gaming or don't kill the golden goose bias:** This potential bias occurs when suppliers purposely exaggerate how much their lighting product sales would decrease in the absence of the program. Their motivations would be to ensure that they continue to receive program discounts/rebates.
2. **The green retailer bias:** This potential bias occurs when suppliers underestimate how much their sales would drop in the absence of the program. The reason for doing so may be an inflated confidence in their company's ability to market environmentally-friendly products. This bias might be considered a variation of the *social desirability bias*, a well-known concept in program evaluation literature.
3. **Lack of adequate market knowledge:** Another potential source of bias is the consideration that some suppliers simply lack the broader market knowledge to competently assess what would happen to product sales in the absence of the program. Lighting manufacturers are less prone to exhibit this bias because they must submit proposals to the Companies indicating how many of each product they think they can sell through each retail channel. The study's sample consisted largely of manufacturers, thereby minimizing the impacts of this potential source of bias.

The relative influence of these three sources of bias on the results and the degree to which they offset each other remain unknown.

2.1.2 Prospective NTG

A primary goal of the R1615 study was to develop prospective NTG ratios for LEDs. To develop prospective NTG ratios, the study asked suppliers to predict future standard and reflector LED market shares for 2017, 2019, and 2021 in Connecticut, first assuming the Companies would continue offering LED rebates through 2021 and then assuming the Companies would terminate program support at the end of 2016. Using the following formula, the responses yielded prospective NTG estimates (i.e., program attributable market share) for both bulb types for each of the three years:

$$NTG = \frac{(LED \text{ market share with program} - LED \text{ market share without program})}{LED \text{ market share with program}}$$

The prospective NTG method differs from the retrospective approach in the following ways:

- Suppliers predicted the program impacts based on where they believed the market would be moving, rather than reviewing past and current market conditions.
- Suppliers predicted the program impacts on LED sales in the Connecticut LED market in general and not just their own LED sales.
- Because they were predicting program impacts for the overall Connecticut LED market, the study did not ask them to differentiate among retail channels.

In most cases, the analysis weighted market share predictions based on respondents' 2015-2016 program sales for each bulb type.

2.2 SALES DATA MODELING – METHODOLOGY

The sales data modeling quantified the relationship between lighting program intensity (e.g., residential lighting program spending per household) and LED lighting sales to estimate a program NTG ratio. It relied primarily on 2015 sales data prepared by the CREED LightTracker initiative, although it also leveraged other data sources.^{25,26} The LightTracker sales data were primarily generated from two sources: point-of-of sale (POS) state sales data (representing a subset of retail channels, with the notable exceptions of home improvement (HI), hardware, and some club stores) and National Consumer Panel (NCP) state sales data (representing a different group of retail channels). These two sources collectively represent bulb sales (and exclude fixtures and downlight kits) at the retailers that account for the majority of such sales across the United States.²⁷ In addition to the LightTracker data, the

²⁵ CREED serves as a consortium of program administrators, retailers, and manufacturers working together to collect the necessary data to better plan and evaluate energy efficiency programs. LightTracker is CREED's first initiative, focused on acquiring full-category lighting data, including incandescent, halogen, CFL, and LED bulb types, for all distribution channels in the entire United States. As a consortium, CREED speaks as one voice for program administrators nationwide as they request, collect, and report on the sales data needed by the energy efficiency community. (<https://www.creedlighttracker.com>)

²⁶ The information contained herein is based in part on data reported by IRI through its Advantage service for as interpreted solely by LightTracker, Inc. Any opinions expressed herein reflect the judgement of LightTracker, Inc. and are subject to change. IRI disclaims liability of any kind arising from the use of this information.

²⁷ For example, in Connecticut in 2015, 90% of LEDs and 70% of CFLs were obtained from HI, club, and mass merchandise stores. In Massachusetts in 2015, 79% of LEDs and 66% of CFLs came from HI, mass merchandise/discount, hardware, and club stores. Estimates of incandescent and halogen sales and all types of

model inputs included a combination of program data from administrators across the nation collected by the evaluation team in coordination with the CREED Initiative, and household and demographic data collected through various publicly available websites. The model input data sources are listed here, and discussed in more detail below:

- National bulb sales
 - POS data (grocery, drug, dollar, discount, mass market, and selected club stores)
 - Panel data (HI, hardware, online, and selected club stores)
- US Census Bureau Import data (CFL imports)²⁸
- ENERGY STAR® shipment data (imports and ENERGY STAR market share)
- North American Electrical Manufacturers Association (NEMA) shipment data
- American Community Survey (ACS) data (household characteristics and demographic data)
- Retailer square footage per state (based on the two primary retailer channel data sources)
- General population surveys, lighting saturation studies and other primary data collection made publicly available through evaluation reports

Although Appendix A.1 addresses the strengths and weaknesses of the LightTracker data in more detail, it is critical to understand that the contract between IRI (the third-party who provides LightTracker data) and the evaluation contractor limits the depth of analysis and reporting of the data. For example, the contract does not allow for the reporting of which retailers report sales or analysis of sales by lumen bins or other bulb features (even if the features were included in the original data set or identifiable based on information contained therein). Despite these shortcomings, the evaluation team believes that the ability to analyze market-level bulb sales data at the state and national level outweighs the contractual limitations placed on the analysis and reporting.²⁹

Appendix A.1 also summarizes the steps taken to develop key variables in the model. Other variables (e.g., demographics, electricity price, etc.) reflect data as collected from third-party sources but required no manipulation for inclusion in the model.

2.2.1 Sales Data Model Specification

The primary goal of the model was to quantify the impact of state-level program activity on the sales of LED lighting. Appendix A.1.2 includes detailed discussion of the data sources for

sales are not readily available, but surveys generally find HI and mass merchandise stores to be the most common sources of bulbs. See *Connecticut LED Lighting Study Report (R154)*. Final delivered to the Energy Efficiency Board January 2016. http://www.energizect.com/sites/default/files/R154%20-%20CT%20LED%20Lighting%20Study_Final%20Report_1.28.16.pdf. NMR. 2015. *Results of the Massachusetts On-site Lighting Inventory: 2014*. Delivered to the Massachusetts Program Administrators and Energy Efficiency Advisory Council Consultants March 2014. <http://ma-eeac.org/wordpress/wp-content/uploads/Lighting-Market-Assessment-and-Saturation-Stagnation-Overall-Report.pdf>.

²⁸ The analysis summarized here focuses on LED-only modeling; however, the LightTracker Initiative included models with CFLs as reported for other program administrators. The report discusses the joint CFL/LED modeling effort in [Appendix A](#).

²⁹ Prior to the LightTracker Initiative, evaluator access to market-level bulbs sales at any level of analyses were sporadic. Most retailers agreed to provide program administrators and evaluators their sales of program-supported bulbs only.

each variable and the modeling equation. Key aspects of the lighting dataset as analyzed include:

- 2015 sales volume and pricing for CFLs, LEDs, halogens, and incandescent bulbs for all channels combined, and broken out by the POS and non-POS channels
- Data reporting by state and bulb type
- Inclusion of all bulb styles and controllability (e.g., three-way and dimmable)

The analysis relies on a market lift approach. The approach first uses the model to predict the count of LED bulbs with and without the program (the counterfactual of no program activity is determined by setting the program variable to zero). This change in count represents the *lift*, or net increase in the number of LED bulbs resulting from program activity. The lift is then divided by the total number of program LEDs sold (i.e., the gross number of LED bulbs) to determine NTG:

$$NTG = \frac{(LED \text{ bulbs sold with program} - LED \text{ bulbs sold with no program})}{LED \text{ program incented bulbs sold}}$$

The study tested other factors that influence the sales of efficient lighting, including demographic, social, household, and retail channel variables to capture and control for the unique characteristics of each state that potentially affect the uptake of efficient lighting products, but none were significant predictors of LED purchases. In fact, the regression coefficients for the LED program intensity variables proved inconsistent across several model specifications.³⁰ The robustness of the models suffered because only 17 states had sufficiently granular data to estimate a lamp-specific model. This was largely because LEDs were still gaining market share in 2015, and it was challenging to gain technology-specific program spending for several states. Additionally, the high cost of LED bulbs means more program dollars must be spent per LED bulb and that the resulting modeled impact will be smaller and more difficult to detect. In short, the sales data model presented in the section [Net-to-Gross Estimates](#) is the best LED sales data model that could be developed.

2.2.2 Review of Program Support and LED Sales

Appendix A.1.2 compares in detail the measures of program support and LED sales for the 17 states included in the model. Program spending on LEDs ranged a great deal, from less than a dollar per household (in Georgia) to nearly \$15 per household in Rhode Island. Connecticut exhibited the second highest spending at \$10.97 per household (Figure 1), but the state also ranked highly in the number of LEDs it supported with those program dollars. Figure 2 shows the relationship between this ranking and the number of LEDs purchased per household according to the LightTracker dataset.

³⁰ As part of the CREED Initiative, Apex Analytics (Apex) developed a combined CFL and LED model for two other states using these same data, but the results are not yet public. Appendix A.1.2 provides the model which was robust and not overly sensitive to specification. The model was driven by CFLs, however, which provides little useful information for understanding LED NTG and predicting prospective NTG through 2018 and beyond. Therefore, the current study (R1615) did not use this joint CFL/LED model.

Figure 1: LED Program Spending and Bulbs Supported per Household in 2015 by State

(Based on literature review, n=17 states)

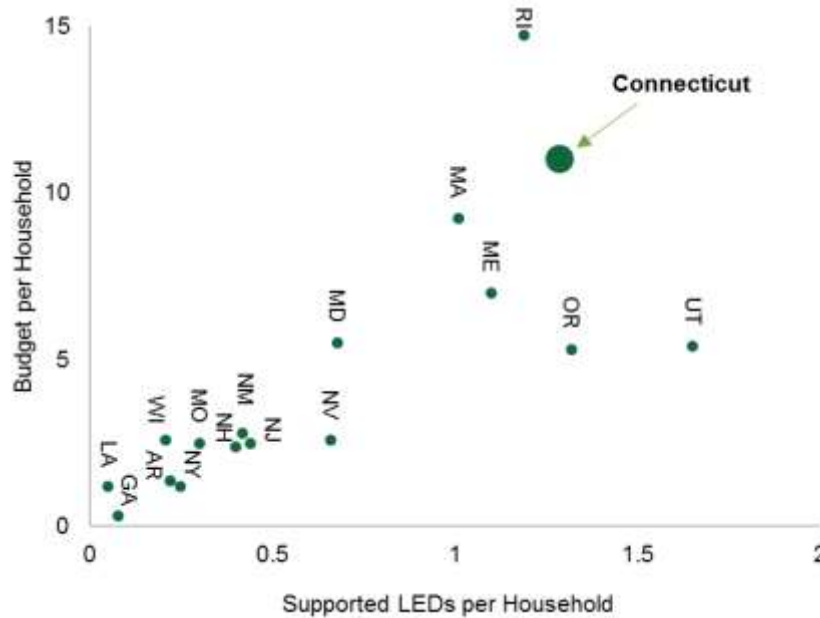
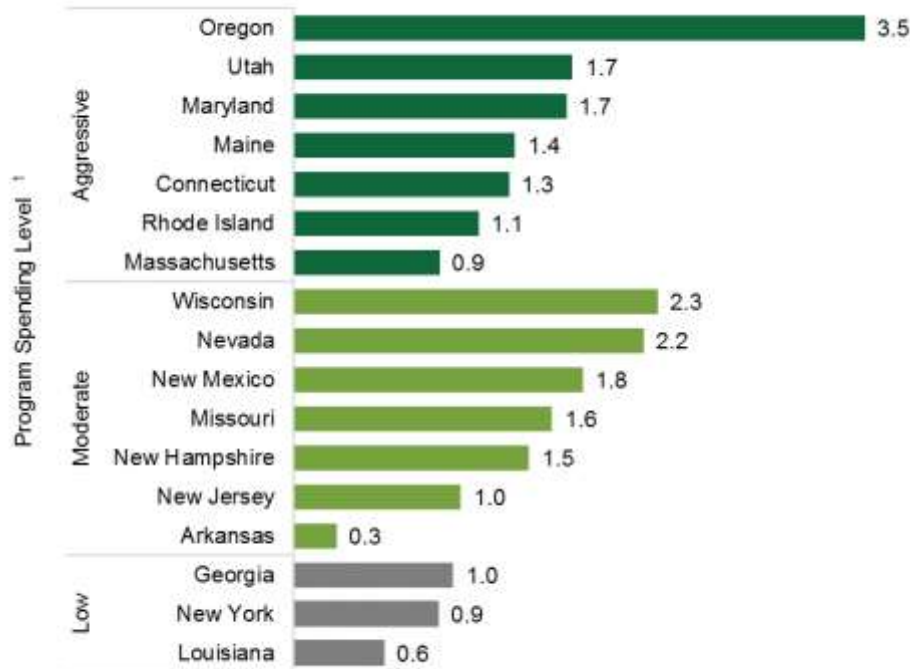


Figure 2: Average LEDs Purchased per Household in 2015 by State

(Based on LightTracker data, n=17 states)



¹ LightTracker classifies the intensity of program spending by the amount spent per household. States spending > \$5 per household are classified as *Aggressive* spending, those spending > \$1 and < \$5 are *Moderate* spending, and those spending =< \$1 are *Low* spending.

More generally, the level of program support was correlated to the number of bulbs supported per household. The states with the most aggressive program spending did not always exhibit the highest number of overall LED purchases. Connecticut (along with Rhode Island and Maine) was in the top tier of program spending but the middle of overall LED purchases within the model sample.

The study attempted to explain the unexpected findings, arriving at three plausible explanations:

- First, as mentioned above, the LightTracker data represent the best source of market-level sales data available, but the dataset is not perfect. The point-of-sale data that make up part of the overall dataset exclude HI, hardware, and some membership stores, which are some of the most common places where consumers buy bulbs.³¹ Except for the mass merchandise channel, retailers in the point-of-sale dataset tend to carry and sell a smaller volume of bulbs, and stocking leans towards inefficient bulb types, which could bias any effort to describe national sales from these channels only. In contrast to the point-of-sale data, the panel data that account for the remainder of the LightTracker dataset include all retail channels and retailers. However, a thorough review of the data suggests that households likely differ in how diligently they scan lighting purchases, which could also create bias (e.g., if they were more likely to scan memorable purchases). Each of these weaknesses may introduce bias, particularly leading to undercounts of purchases made in certain channels (exacerbated by the uneven distribution of retailers across the nation) or transactions—such as light bulb purchases—that may be less memorable (and therefore more prone not to being scanned). The model attempts to control for the channel-related bias through the inclusion of a variable for the square footage of retailers not in the POS data, but the evaluators could not mitigate bias related to inconsistent scanning.
- Second, the modelling team did not have access to estimates of household-level socket saturation for each state, yet previous research has suggested that prior high levels of energy-efficient socket saturation reduce current energy-efficient bulb sales.^{32,33} In short, the more long-lived bulbs a household already has installed, the fewer lighting purchases it must make. Unfortunately, the lack of saturation rates for most of the 17 states preclude us from testing this explanation directly.
- Third, and related to the second point, is the history of program activity.³⁴ Again, research has shown the importance that the duration of prior program activity has on energy-efficient bulb purchases. States with long-standing, aggressive programs succeeded in getting households to adopt these energy-efficient bulbs, and, again,

³¹ For bulb sales by channel in Massachusetts, see NMR Group. 2016. *RLPNC 16-3 Lighting Decision Making*. <http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC-16-3-Lighting-Decision-Making-Memo.pdf>. The forthcoming Massachusetts RLPNC 16-6 Shelf Stocking and Webscraping Study addresses bulb stocking practices and availability by retail channel.

³² See NMR 2010. *Results of the Multistate CFL Modeling Effort*. at <http://www.energizect.com/sites/default/files/FINAL%20CFL%20Modeling%20Report%20CT%20020210.pdf>

³³ See NMR 2011. *Results of the Multistate CFL Modeling Effort (Y2)*. At <file:///C:/Users/Chris/Downloads/2011-Multi-State-CFL-Modeling-Report.pdf>

³⁴ See NMR 2011. *Results of the Multistate CFL Modeling Effort (Y2)*. At <file:///C:/Users/Chris/Downloads/2011-Multi-State-CFL-Modeling-Report.pdf>, section 4.

because of longer measure lives, households need to purchase fewer bulbs. In short, other states are catching up to the level Connecticut and some other program states established in prior years.

2.3 DEMAND ELASTICITY MODELING – METHODOLOGY

Examining lighting products that incur price changes and promotion during the program period provides valuable information regarding the correlation between sales and prices.

Demand elasticity modeling derives from the same economic principle driving program design: demand for efficient lighting is elastic and changes in price and merchandising generate changes in quantities sold (i.e., the upstream buydown approach). Demand elasticity modeling uses sales and merchandising information to achieve the following:

- Quantify the relationship of price and merchandising to sales
- Predict the likely sales level without the program intervention (i.e., baseline sales)
- Estimate freeridership by comparing predicted baseline savings with predicted program savings

Importantly, the demand elasticity approach relies only on program data; therefore, the resulting estimate is net-of-freeriders, which excludes spillover. Including spillover would produce a full NTG estimate and would be higher than net-of-freeriders. However, the data do not allow for this adjustment. Estimating freeridership using the demand elasticity model involved estimating price elasticities and coefficients for non-price effects (e.g., in-store promotions and merchandising).

Price elasticity is measured as a proportional change in demand relative to a proportional change in price. For example, if the price of a light bulb decreases by 10% and sales increase by 20%, the elasticity is equal to two. The upstream program approach assumes that decreasing prices for efficient lighting products will increase demand. Estimating price elasticities and having the price absent program incentives (and therefore the proportional discount) allows researchers to estimate demand for program bulbs absent the program incentives. To estimate a freeridership ratio, predicted program sales and sales likely to occur without program incentives and promotions are first multiplied by savings per-bulb. The freeridership ratio is then the relationship between the predicted savings without the program and the predicted savings with the program:

$$\text{Freeridership Ratio} = \frac{\text{Predicted Savings without Program}}{\text{Predicted Savings with Program}}$$

As the demand elasticity approach relies exclusively on program data, the model's robustness depended on data quality. Overall, the available data from the Connecticut Lighting Strategy achieved a sufficient quality to support the analysis. However, there were adjustments made to several key inputs in the model. The modifications to the following inputs are discussed in greater detail in Appendix A.2.1:

- **Seasonality:** The demand elasticity model included a seasonal trend provided by APT, the previous program implementer, to control for seasonal sales variations that

result from seasonality (i.e., changes in daylight hours) rather than program factors. The seasonal trend represented the proportion of annual national sales expected to occur in a given month from a major national lighting manufacturer. Using data at a national aggregation level, including non-program products and areas without programs, limited the degree that resulting trends correlated with program activity.

- **Price Variation:** The modeling approach combined sales and prices for similar products (e.g., all 60-watt equivalent A-line bulbs) within the same store rather than observing price and sales variations for each individual model number. Aggregating prices and sales captures 1) substitutions between comparable program products within each category and 2) variations in price across comparable products. The model only included sales with price variations as products with no variation in price do not contribute any information to the model. The greater the price variation levels across retailers and lamp styles, the more representative the elasticity estimates became when applied to sales of products that did not exhibit price variations.
- **Promotional Displays:** Program data contained a comprehensive list of all in-store promotional events, but the information on merchandising displays only represented a sample of locations. Due to the merchandising data's nature, the model could not predict sales for observations with missing merchandising data, and substituting merchandising coefficients would risk overstating program impact. However, not accounting for merchandising may overestimate freeridership to the extent that the price coefficients do not reflect all the merchandising impact. Ultimately, the study excluded display merchandising data from the model.

The demand elasticity model specification is described in detail in Appendix A.2.2. In short, the study organized bulb and pricing data as a panel, with a cross-section of program bulb quantities for each unique retail location, bulb type, and baseline wattage combination. These were modeled over time as a function of price, bulb characteristics (specialty, standard, reflector), and retail channel (e.g., club, HI, HTR, and mass market). Nesting elasticity estimates this way accounts for differences in retailer strategies and target demographics, as well as differences in demand given bulb characteristics.

Using *block bootstrap* standard errors, the distribution of freeridership predictions was normally distributed with a median value nearly identical to the estimated freeridership rate (52.8% compared to 52%) with precision of +/- 7% at the 90% confidence interval (Appendix A.2.3).

2.4 BENCHMARKING – METHODOLOGY

After reviewing numerous studies, the team identified 11 studies estimating retrospective and prospective NTG ratios for upstream lighting programs from 2013 to present to use for benchmarking R1615 results. Benchmarking the studies offered insights into the validity and reasonableness of the NTG ratio that the R1615 study estimated. Appendix A.3 lists the references.

2.5 CONSENSUS PANEL – METHODOLOGY

In February 2017, the team held a consensus panel tasked with recommending program NTG.

2.5.1 Background on Approach

The previous tasks yielded multiple estimates of and insights into NTG for 2015 and 2016 and predictions of NTG for 2017 through 2021. Each of the methods, however, has strengths and weaknesses, and only one approach had the ability to provide predictions for prospective NTG. Therefore, the study turned to a team of lighting experts and asked them to engage in a consensus-building approach (i.e., consensus panel) to integrate the NTG estimates into finalized recommended values for LEDs for each year (i.e., retrospective for 2015 and 2016 and prospective for 2017 to 2020). Consensus panels help limit the bias introduced by any single method or evaluation study author in recommending a NTG value. Instead, the reliance on multiple estimates and the collective wisdom of individuals familiar with the Retail Products Program and programs regionally and nationally limits individual bias to successfully assess a rapidly changing market. In fact, members of the evaluation team successfully used this approach recently in Massachusetts.³⁵

2.5.2 Panelists

Panelists included Evaluation Administration (EA) team members, the R1615 evaluation contractor task leads, and one program manager from a different service territory. Given the Connecticut Road Map, the team was precluded from including Eversource and UI Program Managers, members of the EEB Committee, and Connecticut implementation contractors. The team was unable to find a neutral implementation contractor panelist who did not find themselves with conflicts of interest. Ultimately, the panel included six voices:³⁶

1. **EA Team Member A.** R1615 study lead on behalf of the EA team; recognized by the EEB as an industry leader capable of offering unbiased decisions
2. **EA Team Member B.** Consensus panelist in 2013 Massachusetts Multi-Stage Lighting NTG Assessment; recognized by the EEB as an industry leader capable of offering unbiased decisions
3. **Evaluation Contractor A.** R1615 overall study and sales data modeling lead; 2014/2015 R86 lighting NTG study and Massachusetts Multi-Stage Lighting NTG Assessment key contributor; project lead on over a dozen lighting studies since 2008 across the US, including throughout the Northeast, California, and the Midwest
4. **Evaluation Contractor B.** R1615 supplier interview fielding and analysis lead; since 2012, has estimated NTG for Massachusetts, California, and Connecticut lighting programs, typically using a supply-side self-report methodology

³⁵ NMR, Cadmus, and DNV GL, 2015. *Multistage Lighting Net-to-Gross Assessment Overall Report*. Delivered to the PAs and EEAC Consultants in August. <http://ma-eeac.org/wordpress/wp-content/uploads/Multistage-Lighting-Net-to-Gross-Assessment-Overall-Report.pdf>.

³⁶ Panelists were permitted to confer with their colleagues who they felt were knowledgeable, but each firm/organization only had a single “voice” in the process.

5. **Evaluation Contractor C.** R1615 demand elasticity modeling lead; experience conducting demand elasticity modeling in programs in over eight states, including Massachusetts; recently served as a working group member for a lighting NTG study in Pennsylvania
6. **Program Manager.** West coast program administrator; manages measure development, and review processes for emerging technologies; over 20 years of engineering, energy efficiency, and project management experience, including numerous projects involving lighting

The EA Team lead took part as an observer in the final consensus meeting (described below) to ensure objectivity and adherence to the Connecticut Evaluation Roadmap.

2.5.3 Activities and Steps³⁷

Distribution of Research Results

As a first step in this process, the evaluators prepared a summary of the results from the current R1615 research tasks, results from the 2014/2015 R86 Connecticut NTG study, and recent LED NTG results from other jurisdictions, including the known strengths, weaknesses, and sources of potential bias of the various approaches and studies. The summary was distributed to the six panelists (Appendix C.3).

Initial Responses

Next, panelists anonymously provided their own assessments to an NMR staff person acting as an unbiased moderator and protecting the anonymity of all panelists.³⁸ Through email with the moderator, panelists indicated which methods offered the strongest estimates of NTG and their own estimates of NTG based on the results of the various methods together with information on prior saturation trends, NTG estimates from other jurisdictions, their own expertise, and the most current information available on the implementation of EISA 2020 and the ENERGY STAR Lamp 2.0 specification.

Summary of Responses

The moderator gathered and summarized panelists' responses and distributed them in aggregate via email to the group. Then the group met to discuss the approaches and their estimates, and ultimately reach consensus on recommended values for 2015 through 2020.

Panel Meeting

The moderator structured the two-hour meeting by first summarizing panelists' perceptions of the validity of the benchmarking studies and offering panelists the opportunity to make additional cases in favor of or against the validity or applicability of the studies. Next, the moderator framed the NTG discussion by asking attendees to step back and consider the future of the LED market, asking them to predict the direction the market would go without

³⁷ The consensus-panel differed from a Delphi approach: panelists provided only one round of anonymous estimates and the *final* decisions were determined during a single meeting through dialogue as opposed to another round on anonymous submittals.

³⁸ This staff member was not an industry expert, and, therefore, was able to remain unbiased.

potential program support. After facilitating that discussion, the moderator presented the mean, maximum, minimum, and median NTG estimates that panelists had submitted. While doing that, the moderator summarized the rationales that panelists had included alongside their submitted estimates. The moderator asked panelists for their reactions to the results and offered them the opportunity to share why certain values might be more reasonable than others. At the end of the meeting, panelists agreed on which values to recommend for the program.

3

Section 3 Net-to-Gross Estimates

The study examined NTG ratios through supplier interviews, sales data modeling, demand elasticity modeling, and benchmarking. The study then invited a panel of lighting experts to consider the results of these approaches and market intelligence and to recommend NTG values retrospectively for 2015 and 2016 and prospectively for 2017 through 2020. The study estimated retrospective 2015 NTG ratios to serve as an anchor point; the evaluation was conducted in 2016. Table 5 presents the results of the R1615 efforts.

Table 5: Estimated and Recommended LED NTG Estimates

Source	Retrospective ¹		Prospective ²				
	2015	2016	2017	2018	2019	2020	2021
% of CT Lighting Strategy 2015 Program Bulbs	100%	100%	-	-	-	-	-
2016 to 2018 PSD	82%	82%	-	-	-	-	-
In-depth supplier interviews	61%	61%	40%		38%		35%
Sales data modeling	70%	70%	-	-	-	-	-
Demand elasticity modeling ³	61%	61%	-	-	-	-	-
Consensus panel / Recommended	63%	57%	47%	40%	36%	33%	-

¹ The in-depth interviews addressed 2015-2016 estimates together, while the sales data and demand elasticity modeling addressed only 2015. The consensus panel recommended separate estimates for 2015 and 2016.

² Note that the PSD prospective estimates beyond 2018 have not yet been released; other empty cells indicate that the related task did not estimate NTG for the corresponding year.

³ Because the model includes only program data, the estimate is net-of-freeriders, which excludes spillover.

Appendix A.4 describes the consensus panel's reasoning behind their recommendations. In short, four factors drove their decision making, as described in more detail below:

- **Steady declines.** After anonymously providing estimates, the consensus panel used the average of their estimated NTG ratios for the LED market overall which they initially provided for 2015 through 2016. They recommended 63% for 2015 and 57% for 2016.
- **Long-term uncertainty.** Panelists' average estimates for 2018 through 2020 continued the steady decline from 2017: 47% for 2017, 40% for 2018, 36% for 2019, and 33% for 2020.
- **Bulb type.** The panelists ultimately decided to combine standard and reflector bulbs into a single category of non-HTR LEDs due to the similarity in separate estimates and uncertainty regarding the adoption and implementation of the DOE rule that expands the general service lamp definition to include reflectors and many other specialty bulb types.

- **Distinction across markets.** One of the themes stretching across panelists' reports of the market was that incentives appear more pivotal for incenting HTR customers to purchase LED bulbs. Therefore, they recommended that increasing NTG estimates for the HTR market by 20 percentage points across years would result in fair estimates.

3.1 RETROSPECTIVE NTG ESTIMATES: LEDs OVERALL

- *The study tasks resulted in overall 2015 LED NTG ratios ranging from 61% to 70%. The results—coupled with additional market information—led the consensus panel to recommend an overall non-HTR LED NTG ratio (inclusive of standard [A-line], reflector, and other specialty types) of 63% for 2015 and 57% for 2016.*

Table 6 compares the retrospective LED NTG ratios across research activities by bulb type and shows the ratios that the study—supported by the consensus panel—recommends.

