Multistage Lighting Net-to-Gross Assessment: Overall Report

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Prepared for:

The Electric and Gas Program Administrators of Massachusetts

Part of the Residential Evaluation Program Area

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Executive Summary

Study Objectives and Research Questions

The present Massachusetts (MA) program cycle included several studies with different research approaches that estimated net-to-gross (NTG) or net-of-freeridership. The purpose of this report is to describe those approaches briefly (specific details on which are provided in the individual reports, cited throughout) and more importantly, to explain the consensus building process undertaken to develop and finalize NTG estimates, both retrospectively for 2014, and prospectively for 2016-2018 (as required by the MA Department of Public Utilities).[1] A group consisting of Program Administrators (PAs), Energy Efficiency Advisory Council (EEAC) consultants, and evaluation consultants reviewed the CFL and LED NTG and net-of-freeridership estimates derived for 2013 and/or 2014 and on-going evaluation research regarding prices for lighting currently and in the near-term future, ultimately working together to achieve agreement on the recommended NTG estimates.

Recommended Values

Table 1 displays the consensus retrospective (2014) and prospective (2016 to 2018) NTG values for the most critical products. The discussions involved in developing these recommendations are described in more detail below and in the main body of the report. In all cases but one, the consensus values ended up being the average of the NTG values recommended by the group members for each bulb type and program category. The exception was non- hard-to-reach (HTR) LEDs, in which the final consensus values of 90% for 2016, 80% for 2017 and 70% for 2018—agreed upon after considerable discussion over multiple meetings and emails— were slighting lower than the simple average of group members' recommendations (91%, 84%, and 77%, respectively).

[1] By "consensus building process" we are referring to a group of evaluation experts who met several times to discuss the methods, estimates, and strengths and weaknesses of approaches, ultimately achieving agreement on all finalized values. This exact process is explained in detail throughout the report.

Table 1. Consensus Retrospective and Prospective NTG Estimates

Product	Retrospective	Prospective		
	2014	2016	2017	2018
Non-HTR Standard CFLs	53%	54%	53%	53%
HTR Standard CFLs	93%	93%	92%	91%
Non-HTR LEDs	-*	90%	80%	70%
HTR LEDs	102%	100%	99%	98%
All LEDs*	95%	93%	85%	78%
CFL Fixtures	NA	96%	96%	96%
LED Fixtures	NA	98%	93%	89%

* Non-HTR LEDs were not on the initial estimate template that was circulated because the Program Administrators did not target LEDs to one market or the other in 2014. The Team believes the best value to use for LEDs in 2014 is the overall "All LEDs" estimate. Moving forward, if the PAs decide to target some LEDs to HTR channels, then the split out results will become appropriate.

Research Approaches

Table 2 summarizes the NTG and net-of-freeridership research approaches based on 2013 and/or 2014 evaluation study results. It also contains information on study approaches undertaken to help the group in estimating prospective values for the 2016-2018 period. Detailed findings from each approach, as well as citations to full reports on each study are provided in the main body of this report.

Table 2. Studies Providing NTG or Net-of-Freeridership Estimates

Activity	Overview
Supplier Interviews	Team asked suppliers for the percentage change in sales that they attributed to the MA program. Their responses provided a NTG estimate for each retail channel for 2013. Additionally, a 2015 supplier interview effort focused on assessing incremental costs (specifically anticipated price and sales trends through 2018, the latter in both program and non-program scenarios). Preliminary results from this effort informed the consensus process for developing prospective NTG ratios for 2016 to 2018.
Point-of-Sale Data Analysis	Estimated NTG by modeling MA program impact on CFL and LED sales relative to other states with and without significant program activity. POS data represented 44 states over five years. Model inputs included lighting program activity, demographic, social, and economic data and predicted energy-efficient bulb sales in the presence and absence of program activity. Developed unique 2013 NTG ratios for MA.
Self-reported Market-level Purchase Analysis	Compared consumer self-reported purchases to estimate market-level sales in MA and comparison states, one with a recent history of lighting incentives (Georgia, GA), one with no history of lighting incentives (Kansas, KS) and one former program state that recently eliminated lighting incentives (New York, NY). Generated 2013 NTG ratios from using total self-reported purchases in MA compared to KS and GA and 2014 NTG ratios comparing MA and NY.
Changes in Socket Saturation	Compared changes in efficient bulb socket saturation in MA and NY between 2013 and early 2015. NY discontinued support of standard CFLs, allowing for an assessment of the impact of the MA program by comparing it to a demographically similar, former-program state.

Activity	Overview
Demand Elasticity	Developed a demand elasticity model to estimate the price elasticity of program lighting products. The resulting elasticity allowed the Team to estimate sales without the program's incentive, providing a 2013 net-of-freeridership estimate.
Web-based Pricing Modeling	Team members used a web-scraping technique to extract information on LED, CFL, and halogen price trends from major retailers in Massachusetts. The modeling results yielded estimates of prices and incremental costs for various bulb types through 2018, and this information informed prospective NTG development.

The Consensus Approach to Estimating NTG

The ultimate objective of integrating these NTG and net-of-freeridership estimates into finalized values was achieved through a consensus-building process among PAs, EEAC members, and evaluation team members. The first step was for each party taking part in the discussions to review the estimates provided by each research approach described in Table 2**Error! Reference source not found.**. The greatest strength of this approach relies on its balancing of the diverse set of strengths, weaknesses, potential biases, and threats to validity associated with the various methods used to estimate NTG. Relying on a single approach to estimating NTG would exacerbate that approach's limitations, but drawing on estimates from multiple approaches allowed the group to consider the different methods on the basis of their relative strengths and shortcomings. Importantly, a group of experienced evaluation professionals collectively engaged in this process, limiting the subjectivity and personal biases that could have resulted had a single individual attempted to develop the final estimates based on a review of the methods. The consensus approach was a deliberate and purposeful process, obtaining open assessments from a comprehensive set of experienced evaluators working in tandem.

The second step was to reach agreement on appropriate overall NTG values by bulb type for 2014, achieved by eliciting feedback on the differing research approaches and values, and reviewing saturation trends and EISA's schedule for phasing out inefficient lighting, until the group reached agreement. The third step, once the group had agreed on the finalized retrospective NTG estimates for 2014, was to use those values as well as preliminary information from the incremental cost study (specifically anticipated price and market-share trends, converted to anticipated incremental costs and NTG ratios) and suppliers' future price predictions to provide insight and develop recommended prospective (that is, forward-looking) NTG estimates for the 2016-2018 program cycle as required by the Massachusetts DPU. Formal voting on a finalized value was not necessary, as the group was able to reach agreement on those values through a series of discussions.

The next section is a review of the specific retrospective NTG estimates and recommendation ranges provided by the group for 2014. We then discuss how the group utilized finalized 2014 values to develop prospective estimates for 2016-2018 in the section Consensus Prospective NTG Estimates.