Table 6: Estimated and Recommended Retrospective LED NTG Estimates¹

Source	LED Bulb Type ¹				HTR – All LED Styles
	All	Standard	Reflector	Specialty	
% of CT Lighting Strategy 2015 Program Bulbs	100%	68%	23%	9%	-
2016 to 2018 PSD	82%	-	-	-	-
In-depth supplier interviews ²	61%	63%	58%	-	100%
Sales data modeling	70%	-	-	-	-
Demand elasticity modeling ³	61%	73%	62%	40%	-
Consensus panel / Recommended	2015	63%	63%	63%	83%
	2016	57%	57%	57%	77%

¹ Note that the PSD prospective estimates beyond 2018 have not yet been released; other empty cells indicate that the related task did not estimate NTG for the corresponding year.

² The in-depth interviews addressed 2015-2016 estimates together, while the sales data and demand elasticity modeling addressed only 2015. The consensus panel recommended separate estimates for 2015 and 2016.

³ Because the model includes only program data, the estimate is net-of-freeriders, which excludes spillover.

For the 2015-2016 period, suppliers estimated an overall LED NTG ratio of 61%, the sales data modeling resulted in an overall LED NTG ratio of 70%, and demand elasticity estimated net-of-freeriders of 61%. In comparison, the last supply-side-based LED NTG estimate for Connecticut's program (for the 2014 period) was 74% and the 2017 PSD uses a value of 82% (based on the recommendations of the R86 Lighting NTG study).

Suppliers attributed a decline in program attribution to increasing availability of LEDs, declining LED prices, and broader consumer acceptance of LED products. In the words of one supplier,

“The industry has been saying for over a year now, publicly, that the LED transition is happening. It’s happening partially because of programs like the Massachusetts and Connecticut programs, [but also] partly because of non-ENERGY STAR high-quality, low-priced products from major manufacturers.”

Literature over the past several years outside of Connecticut have estimated overall LED NTG ratios ranging from 73% to 100%, with a median value of 85% (n=10 studies or TRMs). The most geographically comparable, recently conducted study relied on a consensus panel to estimate retrospective NTG ratio of 95% for Massachusetts for 2014. The individual research efforts conducted there included supplier interviews, demand elasticity modeling, sales data modeling, and comparison area approaches, with empirical estimates ranging from 75% to 98%. The Massachusetts consensus panel predicted a prospective NTG ratio of 93% for 2016 for Massachusetts. Despite these studies’ results, the study and its consensus panel dismissed the results, deeming them outdated; Section 3.3 includes details and further benchmarking discussion.

3.1.1 Retrospective NTG Estimates by Bulb Type

- ***Suppliers and demand elasticity modeling attributed greater program impact on standard bulb sales compared to specialty and reflector sales. Yet the consensus panel believed that the estimates were adequately similar and the uncertainty great enough to assign standard, reflector, and specialty bulbs the same NTG.***

Supplier interviews and demand elasticity modeling both explored NTG by bulb type. The approaches arrived at the somewhat unexpected finding that NTG or net-of-freeriders estimates were higher for standard LEDs compared to reflector and specialty LEDs.

Suppliers estimated a standard LED NTG ratio of 63% and reflector LED NTG of 58%. Table 7 shows demand elasticity results overall and by bulb type. With greater elasticity, specialty (-2.20) and standard (-1.88) LEDs exhibited higher net-of-freeridership rates (62% and 73%, respectively) when compared with reflector LEDs (40%).

The consensus panelists reported the likely explanations for the lower NTG for reflector bulbs. One explanation ties directly to the characteristics of LEDs: reflectors are directional bulbs (i.e., the light only shines downward), they are typically located in recessed cans or in other difficult to access fixtures (making a long-life bulb appealing), and they are frequently tied to dimmer switches. While most manufacturers strive to make standard LEDs omnidirectional, this feature is not necessary for reflectors. Another explanation for lower elasticities for specialty products stems from the fact that there are few viable alternatives to using a specialty bulb in particular applications. For example, households are unlikely to install anything but a flame-style, small-screw base bulb in a candelabra designed for such bulbs. Likewise, panelists noted that reflector CFLs have not successfully penetrated the market, creating less market competition for energy-efficient reflector LEDs. The panelists concurred that the uncertainty in the estimates—and the fact that panelists’ NTG estimates by bulb type varied by five percentage points or less (Appendix A.4.4)—was too great to justify assigning separate NTG ratios for standard, reflector, and specialty bulbs. Thus, the study, as recommended by the consensus panel, recommends the same retrospective and

prospective estimates for non-HTR LEDs presented in Table 6 be applied to reflector and other specialty bulbs as well.

Table 7: LED Elasticities and Freeridership by Bulb Type
(Demand elasticity modeling results)

Bulb Type	Average Elasticity	Freeridership	Net-of-Freeridership
Reflector	-0.84	60%	40%
Specialty	-2.20	38%	62%
Standard	-1.88	27%	73%
Overall	-1.61	39%	61%

3.1.2 Retrospective NTG Estimates by Retail Channel

➤ *Based on suppliers' estimates, the big box stores, with relatively low NTG ratios, drove the overall NTG ratios.*³⁹

The supplier interviews and demand elasticity analysis could provide NTG estimates for some retail channels. The contract covering the LightTracker data prevented the sales data approach from providing similarly detailed results.

The program discounted bulbs in six retail channels:

- HTR⁴⁰
- Grocery
- Hardware
- HI, such as Lowe's
- Mass market, such as Target
- Club, such as Costco

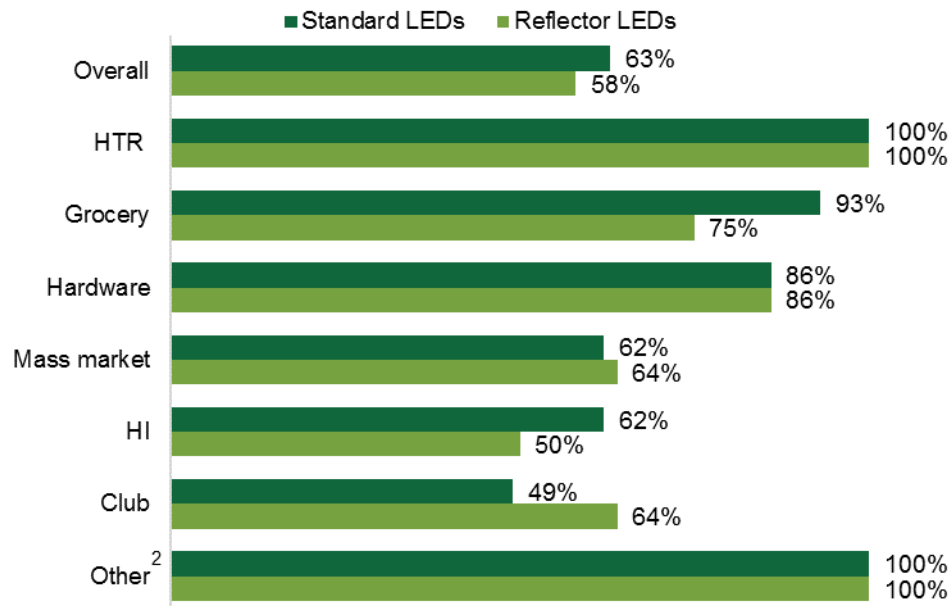
Suppliers' retail channel-level estimates resulted in higher NTG ratios in the HTR channels and lower NTG ratios in the big box stores, including HI, mass market, and club channels (Figure 3). Because big box stores composed over 90% of the program's 2015-2016 program sales for standard LEDs and LED reflectors, the NTG estimates for these channels largely determined the program-level NTG results. For example, HI retailers represented 62% of program LED sales and had NTG ratios of 62% for standard LEDs and 50% for specialty LEDs. Club retailers represented 17% of program LED sales and had NTG ratios of 49% and 64% respectively. Finally, mass market retailers, representing 9% of program LED sales had NTG ratios of 62% and 64%, respectively.

³⁹ Big box stores are retailers with a large volume of floor space, often part of a chain, and offer a wide variety of products.

⁴⁰ According to program staff, the program considers stores HTR based on two factors: 1) if the store is located in a low-income community with a large minority and/or elderly population and 2) if it is a discount store, such as Dollar Tree or Ocean State Job Lot. For the purpose of analysis, the study used the second criterion to classify a store as HTR.

The study agrees with the consensus panel's determination that HTR channels rely on program support more than other channels. Therefore, the study assigned higher NTG ratios for HTR channels; as recommended by the consensus panel, the study therefore adds 20 percentage points to the recommended NTG estimates for HTR channels.

Figure 3: LED Retrospective NTG Estimates by Retail Channel for 2015-2016
(Supplier interview results, n=16)¹



¹ Sample sizes vary by retail channel.

² *Other* represents LED sales through special program-driven community or corporate events.

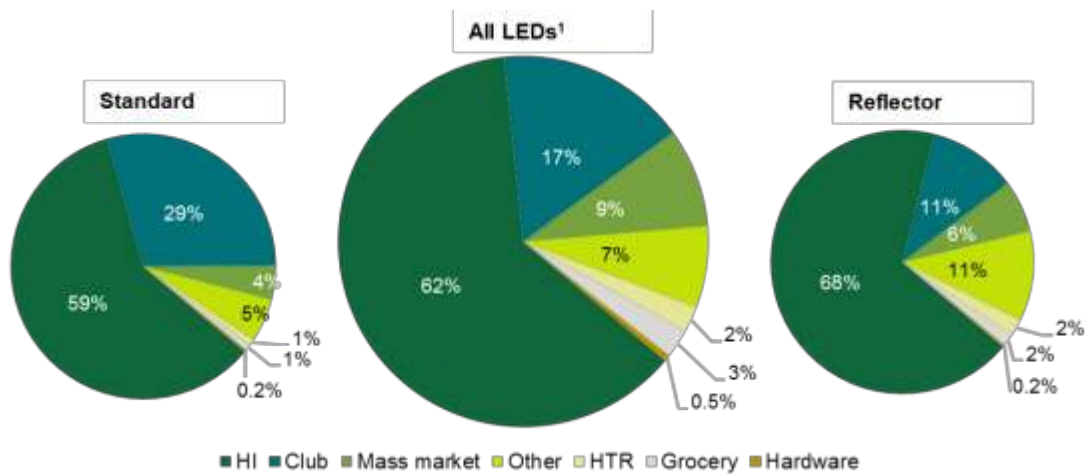
Table 8 shows the number of supplier interviewees who provided NTG estimates (i.e., sample sizes) for each retail channel and the percentage of total program sales through that channel which those interviewees cumulatively represented. Except for the hardware channel, the NTG estimators cumulatively accounted for the vast majority of program sales. Furthermore, as shown in Figure 5 the hardware channel accounted for only a very small percentage of 2015-2016 program LED sales (<1% for both standard and reflector LEDs).

Table 8: Retrospective LED NTG Estimates and Program Sales by Retail Channel and Bulb Type
(Supplier interviews results)

Retail Channel	Standard LEDs			Reflector LEDs		
	n	NTG	% of Program Sales ¹	n	NTG	% of Program Sales ¹
HTR	2	100%	99%	2	100%	99%
Grocery	2	93%	68%	1	75%	59%
Hardware	2	86%	27%	2	86%	27%
HI	7	62%	100%	9	50%	99%
Mass market	4	62%	100%	3	64%	100%
Club	3	49%	100%	4	64%	98%
Other	1	100%	100%	1	100%	100%
Overall	16	63%	99%	16	58%	99%

¹ Percentages of 2015-2016 program sales through the respective channel which estimators represented.

Figure 4: Program LED Sales by Retail Channel
(2015-2016 program data)



¹ Includes standard, reflector, and specialty LED bulbs (n=3.3 million packages).

➤ **Demand elasticity modeling showed particularly high net-of-freeridership among mass market retailers.**

When compared by retail channel, LEDs sold in mass market stores exhibited particularly high net-of-freeridership at 85%. Additionally, mass market retailers produced the greatest estimated elasticity (and therefore price sensitivity) for LEDs (-2.72)—it was noticeably higher than that of LEDs overall (-1.61) (Table 9). According to program data, however, mass market retailers accounted for only 5% of LED sales in 2015, yet club and HI stores accounted for

85% of LED sales among the retailers included in the demand elasticity modeling (Table 20 in Appendix A.2.1).⁴¹

The reader will note inconsistencies between demand elasticity modeling and supplier interview results. For example, demand elasticity modeling yielded much lower NTG ratios for the HTR and grocery channels (42%) than the supplier interviews (ranging from 75% to 100%) and mass market store NTG ratios were much higher (85% versus 62% and 64%). This is the result of the two methods measuring different program influence factors: suppliers assessed the program impact on stocking, while the demand elasticity modeling measured sales and changes in program prices—relying on program data only. In the case of HTR and grocery channels, the results imply that those stores would be less likely to carry bulbs without program support, but customers shopping at those stores were not overwhelmingly sensitive to the reduced prices resulting from program support.

Table 9: LED Retrospective Net-of-Freeridership and Elasticities by Retail Channel

(Demand elasticity modeling results)

Retail Channel	Elasticity	Net-of-Freeridership
Club	-1.52	55%
HI	-1.68	63%
HTR and grocery ¹	-0.53	42%
Mass market	-2.72	85%
Overall	-1.61	61%

¹ HTR stores represented a limited percentage of sales in the model; as such, the analysis aggregated HTR and grocery.

- ***Comparable average markdowns across retail channels indicates that differences in elasticities were a primary driver of differences in freeridership.***

Table 10 shows average prices per LED by retail channel. Before and after applying incentives, grocery retailers exhibited the highest price per bulb.

Overall, LEDs average markdown (i.e., the incentive as a share of the original price) was similar across channels, ranging from 46% to 55%. With relatively comparable markdown levels, differences in elasticities between channels served as the primary driver of freeridership differences between retail channels.

⁴¹ Mass market retailers may provide an opportunity to lower program freeridership with increased program focus. However, mass market retailers typically do not move the same volume as HI and club retailers. Additionally, future elasticities will likely be influenced by the prevalence of and competition from lower-priced, non-ENERGY STAR LEDs.

Table 10: Price per LED by Retail Channel
(Lighting program data – 2015)

Retail Channel	Average Values			
	Initial Price per Bulb	Rebate per Bulb	Final Price per Bulb	Markdown %
Club	\$ 10.07	\$ 4.66	\$ 5.41	46%
HI	\$ 9.84	\$ 4.54	\$ 5.30	46%
HTR and grocery ¹	\$ 13.41	\$ 7.09	\$ 6.32	53%
Mass market	\$ 8.67	\$ 4.74	\$ 3.92	55%
Overall	\$10.12	\$4.79	\$5.33	47%

¹ Demand elasticity modeling required adequate sample sizes for statistical significance so it grouped HTR and grocery channels. HTR retailers alone had the lowest final price per bulb (\$3.50). After removing HTR bulbs from the estimate, the average weighted final price per bulb was still \$6.32, suggesting that grocery stores dominate this combined category.

3.2 PROSPECTIVE NTG ESTIMATES

- *Suppliers predicted decreases in LED NTG from 2017 to 2021, dropping from 40% to 35%. The consensus panel also expected declines, recommending values that drop from 47% in 2017 to 33% in 2020.*

Supplier interviews was the only primary-research task with the ability to measure prospective NTG ratios. This was done by asking suppliers to estimate market share with and without the program in 2017 to 2020.⁴² As shown in Table 11, suppliers predicted steadily decreasing prospective NTG ratios of 40% in 2017, 38% in 2019, and 35% in 2021. They estimated that standard LED NTG would be 39% in 2017 but hold steady through 2021 at 37%. Suppliers estimated lower NTG for reflector LEDs in 2017 through 2021, starting at 41% and declining to 33%.

The consensus panel considered the results of the supplier interviews and various market indicators and intelligence to estimate prospective NTG. While they acknowledged market and legislative uncertainties, the panel reached a consensus estimate of 47% for combined non-HTR LED NTG (standard [A-line], reflector, and other specialty bulbs) in 2017, and expected steady declines after that: 40% for 2018, 36% for 2019, and 33% for 2020. The panel recognized that reflector NTG may be slightly lower than standard NTG, but they predicted that the estimates were close enough (varying by five percentage points or less) and the uncertainty great enough to use the same estimate for all types of LEDs. The study supports these conclusions.

Because they were asked about overall market share, suppliers did not address prospective NTG by retail channel. However, the study concurs with the consensus panel's explanations that other market information points to a stronger program impact on the HTR channel than

⁴² Importantly, the prospective market share estimation method differs from the retrospective one, which was based on suppliers estimating the impact of the program on their organization's sales. Therefore, the two approaches are not directly comparable, and the study discusses only prospective estimates here.

other types of stores and their suggestion that prospective LED NTG estimates be 20 percentage points higher for the HTR market than for the market overall: 67% for 2017, 60% for 2018, 56% for 2019, and 53% for 2020.

Table 11: Prospective NTG Estimates by Year and Bulb Type

(Supplier interview results)

LED Bulb Type	n	Prospective		
		2017	2019	2021
Standard	13	39%	35%	37%
Reflector	13	41%	43%	33%
All	13	40%	38%	35%

3.3 BENCHMARKING

Table 12 lists the literature used in the benchmarking effort. As mentioned previously, overall LED NTG ratios ranged from 73% to 100%, with a midpoint of 85% (n= 10 studies or TRMs). These values are higher than the overall net-of-freeridership and NTG ratios estimated for R1615: 61% from demand elasticity modeling, 70% from sales data modeling, and 61% from supplier interviews. Underscored by the consensus panel, the estimates from other states, however, were developed prior to the R1615 research, and given the rapidly changing market, it is not surprising that Connecticut values would differ from those of earlier studies. Some of the NTG values examined represented deemed or assumed NTG, while others did not clearly define the source of the estimate. The values for Efficiency Maine (77%), Xcel Colorado (91%), and Entergy Arkansas (80%) came from demand and price elasticity modeling. Many of these efforts included participant spillover and nonparticipant spillover—measured through in-store intercept surveys—in addition to freeridership, possibly providing further evidence that the R1615 demand elasticity modeling effort may underestimate the Connecticut program influence.

Supplier interviews also informed the Xcel Colorado and PG&E estimates. Connecticut suppliers' estimate for reflector LEDs (58%) was much higher than the only NTG ratio for reflectors found in literature: PG&E's 2013-2014 upstream lighting program evaluation conducted by DNV GL resulted in a NTG ratio of 27% for reflector LEDs. The reader should note that the two to three years that have passed since that evaluation and the geographical differences between California and Connecticut do not make the R1615 and the California studies perfectly comparable. The California estimates also stand out as being far lower than any others developed, which could reflect a more mature LED market in the state or variations in the estimation methods used there.

Table 12: Benchmarking Retrospective NTG Estimates

State	Entity/Company	Associated year	LED NTG	Research methods
Northeast				
MA	Statewide	2016 ¹	93%	Prospective NTG prediction from consensus panel
	Statewide	2014	95%	Retrospective NTG estimate from consensus panel ³
RI	Statewide	2012	92%	Assumption ³
ME	Efficiency Maine	2013-2014	77%	Price elasticity
CT	Statewide	2014	82%	Demand elasticity, sales data modeling, supplier interviews
Central/Midwest				
CO	Xcel	2015	91%	Demand elasticity, store-intercepts, supplier interviews
Undisclosed (not yet public)		2015	85%	Literature review
IL	ComEd	2014-2015	73%	Store-intercepts
West				
CA	PG&E	2013-2014	40% / 27% ²	Choice model and supplier interviews
	SCE		42% / 28%	
	SDG&E		35% / 28%	
South				
NM	SPS	2014	100%	Assumption ³
TX	CPS Energy	2015	85%	Assumption ³
AK	Entergy	2013	80%	Demand elasticity modeling

¹ Represents a prospective NTG prediction developed in 2015 based on research completed in 2014.

² Standard and reflector LEDs, respectively

³ Values derived from program savings assumptions (such as from a PSD)

One study published prospective NTG ratios, estimating as far forward as 2018, yet the R1615 consensus panel and the study dismissed it, finding its results to be dated given the rapid market changes (Table 13). The study drew on results from a consensus panel held in Massachusetts in May of 2015, and it resulted in LED NTG ratios of 85% for 2017 and 78% for 2018. These rates are considerably higher than those predicted by the supplier interviewees from R1615 which estimated 40% for 2017, yet the R1615 study and consensus panel determined that the Massachusetts results are no longer plausible.

Table 13: Benchmarking Prospective NTG Estimates

State/Region	Entity/Company	LED NTG		Research methods
		2017	2018	
CT	Statewide	40%	-	Supplier interviews
MA	Statewide	85%	78%	Consensus Panel

The consensus panel considered the strengths and weaknesses of each study to guide the selection of the most reliable NTG values to use for Connecticut's LEDs. Ultimately, the

consensus panel determined that all studies were too dated or geographically distant to strongly factor into their considerations. The bullets below address additional strengths and weaknesses of the studies; these assertions come from the authors of the literature and the expertise of the consensus panel:

- **Demand and price elasticity modeling.** Using inputs such as price, promotional activity, product placement, and sales variations within a specified program period, the elasticity modeling approaches offer statistically reliable results compared to activities like in-depth interviewing, literature reviews, or consensus panels. For both Connecticut studies, some retail channel data were missing which may have led to incomplete results that do not consider the full picture. The Xcel Colorado demand elasticity modeling had a low measurement error, signaling its potential reliability; on top of that, it was weighted with two other research effort results (store intercepts and supplier interviews). The Xcel study included spillover in addition to freeridership.
- **Supplier interviews.** R1615, the 2014 Connecticut study, the Xcel Colorado, and California studies drew from supplier interviews. While suppliers offer context and a good understanding of the market, and can represent a large portion of sales in a single interview, they may be biased because of their inherent interest in program continuation because their companies leverage program incentives.
- **Store intercepts.** Store intercepts offer the opportunity to collect details on customers' true decision-making process. They also offer the opportunity to achieve large enough sample sizes to estimate NTG with statistically significant precision. The ComEd Illinois study, for example, had a sample size of 726. It includes spillover and nonparticipant spillover. The California study's choice modeling inputs included store intercept data.
- **Consensus panels and literature reviews.** Qualitative efforts drawing on the perspectives of industry experts and industry-wide data create the opportunity for sanity checks and assessments of the reasonableness of quantitative findings. The Massachusetts study used a consensus panel. The MidAmerican literature review was also perspective based; researchers used the average NTG values associated with programs which they perceived as comparable to the MidAmerican program and were geographically close to Illinois—they do not account for nationwide dynamics.
- **Program savings documents.** A few of the values from the benchmarking effort are assumed values that administrators have used in their program planning documentation. It is unclear from where the Rhode Island, SPS New Mexico, and CPS Energy Texas NTG ratios came so these should be considered with caution.

4

Section 4 Market Trends and Predictions

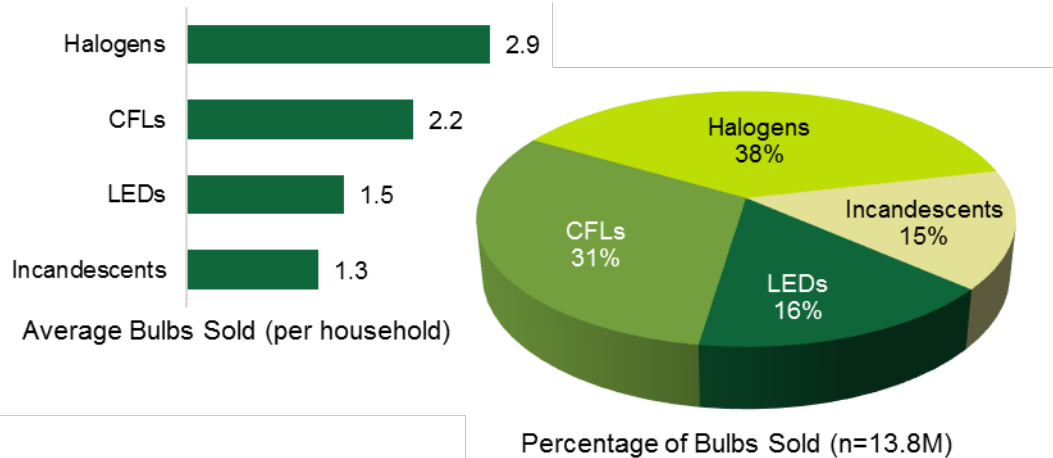
Serving both R1615 and R1616 studies, the following section reports residential lighting sales trends and suppliers' predictions for upcoming sales trends and their expectations for the roles that EISA, ENERGY STAR 2.0, and program support will play in those expected changes.

4.1 RECENT MARKET TRENDS (R1616)

- *Aggregated sales data show that halogens and CFLs dominate the residential market as a whole in 2015, yet LED market share has been on the rise.*

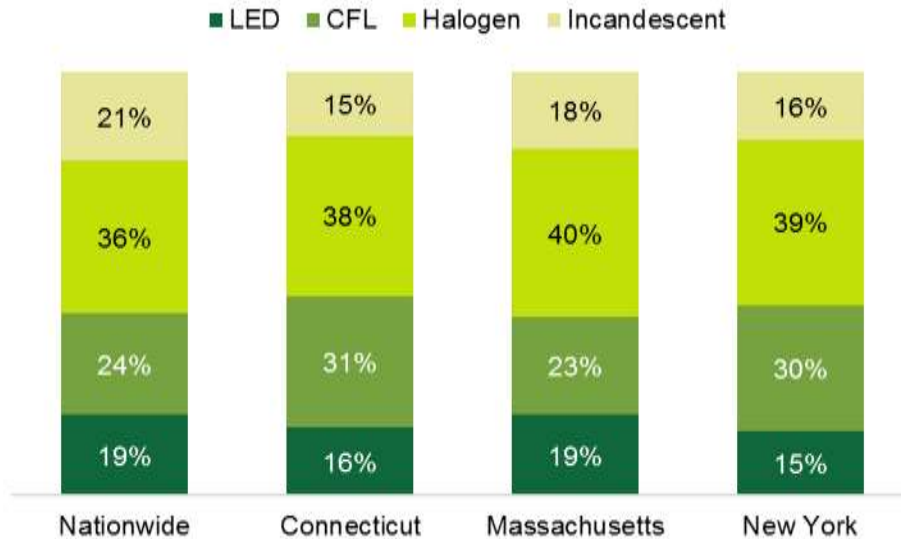
Connecticut residents were most likely to have purchased halogen bulbs in 2015, with the average household having purchased 2.9 halogens that year. In comparison, households purchased only 1.5 LEDs in 2015, on average (Figure 5). LightTracker panel sales data (adjusted by square footage of retail space) showed that across all residential bulb sales in 2015 in Connecticut, LEDs accounted for less than one-fifth purchases (16%), while halogens accounted for 38% of purchases. CREED analysis suggests that approximately 35% of CFLs and 67% of LEDs obtained came from the program.

Figure 5: Residential Lighting Sales in 2015 in Connecticut
(Based on LightTracker adjusted panel data)



When compared with neighboring states Massachusetts and New York and the U.S. overall, Connecticut—while similar to neighbor New York—had higher sales of CFLs and lower sales of LEDs and incandescent bulbs than Massachusetts and the nation as a whole (Figure 6). Given uncertainties in the CREED data, one should not place too much emphasis on these small differences across states.

Figure 6: Residential Lighting Market Shares in 2015 by State and Nationwide
(Based on LightTracker adjusted panel data; represents all retail channels)

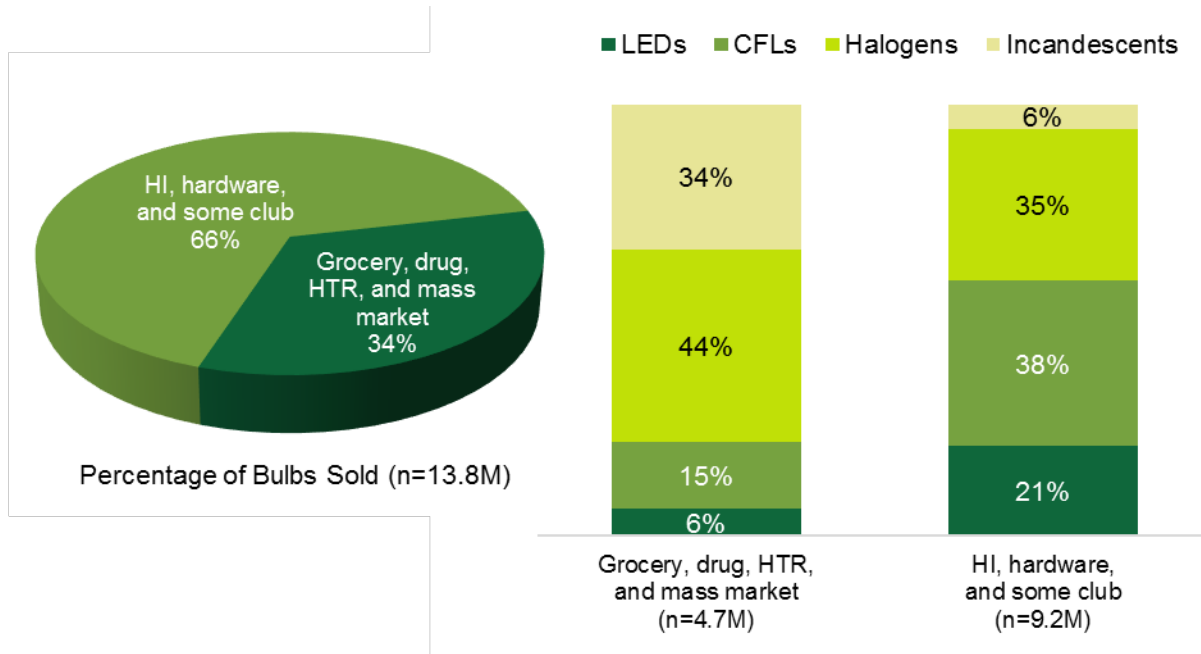


The adjusted panel data included two types of data for 2015—one projected from scanned UPCs of purchased products obtained from a voluntary consumer panel and one derived from POS data. The projected sales consumer panel data included HI, hardware, and some club retailers, while the POS data came from grocery, drug, HTR, and mass market retailers. The latter group accounted for about one-third of 2015 bulb sales in Connecticut (34%). As shown in Figure 7, LEDs (21%) and CFLs (38%) accounted for larger shares of the HI, hardware, and club retailer group's sales in comparison to the grocery, drug, HTR, and mass market retailer group's sales (6% and 15%, respectively). The latter group had considerably larger shares of halogen and incandescent bulbs than the former group.