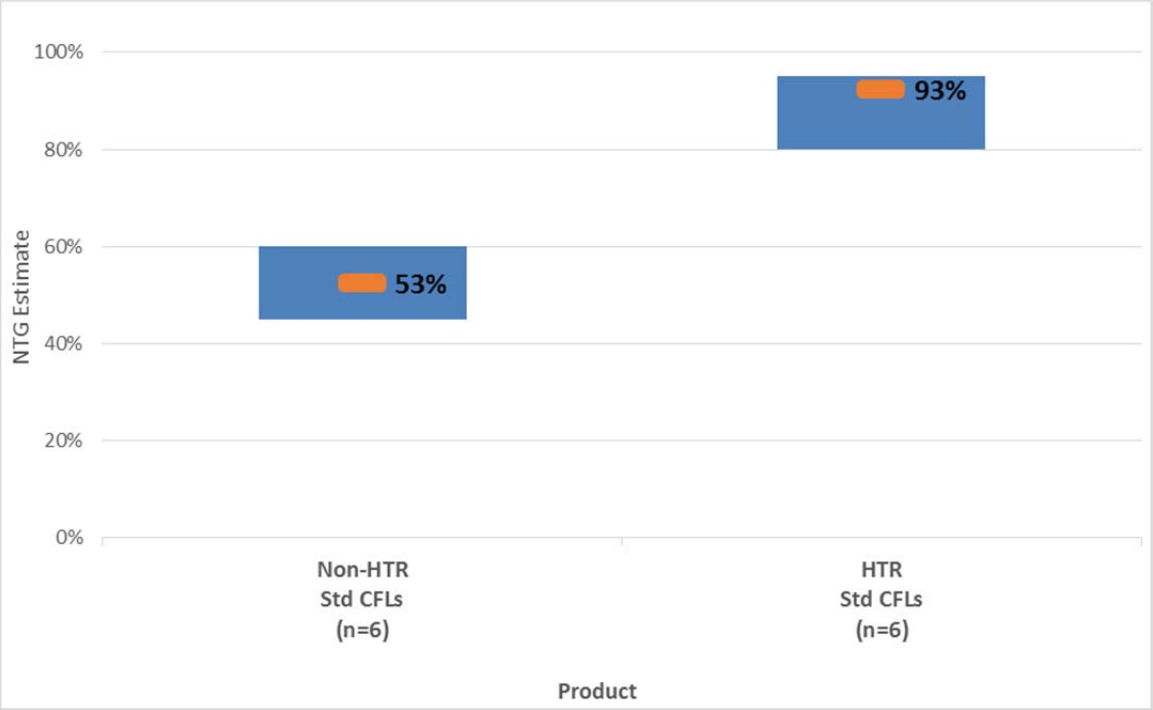
Consensus Retrospective NTG Estimates

Six individuals with extensive experience administering and assessing lighting programs provided recommendations for the retrospective (2014) NTG estimates. The six individuals included a balanced forum consisting of two PAs responding on behalf of their companies, two EEAC consultants, and two evaluation firms. Prior to the meeting, the individuals assessed the strengths and weaknesses of the various approaches used to estimate retrospective NTG ratios and provided their own opinions about the likely ratio for various products for that year. The consensus-building process commenced with a discussion of these perceived strengths and weaknesses as well as the reasoning behind individual opinions about NTG ratios. This discussion laid the foundation for the broader perspective afforded by the group assessment, an important part of the value of this approach for building the most likely and defensible estimates from a variety of evaluation-derived estimates.

Standard CFL NTG Estimates

Figure 1 shows the range of recommended NTG estimates (in blue) and the consensus value (in orange) for the two critical program categories of non-HTR standard CFLs and HTR standard CFLs (those for all of the standard CFL categories are provided in the main body of this report). The consensus NTG estimate (which is also the average of the recommended values across group members for these bulb types) for non-HTR standard CFLs was 53%, with a relatively narrow range of 45% to 60%. The consensus NTG estimate for HTR standard CFLs was higher at 93%, also with fairly narrow range of 80% to 95% (the average being on the high end of the range was the result of several group members recommending 95% and only one recommending 80%). Group members felt that the scale of these estimates was aligned with the different estimates from existing research, particularly the NY saturation-based estimates and the supplier interview estimates, which supported utilizing the straight average of group members' recommended values as the final number. All group members agreed this was appropriate. Group members also felt that the range of NTG estimates for HTR and non-HTR standard CFLs corresponded appropriately to the proportion of their respective program sales (roughly 80% non-HTR and 20% HTR).