Despite the fact that the grocery, drug, HTR, and mass market retailers represented the minority of 2015 sales in Connecticut, they were the only data available for looking back at actual trends across years. Therefore, the trends illustrated and discussed below will likely overestimate incandescent and halogen sales and underestimate CFL and LED sales.

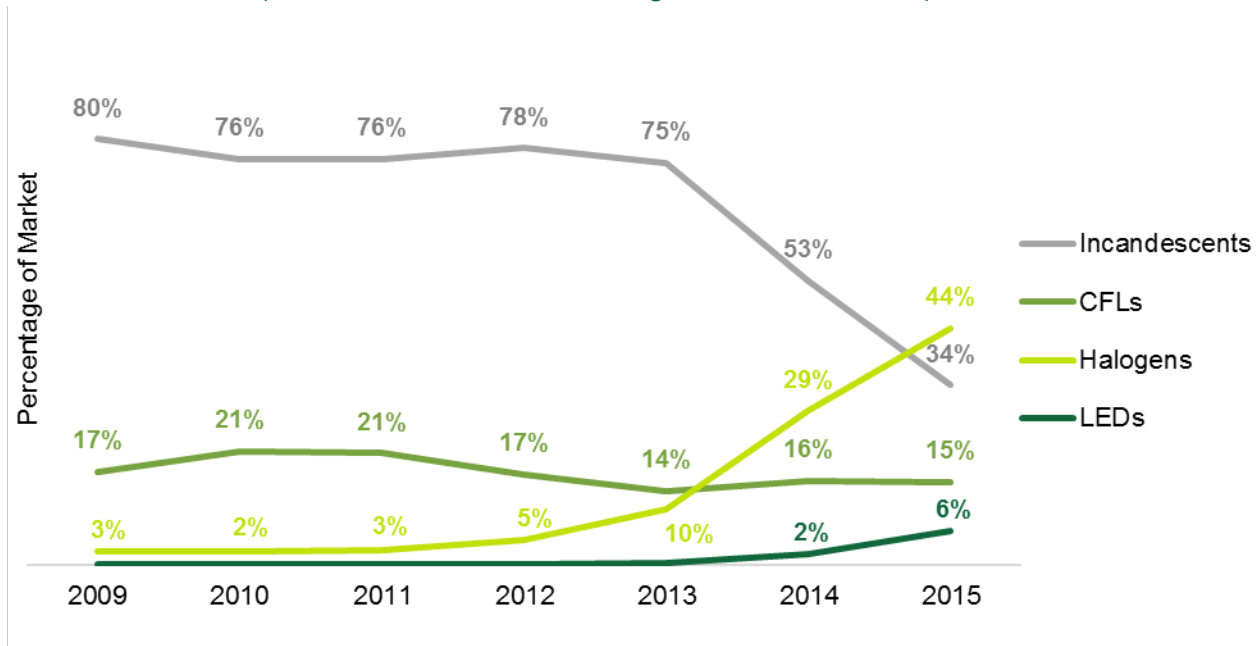
Figure 7: Residential Lighting Market Shares in 2015 in Connecticut by Retailer Group

(Based on LightTracker adjusted panel data)



Longitudinal POS data for the grocery, drug, HTR, and mass market retailers shows that incandescent bulbs decreased from representing four-fifths of the market in 2009 (80%) to only about one-third of the market in 2015 (34%). As shown in Figure 8, halogen bulbs diverged, comprising only 3% of those retailers' market in 2009 but growing to represent more than two-fifths of the market in 2015 (44%). CFLs experienced little change over the seven-year period, beginning at 17% in 2009, peaking in 2010 and 2011 at 21%, and finishing at 17% of that market in 2015. LEDs represented less than 1% of that market until 2014 (2%) and then tripled in market share in one year (6% in 2015). As discussed in detail below, suppliers estimate that LEDs would continue to rapidly gain market share in the coming years, while shares of halogens, CFLs, and incandescent bulbs will decline.

Figure 8: Residential Lighting Sales Trends from 2009-2015 in Connecticut
(Based on subset of retailer LightTracker POS data)¹

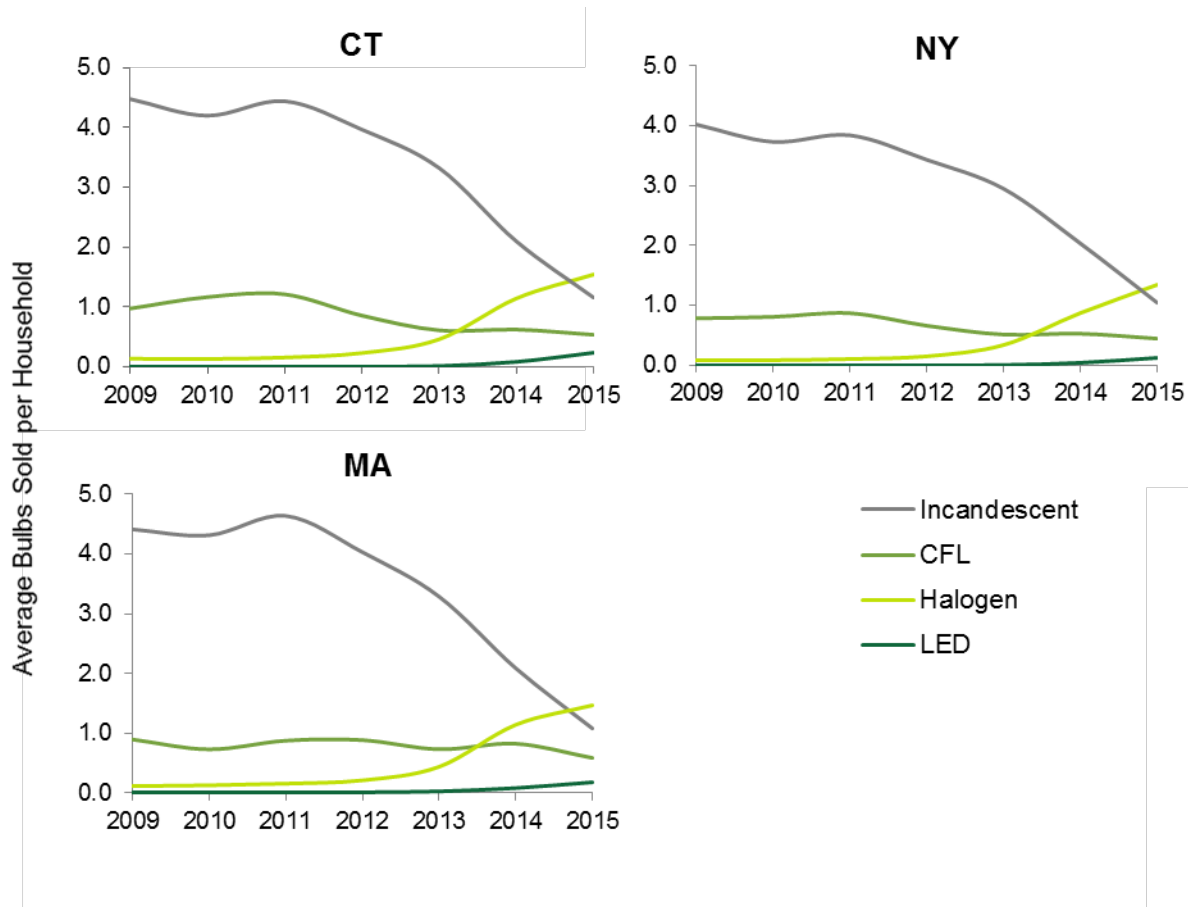


¹ Charts include sales from the grocery, drug, HTR, and mass market retailers only.

The study also examined light bulb market sales trends in Connecticut among subset of retailers that includes mass merchandise, bargain/discount, grocery, drugstores, and most membership stores (about 50% of the lighting market according to a recent estimates in Massachusetts).⁴³ From 2009 to 2015, Connecticut trends mirrored those of its two neighboring states, with average incandescent and CFLs bulb sales per household decreasing since 2011, while halogen and LED sales grew, especially after 2012 when the first phases of EISA took effect (Figure 9).

⁴³ NMR Group. 2017. *Memorandum: RLPNC: 16-3 Lighting Decision Making*. See Figure 3. Bulbs Purchased by Channel. <http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC-16-3-Lighting-Decision-Making-Memo.pdf>.

Figure 9: Residential Lighting Sales Trends from 2009-2015 by State
 (Based on subset of retailer LightTracker POS data)¹

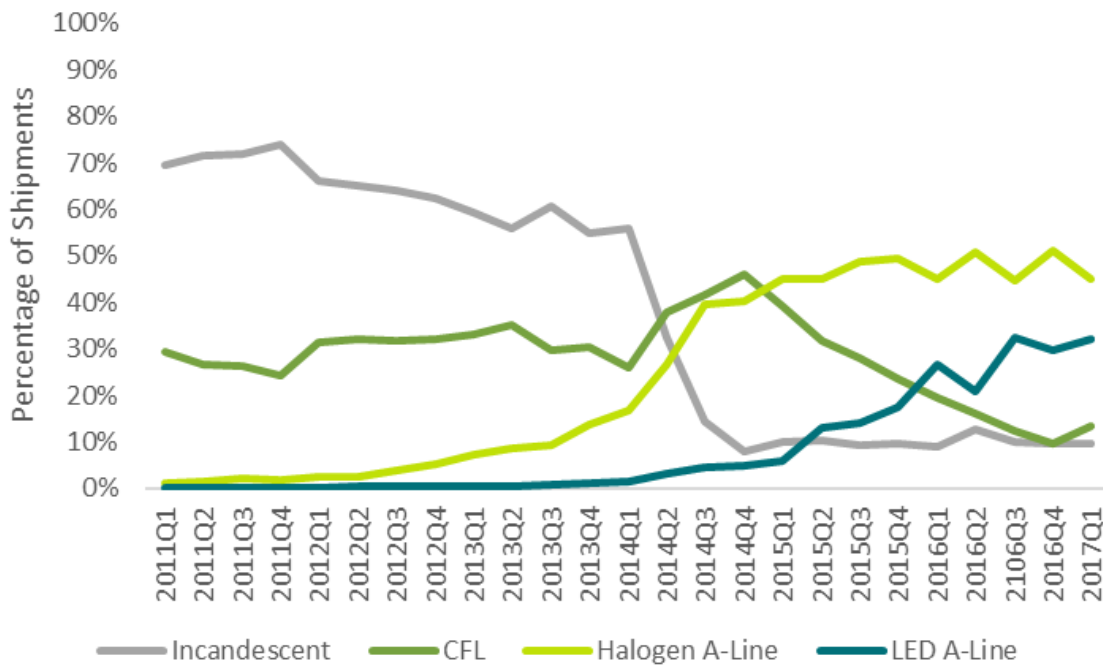


¹ Charts include sales from the grocery, drug, discount/bargain, and mass market retailers only.

- **Shipment data suggest that halogens accounted for the great portion of shipments, followed by LEDs. CFLs and incandescents each account for very small and diminishing portions of shipments.**

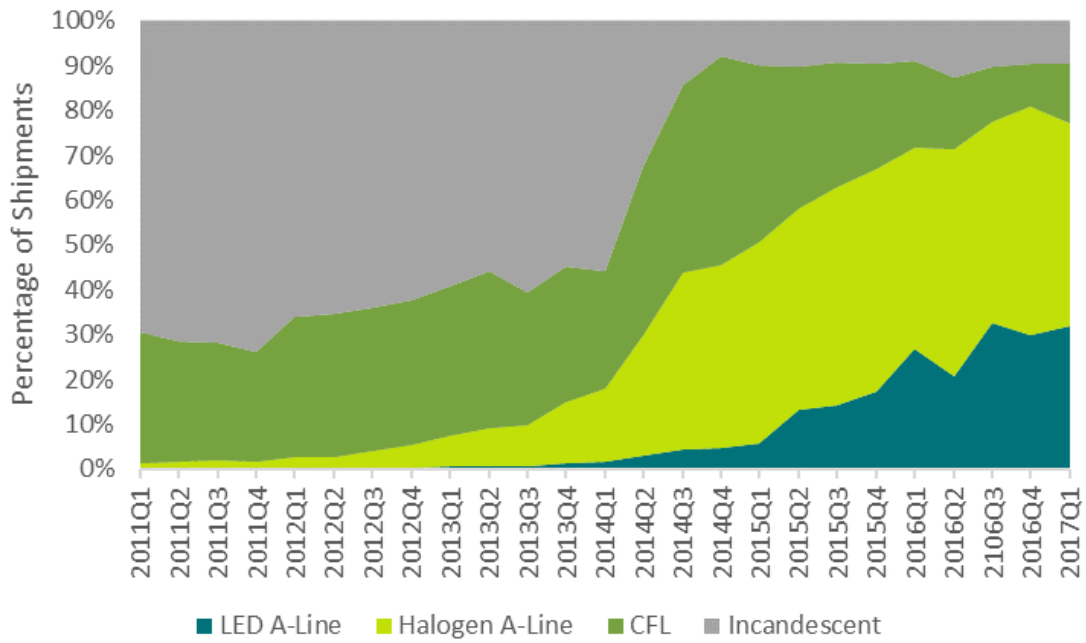
The study also tracked NEMA lamp indices and shipments.⁴⁴ Figure 10 and Figure 11 present the shipment market share trends in two different ways. Figure 10 shows a simple line graph of each bulb’s market share over time, highlighting the change in trends for incandescents and halogens. Figure 11 displays the same data, but as an area graph summing to 100% of the market, highlighting the long-term market shift to halogens and LEDs, even as it shows the impact of volatility in the most recent quarters. Like the sales data, NEMA data point to strong declines in shipments of incandescents and CFLs and strong increases in shipments of halogens and LEDs. In the first quarter of 2017, incandescent shipments (9.6%) fell below those of all other bulb types. At 13.3% of shipments, CFLs deviated from their long-term decline in the first quarter of 2017, likely reflecting an uptick in shipments as manufacturers sought to unload the stock that no longer achieved ENERGY STAR qualification. with CFLs only slightly higher (12.2%). Halogens garnered the greatest market share (44.1%) with LEDs at (32.0%).

Figure 10: Shipment Market Share Q1 2011 to Q1 2017, Line Graph
(All Channels. 100% of Market)



⁴⁴ Unlike the other data sources, NEMA reports only A-line bulbs (but would include bulbs such as rough service) and excludes specialty shapes. NEMA explains that the shipment data are based on statistical surveys of NEMA members, but, as with every survey, the results could be subject to *nonresponse bias*, meaning that those who respond to the survey could differ from those who do not. NEMA does not provide information on potential sources of bias.

Figure 11: Shipment Market Share Q1 2011 to Q1 2017, Area Graph
 (All Channels. 100% of Market)



4.2 VALUE-LINE LEDs

As discussed in Section 1.1, the residential lighting market has seen an influx of low-cost LEDs, marked by shorter measure lives, the inability to dim, and relaxed approaches to such things as light quality, color rendition, and omnidirectionality. Prior to the new ENERGY STAR 2.0 specification, none of these value-line bulbs achieved ENERGY STAR qualification. While the new specification allowed some of these low-cost models to qualify for the ENERGY STAR label, others—what we call *value-line LEDs*—still do not meet the minimum efficacy, quality, and measure life requirements for the label. The study did not find any publicly available studies that demonstrated proven low-quality of value-line LEDs.⁴⁵ Yet, energy-efficiency lighting experts remained concerned about performance because most of the value-line bulbs do not undergo any third-party quality control testing.

The study explored the impact of value-line LEDs through program staff and supplier interviews and through the consensus panel discussion of the future LED market. The key points made by these commentators regarding value-line LEDs are as follows:

- All parties voiced concern about the quality of value-line LEDs and the possibility that consumers may mistakenly generalize any poor value-line LED performance that may arise to all LEDs, including ENERGY STAR qualified ones.
- Despite possible quality and measure life concerns, value-line LEDs still use less energy than halogens and incandescent bulbs. Given their attractive price points, they could displace ENERGY STAR-qualified LEDs, leading to a reduced blended Delta Watts (because the baseline would include additional LEDs), and therefore, cost-effectiveness for program LEDs. However, most suppliers and program staff do not recommend including non-ENERGY STAR models among program offerings to avoid any association between any lower performance that may manifest and the Companies, Energize Connecticut, the EEB, and other Connecticut Energy Efficiency Fund programs.
- Prices for value-line LEDs are generally more accessible to HTR households. In order to ensure that consumer choose ENERGY STAR qualified LEDs to fill the lower-price bulb gap created by the exclusion of CFLs from the program, program incentives may be needed to ensure that longer-lasting, newly qualified ENERGY STAR models are price competitive with their non-qualified rivals, as outlined in the [Recommendations](#).

4.3 MARKET SHARE PREDICTIONS (R1615 AND R1616)

To develop the prospective NTG estimates described in Section 3.2, suppliers provided their estimates of Connecticut LED market share estimates assuming, first, that the Lighting Strategy would continue through 2021, and, second, that the program ended in 2016. Most of the Connecticut interviewees (11 of 16), however, also served the Massachusetts program.

⁴⁵ The evaluation team has been told that some program administrators are engaged in quality testing and comparisons of ENERGY STAR and non-ENERGY STAR LEDs, but none of these studies are public. Most of the sources claiming quality differences come from within the energy-efficiency program community (e.g., ENERGY STAR, program administrators, etc.).

To leverage resources, suppliers engaged in one interview covering related topics in both states. As part of the Massachusetts evaluation, suppliers were asked to predict market shares for **all** lighting technologies for 2017, 2019, and 2021, not only LEDs. As with the Connecticut-specific estimates, the suppliers first assumed that the Massachusetts program would continue to provide LED discounts through 2021, and second assumed the program would end LED discounts at the end of 2016. Due to the length of the interview, the study did not ask for Connecticut-specific estimates for all bulb types, and instead used Massachusetts responses as a proxy for Connecticut market share predictions.

The Connecticut and Massachusetts market share estimates presented below differ. Importantly, this is most likely a result of methodological differences in data collection and not inherent differences in the lighting markets between the two neighboring states. The Connecticut-specific market share estimates obtained to calculate NTG ratios addressed LEDs only, and did not ask for estimates for other bulb technologies. In Massachusetts suppliers had to provide market share estimates for all technologies, and those estimates had to sum to 100%. It is likely that, in Massachusetts, suppliers adjusted their market share estimates until they arrived at values that summed to 100%. In Connecticut, suppliers likely gave the first response for LED market share since they did not have to compare them to other bulb types.

Finally, the study presents the unweighted market share estimates for both Connecticut and Massachusetts.⁴⁶ This reflects a decision made by the Massachusetts Program Administrators and Energy Efficiency Advisory Council consultants reflecting that state's evaluation needs. Showing the unweighted data for both states increases comparability in comparing Connecticut and Massachusetts and avoids any confusion that could arise from comparisons of this report and similar Massachusetts reports.⁴⁷

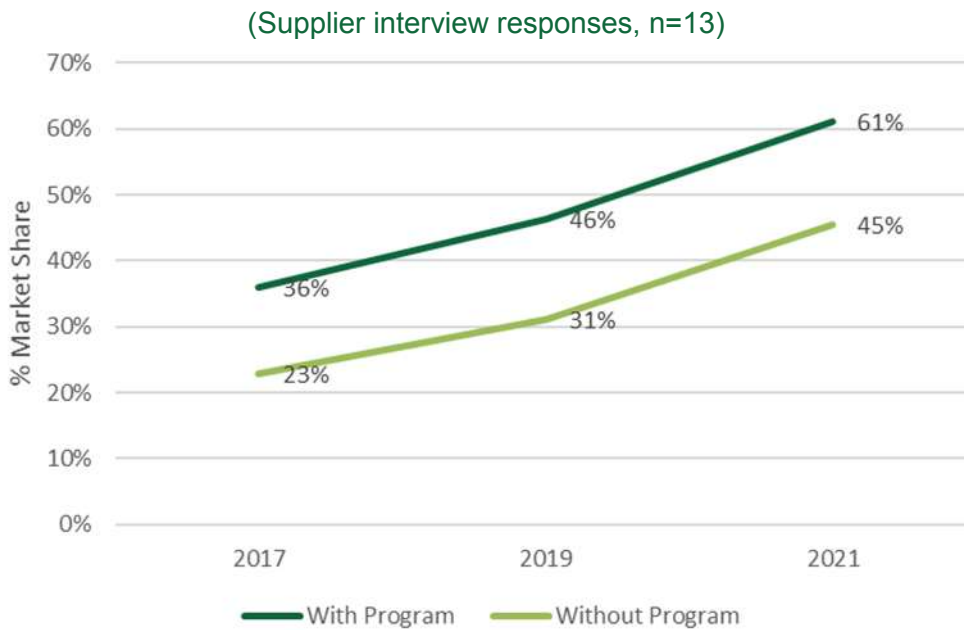
⁴⁶ The NTG ratios presented in Section 3.2 remain weighted by the proportion of sales associated with each supplier, the same weighting method used in prior Connecticut studies.

⁴⁷ That is, if this study presented one set of market share estimates for Massachusetts and the Massachusetts studies presented another set of estimates.

- **Suppliers expect that continued program activity boosts standard and reflector LED market shares by 13 to 16 percentage points, resulting in a 2021 predicted market share of 61% for standard and 53% for reflectors with the program.**

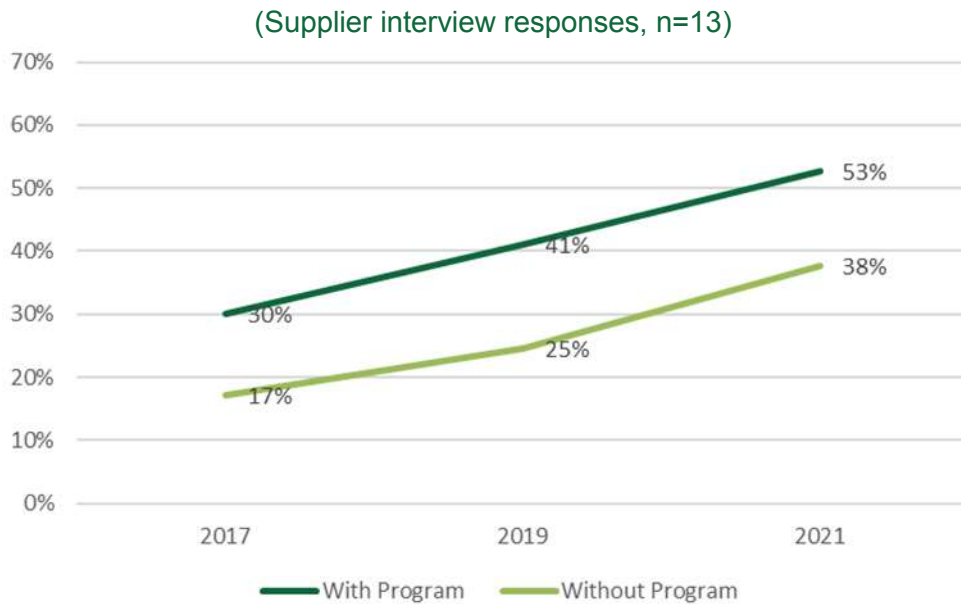
Connecticut suppliers predicted that standard market shares with the program would be 36% in 2017, increasing to 46% in 2019 and 61% in 2021. LED market shares without the program were predicted to be 23% in 2017, 31% in 2019, and 45% in 2021. Predicted market shares with the program were one-fourth to one-third higher than without the program.

Figure 12: Market Share Predictions for Standard Bulbs by Year in Connecticut



The Connecticut suppliers predicted slightly lower market shares for reflector LEDs. They predicted reflector market shares of 30% in 2017, 41% in 2019, and 53% in 2021. Predicted reflector market shares without the program were between 13 and 16 percentage points lower: 17% in 2017, 25% in 2019, and 38% in 2021. Predicted market shares with the program were 39% to 76% higher than without the program.

Figure 13: Market Share Predictions for Reflector Bulbs by Year in Connecticut



- **Suppliers expected that program rebates will continue to be valuable because they reduce the first cost of LEDs, but the rapid adoption of LEDs independent of the program will decrease the influence of the program.**

When asked to explain their market share predictions, the most frequent explanation (46% of respondents) was that if the Connecticut program continued, its rebates would support a higher level of LED sales because first cost is the biggest barrier to LED sales. However, nearly two-fifths of the respondents (38%) also observed that LED sales were increasing at a rapid rate and cited this as a reason for not giving the program more attribution for LED sales in future years.

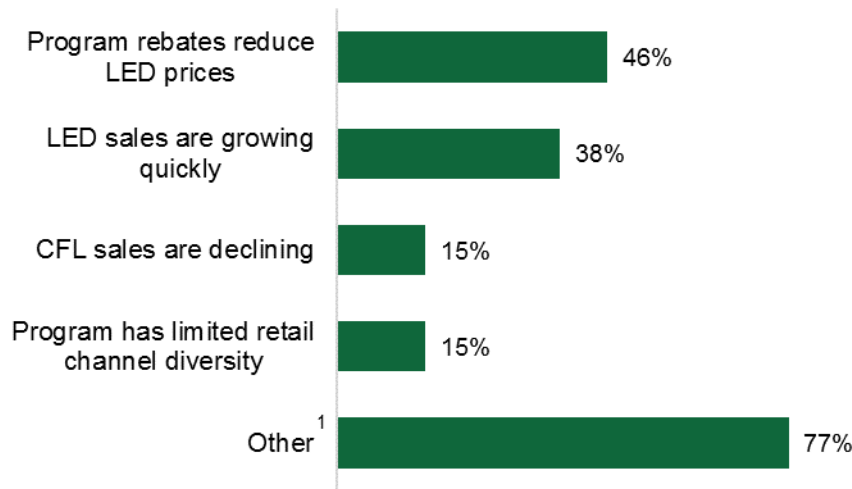
It is important to recall that the suppliers made their predictions about the future of the LED market prior to the 2016 presidential election. Given that some of the suppliers noted that a Trump presidency would change their thoughts about the future of the residential lighting market, it is possible that, if asked today, they would attribute greater impact to the program for future LED sales. Section 4 offers further context for external market factors.

“Without the program, people [wouldn’t] pay for LEDs”

-Supplier interviewee

One interviewee described numerous dynamics that played into the estimates; these responses were unique from the other more common responses. Thus, the *Other* category in the figure is represented by a large percentage (77%). Among the interviewee's explanations, the interviewee pointed to various aspects of the LED industry changing, such as price reductions; lamp, socket, and fixture markets transforming; and advancements in technology.⁴⁸

Figure 14: Explanations for Prospective NTG Estimates
(Supplier interview responses, n=13)



Note: Total response percentages exceed 100% because multiple responses were allowed.

¹ Includes reasons that were mentioned only once.