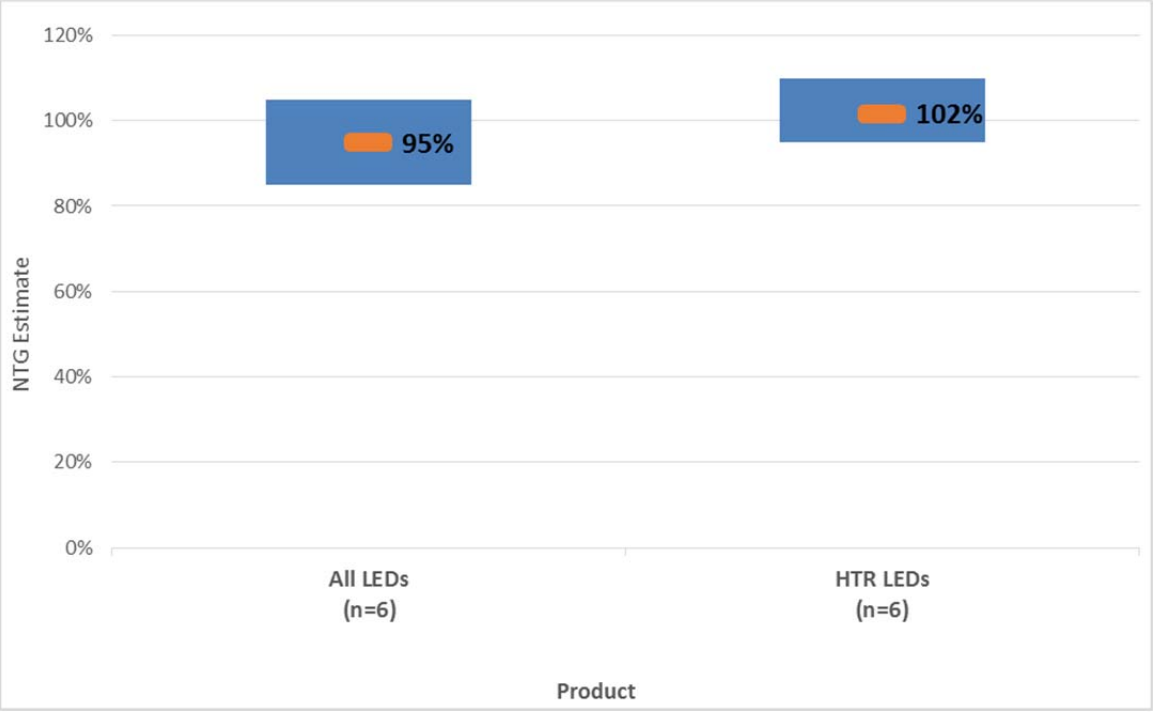
Figure 1. Retrospective (2014) Standard CFL NTG Estimates



LED NTG Estimates

Although the full LED NTG categories mirrored those for standard CFLs prospectively (all LED bulbs, non-HTR, HTR, home improvement, and all other channels) the retrospective values template did not include a separate breakout for non-HTR LEDs because the program did not specifically target LEDs to one market or the other in 2014. The Team believes that the most appropriate retrospective value to use for LEDs is the "all LEDs" estimate of 95% (Figure 2). The full categories of LED estimates are provided in the body of this report. Group members felt that the NTG estimate for HTR LEDs would be at or above 100%, with the final consensus estimate for HTR LEDs at 102% with a range from 95% to 110%.