➤ ***According to the Massachusetts suppliers' predictions, program support in the next several years will remain vital to LEDs' steadily increasing dominance in the regional market.***

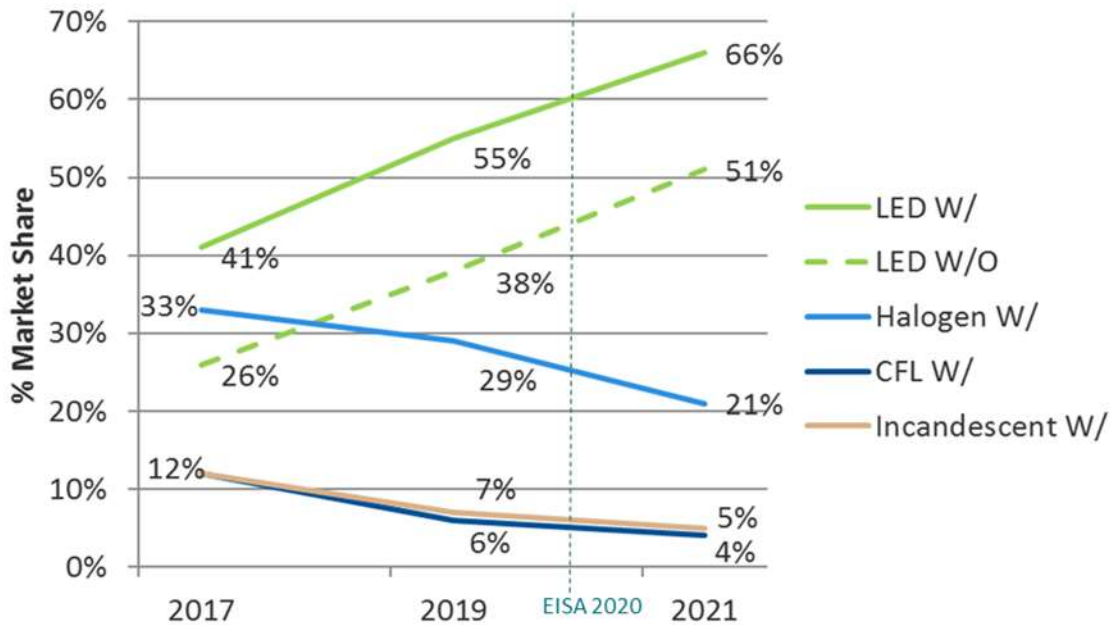
The 15 suppliers serving Massachusetts—most of whom also participated in the Connecticut program—provided predictions of market share for all bulb technologies in the presence and absence of the program from 2017 to 2021. The Massachusetts suppliers predicted that, should the Massachusetts ENERGY STAR Lighting program continue, LEDs would grow to represent one-half of the standard (55%) and reflector (49%) bulb markets by 2021 (Figure 15 and Figure 16). Without the program, standard LEDs would not account for one-half of market share until 2021, and reflectors would only reach 47% market share by 2021. Suppliers predicted that the market share of all other bulb types would decline in the presence

⁴⁸ The interviewees responses in full included 1) the assumptions that halogens will go away in 2020 due to EISA; 2) the assertion that ENERGY STAR is a trusted brand with many consumers; 3) greater general availability of LEDs; 4) new housing will have different mixes of lighting sockets/fixtures than existing homes; 5) the LED fixture business is getting bigger; 6) the Connecticut program has lower rebates and smaller product allocations than the Massachusetts upstream lighting program; 7) A-lamps will continue to be a popular lamp type; 8) LED prices are coming down; 9) LED adoption in Connecticut is lower than it is in Massachusetts; 10) the simultaneous existence of both ENERGY STAR and non-ENERGY STAR LEDs will help LEDs stay competitive with halogens; and 11) the program helps improve LED technology.

(shown) and absence (not shown) of the program. For standard bulbs, incandescent and CFL bulbs garner very small portions of the market share (less than one-fourth) in 2017 and decline from there. Halogens hang onto market share longer, falling from 33% in 2017 to 21% in 2021. Reflector trends vary slightly, driven largely by the expectation that incandescent reflectors would retain market share for a longer period—an assumption that the recent DOE rulemaking regarding the expanded definition of general service lamps brings into question.

Figure 15: Market Share Predictions for Standard Bulbs by Year in Massachusetts¹

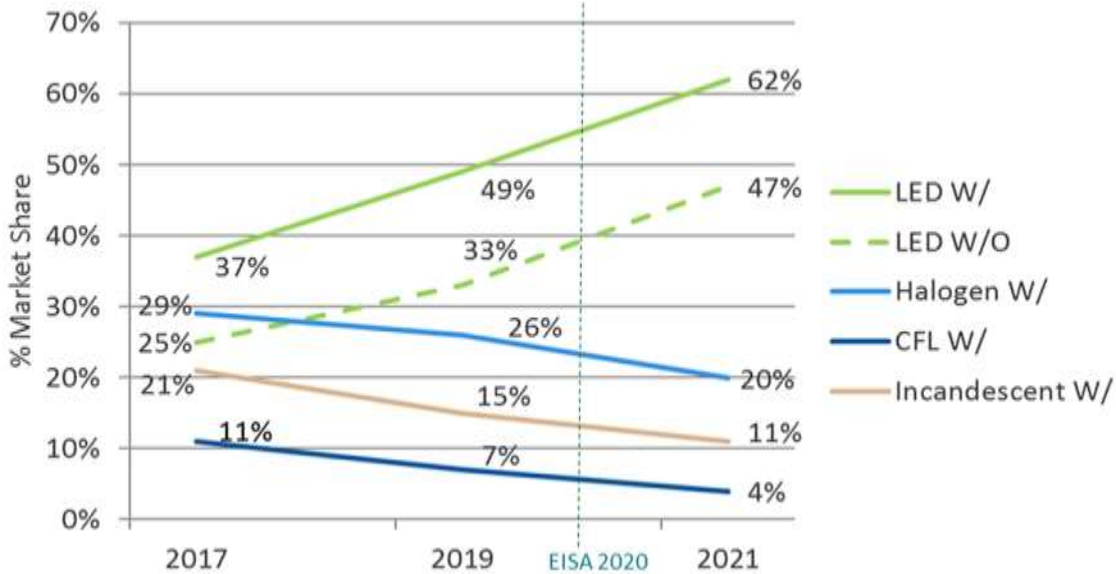
(Supplier interview responses, n=15)



¹ W/ = with the program; W/O = without the program. All other trend lines assume the program will still be providing incentives after 2016.

Figure 16: Market Share Predictions for Reflector Bulbs by Year in Massachusetts¹

(Supplier interview responses, n=15)



¹ W/ = with the program; W/O = without the program. All other trend lines assume the program will still be providing incentives after 2016.

4.4 MARKET IMPACTS OF EISA 2020 (R1616)

As noted above, the second wave of EISA is set to go into effect in 2020. When the supplier interviews were fielded, the DOE had issued a draft rulemaking which stated that implementation would involve requiring all CFLs and LEDs to achieve 85 to 100 lumens per watt (an increase from the 45 lumens per watt in the original legislation). The DOE had also indicated its support of a strict *hard stop* on sales of halogens and incandescents that did not meet the 45 lumens per watt standard and a sell-through of CFLs and LEDs that did not meet the 85 to 100 lumens per watt standard. Ultimately, the DOE did not include these requirements in its final rulings issued at the end of December and published in the *Federal Register* in mid-January.⁴⁹ The final rules dropped the higher wattage requirements, expand the definition of general service lamps, and indicate some flexibility on the hard-stop provision. However, these developments occurred two months after fielding the interviews. Yet, even at the time of the lighting interviews, residential lighting program experts disagreed on the likelihood of the draft rulemaking being adopted for three main reasons:

1. In 2011, Congress passed a budget rider that barred any funding for enforcement of the lighting standards stemming from EISA.
2. NEMA had officially come out against the draft rulemaking.⁵⁰

⁴⁹ See notices here: <http://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0097> and <http://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0098>.

⁵⁰ In fact, NEMA has come out against the final rulings as outlined here: <https://www.nema.org/news/Pages/NEMA-Calls-on-Secretary-of-Energy-to-Complete-Rulemaking-for-General->

3. No one knew who would be elected president; therefore, it was uncertain if the draft rulemaking would be adopted. Most suppliers assumed that a Clinton presidency would increase the likelihood of adoption of the draft rulemaking, while a Trump presidency would decrease the likelihood.

The study explored suppliers' opinions about the future of the EISA legislation and its likely impact on LED, halogen, and CFL sales. It was difficult for suppliers to separate the likely impacts of EISA 2020 and the new ENERGY STAR Specification 2.0 in their responses. Consequently, the report discusses expectations for LEDs and halogens in this section, and addresses CFL sales in the Market Impacts of ENERGY STAR 2.0 section.

4.4.1 General EISA 2020 Market Impacts

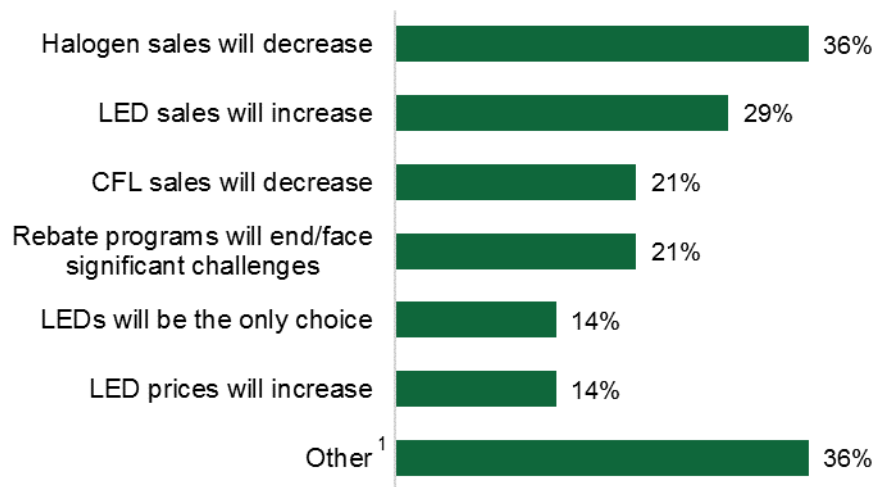
- **Suppliers expected that EISA 2020 would cause halogen sales to decrease and LED sales to increase.**

When asked, all lighting supplier interviewees were aware that in 2020 the next phase of the EISA regulations would go into effect in 2020. When asked what they expected the impacts of the regulations on the Connecticut lighting market would be, suppliers most commonly thought that halogen sales would decrease (36%) and LED sales would increase (29%). As shown in Figure 17, some respondents thought that the regulations would result in higher LED prices due to the higher production costs of making higher efficacy (lumens/watt) bulbs.

Some respondents provided unique responses, categorized as *Other* in the chart; they included 1) the elimination of incandescent sales; 2) the claim that their company would produce CFLs until this is no longer feasible; 3) the fact that any prediction would depend on what the final regulations would allow; 4) the possibility that some halogens may qualify for the new standards; and 5) the claim that the Connecticut upstream residential lighting program has future savings opportunities in retail channels in which the current program lacks a significant presence.

[Service-Lamps.aspx](#). Some sources report that they are considering—and may already have—sued the DOE over the final ruling.

Figure 17: Expected Impacts of EISA 2020 on Connecticut Lighting Market
(Supplier interview responses, n=14)



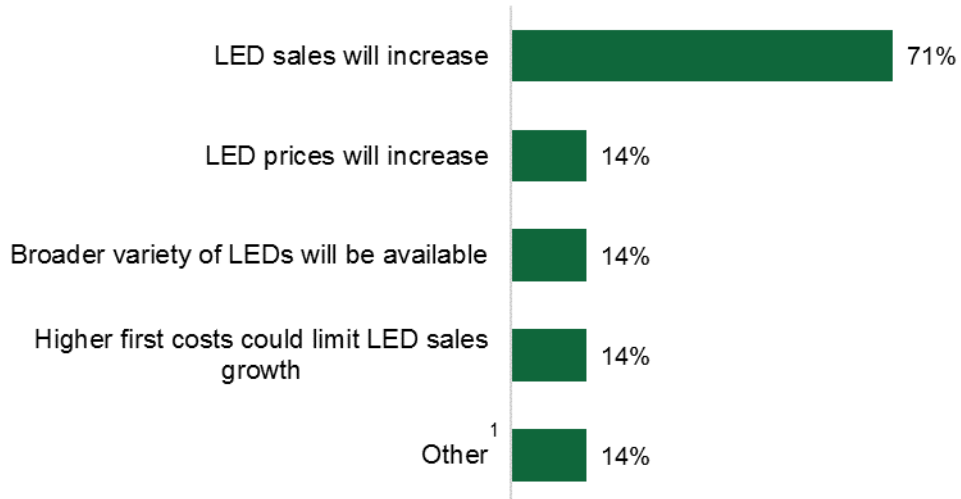
Note: Total response percentages exceed 100% because multiple responses were allowed.

¹ Includes reasons that were mentioned only once.

4.4.2 EISA 2020 Impacts on LEDs and Halogens

When asked to provide more details about the impacts of EISA 2020 on LED bulbs, the majority of lighting suppliers (71%) said that the regulations would lead to an increase in LED sales in the state (Figure 18). However, two respondents thought that higher LED costs could lead to a plateauing of LED market share if alternative lamp technologies were still available. Two said that LED prices could increase not only for higher efficacy general purpose products, but also for newer LED technologies such as higher-wattage and three-way products. One respondent thought that the regulations would have no impact on LED sales and would lead to a market consolidation in which smaller, niche suppliers would disappear and lose their market share to bigger producers.

Figure 18: Expected Impacts of EISA 2020 on LEDs in Connecticut
(Supplier interview responses, n=14)



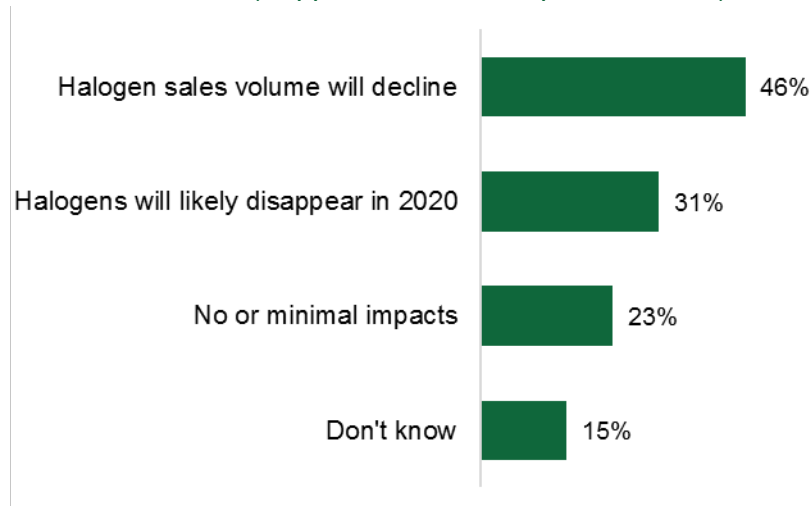
Note: Total response percentages exceed 100% because multiple responses were allowed.

¹ Includes reasons that were mentioned only once.

Lighting suppliers also voiced opinions about the impact of the EISA 2020 regulations on halogen bulbs in Connecticut (Figure 19). The pivotal questions included whether halogens would be able to meet the 2020 efficacy requirements as currently formulated (45 lumens per watt) and whether DOE planned to make any modifications in the final rules. About one-third (31%) of respondents predicted that halogens would not be able to meet the new requirements in their current form and would disappear from store shelves in 2020. Nearly one-half (46%) thought that halogen sales would decline until 2020, with some of these respondents assuming a small niche market for halogens would remain in 2020.

Some of the suppliers who predicted a decline in halogen sales anticipated that it would not be as sudden as for CFLs (as discussed below) because halogens remained popular with some segments of the lighting market. Two suppliers involved in manufacturing halogens said that they did not plan to ramp down production of these bulbs until 2019.

Figure 19: Expected Impacts of EISA 2020 on Halogens in Connecticut
(Supplier interview responses, n=13)



Note: Total response percentages exceed 100% because multiple responses were allowed.

4.4.3 EISA 2020 Impacts on Supplier and Retailer Sales

When asked about the impact of EISA 2020 on their own sales, suppliers voiced a variety of perspectives, typically aligning with their respective current mix of lighting products. In general, suppliers who sold only LED products were the most optimistic about their prospects. Suppliers selling a broader range of lamp technologies predicted that their sales should be adequate in 2017 and 2018 but were uncertain about what would happen in 2019 and 2020 due to the uncertainties surrounding federal regulations. One major retail buyer was concerned about the impact that the long lifespans of LEDs would have on their lighting sales. Finally, suppliers who were heavily dependent on incentives from upstream lighting programs feared that their sales volumes would decline significantly if these incentives went away.

4.5 MARKET IMPACTS OF ENERGY STAR 2.0 (R1615 AND R1616)

This section summarizes the interview responses of participating lighting market actors concerning the implementation of the new ENERGY STAR specification 2.0. The key implications of this new specification are that

1. Most CFLs no longer qualify for the ENERGY label, and
2. Some previously unqualified LEDs now qualify for the label. These newly qualified LEDs tend to have shorter measure lives (15,000 hours) when compared to many LEDs previously qualified under ENERGY STAR 1.1 (25,000 hours for general service).

Although it officially went into effect on January 2, 2017, the DOE allowed manufacturers to qualify and label bulbs under ENERGY STAR 2.0 in the summer of 2016. Programs across the nation—including the Connecticut Lighting Strategy—have started to offer newly qualified LEDs. The Companies have also accelerated the timeline for removing all program incentives from CFLs and ceased offering them in 2017 instead of 2018. The program and evaluation

staff members explain that this decision rested on the fact that they only incent ENERGY STAR-qualified products because the more rigorous testing provides greater assurance of the quality of the product.⁵¹ As part of its benchmarking efforts, this study has confirmed that nearly all program administrators that were still offering CFLs in 2016 also removed them from their program offerings in 2017, citing the same reasons as the Companies in Connecticut.

Interviewers asked suppliers to reflect on 1) ENERGY STAR 2.0's impacts on the market as a whole; 2) its impacts on the LED market, specifically; 3) its impacts on the halogen market, specifically; and 4) how ENERGY STAR 2.0 together with EISA 2020 would impact the CFL market. This sequential ordering of questions may make responses appear inconsistent in the following section. For example, when first asked about ENERGY STAR 2.0's impact on the market generally, only three interviewees suggested that it would cause LED sales to increase; however, when asked what its impact would be on LEDs specifically, five other interviewees predicted that it would cause LED sales to increase.

4.5.1 General ENERGY STAR 2.0 Market Impacts

- *Suppliers anticipated that ENERGY STAR 2.0 would cause CFL sales to decrease and stimulate LED sales to increase, with some suggesting LEDs and halogens would take the place of CFLs.*

As shown in Figure 20, when asked to project the impacts of ENERGY STAR 2.0 specification on the lighting market in Connecticut, suppliers were most likely to say that it would cause CFL sales to decrease (36%), LED sales to increase (21%), or would have no impact (21%). Some respondents predicted that both LEDs and halogens would take over parts of the CFL lost market share. A few lighting suppliers noted that all their products were already compliant with ENERGY STAR 2.0.

One respondent envisioned a scenario where the new specification would cause the ENERGY STAR share of total LED lamp sales to increase initially from current levels and then eventually decrease. The initial increase would be due to the new specification, including some value-line LED lines which were not formerly ENERGY STAR qualified.⁵² However, the respondent feared that consumers would then shift to the even less expensive value-line LEDs that would still lack ENERGY STAR qualification. Assuming they are satisfied with the quality of these bulbs, it could lead to decreases in ENERGY STAR market share, even if overall LED market share increases.

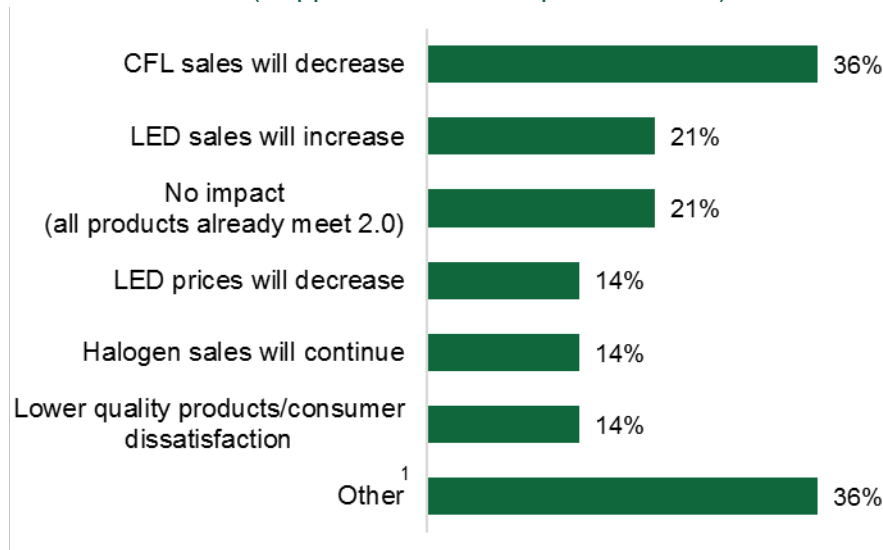
Two lighting suppliers raised concerns about the quality of some of the new ENERGY STAR-qualifying LED products; one was concerned that inconsistent quality could lead to customer dissatisfaction.

⁵¹ As part of the preliminary work for Study R1616, the interviews addressed the invigorated HTR component of the Lighting Strategy. The decision not to offer CFLs will lead the program to shift from CFLs to LEDs in the stores targeted to reach customers considered HTR.

⁵² The report addresses value-line LEDs that still will not qualify for ENERGY STAR 2.0 in [Market Impacts of Non-ENERGY STAR LEDs](#).

Figure 20: Expected Impacts of ENERGY STAR 2.0 on Connecticut Lighting Market

(Supplier interview responses, n=14)



Note: Total response percentages exceed 100% because multiple responses were allowed.

¹ *Other* effects include all effects which only a single respondent mentioned. These include 1) the possibility that halogen market share would increase as it takes over CFL market share; 2) the prospect of an increase in the quality of LEDs due to the new specification; 3) a prediction of higher LED prices due to the new specification; 4) the need for larger program incentives to make the more expensive LEDs more competitive with other lamp technologies; and 5) the prospect (discussed above) that the new specification would cause the ENERGY STAR share of total LED lamp sales to initially increase from current levels and then eventually decrease.

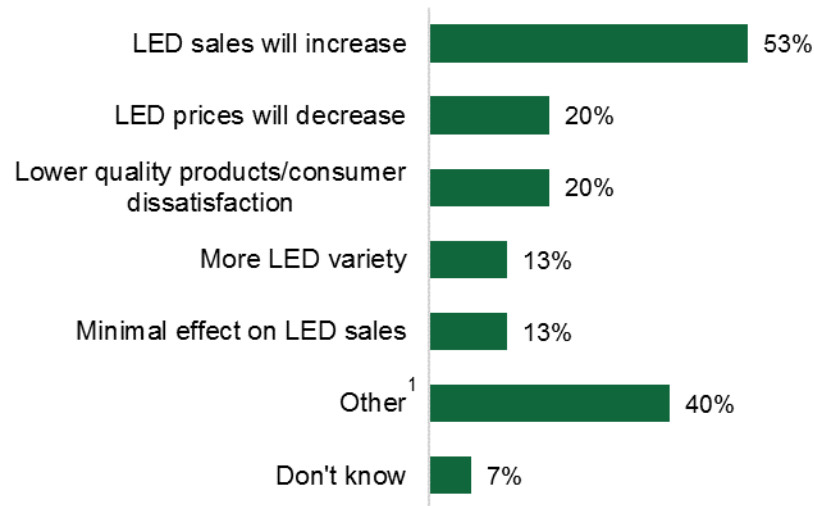
4.5.2 ENERGY STAR 2.0 Impacts on LEDs and Halogens

The interviewers also asked the lighting suppliers about the impacts of the ENERGY STAR 2.0 specification on LED bulbs in particular. Over one-half of respondents (53%) said that the new specification would lead to an increase in LED sales (Figure 21). Most suppliers cited lower prices as the main driver of increased sales. They speculated that the new specification would allow the sale of less expensive LEDs that would be more cost competitive with other lighting technologies, particularly if program incentives were still available for standard LEDs. One respondent also thought that LEDs would grab some of the market share that CFLs would be losing. Two respondents thought that higher LED costs could lead to a plateauing of LED market share as long as alternative lower-cost lamp technologies were still available.

Three suppliers predicted that the new specification would lead to lower quality LEDs. One respondent stated that consumers do not care much about the shorter lifespan of some of these new ENERGY STAR-qualified bulbs, but that they may have issues with some LED A-lamps being much less omnidirectional.

Three said that LED prices could decrease and noted that this price decrease would not only be for general purpose LED products, but also for newer LED technologies such as higher-wattage and three-way products which are more expensive to produce.

Figure 21: Expected Impacts of ENERGY STAR 2.0 on LEDs
(Supplier interview responses, n=15)



Note: Total response percentages exceed 100% because multiple responses were allowed.

¹ *Other* effects include all effects which only a single respondent mentioned. These included 1) helping ENERGY STAR standard LEDs compete better with non-ENERGY STAR LEDs, 2) more variety in LEDs, 3) less variety in LEDs, 4) not much impact because all their products already meet the new ENERGY STAR specification, 5) the new specification would cause the ENERGY STAR share of total LED lamp sales to initially increase from current levels and then eventually decrease, and 6) the specification would result in customers only purchasing ENERGY STAR LEDs if program rebates are available.

Suppliers discussed their opinions about the impact of the new ENERGY STAR specification on halogens. They did not agree as to whether halogen sales would increase, decrease, or stay the same due to the new specification. Those who predicted that halogen sales would decline assumed that most halogens would be unable to meet the EISA 2020 efficacy standards, so manufacturers may reduce production. Likewise, the increasing popularity and decreasing cost of LEDs would also take away market share from halogens.

Interviewees who thought halogen sales would remain the same or possibly increase pointed to the decline in CFL market share as an opportunity for halogens. They noted that once CFLs disappear, halogens would be the lowest cost option for price-sensitive customers. One respondent also observed that there continued to be a segment of the lighting market that simply prefers incandescent and/or halogen technologies over CFLs and LEDs.

Some respondents noted that whether the Connecticut program continued to rebate LEDs would be the key factor as to whether halogen sales would increase or decrease. They theorized that if the program removed LED subsidies, many customers would switch back to halogens for first cost reasons.

4.5.3 ENERGY STAR 2.0 and EISA 2020 Impacts on CFLs

- *Suppliers predicted that ENERGY STAR 2.0 coupled with EISA 2020 would greatly curtail CFL sales and significantly decrease CFL market share.*

Because the impact of ENERGY STAR 2.0 and EISA 2020 on CFLs intertwine, the report addresses these two topics together. To summarize the relationship, most suppliers believed ENERGY STAR 2.0 would greatly curtail sales and market share of CFLs, and coupled with EISA 2020, CFLs would essentially become a very small part of the light bulb market.

In response to ENERGY STAR 2.0, which means that most CFLs no longer qualify for the label, one manufacturer reported that his company briefly considered producing CFLs that could meet the new specification but eventually decided against it. Two manufacturers said that their companies planned to stop producing CFLs, and others noted that a major national mass market retailer announced it would stop selling CFLs in 2017. Some interviewees speculated that not only would CFL sales decline, but CFL diversity also would decrease. One respondent hypothesized that the majority of future CFLs sales would be limited to more popular higher-wattage models. Only one respondent explicitly thought that much of the lost CFL market share would go to halogens.

Regarding EISA 2020 impacts, the majority of respondents (69%) projected that EISA 2020 regulations would lead to a significant decline in CFL shares, giving various scenarios regarding how CFL sales would decline:

- One supplier predicted that the PAR and higher-wattage CFLs would disappear from the market first, and the 14-Watt and 23-Watt CFLs would stay around a bit longer.
- Another said that while the ENERGY STAR CFLs would disappear due to their inability to meet the new specifications, some inexpensive non-ENERGY STAR CFLs would remain.
- A third predicted that most CFL sales in 2017 and 2018 would be through retailers catering to HTR customers because CFLs would still likely be less expensive than LEDs; he also speculated that these retailers would seek to sell through their CFL inventory.

Two respondents suggested that EISA 2020 regulations would have no effect on CFL sales because reduced production and retailing of these products would cause sales to plummet regardless of the new regulations.

4.6 MARKET IMPACTS OF CFL PHASE-OUT (R1615)

- *Suppliers predicted that the program's CFL phase-out would not intensify declining CFL sales, but also said that program support would be vital in LEDs taking over that market share.*

According to program staff, at the start of 2012, only 1% of program incentive dollars went to LEDs, and in the 2012 to 2015 cycle 57% of the budget, on average was devoted to LEDs. In September 2016, program staff estimated that LEDs accounted for about 70% of program

incentives. Because of ENERGY STAR Specification 2.0, the Lighting Strategy shifted to an all-LED program at the start of 2017.

Suppliers shared their perspectives on this programmatic shift. The consensus was that CFL sales were declining sharply anyway, and the removal of program support would not have much impact on this trend. One supplier predicted that some retailers would continue to sell CFLs, but these would be limited to 60W- and 75W-equivalent multi-packs, high-wattage CFLs, and 3-way products. The lighting suppliers predicted that LEDs would take over most of the lost CFL market share, with halogens also gaining some sales.

Respondents also emphasized that continued program support was necessary to ensure that LEDs—and not halogens—captured the lost CFL market share, especially in the 75W- and 100W-equivalent ranges. They claimed that if the program failed to make these LEDs price-competitive, many consumers would seek out halogens and lower cost incandescent and CFL bulbs still on the shelves. One supplier summarized,

“If the program stays, we will see LED market share go up, and we will see every other market share go down, at least a little bit. If the program goes, halogen market share is going to go up. LED market share will fill the void of CFLs and probably some of the incandescent market as it dies. But if Massachusetts or Connecticut—or any other program—pulled out today, the sale of LEDs would be reduced by significant margins. The sale of halogen-compliant products would be increased by significant margins.”