Figure 2. Retrospective (2014) LED NTG Estimate



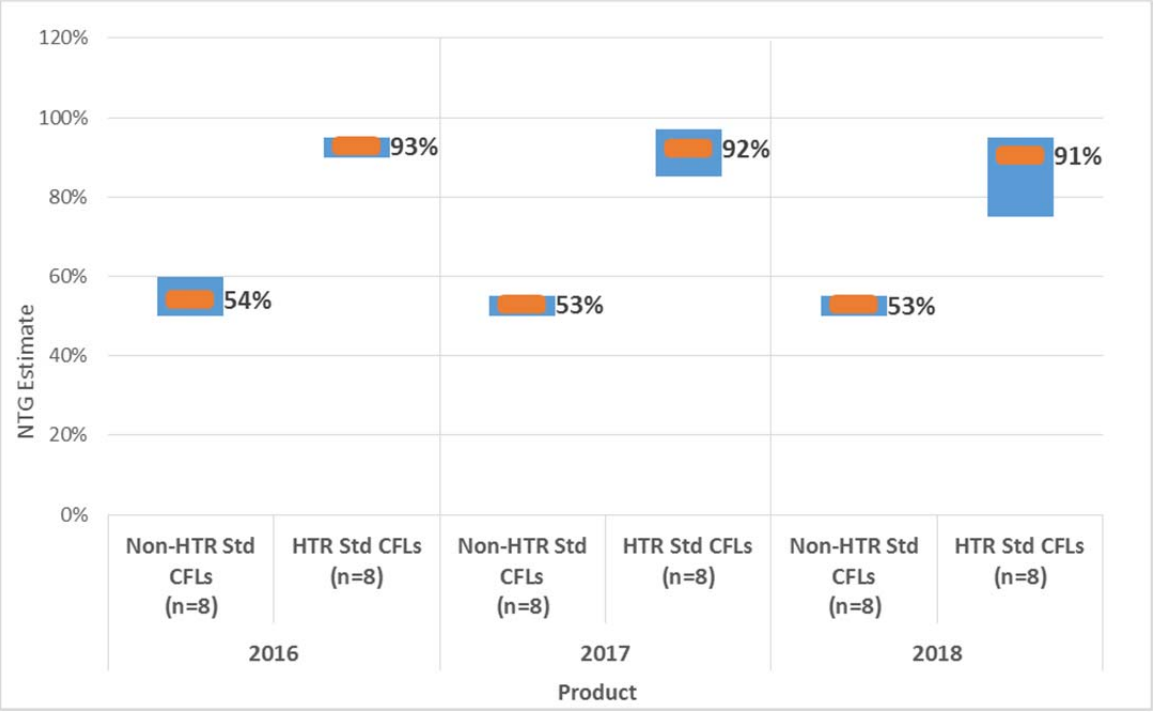
Consensus Prospective NTG Estimates

Eight experienced evaluation professionals —a balanced forum of three PAs, two EEAC consultants, and three evaluation firms—submitted estimates for prospective NTG values for 2016 to 2018, the period of the next program planning cycle. The group made their recommendations after finalizing the 2014 consensus NTG estimates, and reviewing two estimates of future LED prices from an on-going LED incremental cost study of near-term extrapolated estimates, the manufacturer and retailer interview data on future near-term bulb prices and market shares without and without the program, trends in efficient bulb saturation over time in program and non-program states, and EISA's schedule for phasing out inefficient lighting (information the group received is provided in Appendix A: Materials for NTG Meetings.

Standard CFL NTG Estimates

The consensus (once again the average recommended estimates across group members) prospective NTG estimates for non-HTR standard CFLs were similar to the retrospective values and fairly stable at 54% (for 2016), 53% (2017) and 53% (2018), reflecting a mature market with stable prices. The consensus NTG estimates for HTR CFLs for 2016-2018 were higher at 93%, 92%, and 91%, as the group believed program bulbs would continue to have more impact in these channels less likely to carry efficient bulbs otherwise (Figure 3).