Appendix A Methodology – Additional Details

The following appendix offers additional details on the methodology behind the research findings.

A.1 SALES DATA MODELING

The following appendix section includes additional details on the methods for conducting the sales data modeling.

A.1.1 Sales Data Sources and Inputs

A.1.1.1 Lighting Sales

The sales data model drew on two datasets, the point-of-sale (POS) data and the National Consumer Panel (NCP) dataset, both described below.

The LightTracker POS data set includes lighting sales data for grocery, drug, dollar, club, and mass market distribution channels. These data represent actual sales that are scanned at the cash register for participating retailers.

The NCP represents a panel of approximately 100,000 residential households across the nation that are provided a handheld scanner for their home and instructed to scan every purchase they make that has a bar code. For Connecticut, the NCP included approximately 680 households in 2015. The use of a scanner avoids potential *recall bias* that is prevalent in self-report methods that ask about lighting purchases, although some bias likely remains related to how often and for which products panelists remember to scan their purchases.

Although the dataset the LightTracker Initiative received from IRI included detailed records of lighting data purchases, the data required a considerable cleaning effort to ensure integrity and inclusion of all the necessary bulb attributes. For example, not all records had some of the more critical variables populated, including bulb type, style, or wattage, or had clearly erroneous values (e.g., 60-watt CFLs).⁵³

After thorough review and quality control of the dataset, LightTracker then re-classified and standardized the data, populated missing records, created additional variables, and performed general enhancements to the data, as described below.

To populate missing records, validate existing records, and include additional bulb attributes, the team created a proprietary Universal Product Code (UPC) database with approximately 20,000 bulbs from four sources:

- Manufacturer product databases provided to LightTracker;

⁵³ As mentioned earlier, the contract with the third-party data source precludes including many of these variables in the analysis, but the evaluators can use such data to identify errors and reclassify certain products (e.g., night lights).

- Product catalogs downloaded from manufacturer web sites via python-code based *web scraping*
- Product offerings downloaded from retailer web sites
- Automated lookups of online UPC databases, such as www.upcitemdb.com

LightTracker next merged the bulb database with the POS/Panel data, populating fields based on a hierarchy of data sources believed to be most reliable. Prioritization was typically based on the following order: manufacturer specifications, UPC lookups, original IRI-based database values. Web lookups also served to determine final assignments for a large number of bulbs.

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

A.1.1.2 Program Activity

To research program activity, LightTracker utilized internal resources of evaluation teams working for CREED members (including NMR working for the EEB) and conducted a literature review of publicly available reports found on the internet or provided by program administrators or their evaluators,⁵⁴ and reached out to local utilities when reports were not available. Program activity data collected included:

- Total claimed CFL and LED upstream bulbs (broken out by bulb type) reported by each program
- Upstream CFL and LED incentives
- Total upstream program budget

It should be noted that, where available, LightTracker leveraged program expenditures as reported directly by administrators; otherwise they defaulted to ENERGY STAR reported expenditures as a proxy. Data from each program administrator were aggregated by state. Each state was assigned a modeling flag based on the source of and confidence in the data provided across all major program administrators, as outlined in Table 14. As an example, any state with no program activity (verified across members of each evaluator team) was assigned a 0. A 1 was assigned if LightTracker had successfully collected all program activity data points from every program administrator (including any muni or coop activity) in a state. A 2 was assigned to any state that had some program administrator data captured but other program administrator data (usually overall program expenditures) derived from ENERGY STAR. A 3 was assigned to the remaining states where the sole data points were derived

⁵⁴ In particular, the approach relied on searches in the ENERGY STAR® Summary of Lighting Programs https://www.energystar.gov/ia/partners/downloads/FINAL_2015_ENERGY_STAR_Summary_of_Lighting_Programs.pdf website and also referenced the www.dsireusa.org website.

from ENERGY STAR. The modeling team was then able to iterate through the model using states with the most accurate data.

Table 14: Program State Classification based on Accuracy of Program Data for Sales Data Modeling
(Classifications made by LightTracker)

Source of Data in Model	Non-program State	LightTracker (solely) ²	LightTracker and ENERGY STAR	ENERGYSTAR (solely)
Model Flag ¹	0	1	2	3
States	Alabama Delaware Kansas Kentucky Mississippi Montana Nebraska North Dakota Tennessee Virginia	Arkansas Connecticut Georgia Louisiana Maine Maryland Massachusetts Missouri Nevada New Hampshire New Jersey New Mexico New York Oregon Rhode Island Utah Wisconsin	Arizona California Colorado Idaho Iowa Ohio Pennsylvania Texas Washington Wyoming	Florida Illinois Indiana Michigan Minnesota Oklahoma South Carolina South Dakota Vermont West Virginia

¹ The modeling flag is associated with the source and confidence in the data.

² States included in the sales data modeling.

For Connecticut program activity, the modeling team restricted the data to the 17 states with the most detailed level of program activity gathered (noted in Table 14), which ranged from very low levels of LED program activity to very high levels. This decision reflected two factors: 1) the desire to use the strongest data available on program activity, and 2) the fact that LED sales in 2015 remained small compared to other bulb types, limiting the model’s ability to identify the impact of program activity on sales, which the researchers feared would result in Type II error (concluding that programs had no impact, when in fact they did)⁵⁵ simply because of low statistical power and incomplete data. The evaluators recognize the small sample size and limitation to states with programs as shortcomings of the resulting model.

⁵⁵ In statistical nomenclature, failing to reject the null hypothesis when in fact the alternative hypothesis is true.

For this reason, Table 15 shows the results of the Connecticut 2015 LED sales data model with non-program states included. Utilizing the non-program states adjusted r-squared to go negative and all of the predictors to no longer be significant.

Table 15: LED Sales Data Model with Program and Non-Program States

(n=27 states)

		Model Coefficient & P-Value
Independent Variables	Intercept	0.489
		0.844
Row 1 = regression coefficient	LED Program Spending per Household	0.056
		0.431
Row 2 = p-value of coefficient	Non-POS Retailers Sqft per Household	0.003
		0.980
	Political Index	0.030
		0.324
	Average Electricity Price	-0.268
		0.113
Model Adjusted R-squared		-.048

A.1.1.3 Presence and Absence of Retailers (Channel Variables)

LightTracker conducted secondary internet research in order to determine the number and the total square footage of store locations in each state for five primary energy efficient bulb retailers: Home Depot, Lowe's, Walmart, Costco, and Menards (a combination HI, mass market store located in the Midwest).⁵⁶ These data were utilized as explanatory variables in the model since these retailers sell such a large quantity of light bulbs but their concentration varies in states across the nation.

A.1.2 Sales Data Model Specification

The primary goal of the model was to quantify the impact of state-level program activity on the sales of LED lighting. Key aspects of the lighting dataset as analyzed include:

- 2015 sales volume and pricing for CFLs, LEDs, halogens, and incandescent bulbs for all channels combined, and broken out by the POS and non-POS channels
- Data reporting by state and bulb type
- Inclusion of all bulb styles and controllability (e.g., three-way and dimmable)

The general form of the model is specified below, followed by a more detailed discussion of the data sources for each variable.

⁵⁶ This is a national model, and Menards is an important and expanding retailer in the Midwest. To exclude it would exclude a key retailer that could affect the results.

Total LED Sales per HH_i

$$= \beta_0 + \beta_1 * LED \text{ Program Spending per HH} + \beta_c * \sum_1^c \text{Channel Variables} \\ + \beta_d * \sum_1^d \text{Demographic Variables}$$

Where:

Total LED Sales per HH_i = Total LED sales in state i divided by the number of households in state i.

LED Program Spending per HH_i = The number of 2015 retail lighting program dollars per household in state i. Equal to total retail lighting program expenditures in state i (LED incentive + non-incentive) divided by the number of households in state i.

Channel Variables:

Sqft NonPOS per HH_i = The average non-POS retail square footage per household in state i. Equal to non-POS sqft divided by the number of households in state i.

Demographic Variables:

Political Index_i = A state-level partisan voter index developed by Cook Political Report,⁵⁷ using presidential election voting results through 2014 as a state-level partisan proxy. A higher than 1.0 value represents greater Democratic influence and a value less than 1.0 indicates greater Republican influence.

Average Electricity Cost_i = The State-level average residential retail rate of electricity, sourced directly from the Energy Information Agency (EIA)⁵⁸

β₀ = The model intercept

β₁ = The primary coefficient of interest. This represents the marginal effect or program intensity, or the expected increase in the number of LED sales for \$1 in additional program spending per household.

β_c and β_d = Array of regression coefficients for the channel variables and demographic variables

ε_i = Error term.

Clearly, there are other factors that influence the sales of efficient lighting, and the team considered several demographic, social, household, and retail channel variables to capture and control for the unique characteristics of each state that potentially affect the uptake of efficient lighting products. The study tested the following predictor variables, but each was an insignificant predictor of LED purchases:

⁵⁷ <http://cookpolitical.com/house/pvi>

⁵⁸ <https://www.eia.gov/electricity/data/state/>

- Square Feet of POS Retailers per Household
- Median Income
- Average Cost of Living
- Households Built before 1980
- Renter Pays Utilities
- Owner Occupied Household
- Percentage of Population with a College Degree

The modeling team also explored variance inflation factors (VIF), which serve as a test of multicollinearity. The VIF measures how much the variance of estimated regression coefficients are inflated as compared to when the predictor variables are not linearly related. The lower the VIF value (scale starts at zero) the smaller the correlations among predictor variables while a VIF over 10 is considered highly correlated. Table 16 shows that the modeled independent variables have a low level of collinearity and are appropriate to use in the same model.

Table 16: Sales Data Model Predictor Variables Inflation Factors

Predictor Variable	Variable Inflation Factors
Average Electricity	2.84
Political Index	2.40
LED Program Spending per household	1.60
Non-POS Retailers sq. ft. per household	1.24

Table 17 shows the preferred sales data modeling results, including regression coefficient and p-value for all included independent variables. All p-values listed were significant at the 95% confidence level.

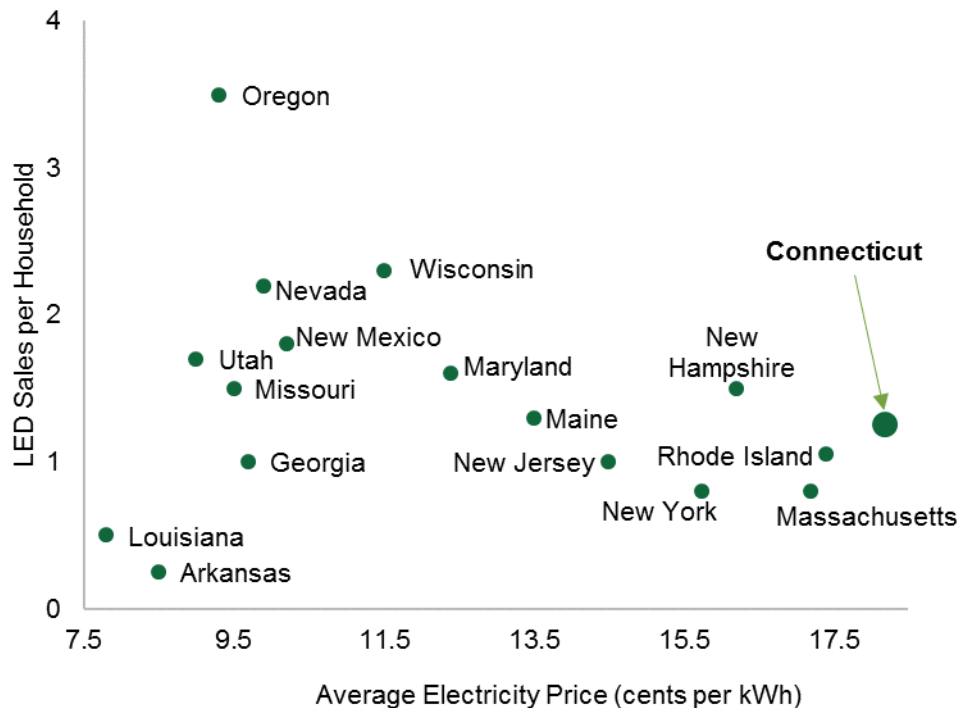
The model suggests that for each dollar increase in program spending per household, LED sales increased by 0.08 bulbs. The model also suggests that higher statewide square footage of non-reporting retailers and greater Democratic influence (versus Republican) were associated with more LED purchases in a state. Somewhat counterintuitively, the model also found that the average electricity price had a negative relationship with number of LED purchases (Figure 22). However, the states with the highest electricity prices also tended to have long standing programs and higher saturation rates, which, as discussed above, may reduce current bulb purchases.⁵⁹

⁵⁹ Oregon presented as an outlier with LED per household sales of 3.7 and an average price of electricity of \$0.88 kWh, the study performed a sensitivity analysis by removing Oregon from the model, and found that the model was not sensitive to Oregon's influence.

Table 17: Preferred Sales Data Model Summary Statistics
(n=17 states)

		Model Coefficient & P-Value
Independent Variables	Intercept	-6.30
		0.003
Row 1 = regression coefficient	LED Program Spending per Household	0.084
		0.035
Row 2 = p-value of coefficient	Non-POS Retailers sq. ft. per Household	0.560
		0.001
	Political Index	0.085
		0.001
	Average Electricity Price	-0.268
		0.000
Model Adjusted R-squared		0.64

Figure 22: Relationship between LED Sales and Average Electricity Price
(Based on sales data modeling, n=17 states)



The NTG inputs are shown in Table 18. Note that a NTG ratio based on 2013 data from the point-of-sale source only and using a different model specification yielded an estimate of 87%. Given the increased and widespread adoption of LEDs over the past two years, coupled with the addition of the panel data and the related data cleaning and altered model

specification, the reduction in NTG from 87% to 70% seems to make intuitive sense to the evaluation team.

Table 18: LED NTG Sales Data Modeling Estimate Inputs

Formula	Calculation Term	Value
	Total Connecticut LEDs 2015	2,312,398
	LED Program \$ per Household Actual	\$10.97
	LED Program \$ per Household Counterfactual	\$0.00
A	LED Bulbs Counterfactual	77,485
B	LED Bulbs Modeled	1,469,263
C	LED Program Bulbs 2015	1,976,639
D = (B-A)	Net LED Bulbs Modeled	1,391,778
D ÷ C	LED NTGR Modeled	70.4%

A.2 DEMAND ELASTICITY MODELING

The following appendix section includes additional details on the methods for conducting the demand elasticity modeling.

A.2.1 Modifications to Inputs

As the demand elasticity approach relies exclusively on program data, the model's robustness depended on data quality. Overall, the available data from the Connecticut Lighting Strategy achieved a sufficient quality to support the analysis. However, there were several necessary adjustments, as discussed below regarding several key input categories:

- Seasonality
- Price Variation
- Promotional Displays

A.2.1.1 Seasonality

Conducting accurate economic analysis critically depends on separating data variations that result from seasonality from those that result from relevant external factors. For example, suppose umbrella prices fell at the beginning of the rainy season. One might erroneously conclude that the price reductions drove sales, when in actuality, the increase in precipitation likely had more to do with it. Skewed estimations result from an analysis that does not account for the natural seasonality of umbrella sales.

The current lighting demand elasticity model included a seasonal trend, provided by APT, the previous program implementer. The seasonal trend represented the proportion of annual national sales expected to occur in a given month from a major national lighting manufacturer. Using data at a national aggregation level, including non-program products and areas without programs, limited the degree that resulting trends correlated with program activity.

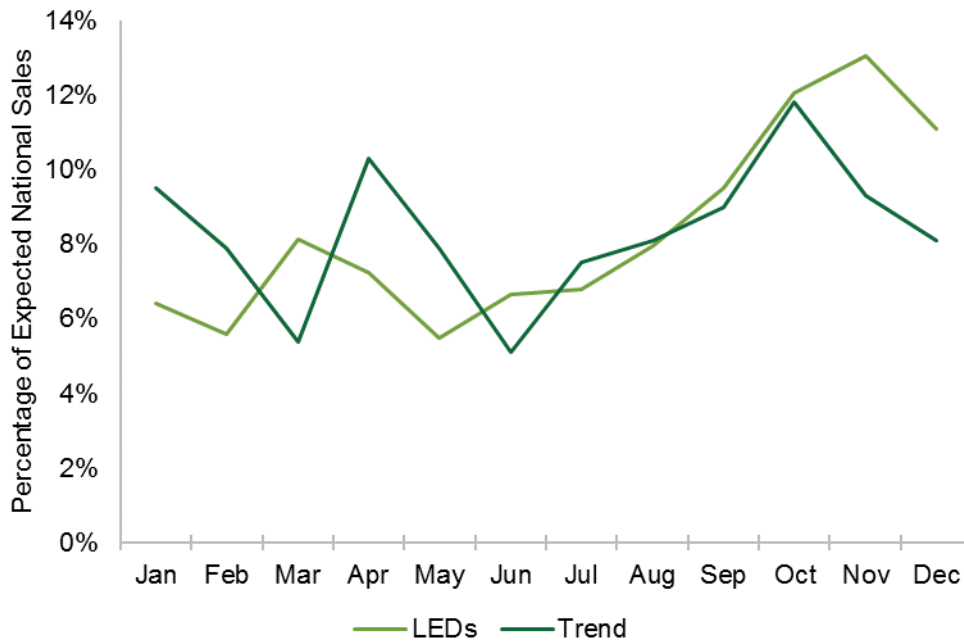
For example, sales fall during July (presumably due to longer daylight hours); so, if program activity increases sales in July, analysis underestimates the program's impact if it does not

control for seasonal variations. Alternatively, sales tend to rise in October; not controlling for seasonality likely overestimates program activity impacts during that month.

The sales data included in the model also fit this pattern, with peak sales in October and November 2015. Therefore, the model included the seasonal trend to control for seasonal sales variations.

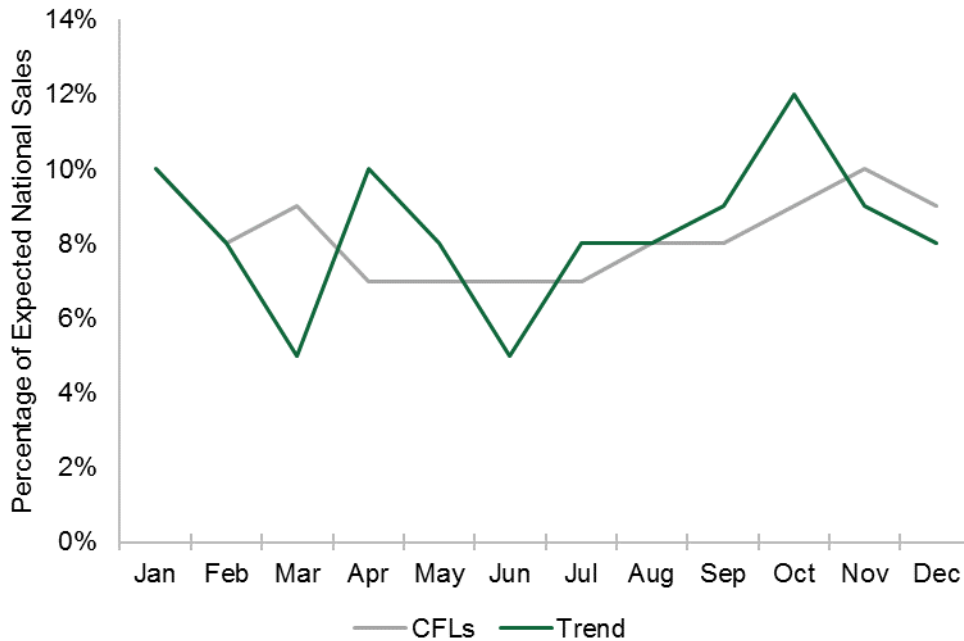
LED sales followed the trend in the second half of 2015, excluding November and December. In the last two months of the year, as shown in Figure 23, LED sales were considerably higher than what we would expect given the trend. Additionally, incentive levels for LEDs decreased after March but the retailer price absent incentives also decreased, which more than offset the decreased incentives leading to lower LED prices throughout the remainder of 2015.

Figure 23: Percent of 2015 LED Sales by Month and Seasonal Trend
(2015 program data and APT seasonal trend data)



Incentive levels also changed for CFLs after March of 2015. Decreased incentive levels and correspondingly increased average bulb prices for CFLs did not appear to correspond with the sales drop other than April, the month immediately following the decrease in incentives. As shown in Figure 24, CFL sales increased in the fall, coinciding with the peak of the seasonal trend.

Figure 24: 2015 CFL Sales by Month and Seasonal Trend
 (2015 program data and APT seasonal trend data)¹



¹ Because prices and program activity changes over time, there are deviations between the seasonal trend and program CFL sales. For example, starting in April incentive levels dropped and sales decreased whereas the trend indicates an expected increase in sales. And in October the trend peaks but program CFL sales did increase as much as expected because incentives were lower after March. However, the general pattern holds with a dip in the summer months and an increase in sales going into fall.

Prices and incentives by month and technology are shown in Table 19.

Table 19: 2015 Prices per Bulb by Month and Technology
(2015 program data)¹

Technology	Month	Initial Price Per Bulb	Rebate Per Bulb	Final Price Per Bulb
CFL	Jan	\$3.72	\$0.87	\$2.85
	Feb	\$3.55	\$0.87	\$2.68
	Mar	\$3.62	\$0.86	\$2.76
	Apr	\$2.78	\$0.77	\$2.01
	May	\$3.34	\$0.79	\$2.55
	Jun	\$3.40	\$0.79	\$2.61
	Jul	\$3.39	\$0.79	\$2.61
	Aug	\$3.41	\$0.78	\$2.63
	Sep	\$3.42	\$0.78	\$2.63
	Oct	\$3.42	\$0.78	\$2.64
	Nov	\$3.46	\$0.78	\$2.67
	Dec	\$3.48	\$0.78	\$2.69
LED	Jan	\$16.49	\$6.68	\$9.81
	Feb	\$16.18	\$6.59	\$9.58
	Mar	\$16.49	\$6.59	\$9.90
	Apr	\$13.83	\$5.58	\$8.26
	May	\$14.56	\$5.72	\$8.84
	Jun	\$14.53	\$5.66	\$8.87
	Jul	\$14.51	\$5.65	\$8.87
	Aug	\$14.58	\$5.65	\$8.93
	Sep	\$14.45	\$5.56	\$8.88
	Oct	\$14.13	\$5.49	\$8.64
	Nov	\$14.09	\$5.43	\$8.66
	Dec	\$13.94	\$5.38	\$8.56

¹ Prices and incentives in the table are not sale-weighted as they are in the model. These prices reflect the options the consumer faces on the shelf rather than reflecting the ultimate decision of the consumer.

Because price trends differed between CFL and LED bulbs, analysis interacted the seasonal trend with the retail channel and with bulb technology to control for changes in sales not related to price changes at a greater level of granularity.

A.2.1.2 Price Variation

Overall, a substantial number of products exhibited price variation. Additionally, most retailers offered multiple products that exhibited price variations.

Model sales and prices combined across all comparable products within each unique retailer's store location. The average price for each bulb type within each store reflects the monthly sales-weighted, per-bulb price across all comparable products. Monthly sales equaled the sum of all sales within each store across the same group of comparable products (e.g., prices and monthly sales for all 60-watt, incandescent-equivalent, general purpose LED bulbs at a single Home Depot store).

Combining sales and prices this way (rather than observing price and sales changes for each individual model number) presented an advantage: capturing any substitutions between comparable products (e.g., a decrease in the average price per-bulb when adding a three-pack of an existing bulb to the program).

Similarly, suppose an updated version of a bulb (with a different model number) replaced an original bulb model. The first model's sales likely drop because the retailer sells off back stock, even as the second model's sales increase. Aggregating prices and sales captures variations across both products rather than controlling for the sales impacts of factors unrelated to price (i.e., products phased out and replaced).

The demand elasticity model only included sales with price variations as products with no variation in price do not contribute any information to the model. The greater the price variation levels across retailers and lamp styles, the more representative the elasticity estimates became when applied to sales of products that did not exhibit price variations.

Overall the model included products that represented 79% of LED sales and 80% of CFL sales, though the representativeness varied by retail channel. As shown in Table 20, prices varied for more than 90% of both CFL and LED sales at HI stores, which accounted for 52% of all program sales. Mass market retailers also showed significant variation in prices with products representing over 90% of sales exhibiting changes in price. Club store prices varied less, with 44% of LED sales and 36% of CFL sales exhibiting price variations. Prices varied for over 60% of sales at HTR retailers for both CFLs and LEDs.

Table 20: Sales Represented in Demand Elasticity Model by Channel and Technology

(Based on demand elasticity modeling and 2015 program data)

Retail Channel	Technology	Percent of Sales in Model	Percent of Total Program Sales (2015)
Club	CFL	36%	8%
	LED	44%	17%
HI	CFL	96%	19%
	LED	96%	33%
HTR	CFL	63%	4%
	LED	69%	6%
Mass market	CFL	92%	11%
	LED	94%	3%

Additionally, significant variations occurred for most bulb styles, as shown in Table 21.

Table 21. Sales Represented in Demand Elasticity Model by Style and Technology

(Based on demand elasticity modeling and 2015 program data)

Technology	Bulb Type	Percent of Sales in Model	Percent of Total Program Sales (2015)
LED	Reflector	92%	13%
	Specialty	26%	5%
	Standard	81%	40%
CFL	Reflector	0%	1%
	Specialty	16%	0%
	Standard	82%	41%

The model included sales representing more than 80% of standard, general service bulbs sales (both CFLs and LEDs) and 92% of reflector LED sales. Together, these accounted for 94% of total sales. The model included fewer specialty bulbs (e.g., globe, candelabra): 16% of CFLs and 26% of LEDs. These accounted for only 5% of total program sales. The model did not include CFL reflector sales as none exhibited price variations; reflector CFLs accounted for less than 1% of total program sales.

Overall, the model included 79% of total bulb sales in 2015 that exhibited price variations; 21% did not exhibit price variations.

A.2.1.3 Promotional Displays

Program data included records of in-store promotional events and product displays. Program implementer field staff collected these data when visiting stores to ensure compliance with retailer contractual agreements. Field staff verified prices, product placements, and shelf signs that indicated products were included as part of the program. They also collected data that tracked whether retailers displayed program bulbs in prominent promotional displays (e.g., clip strips, end caps, pallet displays).

While these data contained a comprehensive list of all in-store promotional events, the information on merchandising displays only represented a sample of locations that program implementer field representatives visited within a given week.

Due to the merchandising data's nature, the demand elasticity model could not predict sales for observations with missing merchandising data. Consequently, the team considered two separate models:

- Model 1 - included all observations with varying prices but did not control for merchandising
- Model 2 - controlling for price, but only using observations with merchandising data⁶⁰

Although two models would have allowed for combining the estimated price coefficients from the first model and the estimated merchandising coefficients from the second model to predict sales and estimate freeridership, prices correlated with merchandising in the second model. This means that the first model's price coefficients reflected some merchandising impacts (as the model did not control for merchandising). Adding merchandising coefficients to the first-model's estimates would double-count some of the merchandising's effect, thus biasing predicted sales and overstating the program impact.

Ultimately, the study utilized the first model, which included in-store promotion data but excluded display merchandising data. Not accounting for merchandising may overestimate freeridership to the extent that the price coefficients do not reflect all of the impact of merchandising.

A.2.2 Demand Elasticity Model Specification

The demand elasticity model organized bulb and pricing data as a panel, with a cross-section of program bulb quantities for each unique retail location, bulb type, and baseline wattage combination. These were modeled over time as a function of price and retail channel (e.g., club, do-it-yourself, HTR, and mass market). This study also involved testing a variety of specifications to ascertain price impacts—the main instrument affected by the program—on the demand for bulbs. The model adopted the following basic equation (for cross-section i , in month t):

$$\begin{aligned} \ln(Q_{it}) = & \sum(\beta_{\pi} * ID_{\pi,i}) + \sum(\beta_{\theta 1}[\ln(P_{it}) * (Retail\ Channel_{\theta,i})]) \\ & + \sum(\beta_{\theta 2}[\ln(P_{it}) * (Technology_{\theta,i})]) + \sum(\beta_{\theta 3}[\ln(P_{it}) * (Bulb\ Type_{\theta,i})]) \\ & + \sum(\beta_{\theta 4}[Display * (Retail\ Channel_{\theta,i})]) + \beta_{\theta 5} * Promo \\ & + \sum(\beta_{\theta 6}[Trend * (Retail\ Channel_{\theta,i})]) + \varepsilon_{it} \end{aligned}$$

Where:

- \ln = Natural log
- Q = Quantity of bulbs sold during month t
- P = Retail price per bulb in month t
- Retail Channel = Retailer category (HI, mass market, HTR, club)
- Technology = CFL or LED
- Bulb Type = Product category (standard, reflector, specialty)

⁶⁰ Model 2 has more than 450,000 fewer sales than Model 1 due to excluding those that do not have merchandising data.

- ID = Dummy variable equaling 1 for each unique retail location, bulb type, and base watt; 0 otherwise
- Seasonal Trend = Quantitative trend representing the impact of secular trends not related to the program
- Display = Dummy variable equaling 1 if a product was featured in an off-shelf display in time period t
- Promo = Dummy variable equaling 1 if an in-store promotion event took place in time period t
- ε_{it} = Cross-sectional random-error term in time period t

The model specification assumed a negative binomial distribution. This served as the best fit of the plausible distributions (e.g., log normal, poisson, negative binomial, or gamma). The negative binomial distribution's long right tail coincides with a small proportion of products accounting for a disproportionate share of sales.⁶¹

The study tested numerous model scenarios to identify the model with the best parsimony and explanatory power using the following criteria:

- Model coefficient p-values (keeping values less than <0.1)⁶²
- Explanatory variable cross-correlation (minimizing where possible)
- Model AIC (minimizing between models)⁶³
- Utilizing the heteroskedastic consistent covariance matrix and clustered standard errors to account for heteroskedasticity
- Minimizing multicollinearity
- Optimizing model fit

The study preferred model specifications with elasticity estimates nested by technology, retail channel, and bulb type (general purpose, specialty, and reflector). This accounts for differences in retailer strategies and target demographics, as well as differences in demand given bulb characteristics. Ultimately, models were ranked by lowest AICs and lowest differences between monthly actuals and monthly predictions. The model with the lowest rank with the most intuitive specification and parameter estimates was chosen.

The model's fit can be examined by comparing model-predicted sales with actual sales. As shown in Figure 1, the model-predicted sales very closely matched actual sales without persistent bias in a single direction (over- or under-predicting for each month). This indicated that the model fit the data well.

⁶¹ Figure 3 in the appendix presents a histogram of monthly bulb sales across all products and demonstrates the degree to which the observations are skewed.

⁶² Where a qualitative variable had many states (such as bulb types), variables were not omitted if one state was not significant, but rather considered the joint significance of all states.

⁶³ Akaike information criterion (AIC) is a measure of relative quality used compare and assess model fit, as nonlinear models do not define the R-square statistic. AIC also offers a desirable property in that it penalizes overly complex models, similarly to the adjusted R-square.

As Figure 25 shows, the two largest discrepancies between predicted and actual sales occurred at the end of 2015. Overall, the predictions fit actual sales well, though the model over-predicted sales by 1.6% in aggregate.

Figure 25. Predicted and Actual Sales by Month in 2015

(Based on demand elasticity modeling and 2015 program data)

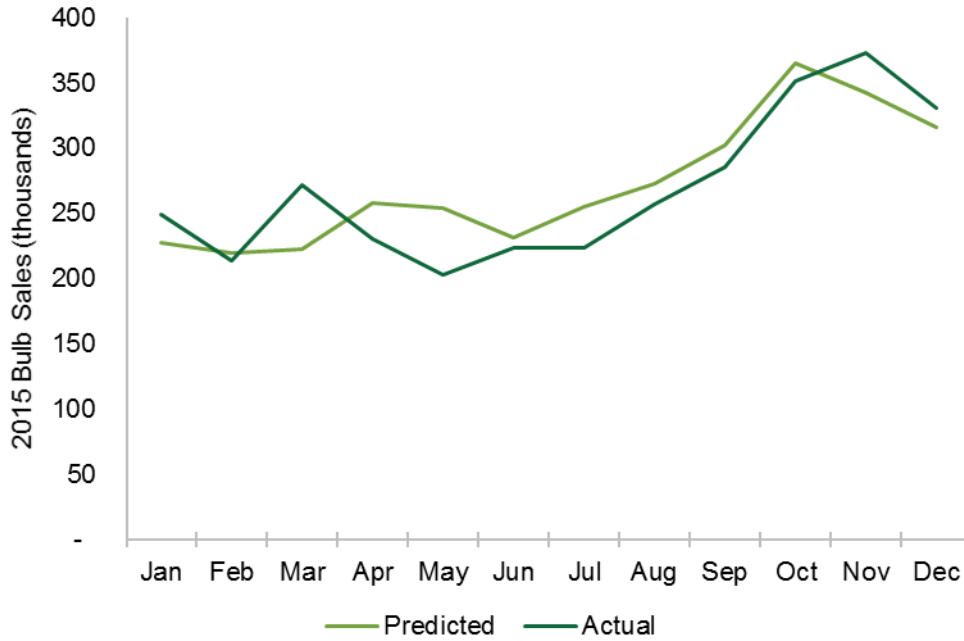


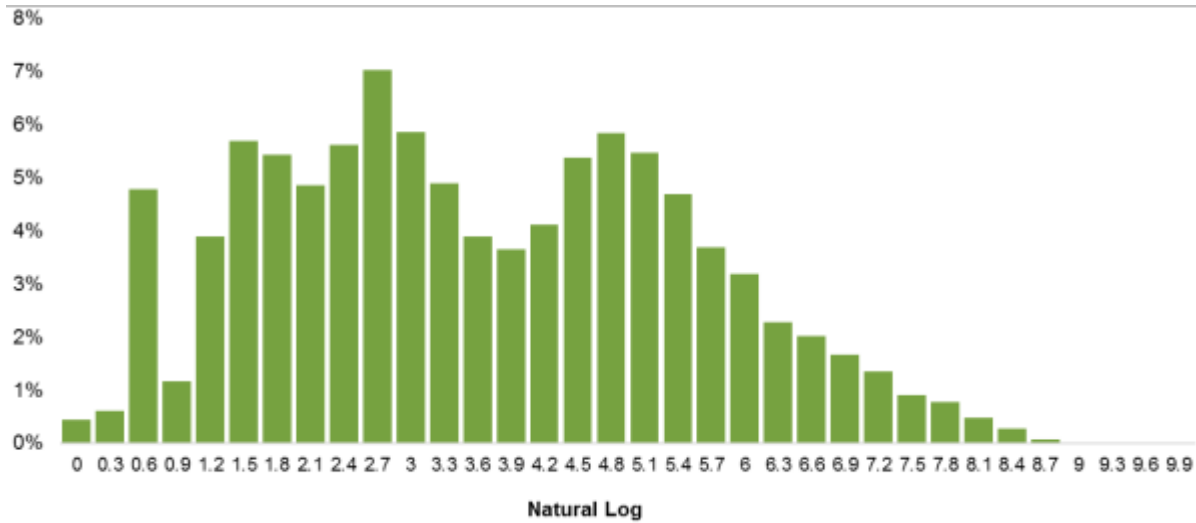
Table 22. Final Demand Elasticity Model Parameters

Parm.	Level1	Level2	Level3	Estimate	Stderr	Lower CL	Upper CL	Z	ProbZ
Intercept				0.00	0.00	0.00	0.00	0.00	0.00
LnPe*Chan*Type*Techn	Club	Reflector	LED	-1.11	0.23	-1.56	-0.65	-4.77	0.00
	Club	Standard	CFL	-0.75	0.45	-1.63	0.14	-1.65	0.10
	Club	Standard	LED	-2.53	1.07	-4.64	-0.43	-2.36	0.02
	DIY	Reflector	LED	-0.58	0.09	-0.74	-0.41	-6.77	0.00
	DIY	Specialty	CFL	-2.71	0.84	-4.34	-1.07	-3.24	0.00
	DIY	Specialty	LED	-2.88	0.12	-3.11	-2.66	24.91	0.00
	DIY	Standard	CFL	-0.75	0.10	-0.93	-0.56	-7.81	0.00
	DIY	Standard	LED	-1.89	0.09	-2.06	-1.72	21.62	0.00
	HTR	Reflector	LED	-0.42	0.09	-0.59	-0.24	-4.68	0.00
	HTR	Specialty	LED	-0.77	0.19	-1.14	-0.40	-4.08	0.00
	HTR	Standard	CFL	-1.64	0.13	-1.90	-1.38	12.41	0.00
	HTR	Standard	LED	-0.54	0.15	-0.82	-0.25	-3.68	0.00
	Mass	Reflector	LED	-1.84	0.15	-2.13	-1.55	12.35	0.00
	Mass	Specialty	CFL	-1.85	0.63	-3.07	-0.62	-2.95	0.00
	Mass	Specialty	LED	1.07	0.41	0.26	1.88	2.60	0.01
Mass	Standard	CFL	-0.54	0.14	-0.82	-0.26	-3.73	0.00	
Mass	Standard	LED	-3.11	0.15	-3.41	-2.81	20.33	0.00	
Promos				0.03	0.00	0.02	0.04	7.19	0.00
trend*Chan*Technol	Club	CFL		1.03	2.55	-3.98	6.03	0.40	0.69
	Club	LED		2.14	1.10	-0.02	4.29	1.94	0.05
	DIY	CFL		3.41	0.42	2.59	4.23	8.12	0.00
	DIY	LED		4.19	0.47	3.27	5.11	8.91	0.00
	HTR	CFL		5.01	0.52	4.00	6.03	9.65	0.00
	HTR	LED		5.22	0.99	3.27	7.17	5.24	0.00
	Mass	CFL		2.58	0.48	1.64	3.52	5.40	0.00
	Mass	LED		8.68	0.88	6.96	10.39	9.91	0.00

Table 23. Comparative Demand Elasticity Model Fit Statistics by Distribution

Assumed Error Distribution	AIC	BIC
Negative Binomial	151,528	164,393
Poisson	644,400	657,257
Log-Normal	229,597	242,463
Gamma	151,901	164,766

Figure 26: Natural Log of Monthly Bulb Sales Histogram
(From demand elasticity modeling)



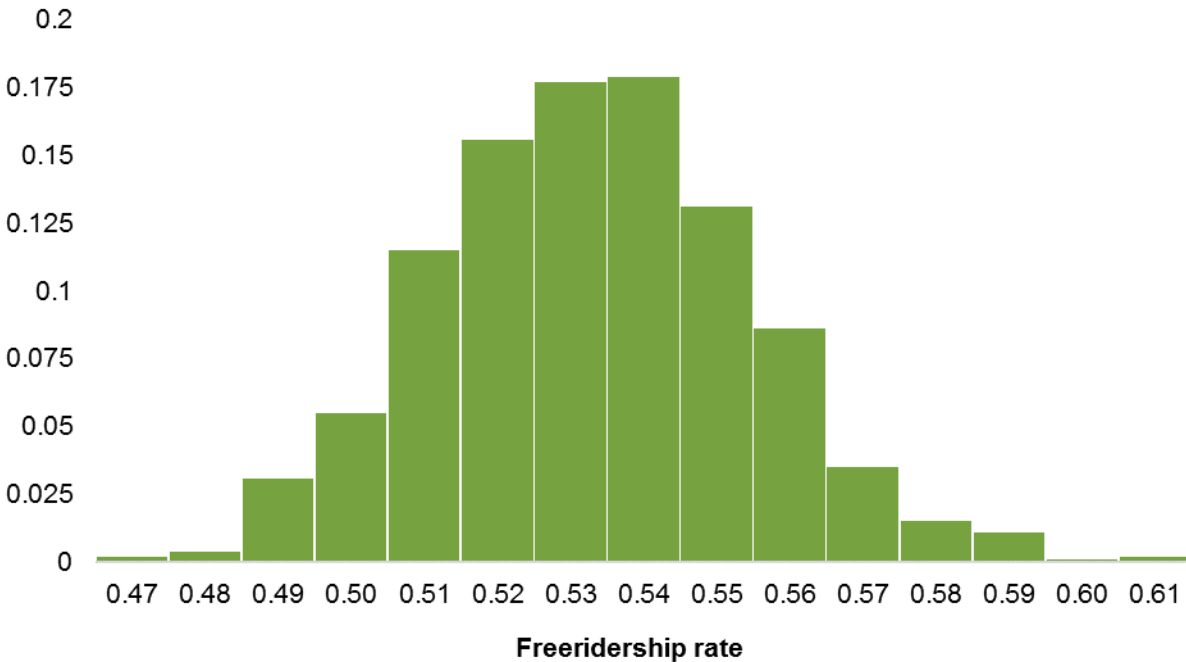
A.2.3 Demand Elasticity Model Precision

Upon developing the final model specification, the study calculated precision using *block bootstrap* standard errors to determine the sensitivity of the net-to-gross ratios. To develop bootstrap standard errors, analysts drew 1,000 new samples (with replacements drawn at the cross-section level) from the original data, estimating coefficients with each sample, predicting sales and saving with and without program incentives, and calculating a new freeridership ratio. Using this method, the 5th and 95th percentiles in these freeridership ratios represented the lower and upper bounds of the 90% confidence interval, as shown in Table 24. The distribution of freeridership predictions was normally distributed with a median value 52.8%, which is very similar to the program freeridership estimate of 52% presented in Table 25. Figure 27 shows the distribution of freeridership predictions from the bootstrap analysis.

Table 24: Demand Elasticity Modeling Freeridership Estimate Confidence Interval

Program Freeridership	5% Lower Bound Confidence Interval	95% Upper Bound Confidence Interval	Relative Precision at 90% Confidence
52%	49%	56%	± 7%

Figure 27: Demand Elasticity Modeling Bootstrap Freeridership Estimate Histogram



A.3 BENCHMARKING

The benchmarking analysis draws on the following references:

Cadmus Group. *Evaluation of Xcel Energy's Home Lighting and Recycling Program*.

January 13, 2016. <http://www.xcelenergy.com/staticfiles/xe/PDF/Regulatory/CO-DSM/CO-Regulatory-DSM-Home-Lighting-and-Recycling-Evaluation.pdf>

Cadmus Group. *Arkansas Energy Efficiency Program Portfolio Annual Report*. Docket No. 07-085-TF: 2013 Program Year. April 1, 2014.

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DNV GL. *Impact Evaluation of 2013-14: Upstream and residential downstream lighting programs*. California Public Utilities Commission. April 1, 2016.

<http://www.energydataweb.com/cpucFiles/pdaDocs/1488/2013-2014%20California%20Upstream%20and%20Residential%20Lighting%20Impact%20Evaluation%20Report%20FINAL.pdf>.

Frontier Associates. *Evaluation, Measurement, and Verification of CPS Energy's FY 2015 DSM Programs*. June 11, 2015.

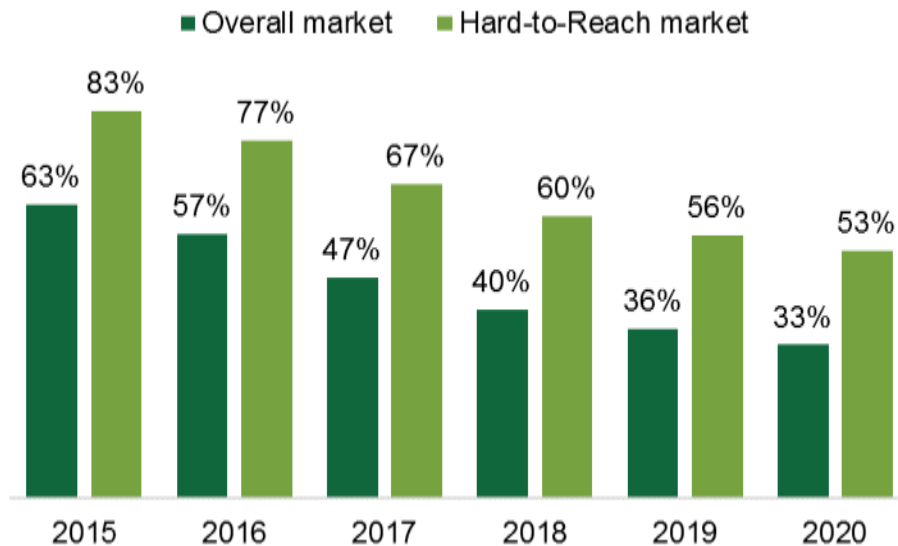
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<http://www.energymaine.com/docs/Efficiency-Maine-Retail-Lighting-Program-Evaluation-Report-2015.pdf>.
- Southwestern Public Service Company. *2014 Energy Efficiency and Load Management Plan*. Case No 13-_-UT. August 28, 2013.
http://www.swenergy.org/Data/Sites/1/media/documents/news/news/file/SPS_2014_DSM_plan.pdf.

A.4 CONSENSUS PANEL

This appendix details the consensus panel's decisions, including the steps undertaken and the reasoning behind the recommended values. Figure 28 illustrates the consensus panel's recommended LED NTG estimates.

Figure 28: LED NTG Retrospective and Prospective Estimates by Market
(Consensus panel results, n=6)



A.4.1 Retrospective and Near-Term

When making their estimates, panelists highly valued the R1615 results in comparison to the benchmarking studies. When asked to rate the importance of the three primary activities completed for this evaluation on a scale of one to five, where one equals *not at all important* and five equals *extremely important*, they rated all three R1615 primary-research tasks the highest. They rated demand elasticity modeling (4.2) and supplier interviews (4.4) notably higher than the sales data modeling (3.0) with the explanation that the sales data modeling held some methodological weaknesses, such as the inability to control for prior saturation, low sample size, and unstable specifications (Section 2.2). As such, panelists' retrospective estimate for 2015 (63%) was nearly identical to the net-of-freeridership estimate from the demand elasticity modeling and the NTG estimate from supplier interviews, which were both 61%. They rated the benchmarking studies 2.67 or lower, on average, citing differences in geography and datedness (Section 3.3).

A.4.2 Long-term

Panelists' average LED NTG estimates for 2018 through 2020 assumed a steady decline, from 44% in 2018 to 33% in 2020, or almost one-half of their initial NTG estimate of 63% for 2015. In fact, one panelist estimated that NTG would slide to 10% in 2020.

Both their written responses and discussion during the panel demonstrated that the LED market in the long-term held a great deal of uncertainty. They considered program support to be vital to driving LED sales historically and at present. While they forecasted that the future LED market should be able to grow independent of program support, they could not reach consensus on *when* that would occur.

Panelists also reflected on market variables (explored in greater detail in Section 4). They reported the following as driving LED adoption: the influx of value-line LEDs (defined in

Section 1.1) yielding decreased prices, and the imminent disappearance of CFLs and rollout of ENERGY STAR 2.0 reducing energy-efficient lighting options. One panelist called LEDs a *market juggernaut*, estimating that LED prices are declining roughly 20% to 30% each year, but most agreed that changes in federal administration and the resulting uncertainty around the implementation and enforcement of EISA 2020 add additional layers of confusion.

A.4.3 Retail Channel

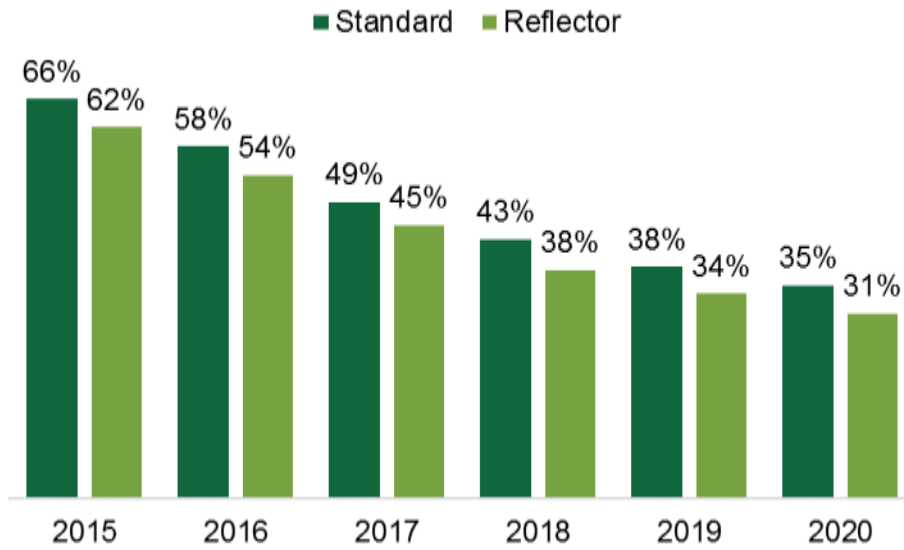
The panel discussion heavily considered HTR market dynamics where prices typically dictate adoption, current penetration is low, and distribution costs are high. Panelists forecasted that many HTR stores would not carry LEDs in absence of the program. Supplier interview results underscored this distinction, where, for example, standard bulb retrospective NTG was 63% for the program overall but was 100% for HTR retailers. To acknowledge this particularity, the panel determined that an increase of 20 percentage points for the HTR market's LED NTG across years would result in fair estimates, starting with 83% in 2015 and ending at 53% in 2020 (Figure 28).

A.4.4 Bulb Type

Panelists also provided separate estimates for standard and reflector bulbs. Reflector LED NTG estimates from the panelists (as well as demand elasticity modeling and supplier interviews) were consistently lower than those of standard LEDs, but they did not differ by more than five percentage points for any year. The consensus panelists ultimately decided to combine standard and reflector bulbs into a single category of non-HTR LEDs due to the similarity in separate estimates and uncertainty regarding the adoption and implementation of the DOE rule that expands the general service lamp definition to include reflectors and many other specialty bulb types.

Prior to making this decision, the discussion around reflectors focused on the nature of the separate estimates and the current and future reflector market. While one panelist was unaware of evidence supporting differences between standard and reflector LED NTG, others justified the difference in their estimates. Another panelist concluded that because LED reflectors were introduced before standard LEDs they have had more time to penetrate the market; another added that, as a result, they are currently at price parity with halogens for same light output. Additionally, one observed that customers perceived halogen reflectors as poor quality; another added that reflectors are natural applications for LEDs due to directional light output making them an easier market penetrator. Figure 29 illustrates the consensus panel estimates by bulb type.

Figure 29: LED NTG Retrospective Estimates by Bulb Type
 (Consensus panel results, n=6)



B

Appendix B Additional Results

B.1 NET-TO-GROSS ESTIMATES BY TECHNOLOGY

The demand elasticity modeling analysis estimated freeridership for CFLs in addition to LEDs to estimate an overall program freeridership ratio for 2015. As reported, the overall freeridership for LEDs alone was 39%, and the ratio for CFLs was 67%, resulting in an overall program freeridership ratio of 52% (Table 25). The resulting net-of-freeridership or, in this case NTG ratio, for LEDs (61%) was therefore higher than that of CFLs (33%).

Though freeridership was lower for LEDs, they accounted for a greater share of sales (58%) than CFLs (42%). However, they accounted for fewer savings that were modeled (53%) and therefore contributed less to overall program freeridership.⁶⁴

Table 25: Net-of-freeridership, Sales, and Savings by Technology

(Based on demand elasticity modeling)

Technology	Modeling Results		2015 Program Data Associated with Modeling			
	Free-ridership	Net-of-Free-ridership ¹	Total Bulb Sales	% of Sales	Total Savings (MWh)	% of Savings
LED	39%	61%	1,605,989	58%	44,022	53%
CFL	67%	33%	1,150,981	42%	38,655	47%
Overall	52%	48%	2,756,970		82,676	

¹ Given that the model does not include spillover, the NTG is equal to 1 minus freeridership (i.e., net-of-freeridership).

Table 26 shows average elasticity estimates and freeridership estimated through demand elasticity modeling by bulb type and technology.

- Specialty (38%) and standard (27%) LEDs were associated with the lowest freeridership rates; they also had high elasticity (-2.20 and -1.88, respectively).
- Like specialty LEDs, specialty CFLs (-2.64) proved highly elastic; however, they had high freeridership (71%). Meanwhile, standard CFLs also had high freeridership (67%), yet they (-0.76) proved the least elastic—they accounted for the largest share of sales in 2015 for a single bulb type (41%).
- Reflector LEDs also had high freeridership (60%) with low elasticity (-0.84).

While specialty bulbs produced lower observed elasticity, they also sell at lower rates than standard and reflector bulbs, producing more noise in the data for demand elasticity modeling. However, specialty bulbs typically do not account for a large share of program

sales and had the lowest proportion of sales included in the model due to little price variation. As prices for LEDs decreased through 2015 and program incentives continued to shift to LEDs,⁶⁵ the average final prices of standard CFLs increased relative to LEDs. However, demand for standard CFLs remained relatively stable, suggesting somewhat inelastic demand—Appendix A.2 provides more details on these program trends. The inelastic demand could result from inertia in the market. Utility-sponsored programs have promoted CFLs for many years, and some consumers—absent dramatic changes in price—may be more likely to buy bulbs with which they have the greatest familiarity.

Table 26: Elasticities by Technology and Bulb Type

(Based on demand elasticity modeling)

Technology	Bulb Type	Average Elasticity	Freeridership
LED	Reflector	-0.84	60%
LED	Specialty	-2.20	38%
LED	Standard	-1.88	27%
CFL	Specialty	-2.64	71%
CFL	Standard	-0.76	67%

B.2 ADDITIONAL INSIGHTS FROM PROGRAM STAFF INTERVIEWS

Some questions from the program staff laid further groundwork for the R1616 study. We present those results here.

B.2.1 Connecticut Program Lighting Strategy

Interview questions attempted to gain insight into aspects of the program's Lighting Strategy. Only one interview left ample time to directly assess the strategy's strengths, weaknesses, opportunities, and threats:

- Rapidly Changing Market.** While program staff perceived the program as strong, they expressed concerns about market saturation and the program's relevance in the future. They underscored that the program needs to stay focused on how quickly it can change its POS materials—and its focus, in essence—to keep up with the rapidly changing lighting market and external factors. Some retailers require a lag time to communicate with corporate headquarters, which can present problems with pivoting quickly.
- Flexibility.** From their perspective, one of the program's top strengths is its flexibility which allows it to remain open to new cost-effective products. The theme of program flexibility as an asset streamed through both interviews. As an example, they pointed to its memoranda of understanding with participating stores, calling them flexible on the program's end—given adequate lead time, products can be added or removed,

⁶⁵ Section 4 explores changing market shares across bulb types and the program and market transitions to LEDs away from other bulb types, including CFLs.

incentive levels can be changed, and product volumes can be increased throughout the program cycle.

- **Broad Market.** They pointed to the wide range of retailer and manufacturer participants as a program asset, explaining that the approach allows the program to offer a wide range of products and touch a wide range of geographic areas.

The remainder of this section provides more supporting evidence of these opinions.

B.2.2 Marketing

Program staff described the marketing approach. The program engages in co-marketing efforts with participants (manufacturers and retailers) to create educational flyers. Implementers prepare and place POS materials and hold promotional demonstrations and events where they interact with customers on the sales floor. The program airs radio advertisements and publicizes the program in local newspapers and on billboards. More specifically, they conduct geo-targeting to customers within five miles of stores where seasonal promotions are held. Part of the program's strategy is to provide participating stores with as much support as possible in promoting the program. While the Companies prepare annual marketing plans, they are flexible in altering those as needed.

Currently, the implementation contractor visits big box retailers weekly and independent stores monthly—they check that prices and POS materials are in line with contracts.

B.2.3 Hard-to-Reach Customers

Both interviews explored the program's approach towards its HTR customers; as part of the Lighting Strategy, the program targets HTR populations. Interviewees described how the program considers stores HTR based on two factors: 1) if the store is in a low-income community with a large minority and/or elderly population and 2) if it is a discount store, such as Dollar Tree or Ocean State Job Lot. In their proposals to participate in the program, stores that seek to be considered HTR according to the first factor are asked to provide evidence of area demographics to prove that they are in a HTR community. Independently-owned stores can be considered HTR on a case-by-case basis. However, no program sales from national chain stores outside of the discount channel are considered HTR even if some of their locations happen to be in low-income communities. Program staff members noted that this reflects an understanding that people travel to stores outside of their neighborhood to shop.⁶⁶

The program ensures that its co-marketing educational materials are translated into non-English languages to help inform non-native speakers. From program staff's perspective, the program and industry's shift away from CFLs may impact HTR populations the most—given that CFL price points are typically lower than those of LEDs and, as a result, more accessible for low-income customers. Program staff explained that the program's response to this is to pursue a product mix with *good quality and low-cost* ENERGY STAR LEDs (such as the newly qualified Specification 2.0, shorter life bulbs) *to fill the CFL gap* so that the gap is not

filled by halogens; nonetheless, they have still seen an increase—albeit less dramatic—in HTR customers' LED purchasing.

B.2.4 Product Selection

The program became LED-only in 2017. In 2016, it sought to compose 70% of sales with LEDs and 30% with standard CFLs, gently phasing standard CFLs out through lower incentive levels. The program had already phased out specialty CFLs in 2015. As mentioned in the main body of the report, the decision to exclude CFLs from the program in 2017, rather than in 2018 as originally planned, reflects the new ENERGY STAR 2.0 specifications, because only a handful of CFLs qualify. Program staff explained that the program's selection of products draws on knowledge from evaluation studies and other market reports and the insights of EEB consultants. Discussions with retailers and manufacturers to understand their corporate trajectories also offer guidance into the program's product selection. Retailers and manufacturers have communicated to program staff that they are minimizing their shelf-space and promotional efforts devoted to CFLs. The program determines the volume that a partnering retailer can move by using the retailer's sales track record.