Figure 3. Standard CFL NTG estimates, 2016-2018



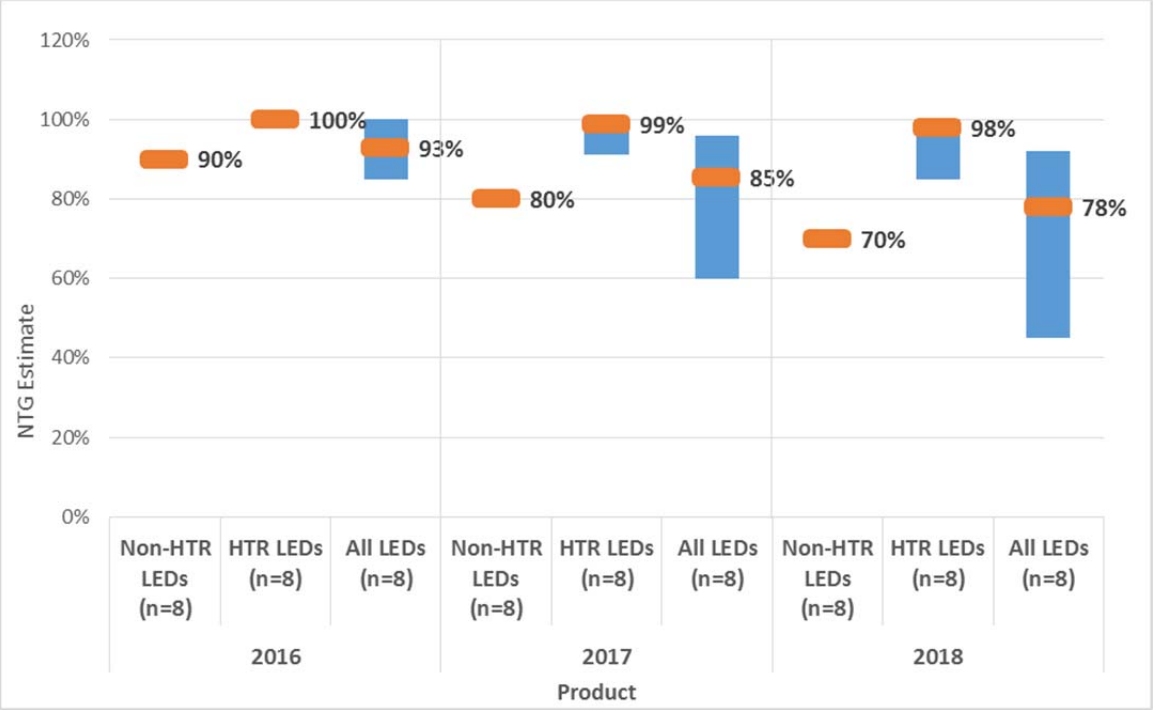
LED NTG Estimates

The individual LED NTG estimates varied by year more than standard CFL estimates due to uncertainties in the rapidly changing LED market (e.g., how quickly consumers will adopt them, price trends, concerns about quality, etc.). Overall, the group agreed that prospective non-HTR LED NTG estimates would drop over time, and future NTG is likely to be influenced by declining LED prices. While the group did not reach full consensus on the non-HTR LED estimates in their initial meetings, from that first meeting the need was identified that all group members should be given a preliminary incremental cost estimate from the manufacturer and retailer interviews and the corrections and adjustments needed in those.[2] A final meeting in late May 2015 did bring about agreement for that bulb category, largely driven by the provision of more accurate preliminary incremental costs, with final consensus estimates of 90% for 2016, 80% for 2017, and 70% for 2018. This agreement was largely driven by group members obtaining the most accurate preliminary incremental cost information from manufacturers and retailers during supplier interviews as well as results from the web-based modeling approach. The group also agreed that the NTG estimates for HTR LEDs are likely to remain high and only decrease by small amounts. The

[2] For the initial meeting one of the participants had calculated this and it drove that individual's estimates and then the range in LED estimates. Yet, the discussion brought forth the need to correct the method used. The corrections significantly changed the LED incremental cost estimates and that was a significant driver in bringing substantial, though not complete, agreement on LED NTG estimates.

average NTG estimates for HTR LEDs were expected to be 100% in 2016, 99% in 2017, and 98% in 2018 (Figure 4).