Value-Line LEDs

The study defined value-line LEDs as those LEDs that did not qualify for the ENERGY STAR label under Specification 2.0. Program staff recognized that value-line LEDs' price points are attractive to consumers, yet they held reservations about their impacts, emphasizing that the program plans to hold onto the ENERGY STAR label, citing that, in contrast to value-line LEDs, ENERGY STAR labeling offers customers and the program with reassurance on product quality. Program staff explained that they have *learned a lot with CFLs* when it comes to how product quality can influence customer perceptions about bulb types. They noted some concerns associated with value-line LEDs: flickering, lack of dimmability, limited testing, and short lifetime. In contrast, they pointed out that one of their marketing strategies highlights LEDs' long lifetime.

They predicted that, while low costs might drive increased sale of LEDs, poor quality LEDs could have an adverse impact, causing customers to return to less-efficient bulbs like halogens or possibly incandescent bulbs. In response to this, they suggested increasing marketing around the distinction between value-line LEDs and higher quality LEDs to help customers make educated purchases to avoid risking the *momentum* of LED growth. In that direction, one said a program strategy has been to educate customers to read lighting facts labels.

Finally, one program staff person concluded that *time will tell* when it comes to the success of value-line LEDs.

B.3 FORECASTING EISA 2020 SCENARIOS

Interviewers asked suppliers to forecast what form EISA 2020 regulations would take. The interviews were conducted prior to the November 7, 2016, presidential election and the December 2016 DOE Rulemaking that rejected the proposed increase in lumens per watt for CFLs and LEDs but introduced a broader definition of general service lamps. In short, the

questions and responses to them are dated. However, the results still provide insights into how suppliers think about market conditions and what affects them, as presented below.

Interviews asked respondents to consider two main issues when giving their predictions, recalling that the interviews happened before the final rules were released that returned to the 45 lumens per watt level and expanded the definition of general service lamps:

1. First, the original EISA 2007 legislation included a backstop standard of 45 lumens per watt for general service incandescent, halogen, CFL, and LED lamps set to go into effect January 1, 2020. This backstop applies to the manufacture, import, and sales of all general service lamps.
2. Second, on February 12, 2016, the DOE issued a proposed rulemaking that included a new efficiency standard for general service CFLs and LEDs ONLY. The DOE has proposed a higher lumens/watt standard for medium screw-base CFL and LED lamps of 85-100 lumens per watt depending on lumen output. This standard is to be effective on January 2, 2017, and would apply to manufacture and import of lamps but would allow all existing non-compliant lamps to sell through. The final ruling on this issue is due on December 31, 2016.

The three defined scenarios included the following:

Scenario 1: Strictly enforced – EISA 2007 backstop strictly enforced (no sell-through) and proposed 2020 LED/CFL standard is not enacted.

Scenario 2: Sell-through – Non-compliant lamps may no longer be manufactured or imported but existing stock can be sold through; the 2020 LED/CFL standard is enacted.

Scenario 3: Repealed – EISA 2007 backstop is repealed and the proposed CFL/LED standard is not enacted.

Respondents had the opportunity to define a fourth scenario if they thought the three scenarios did not cover all the possible options. None of the suppliers gave a fourth scenario. Most suppliers answered the survey before the 2016 presidential election.

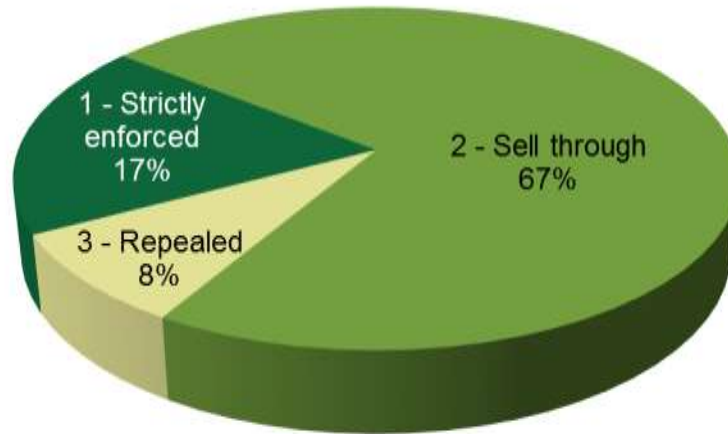
When asked, 12 of 15 supplier interviewees provided predictions for one scenario over the others. Two other suppliers did not predict any scenario as being more likely than another, and a third declined to give any predictions. Figure 30 shows that two-thirds of the suppliers predicted that Scenario 2 was most likely.

“It’s nearly impossible to do a hard stop without pushback from customers.”

-Lighting supplier

Figure 30: Supplier Predictions – Likelihood of EISA Phase 2 Scenarios

(Supplier interview responses, n=12)



Suppliers projecting that the sell-through scenario (Scenario 2) would be more likely offered explanations:

“Scenario 2 is a more compromising scenario, and because there are strong opinions on both sides, that’s most likely. Manufacturers are lobbying for that backstop to go into effect. I hope Congress hears out the industry and repeals the backstop. If congress repeals the backstop, then Scenario 3 is more likely.”

“It’s nearly impossible to do a hard stop without pushback from customers; it violates fundamentals of change management to have a hard stop.”

“This happened with Phase 1 of EISA. I understand the desire to stop manufacturing and importing, but [the] reality is that if it is in the warehouse or already manufactured, it will be sold; they can’t stop that. If they’re in circulation, then it will be very difficult to stop the sale of those lamps.”

“Strictly enforced is going to be really hard to enforce, so it’s unlikely it’ll happen. Scenario 3 you may have a regime change, so who knows. Scenario 2 is the most logical because they want to work with utilities to make sure they can continue to participate in the program.”

“The market has already been shifting quickly to LEDs, so the backstop won’t be a big burden; CFLs and LEDs already meet the 45 lumens/watt standard. Since manufacturers are already focusing on LEDs more so than CFLs (because people don’t like them), meeting the 85 lumens/watt standard also won’t be a problem either.”

Some of the explanations for why the lighting suppliers chose the strictly enforced scenario (Scenario 1) included the following:

“I don’t think they’ll bother to repeal the law just to protect the halogen bulb, because there are other issues that are more important. The law is weak and enforcement will be difficult, so why bother repealing it?”

“There will be increasing pressure to increase energy efficiency in coming years. It won’t affect our sales. By 2020, we’ll only be selling LEDs. Three years is long enough for companies to sell their existing product.”

Two respondents predicted that the repealed scenario (Scenario 3) was the most likely. One said that utilities want energy efficiency lighting programs to continue, and these programs would be threatened as EISA 2020 would eliminate much of the *low-hanging fruit*—halogen and CFL bulbs that are less efficient than LEDs. The other respondent noted that implementing EISA 2020 would eliminate halogen and most CFL lamps, and would therefore close the U.S. factories manufacturing these bulbs and eliminate jobs. This respondent said Scenario 3 (Repealed) was most likely because legislators would not want to be associated with job loss and would instead vote to repeal EISA legislation.

➤ ***Program and evaluation staff from the Companies emphasized the uncertainty of the future of EISA Phase 2.***

Residential Products and Lighting Strategy program staff members and evaluation staff members at both Eversource and UI provided likelihood ratings for the scenarios, but they did so after the 2016 presidential election. One Company’s staff members answered one week after the election, and other Company’s staff three weeks after the election. Staff members at one of the Companies provided a fourth scenario in which the EISA 2007 legislation remained on the books but lacked any regulatory enforcement. Table 27 summarizes their responses.

The staff from Company 1 feared that their nearly even allocation of likelihood would make it seem that they did not give the question proper thought; in reality, the respondents carefully considered the various actions the new administration might take, and decided that, only six days after the election, the future of lighting was far too uncertain to place emphasis on one scenario over the others. Company 2 had the benefit of three weeks of information and reflection on presidential appointments, which signaled a shift from an energy policy focused on efficiency and renewable technologies toward one focused on increased extraction and use of fossil fuels. This company opted more heavily for repeal over other options. For now, DOE decisions call for EISA 2020 to remain on the books with the 45 lumens per watt standard, an expanded definition of general service lamps, and the likelihood of some sort of sell-through/ramp up. The new administration may provide more clarity on their intentions regarding lighting over the next few months, but many lighting experts believe that if the administration or Congress take up lighting, it will be closer to the January 2020 implementation date.

Table 27: Company Predictions – Likelihood of EISA Phase 2 Scenarios

(Program and evaluation staff interview responses, n=2 interviews)

Scenario	Company 1 (6 days after election) ¹	Company 2 (3 weeks after election) ¹
1 - Strict Enforcement	23%	5%
2 - Sell Through	23%	35%
3 - Repeal	23%	60%
4 - No Enforcement (<i>unprompted</i>)	31%	-

Note: Percentages represent the likelihood of the scenario out of 100%.

¹ Refers to the rough timing in which interviews took place in relation to the 2016 presidential election results.



Appendix C Research Instruments

This appendix includes the instruments used for the supplier interviews and program staff interviews.

C.1 SUPPLIER INTERVIEWS

Contact Protocol

1. Call potential interviewees to ascertain most appropriate interviewee. Obtain email address(es) of appropriate interviewees. If company refuses interview, determine reasons for refusal and if it's logistical in nature, try to find workaround.
2. Send email interview invitation to appropriate interviewee. This invitation will include:
 - a. Explanation of purpose and scope of interview.
 - b. Explanation of time frame within which the interview will need to be completed.
 - c. Explanation of expected duration of interview and flexibility to complete interview over multiple sessions.
 - d. Instructions to propose a convenient interview time.
 - e. Contact information for interviewers.
 - f. Assurances of confidentiality.
3. Once an interview time has been arranged, the interviewee will be emailed, a couple days in advance of the interview, a summary of the interview topics and a table summarizing their shipments of discounted lighting products through the Connecticut ENERGY STAR Lighting Program disaggregated by lighting product categories and retail channels (for lighting manufacturers). The email will contain additional assurances of confidentiality.
4. At the beginning of the interview, collect information on interviewee's position and overall responsibilities, and experience with the program

C.1.1 Section 1: Program Participation Confirmation and Reasons for Participation

The Nature of Program Participation

- 1-1. Eversource, United Illuminating, and the Connecticut Energy Efficiency Board jointly participate in an ENERGY STAR Lighting Program. According to our records, your company has supplied/purchased lighting products that have received upstream incentives from the Connecticut ENERGY STAR Lighting Program during the past 12 months. This program has for many years offered upstream buydown or markdown discounts for CFL and LED products that are sold through various Connecticut retailers. Are you familiar with your company's participation in this program?

[IF UNAWARE, FIND SOMEONE WITH THE COMPANY WHO IS AWARE. IF THEY RECOGNIZE THIS PROGRAM BY A DIFFERENT NAME, EXPLAIN THAT FOR THE SAKE OF SIMPLICITY YOU'LL HENCEFORTH REFER TO THE PROGRAM AS "THE CONNECTICUT ENERGY STAR LIGHTING PROGRAM."]

a) Besides getting these financial incentives, are there any other aspects of the Connecticut ENERGY STAR Lighting Program in the past 12 months that your company has actively taken part in?
[IF NOT MENTIONED, PROBE FOR:

- THEIR INVOLVEMENT IN POINT-OF-SALE PROMOTIONS (SIGNAGE, DISPLAYS, PROGRAM COLLATERAL, PRODUCT PLACEMENT) FOR THE CT PROGRAM
- THEIR INVOLVEMENT WITH ANY EXTERNAL MARKETING OF THE CT ENERGY-EFFICIENT LIGHTING REBATES
- THEIR INVOLVEMENT WITH ANY CUSTOMER EDUCATION EFFORTS IN CT CONCERNING LIGHTING PURCHASES]

b) [IF YES TO 1-1a.] What other aspects of this program has your company been involved in?

1-2. **[Previously Interviewed Only]** Has your company's participation or involvement in the Connecticut ENERGY STAR Lighting Program changed since you were last interviewed?

a) If so, how has it changed?

1-3. **[Not Previously-Interviewed Only]** About what year did your company first get involved with the Connecticut ENERGY STAR Lighting Program?

1-4. **[Not Previously-Interviewed Only]** What was your primary reason for getting involved with the Connecticut ENERGY STAR Lighting Program?

- 1) Retail partners wanted to participate
- 2) Rebates/discounts were attractive
- 3) Wanted prices to be competitive with other suppliers
- 4) Program branding/association helped product sales
- 4) Other reasons _____ [PLEASE SPECIFY]

1-5. **[Not Previously-Interviewed Only]** Did you have any other reasons for getting involved with the Connecticut ENERGY STAR Lighting Program?

a) [IF YES] What were these?

C.1.2 Section 2: Verifying Program Sales

2-1. Earlier I emailed you a table that shows the types of CFL and LED bulbs that our records show you sold through the Connecticut Lighting Program in the past 12 months.

Does the table I sent to you seem correct in terms of the types and volume of CFLs and LED products you sold through the Connecticut ENERGY STAR Lighting Program?

a) [IF NO] [Record any corrections to the table]

2-2. Why did you choose to sell these particular products and packages through the Connecticut ENERGY STAR Lighting Program?

2-3. During the past 12 months, were there any ENERGY STAR lighting products which you sold in Connecticut without selling them through the program?

a) [IF YES] Which ENERGY STAR lighting products were these?

b) [IF YES] Why didn't you sell these ENERGY STAR lighting products through the program?

C.1.3 Section 3: Lighting Market Trends

[READ] *Now I would like to get your perspective on some forthcoming changes in the lighting market.*

EISA 2020

3-1. The Energy Independence and Security Act of 2007, otherwise known as "EISA" has established new lumens/watts standards for general service lighting. Are you aware that in 2020 the next phase of these EISA regulations will go into effect? [IF NECESSARY: A GENERAL SERVICE LAMP IS ONE WITH A MEDIUM SCREW BASE INTENDED FOR GENERAL SERVICE APPLICATIONS WITH LIGHT IN THE 310-2,600 LUMEN RANGE].

3-2. [IF AWARE OF EISA 2020, ELSE SKIP TO Q3-4] What do you expect will be the impacts of these 2020 EISA regulations on the Connecticut lighting market? [PROBE FOR WHEN EACH IMPACT MENTIONED EXPECTED (e.g. YEAR)]

[IF NOT ALREADY MENTIONED, PROBE FOR:]

3-2a. Impact on LEDs - sales volume and lamp variety sold

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

[PROBE FOR ANY DIFFERENCES IN IMPACTS ON ENERGY STAR LEDs VS. NON-ENERGY STAR LEDs]

3-2b. Impact on CFLs - sales volume and lamp variety sold

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

3-2c. Impact on halogens – sales volume and lamp variety sold

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

[IF NOT ALREADY MENTIONED, ASK ABOUT THE IMPACT ON NON-COVERED HALOGEN PRODUCTS, PARTICULARLY REFLECTORS]

3-3. How do you expect these 2020 EISA regulations will impact your own company’s lighting sales?

Table 28: Impacts of 2020 EISA Regulations

Topics	Interviewee Responses	
3-2 General impacts of regulations		
	Impacts on Sales Levels	Impacts on Variety of Lamps Sold
3-2a. Impacts on LEDs		
3-2b. Impacts on CFLs		
3-2c. Impacts on halogens		
3-3 How regulations will impact their own lighting sales		

ENERGY STAR Lamp 2.0 Specification

3-4. Are you aware that in 2017 a new ENERGY STAR specification – 2.0 – is scheduled to go into effect which will adjust measure life and efficacy requirements?

[IF UNAWARE, SKIP TO NEXT SECTION ‘LIKELIHOOD OF PHASE 2 EISA SCENARIOS’]

3-5. [IF AWARE OF ENERGY STAR 2.0] What do you expect will be the impacts of these new ENERGY STAR specifications on the Connecticut lighting market? [PROBE FOR TIMING OF CHANGE (e.g. YEAR) FOR EACH IMPACT MENTIONED]

[IF NOT ALREADY MENTIONED, PROBE FOR:]

3-5a. Impact on LEDs on both sales volume and lamp variety sold

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

[PROBE FOR ANY DIFFERENCES IN IMPACTS ON ENERGY STAR LEDs VS. NON-ENERGY STAR LEDs]

3-5b. Impact on CFLs on sales volume only

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

3-5c. Impact on halogens on both sales volume and lamp variety sold

[PROBE FOR WHEN IMPACT EXPECTED (e.g. YEAR)]

[IF NOT ALREADY MENTIONED, ASK ABOUT THE IMPACT ON NON-COVERED HALOGEN PRODUCTS, PARTICULARLY REFLECTORS]

3-6. How do you expect these new ENERGY STAR specifications will impact your own company’s lighting sales?

Table 29: Impacts of Energy Star 2.0 Specifications

Topics	Interviewee Responses	
3-5 General impacts of new ES specs		
	Impacts on Sales Levels	Impacts on Variety of Lamps Sold
3-5a. Impacts on LEDs		
3-5b. Impacts on CFLs		
3-5c. Impacts on halogens		
3-6 How new ES specs will impact their own lighting sales		

[PROCEED ONLY IF RESPONDENT ANSWERED YES TO Q 3-1 (I.E. AWARE OF EISA 2020), ELSE SKIP TO Q3-17]

Likelihood of Phase 2 EISA Scenarios

[READ] I next want to draw on your market experience to predict the lighting regulations in effect in the year 2020.

As you likely know, the specifics of Phase 2 EISA are somewhat complicated given additional legislation and the recent DOE proposed rulemaking covering CFLs and LEDs. There are two main issues we would like you to consider for the scenarios in this section.

First, the original EISA 2007 legislation included a backstop standard of 45 lumens per watt for general service incandescent, halogen, CFL, and LED lamps set to go into effect January 1, 2020. This backstop applies to the manufacture, import, and sales of all general service lamps.

Second, on February 12, 2016, the DOE issued a proposed rulemaking that included a new efficiency standard for general service CFLs and LEDs **ONLY**. The DOE has proposed a

higher lumens/watt standard for medium-screw based CFL and LED lamps of 85-100 lumens per watt depending on lumen output. This standard is to be effective in January 1, 2020 and would apply to manufacture and import of lamps but would allow all existing non-compliant lamps to sell through. The final ruling on this issue is due on or before December 31, 2016.

For these next questions, I will ask you to estimate the likelihood of each of a number of scenarios in terms of percentage. The total of your estimates should add up to 100%. We have defined three scenarios and will give you the opportunity to define a fourth if you think it is worth considering. First, let me read the three defined scenarios:

Scenario 1: EISA 2007 backstop is strictly enforced with a “hard-stop.” In this scenario the EISA 2007 backstop is strictly enforced as of 2020 and lamps that do not meet the specifications may no longer be sold, manufactured or imported into the US after the effective date of the regulation. In this scenario, the proposed CFL/LED federal standard is not implemented.

Scenario 2: In this scenario both the EISA 2007 backstop and the proposed CFL/LED standard are implemented as of 2020. As in scenario 1, the EISA 2007 backstop is strictly enforced. In addition, the proposed CFL/LED federal standard with “sell-through” is implemented. In this scenario, CFL and LED lamps that do not meet the proposed CFL/LED federal standard cannot be manufactured or imported into the US. However, manufacturers and retailers would continue to “sell through” the existing stock of all non-compliant lamps, regardless of technology, until it is depleted.

Scenario 3: The EISA 2007 backstop is repealed and the proposed CFL/LED standard is not implemented. In this scenario, the manufacture and sale of all currently allowed lamp types continues. It is the scenario where the market operates without additional regulations other than those already in place.

Scenario 4: This is a scenario you define if you think that the three scenarios mentioned do not fully represent the likely options.

Before we continue, would you like me to restate the three defined scenarios?

[IF YES, DO SO. IF NO, PROCEED]

3-7. So, considering the three defined scenarios, is there another scenario that you think should be considered?

3-8. [IF ANOTHER SCENARIO] “What is that other scenario?” AND RECORD BELOW, IF NO, PROCEED]

Scenario 4: OTHER (SPECIFY)

3-9. In terms of percentage, what probability would you assign to Scenario 1 - EISA 2007 backstop is strictly enforced with a “hard-stop” and the proposed 2020 LED/CFL standards are not enacted?

3-10. What probability would you assign to Scenario 2 – both the EISA 2007 backstop and the proposed CFL/LED standard are implemented and manufacturers and retailers would continue to “sell through” all existing non-compliant lamps?

3-11. What probability would you assign to Scenario 3 –The EISA 2007 backstop is repealed and the proposed CFL/LED standard is not implemented?

3-12. [IF APPROPRIATE] And finally, what probability would you assign to the alternative you suggested?

[COMPLETE TABLE BELOW. MUST SUM TO 100%. IF NOT, ASK RESPONDENT TO REVISE PERCENTAGES UNTIL SUMS TO 100%.]

Table 30: Probability of Different EISA2 Scenarios

Scenario	%
1 – Strictly enforced	
2 – Sell through	
3 – Repealed	
4 – Other	
SUM	100%

3-13. Why do you think Scenario [IDENTIFY SCENARIO WITH HIGHEST PROBABILITY IN TABLE ABOVE] is the most likely scenario?

3-14. Do you think any future events—whether political, economic or other types of events—might cause you to change your probabilities?

3-15. [IF YES] How so? Anything else?

3-16. Which future event(s) do you think has the greatest impact on changing your probabilities?

3-17. [IF THEY INDICATED IN RESPONSE TO QUESTION 3-4 THAT THEY WERE AWARE OF THE NEW ENERGY STAR SPECS] Are you aware that the Connecticut ENERGY STAR lighting program may substantially reduce or even eliminate CFL discounts in 2017

3-18. How do you think the withdrawal of program support for CFLs would impact the Connecticut lighting market?

Non-ENERGY STAR LEDs

3-19. Recently the lighting market has experienced a growth in non-ENERGY STAR LEDs that do not qualify according to the new specification, ENERGY STAR Lighting 2.0, which was approved in 2016. These are these less expensive LED models which may lack some features (such as dimmability), have shorter measure lives, use slightly more energy, and may not be as bright when compared to ENERGY STAR-qualified LEDs. Are you familiar with these non-ENERGY STAR LED lamps?

[IF UNFAMILIAR WITH NON-ENERGY LEADS, SKIP TO Q3-20]

3-20. What do you expect will be the impacts of these non-ENERGY STAR LEDs on the overall Connecticut lighting market?

3-21. What do you expect will be the impacts of these non-ENERGY STAR LEDs on sales of LEDs in the Connecticut lighting market?

3-22. What do you expect will be the impacts of these non-ENERGY STAR LEDs on sales of ENERGY STAR LEDs in the Connecticut lighting market?

3-23. What do you expect will be the impacts of these non-ENERGY STAR LEDs on your own company's lighting sales?

Lingering Incandescents

3-24. Are you aware of any continuing availability of traditional incandescent bulbs?

- a) [IF YES] What wattages of bulbs are you seeing? Any specific styles/types of bulbs? [Probe whether EISA-exempt bulbs or non-EISA exempt]
- b) [IF YES] In what retail channels are these being sold?
- c) Why are stores still selling these incandescents?

C.1.4 Section 4: Program Attribution in the past 12 months**Whether They Would Have Sold Any LED Lighting Products without the Program**

[READ] *My next set of questions covers your sales of LED lamps in the past 12 months.*

3-25. [MANUFACTURERS ONLY] The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$3.74 to \$4.24 per LED A-lamp bulb and \$5.49 to \$5.62 per LED reflector bulb. Are there any retailers or retailer categories that you worked with through the Connecticut lighting program in the past 12 months that you think would not have been selling any LED products in Connecticut if these discounts had not been available?

a) [IF YES] Which retailers or retailer categories?

b) [IF YES] Why do you say this?

[IF RESPONDENT INDICATED THEY WOULD NOT HAVE SOLD ANY LEDS WITHOUT PROGRAM REBATE, SKIP TO C.1.5 5]

3-26. [RETAIL BUYER ONLY] The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$3.74 to \$4.24 per LED A-lamp bulb and \$5.49 to \$5.62 per LED reflector bulb. Do you think you would have sold any LED products in Connecticut if these discounts had not been available?

a) [IF NO] Why do you say this?

[IF RESPONDENT INDICATED THEY WOULD NOT HAVE SOLD ANY LEDS WITHOUT PROGRAM REBATE, SKIP TO C.1.5 5]

Retrospective Net-to-Gross – LED A Lamps

3-27. [MANUFACTURERS ONLY]
[INSTRUCTIONS TO SURVEYOR:

- FIRST ASK THE MANUFACTURER THE FREERIDERSHIP QUESTION SEQUENCE FOR THE RETAILER CATEGORY THROUGH WHICH THEY SOLD THE MOST LEDS THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILER CATEGORIES THAT THEY IDENTIFIED IN QUESTION 3-25 AS NOT SELLING ANY LED BULBS AT ALL WITHOUT THE BUYDOWNS.
- REPEAT THE FREERIDERSHIP BATTERY FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THE SUPPLIER'S PROGRAM SALES]

The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$3.74 to \$4.24 per LED A-lamp bulb. If these program buydown/ markdown discounts and program promotional materials had not been available in the past 12 months, do you think your sales of these types of bulbs through [RETAILER CATEGORY] stores in Connecticut would have been about the same, lower, or higher?

b) [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND THEN SKIP TO NEXT SECTION]

c) [IF LOWER] By what percentage do you estimate your sales of LED A lamps would be lower in the past 12 months if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

- i. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM QUESTION above] % lower without the program support. So if you actually sold 100 LED bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM QUESTION 3-13b * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

[REPEAT QUESTION BATTERIES FOR ALL RETAIL CHANNELS WITH SIGNIFICANT PROGRAM SALES]

3-28. [RETAIL LIGHTING BUYERS ONLY] The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$3.74 to \$4.24 per LED A-lamp. If these program buydown/ markdown discounts and program promotional materials had not been available in the past 12 months, do you think your sales of these types of bulbs in Connecticut would have been about the same, lower, or higher?

- a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND THEN SKIP TO NEXT SECTION]
- b. [IF LOWER] By what percentage do you estimate your Connecticut sales of Energy Star LED A lamps would be lower in the past 12 months if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]

- i. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM QUESTION 3-24b.] % lower without the program support. So if you actually sold 100 LED bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM QUESTION 3-24b.) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

Retrospective Net-to-Gross – LED Reflectors

3-29. [MANUFACTURER ONLY]
[IF RESPONSE TO QUESTION 3-25 WAS THAT THEY WOULD NOT HAVE SOLD ANY LEDS WITHOUT PROGRAM REBATE, SKIP TO C.1.5 5]

[INSTRUCTIONS TO SURVEYOR:

- FIRST ASK THE MANUFACTURER THE FREERIDERSHIP QUESTION SEQUENCE FOR THE RETAILER CATEGORY THROUGH WHICH THEY

SOLD THE MOST LEDS THROUGH THE PROGRAM (SEE TRACKING DATA MATRIX). EXCLUDE ANY RETAILER CATEGORIES THAT THEY IDENTIFIED IN QUESTION 3-25 AS NOT SELLING ANY LED BULBS AT ALL WITHOUT THE BUYDOWNS.

- REPEAT THE FREERIDERSHIP BATTERY FOR ALL RETAIL CHANNELS WHICH ACCOUNTED FOR AT LEAST 20% OF THE SUPPLIER'S PROGRAM SALES]

The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$5.49 to \$5.62 per LED reflector bulb. If these program buydown/ markdown discounts and program promotional materials had not been available in the past 12 months, do you think your sales of these types of bulbs through [RETAILER CATEGORY] stores in Connecticut would have been about the same, lower, or higher?

- a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND THEN THANK AND TERMINATE]
- b. [IF LOWER] By what percentage do you estimate your sales of LED reflectors would be lower in the past 12 months if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]
 - i. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM QUESTION 3-16b.] % lower without the program support. So if you actually sold 100 LED bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM QUESTION 3-16b * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

[REPEAT QUESTION BATTERIES FOR ALL RETAIL CHANNELS WITH SIGNIFICANT PROGRAM SALES]

3-30. [RETAIL LIGHTING BUYERS ONLY]

[IF RESPONSE TO QUESTION 3-26 WAS THAT THEY WOULD NOT HAVE SOLD ANY LEDS WITHOUT PROGRAM REBATE, SKIP TO C.1.5 5]

The Connecticut ENERGY STAR Lighting Program in the past 12 months paid average buydown or markdown discounts of \$5.49 to \$5.62 per LED reflector. If these program buydown/ markdown discounts and program promotional materials had not been available in the past 12 months, do you think your sales of these types of bulbs in Connecticut would have been about the same, lower, or higher?

- a. [IF THE SAME OR HIGHER] Why do you say this? [RECORD RESPONSE AND THEN THANK AND TERMINATE]
- b. [IF LOWER] By what percentage do you estimate your Connecticut sales of Energy Star LED reflectors would be lower in the past 12 months if these program buydowns/ markdowns and program promotional materials had not been available? [RECORD % DECREASE]
 - i. I want to make sure I understand you correctly. You estimate that your sales would have been [PERCENTAGE FROM QUESTION 3-30b)] % lower without the program support. So if you actually sold 100 LED bulbs in a given week, you think you'd have sold only about [100 – (PERCENTAGE FROM QUESTION 3-30b) * 100)] in that period if the buydowns/markdowns hadn't been available? [IF RESPONSE IS ≠ YES, THEN CLARIFY ESTIMATED SALES DECREASE]

C.1.5 Section 5: Program Attribution - Prospective

Prospective NTG -- LEDS

[READ] My final set of questions will cover what you think will be the likely future market penetration of LEDs in Connecticut both with and without the Connecticut ENERGY STAR lighting program.