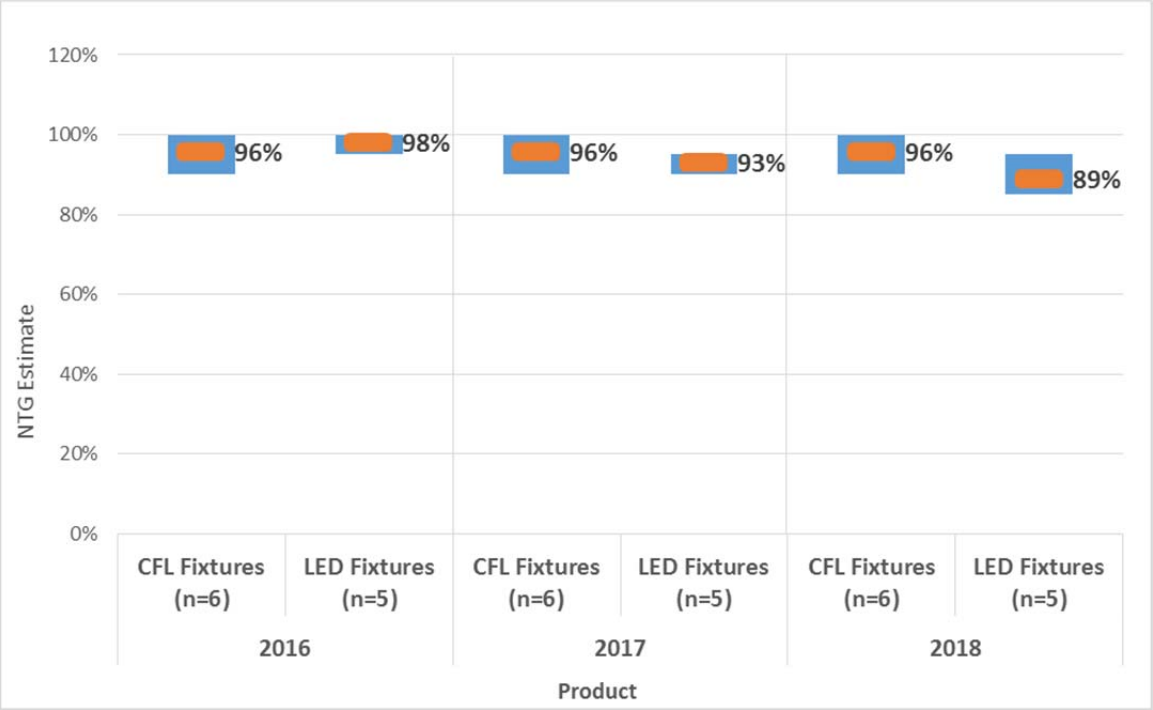
Figure 4. LED NTG estimates, 2016-2018



CFL and LED Fixtures NTG

Figure 5 shows the consensus 2016 NTG estimates for CFL and LED fixtures. The consensus NTG values for CFL fixtures remain steady at 96% throughout 2016-2018; estimates ranged from 90% to 100%. The consensus NTG estimates for LED fixtures start at 98% in 2016 and gradually declines each year to 93% in 2017 and 89% in 2018.

Figure 5. CFL and LED fixture NTG estimates, 2016-2018



Strengths and Weaknesses of Approaches

Each of the approaches that the Team utilized to estimate NTG and net-of-freeridership in this evaluation cycle had its own strengths and weaknesses. These strengths and weaknesses are summarized in Table 3 below. Note that the web-based modeling assessment comes solely from the evaluation team; it did not provide retrospective NTG estimates, so the six individuals did not discuss its strengths and weaknesses.

Table 3. Strengths and Weaknesses of Research Approaches

Activity	Strengths of Approach	Weaknesses of Approach
Demand Elasticity Modeling	Actual variation in prices Not dependent on respondent recall Unlike other methods can be used to estimate future net-of-freeridership levels	Does not take spillover into account
POS Data Modeling	Actual sales data Not dependent on respondent recall Five years of data to assess trends Statistically modeled comparison area takes multiple factors into account	Only some channels are included in the data Only ~22% of MA program sales Stores covered in MA may not be the same as those covered in other states

Activity	Strengths of Approach	Weaknesses of Approach
Supplier Interviews	Large portion of the market accounted for Many respondents have been following the market for years	Suppliers have inherent self-interest in the continuation of the program and may underestimate purchases in the absence of the program Suppliers may desire to make their company appear "greener" and overestimate purchases in absence of program. Suppliers don't actually make the decisions to purchase CFLs for home installation
Comparison Area Research – KS and GA Self-Reported Purchases	Prior saturation estimates to assess trends Range of program support in GA and KS provides good comparison areas	Depends on respondent recall Small sample sizes in GA and KS GA/KS and MA are different demographically Possible non-response bias MA started with higher saturation than GA which could affect future sales KS had fewer specialty fixtures than MA KS has many more Walmarts per household than MA; Walmart has aggressively promoted CFLs since 2007
Comparison Area Research – NY Self-Reported Purchases	Have prior saturation estimates (2013) to assess trends NY discontinued support for standard CFLs in 2012, providing good comparison area Saturation levels in MA and NY in 2013 were similar NY is relatively similar to MA demographically	Only covers the last six months of 2014 Depends on respondent recall about when they purchased bulbs Small sample size in NY Possible non-response bias is greater in NY because of lower response rate While comparable to MA, NY is not the same as MA.
Comparison Area Research – NY Saturation Based	Not dependent on respondent recall Have prior saturation estimates (2013) to assess trends NY discontinued support for standard CFLs in 2012, providing good comparison area Saturation levels in MA and NY in 2013 were similar NY is relatively similar to MA demographically	Small sample size in NY Possible non-response bias is greater in NY because of lower response rate While comparable to MA, NY is not the same as MA.