We are going to explore two different scenarios.

In the first scenario the Connecticut Energy Star lighting program continues to offer upstream discounts for LEDs through 2020.

In the second scenario this program is discontinued after 2016.

And just to be clear we're talking about the retail lighting market and not sales through lighting distributors.

Prospective NTG – LED A-LAMPS

3-31. First, let's start by assuming that the Connecticut ENERGY STAR lighting program will continue to provide LED discounts through 2021. Please provide your best estimate of what you think the market shares of these LED A-lamps will be at year-end 2017, 2019 and 2021 with the Connecticut program continuing through 2020. Your predictions should include all LED A-lamps, including both ENERGY STAR and non-ENERGY STAR LED A-lamps.

**Table 31: Market Shares for LED A- Lamps
if Connecticut Program Continues to Provide LED Discounts Through 2021**

Bulb Type	2015 CREED data (reference point)	2017 CT Retail Market Shares	2019 CT Retail Market Shares	2021 CT Retail Market Shares
LED A— Lamps	16%	%	%	%

3-32. Next let's assume that the Connecticut ENERGY STAR lighting program is discontinued after 2016. Again, please provide your best estimate of what you think the market shares of these LED A-lamps will be at year-end 2017, 2019 and 2021 with the Connecticut program ending in 2016. Your predictions should include all LED A-lamps, including both ENERGY STAR and non-ENERGY STAR LED A-lamps.

**Table 32: Market Shares for LED A-Lamps
if Connecticut Program is Discontinued After 2016**

Bulb Type	2015 CREED data (reference point)	2016 CT Retail Market Shares	2019 CT Retail Market Shares	2021 CT Retail Market Shares
LED A-Lamps	16%	%	%	%

3-33. What assumptions are you making when predicting this Connecticut market share trend for LED A-lamps both with and without the program?

Prospective NTG – LED Reflectors

Next please provide your best estimate of what you think the market shares of these LED reflectors will be at year-end 2017, 2019 and 2021 with the Connecticut program continuing through 2021. Your predictions should include both ENERGY STAR and non-ENERGY STAR LED reflectors.

**Table 33: Market Shares for LED Reflectors if Connecticut Program Continues to
Provide LED Discounts Through 2021**

Bulb Type	2017 CT Retail Market Shares	2019 CT Retail Market Shares	2021 CT Retail Market Shares
LED Reflectors	%	%	%

3-34. Next let's assume that the Connecticut ENERGY STAR lighting program is discontinued after 2016. Please provide your best estimate of what you think the market shares of these LED reflectors will be at year-end 2017, 2019 and 2021 with the Connecticut program ending in 2016. Your predictions should include both ENERGY STAR and non-ENERGY STAR LED reflectors.

**Table 34: Market Shares for LED Reflectors
if Connecticut Program is Discontinued After 2016**

Bulb Type	2017 CT Retail Market Shares	2019 CT Retail Market Shares	2021 CT Retail Market Shares
LED Reflectors	%	%	%

3-35. What assumptions are you making when predicting this Connecticut market share trend for LED reflectors both with and without the program?

That's all the questions I had for you today. Thanks again for taking the time

C.2 PROGRAM STAFF INTERVIEWS

Appendix content

Hello, may I speak to [_____] ? My name is _____, and I'm calling from NMR Group, an independent research firm, on behalf of the sponsors of the Energize Connecticut Residential Retail Products Program. We are conducting interviews with [COMPANY] program staff members most familiar with the Lighting Strategy of this Program. The purpose of my call is to ask you some questions about the design and delivery of the lighting program and also to get your perspectives on the current nature and future direction of the Connecticut lighting market.

Is now a good time to speak with you?

Is this a good time for us to speak with you? (IF NOT, SET UP CALL BACK APPOINTMENT).

May I record this conversation?

C.2.1 Responsibilities, Organization

Let's start with a little information about you.

1. What is your position or job title?
2. What are your current responsibilities as manager for Lighting Strategy components of the Residential Retail Products Program? [ALLOW THEM TO RESPOND FIRST IN AN OPEN-ENDED FASHION, AND THEN PROBE FOR THEIR ROLES IN THE FOLLOWING KEY PROGRAM ACTIVITIES]
 - a. Program planning? Program design? Management?
 - b. Marketing the program to end users (e.g., point-of-sales marketing collateral, signage)
 - c. Working with the program implementation contractors
 - d. Tracking program activity/program tracking data

C.2.2 Program Design, Program Offerings, Hard to Reach

First, I'd like to talk about the program design and the lighting products your program supports.

3. Currently, what types of products does the program support? [PROBE: standard and specialty CFLs (including reflectors), standard and specialty LEDs (including reflectors), fixtures (including downlight kits), lighting controls.]
4. How has the product mix changed since the 2012 to 2015 program cycle? How has the product mix changed since the start of the 2016-2018 program cycle? Why has it changed? [PROBE FOR ENERGY STAR 2.0 AND EISA2 IF NOT MENTIONED; PROBE ON CFLS NO LONGER BEING QUALIFIED AND SOME VALUE-LINE BECOMING QUALIFIED.]
5. How are the types of products sold by program partners determined? [PROBE: Do the Companies determine it? The implementers? The partners?]

6. How are the volumes of products they sell determined? [PROBE: Do the Companies determine it? The implementers? The partners?]
7. Can partners change what they are doing after the MOU has been signed for the cycle?
 - a. [IF YES] What kinds of changes can they make?
 - b. What can't they change?
 - c. What is the process for making these changes?
8. How is it determined which retail channels the lighting suppliers are selling program-discounted lighting product through?

[IF NOT ADDRESSED EARLIER] The 2016 to 2018 plan discussed increasing the promotion of CFLs in retail channels expected to serve “hard-to-reach” customers. I have a few questions about this component of the lighting strategy.

9. Which customers does the program considers to be “hard-to-reach”?
10. Can you tell me about the process of deciding in which stores to sell HTR bulbs?
11. [IF NOT ADDRESSED IN Q10] Do you base HTR sales on store location? Store type? Both? Are there any retailers for which some of the store locations are HTR but others are not?
12. [IF BASED ON STORE TYPE AND NOT ADDRESSED IN Q10 OR Q11] Why target these stores?
13. As you know, as of right now, no CFLs will qualify for ENERGY STAR 2.0 but some lower cost LEDs will become qualified. Have you changed your HTR strategy given the new specification?
 - a. If so, how? [PROBE: Are you changing the stores you are targeting for HTR? Are you shifting to LEDs in general? Only to lower-cost LEDs that meet Spec 2.0 but not 1.1?]

C.2.3 Program Marketing and Outreach

Now let's talk about your program's marketing and outreach efforts.

14. What types of marketing and outreach is currently being done to promote this program?
15. Who develops these marketing/outreach strategies?
16. Who implements these marketing/outreach activities?
17. Are there any marketing/outreach activities designed to target customers who are in hard-to-reach (HTR) lighting market sectors such as low-income customers, or customers for whom English is not their first language?
 - a. [If YES] What are these HTR marketing/outreach activities?
18. Which program marketing and outreach activities do you believe have been the most effective? Why do you say this?
19. Which program marketing and outreach activities do you believe have been less effective? Why do you say this?

20. Does your program work directly with lighting suppliers and retailers on content and timing of their own promotional campaigns?
- b. [IF YES] What is the nature of your collaboration

C.2.4 Future of Lighting Market

I'd like to talk more about the future of the lighting market. We are asking manufacturers and suppliers the next question in Connecticut and other states, and we'd like to get your input on these questions as well.

As you likely know, the specifics of Phase 2 EISA are somewhat complicated given additional legislation and the recent DOE proposed rulemaking covering CFLs and LEDs. There are two main issues we would like you to consider for the scenarios in this section.

First, the original EISA 2007 legislation included a backstop standard of 45 lumens per watt for general service incandescent, halogen, CFL, and LED lamps set to go into effect January 1, 2020. This backstop applies to the manufacture, import, and sales of all general service lamps.

Second, on February 12, 2016, the DOE issued a proposed rulemaking that included a new efficiency standard for general service CFLs and LEDs **ONLY**. The DOE has proposed a higher lumens/watt standard for medium-screw based CFL and LED lamps of 85-100 lumens per watt depending on lumen output. This standard is to be effective in January 1, 2020 and would apply to manufacture and import of lamps but would allow all existing non-compliant lamps to sell through. The final ruling on this issue is due on or before December 31, 2016.

For these next questions, I will ask you to estimate the likelihood of each of a number of scenarios in terms of percentage. The total of your estimates should add up to 100%. We have defined three scenarios and will give you the opportunity to define a fourth if you think it is worth considering. First, let me read the three defined scenarios:

Scenario 1: EISA 2007 backstop is strictly enforced with a “hard-stop.” In this scenario the EISA 2007 backstop is strictly enforced as of 2020 and lamps that do not meet the specifications may no longer be sold, manufactured or imported into the US after the effective date of the regulation. In this scenario, the proposed CFL/LED federal standard is not implemented.

Scenario 2: In this scenario both the EISA 2007 backstop and the proposed CFL/LED standard are implemented as of 2020. As in scenario 1, the EISA 2007 backstop is strictly enforced. In addition, the proposed CFL/LED federal standard with “sell-through” is implemented. In this scenario, CFL and LED lamps that do not meet the proposed CFL/LED federal standard cannot be manufactured or imported into the US. However, manufacturers and retailers would continue to “sell through” the existing stock of all non-compliant lamps, regardless of technology, until it is depleted.

Scenario 3: The EISA 2007 backstop is repealed and the proposed CFL/LED standard is not implemented. In this scenario, the manufacture and sale of all

currently allowed lamp types continues. It is the scenario where the market operates without additional regulations other than those already in place.

Scenario 4: This is a scenario you define if you think that the three scenarios mentioned do not fully represent the likely options.

Before we continue, would you like me to restate the three defined scenarios?

[IF YES, DO SO. IF NO, PROCEED]

21. Considering the three defined scenarios, is there another scenario that you think should be considered?
22. [IF ANOTHER SCENARIO] “What is that other scenario?” RECORD, IF NO, PROCEED]
23. In terms of percentage, what probability would you assign to Scenario 1 - EISA 2007 backstop is strictly enforced with a “hard-stop” and the proposed 2020 LED/CFL standards are not enacted?
24. What probability would you assign to Scenario 2 – both the EISA 2007 backstop and the proposed CFL/LED standard are implemented and manufacturers and retailers would continue to “sell through” all existing non-compliant lamps?
25. What probability would you assign to Scenario 3 –The EISA 2007 backstop is repealed and the proposed CFL/LED standard is not implemented?
26. [IF APPROPRIATE] And finally, what probability would you assign to the alternative you suggested?

[COMPLETE TABLE BELOW. MUST SUM TO 100%. IF NOT, ASK RESPONDENT TO REVISE PERCENTAGES UNTIL SUMS TO 100%.]

Table 35: Probability of Different EISA2 Scenarios

Scenario	%
1 – Strictly enforced	
2 – Sell through	
3 – Repealed	
4 – Other	
SUM	100%

27. Why do you think Scenario [IDENTIFY SCENARIO WITH HIGHEST PROBABILITY IN TABLE ABOVE] is the most likely scenario?
28. Do you think any future events—whether political, economic or other types of events—might cause you to change your probabilities? [IF YES] How so?

The last set of questions I have for you is about a subset of LEDs that do not qualify under ENERGY STAR Version 1.1 and still won’t qualify under Version 2.0. These LED bulbs

often lack certain efficacy (lumens per watt) and lifetime requirements that keep them qualifying for ENERGY STAR models. Some people call these “value-line” LEDs.

29. Are you familiar with these types of LEDs?

[IF YES CONTINUE; IF NO, GO TO CONCLUSION]

30. What do you think are the strengths of value-line LEDs? What about weaknesses? [Probe: I’m thinking not only about engineering characteristics but also about such things as price, availability, etc.]

31. What impact will value-line LEDs have on the residential lighting market in general? On energy-efficient lighting programs such as Connecticut Lighting Strategy of the Retail Products Program?

C.2.5 Conclusion

32. What would you say are the biggest strengths of the Lighting Strategy?

33. What are its biggest weaknesses?

34. What are the most important opportunities for the Lighting Strategy?

35. What are the threats to the program?

36. Is there anything we did not discuss that you feel is important to understanding the Connecticut Lighting Strategy?

Thank you so much for your time. That is all the questions I have for you.

C.3 SUMMARY FOR CONSENSUS PANELISTS

The aim of this instrument is to obtain your prospective estimates of Net-to-Gross ratios (NTG) for LEDs for the years 2016-2020. You will fill in the cells shaded orange in the table on the final pages of this document. **Before you fill out the tables, however**, we have provided a number of resources for your review to help you develop your prospective NTG estimates.

Resource #1: NTG Estimates Excel File

Description: The accompanying Excel file, "NTG Estimates," provides the NTG ratios estimated through the three research approaches from the current CT NTG cycle for each relevant bulb as well as the recommended LED NTG ratio from the 2013 CT Lighting NTG study. This file also includes NTG ratios from studies in other jurisdictions as identified in a literature review of publicly available resources. The spreadsheet also lists the relative strengths and weaknesses of each approach used in CT and, where possible, elsewhere. We provide links to all reports currently available online.

Action: Please review the spreadsheet. Then, describe any additional strengths and weaknesses to each method in the yellow-shaded cells in the spreadsheet. Next, rate the importance of the results from each method for the overall NTG estimate in the blue shaded cells. Finally, after reviewing the current estimates from CT and other states and the strengths and weaknesses of the approaches, we ask that you add your *own NTG estimates for CT for 2015* in the green-shaded cells in Rows 7 and 8 of the spreadsheet, and explain your reasoning. We provide the opportunity to provide estimates for all LEDs combined as well as A-line and reflector LEDs separately. The idea is that estimating NTG for the recent past should help you develop your estimates for 2016 and for the future. Please estimate NTG levels for the 2015 program year only, without taking spillover from past program efforts into account.

Resource #2: Information Contained in this Word Document

Description: The following pages in this Word document provide information that may be helpful as you develop your prospective NTG estimates. Tables 1 and 2 provide retrospective and prospective NTG estimates for the several areas of interest. Table 3 (Saturation Trends) shows saturations of different bulb types over the years for Connecticut and Massachusetts (which continue to provide substantial discounts for LEDs), California (greatly limited LED program support in most channels in 2013), New York (stopped supporting LEDs at the end of 2014), and Kansas (which still does not have programs).⁶⁷ Table 4 (POS Trends) shows

⁶⁷ KCP&L in neighboring Missouri does have programs but they started after the last saturation estimates provided here were collected.

sales of different types of light bulbs in certain channels—**excluding home improvement and hardware**⁶⁸—for the years 2009 through 2015.

Action: After you are finished, please **save this Word file** with your last name as part of the file name, and email **BY COB January 24, 2017**. We will compile and distribute responses by COB January 31, 2017 so you can review them before the NTG Integration meeting to be scheduled for early February. We will need to block out two hours for this integration call. We will discuss people’s 2016-2020 NTG estimates and associated ratings and rationales during our February integration meeting.

Please fill out the orange cells on the last page of this document under “Your 2016-2020 NTG Estimates.” In this case, please assume the program continues to support LEDs through 2020 with similar percentages of discounts (even if the dollar amount of those discounts changes). Provide estimates of NTG ratios separately for A-line and reflector LEDs and for all LEDs for each year. Please **do not** take spillover from pre-2016 programs into account.

Benchmarking Retrospective NTG Estimates

(Excludes Non-Public Studies)

State	Entity/Company	Associated year	LED NTG	Research methods
Northeast				
MA	Statewide	2016 ¹	93%	Prospective NTG prediction from consensus panel
	Statewide	2014	95%	Retrospective NTG estimate from consensus panel ³
RI	Statewide	2012	92%	Assumption ³
ME	Efficiency Maine	2013-2014	77%	Price elasticity
CT	Statewide	2014	82%	Demand elasticity, sales data modeling, supplier interviews
Central/Midwest				
CO	Xcel	2015	91%	Demand elasticity, store-intercepts, supplier interviews
Undisclosed (not yet public)		2015	85%	Literature review
IL	ComEd	2014-2015	73%	Store-intercepts
West				
CA	PG&E	2013-2014	40% / 27% ²	Choice model and supplier interviews
	SCE		42% / 28%	
	SDG&E		35% / 28%	
South				
NM	SPS	2014	100%	Assumption ³
TX	CPS Energy	2015	85%	Assumption ³
AK	Entergy	2013	80%	Demand elasticity modeling

¹ Represents a prospective NTG prediction developed in 2015 based on research completed in 2014.

² Standard and reflector LEDs, respectively

³ Values derived from program savings assumptions (such as from a PSD)

⁶⁸ The IRI Point-of-Sale dataset does not include these channels.

Benchmarking Prospective NTG Estimates

State/Region	Entity/Company	LED Bulb Type	LED NTG		Research methods
			2017	2018	
CT	Statewide	Standard	39%	-	Supplier interviews
		Reflector	41%	-	
MA	Statewide	All	85%	78%	Consensus Panel

Saturation Trends

Sockets Containing	Connecticut							Massachusetts						New York (Upstate)				Kansas			California	
	2009	2010	2011	2012	2013	2014	2015	2009	2010	2012	2013	2014	2015	2009	2010	2013	2015	2009	2010	2014	2009	2012
Sample Size	95	Interp.	Interp.	100	90	Interp.	81	100	150	151	150	261	354	203	200	127	101			67	1,232	1,987
Incandescent	63%	59%	54%	50%	48%	41%	33%	62%	57%	53%	55%	45%	43%	65%	57%	53%	51%			51%	56%	49%
CFLs	24%	25%	25%	26%	32%	34%	35%	26%	26%	27%	28%	33%	32%	19%	24%	26%	22%	21%	19%	29%	22%	30%
Fluorescent	7%	8%	10%	11%	11%	11%	11%	6%	9%	8%	9%	9%	9%	10%	12%	11%	12%			6%	12%	11%
Halogen	6%	7%	8%	9%	4%	5%	6%	5%	7%	11%	5%	6%	6%	5%	6%	4%	8%			6%	8%	9%
LEDs	<1%	1%	1%	2%	2%	6%	10%	<1%	<1%	1%	2%	3%	6%	1%	1%	1%	3%			3%	<1%	1%
Other	0%	1%	2%	3%	3%	4%	4%	<1%	1%	-	2%	4%	4%	<1%	<1%	5%	5%			5%	1%	<1%
CFLs + LEDs	24%	26%	27%	28%	34%	39%	45%	26%	26%	28%	30%	36%	38%	20%	25%	27%	25%			32%	22%	31%
CFLs + LEDs + Fluorescents	31%	34%	36%	39%	45%	50%	56%	32%	35%	36%	39%	45%	47%	30%	37%	38%	37%			38%	34%	42%
Any specialty bulb								30%	31%	48%	38%	40%	42%	33%	48%	38%	37%			27%		
Any specialty CFL								4%	7%	8%	8%	11%	10%	8%	5%	6%	5%			3%		
Any specialty CFL (not including A-line CFLs)								-	-	7%	6%	9%	8%	-	-	5%	4%			3%		
Incandescents + Halogens	69%	66%	62%	59%	52%	46%	39%	67%	64%	64%	60%	51%	49%	70%	63%	57%	59%			57%	64%	58%

Point-of-Sale (POS) Trends

CFLs	Connecticut	Massachusetts	New York	Kansas	California
2009	15%	14%	14%	18%	19%
2010	19%	12%	15%	18%	18%
2011	18%	14%	16%	20%	22%
2012	15%	15%	14%	18%	25%
2013	12%	14%	12%	12%	18%
2014	13%	17%	13%	14%	17%
2015	13%	15%	13%	13%	16%
LEDs	Connecticut	Massachusetts	New York	Kansas	California
2009	0%	0%	0%	0%	0%
2010	0%	0%	0%	0%	0%
2011	0%	0%	0%	0%	0%
2012	0%	0%	0%	0%	0%
2013	0%	0%	0%	0%	0%
2014	2%	2%	1%	1%	1%
2015	5%	5%	3%	3%	4%
CFLs + LEDs	Connecticut	Massachusetts	New York	Kansas	California
2009	15%	14%	14%	18%	19%
2010	19%	12%	15%	18%	18%
2011	19%	14%	16%	20%	22%
2012	15%	15%	14%	18%	25%
2013	12%	15%	12%	13%	18%
2014	15%	19%	14%	14%	18%
2015	18%	20%	16%	16%	20%
Incandescents	Connecticut	Massachusetts	New York	Kansas	California
2009	69%	71%	72%	68%	64%
2010	66%	73%	70%	70%	65%
2011	67%	73%	71%	69%	62%
2012	68%	69%	72%	69%	55%
2013	65%	64%	68%	67%	44%
2014	45%	44%	51%	53%	34%
2015	28%	27%	30%	33%	30%
Halogens	Connecticut	Massachusetts	New York	Kansas	California
2009	2%	2%	1%	2%	2%
2010	2%	2%	2%	2%	2%
2011	2%	3%	2%	2%	3%
2012	4%	4%	3%	3%	5%
2013	9%	9%	8%	9%	21%
2014	25%	24%	22%	21%	31%
2015	37%	37%	39%	36%	32%

Incandescents + Halogens	Connecticut	Massachusetts	New York	Kansas	California
2009	71%	73%	73%	70%	66%
2010	69%	75%	72%	71%	67%
2011	70%	75%	73%	71%	65%
2012	72%	73%	75%	72%	61%
2013	74%	72%	76%	76%	65%
2014	70%	68%	73%	74%	65%
2015	65%	65%	69%	69%	62%

Your 2016-2020 NTG Estimates

Please estimate NTG levels for 2016 through 2020, without taking spillover from pre-2016 programs into account.

YEAR	A-line LEDs		Reflector LEDs		All LEDs	
	WHAT IS YOUR RECOMMENDED NTG FOR A-LINE LEDS ? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR A-LINE LEDS ?	WHAT IS YOUR RECOMMENDED NTG FOR REFLECTOR LEDS ? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR REFLECTOR LEDS ?	WHAT IS YOUR RECOMMENDED NTG FOR ALL LEDS ? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR ALL LEDS ?
2016						
2017						
2018						
2019						
2020						

Excel File (NTG Ratios)

State	Program Year	Study	All LEDs	LED A-line	LED Refl.	LED A-line			LED Reflector			non-HTR LEDs			HTR LEDs			All LEDs				
						2017	2019	2021	2017	2019	2021	2016	2017	2018	2016	2017	2018	2015	2016	2017	2018	
CT	2013	CT 2014 Lighting NTG study	82%																			
CT	2015	CT Demand Elasticity Modeling	61%																			
CT	2015	CT Sales Data Modeling	70%																			
CT	2015	CT Supplier Interviews		63%	58%	39%	35%	37%	41%	43%	33%											
YOUR RECOMMENDED NTG FOR CONNECTICUT FOR 2015 Please																						
WHY DO YOU RECOMMEND THIS NTG LEVEL?																						
Other Northeast and Mid-Atlantic																						
MA	2016-18	MA Consensus NTG										90%	80%	70%	100%	99%	98%		93%	85%	78%	
ME	2013-14	Efficiency ME Retail Lighting Overall Evaluation	77%																			
RI	2012	RI TRM	92%																			
Outside of Northeast																						
AK	2013	ENTERGY AK Demand Elasticity Modeling	80%																			
CA*	2013-14	Comb. Weighted Lamp Choice Mod./Suppl. NTG		40%, 42%, 35%	27%, 28%, 28%																	
CD	2015	Eval. of Xcel Energy's Home Light/Recycling Progr.	91%																			
Undisc.	2015	Undisclosed Literature Review	85%																			
IL	2014-15	Res. ENERGY STAR Lighting PY7 Eval. - ComEd	73%																			
NM	2014	SWE's EE and Load Management Plan	100%																			
TX	2015	EM&V of CPS Energy's FY2015 DSM Programs	85%																			

* Order is PG&E, SCE, and SDG&E

Excel File (Strengths and Weaknesses – Northeast and Mid-Atlantic)

State	Program Year	Study	Strengths	Weaknesses
CT	2013	CT 2014 Lighting NTG study	Utilized 3 methods for estimating NTG and net-of-freeridership: DEM, POS Modeling, and Suppl. IDIs; DEM POS models use sales data while IDIs draw on expert judgment.	Both sets of modeling data had limited info. such as incompl. data on CFL sales (DEM), and missing data from some retail channels (POS Modeling). The supplier IDIs may have been biased if partners have inherent interest in
CT	2014	CT 2014 Lighting NTG study	Study uses program sales data and provides estimates by bulb type as well as retail channel.	Model relies on progr. sales data, and could account for SO or MEs. Model was limited to 1yr of program data and could not capture program influence over time.
CT	2015	CT Sales Data Modeling	Sample includes multi states recording actual purchases at time of acquisition. Gives a more complete and unbiased pic. of the lighting mkt.	LEDs were difficult to capture and may be underrepresented in the data leading to bias in the model.
CT	2015	CT Supplier Interviews	Sample includes suppliers that represent a considerable share of the efficient lighting market and are knowledgeable about related mkt. trends.	Self-reported data and potential for related biases.
YOUR RECOMMENDED NTG FOR CONNECTICUT FOR 2015 Please				
WHY DO YOU RECOMMEND THIS NTG LEVEL?				
Other Northeast and Mid-Atlantic				
MA	2016-18	MA Consensus NTG	Consensus approach draws on multiple NTG studies and take into consideration a range of relative strengths and weaknesses.	Emphasizes that rapid transformation stemming from tech. change and increased fed. efficiency stds. in the lighting market limit ability to provide prospective NTG estimates, and recommends closely monitoring the changes in the market and potentially revising the prospective estimates.
ME	2013-14	Efficiency ME Retail Lighting Overall Evaluation	Price elasticity analysis used to capture program-incentivized sales that would have occurred without the program. Model captures the inverse relationship between price and sales.	Price elasticity modeling used for FR estim. is likely conservative. Do not account for effects of favorable placement. Little produce price variation and model does not capture the substitute good with pos. price elasticity effects of bulbs. No SO detected. NTG is likely conservative overall.
RI	2012	RI TRM	Provides commonly used formulas for calculating NTG	Does not go into detail as to how to obtain factors that make up NTG

Excel File (Strengths and Weaknesses – Outside of Northeast)

State	Program Year	Study	Strengths	Weaknesses
Outside of Northeast				
AK	2013	ENTERGY AK Demand Elasticity Modeling	Study uses price, promotional activity, and sales variations within the program period as the basis for the demand modeling.	Due to relatively low levels of price variation for specialty bulbs and no variation for LEDs, the study was unable to estimate price elasticity at the bulb level.
CA*	2013-14	Comb. Weighted Lamp Choice Mod./Suppl. NTG	Samples includes a range of retail channels. The model captures differences in shopper populations, and is based on up-to-date retail stocking information.	Modeled data does not explicitly rep. sales volume and provides a snapshot in time so it does not reflect the entire program period. Both samples rely on self-reports. Study estimates for 2013-14, which may be out of date given the fast-changing nature of the LED market.
CO	2015	Eval. of Xcel Energy's Home Light/Recycling Prog	Used a triangul. method to determine FR: DEM, store-intercepts, supplier IDs. NTG includes MEs. DEM produces reliable estimates with little msrmt. error for customer recall. Estimates indiv. program impacts from price, advert., and prod. placement. The 3 are weighted and averaged to acct for pros/cons of each method to prod. an average FR. MEs supported by ME indicators such as incr. CFL awareness, retail store program participation, and stocking of non-program bulbs, and detected SO from intercepts.	Store intercept surveys subject to reporting bias.
Undisc.	2015	Undisclosed Literature Review	4 studies in review utilized in-store intercepts, which is aligned with the statewide TRM, suggesting in-store intercepts to estimate FR for program-discounted lighting. The statewide TRM stipulated NTG values fall within the range of NTG values from these four studies.	Two of the programs in the review offered an alternative approach for retailers that cannot support an upstream markdown (coupons for customers to complete at the register to receive a discount). In addition, the studies included in the review are all two to three years old.
IL	2014-15	Res. ENERGY STAR Lighting PY7 Eval. - ComEd	Conducted both demo event and non-demo event surveys and weighted the NTG. A total of 726 in-store surveys were conducted. Includes both participant spillover and non-participant spillover.	No prev. PY estimates for trend analysis/comparison. FR based on Program Influence Score and No-Program Score (NPS). NPS is based on a hypothetical scenario. Omni/directional LEDs not separated due to small sample.
NM	2014	SWE's EE and Load Management Plan	—	Recommended by SPC based on the belief that customers would not purchase LEDs without an incentive. Not based on estimation procedure.
TX	2015	EM&V of CPS Energy's FY2015 DSM Programs	—	Does not provide details on estimation.