Activity	Strengths of Approach	Weaknesses of Approach
Web-based Modeling	Large amount of pricing data collected remotely for MA region for several key LED product types Broader coverage of data sources, contains price data from a large number of distribution channels including home improvement stores Extrapolations based on several years of historical pricing data – starting in 2012 and collected quarterly	Approach does not allow for a sales-weighted price analysis Recent steep price decline for LED lamps impact extrapolation results While an exponential function provides the best-fit for the historical price data, forward-looking extrapolations could be lower than actual

Conclusions and Recommendations

This report provides the team's recommended retrospective (for 2014) and prospective (for 2016 to 2018) NTG ratios for CFLs and LEDs (Table 1). The report also summarizes the methods used to calculate various NTG and net-of-freeridership estimates in individual tasks and describes the process of integrating those results into agreed-upon values.

The prospective NTG estimates are based on the best information available to the PAs, EEAC consultants, and evaluation team in the Spring of 2015. Any number of market changes or new information could call for significant revisions to the team's estimates. Three of the most likely factors that could lead to a need for revised estimates include the following:

1. Unexpected changes in the LED price trends;
2. Introduction of new efficient lighting technologies; and
3. Overturning or otherwise negating the EISA lighting efficiency standards to be implemented in 2020—only CFLs and LEDs currently meet the standard.

Evaluation Contractor Recommendation to Policy-Makers

The evaluation contractor team is an independent third party; while we seldom do so, this status provides us the freedom to make recommendations to policy makers, in addition to the more common recommendations regarding program operations, data, and future evaluations. The Team recognizes that recommendations to policy makers must come solely from the evaluation contractor team and must not be influenced by the PAs or the EEAC Consultants. With this perspective in mind, the Team offers the following recommendation to policy makers.

We agree with and applaud the effort to look for opportunities to define NTG values prospectively. There are many products and technologies for which the body of research, market experience, and trends are substantial and stable enough to make reasonable forecasts of NTG given consistent program design and implementation. Lighting, in contrast, is not such a technology. The lighting market has been undergoing rapid transformation stemming from technology change and increased federal efficiency

standards. As a result, any attempt to project NTG beyond a year – even in the face of consistent program design and implementation – goes beyond the typical expectations and responsibilities of an independent third-party evaluation.

As physicist Neils Bohr said, "Prediction is very difficult, especially about the future." In the end, it is impossible to know the future. Nevertheless, while the team feels confident about the validity of the retrospective NTG estimates for residential lighting and, to an extent, the one-year (2016) prospective estimates, we are less confident about the two-year (2017) and three-year (2018) prospective estimates, which are based on conjecture as much as on evidence. Given the reliance of the residential portfolio on lighting savings and the uncertainty of prospective estimates in a rapidly changing market and policy environment, the PAs run the risk of either exceeding or falling short of the savings targeted in the 2016-2018 plan, especially toward the end of the period. The Team strongly believes that the PAs should closely monitor the market, and periodically revisit and potentially revise the 2016-2018 NTG estimates. If these NTG estimates change substantially, moreover, the Team recommends that the PAs be allowed to apply the new NTG estimates to develop revised savings targets for the 2016-2018 period.

Introduction and Study Objectives

This report summarizes several studies from the present MA program cycle that provided net-to-gross (NTG) or net-of-freeridership estimates for the programs, and describes an effort that developed consensus NTG estimates for 2014 and 2016-2018.[3] To begin the process, the Team relied on a number of different methods—each with its own strengths and weaknesses—to estimate retrospective NTG ratios for 2013 and/or 2014 for LEDs and CFLs. The Program Administrators (PAs), the Energy Efficiency Advisory Council (EEAC) consultants, and the evaluation consultants then reviewed these NTG estimates, as well as saturation trends and EISA's schedule for phasing out inefficient lighting, in order to develop a single retrospective NTG estimate for LEDs and CFLs for each product category using an assessment of the strength and weaknesses of methods.. The same group then reviewed the consensus retrospective NTG estimates, the same saturation trends and EISA phase-out schedule, and also two estimates of future LED prices in order to develop consensus *prospective* NTG estimates for 2016 through 2018 for specific product categories of LEDs and CFLs. The reliance on multiple methods and consensus-building among seasoned program administration and evaluation professionals limit the individual biases that can result from recommended NTG ratios based solely on one method or through the opinion of just one person.

[3] By "consensus NTG estimates" the Team is referring to a group of evaluation experts who met several times to review and discuss all studies providing NTG and net-of-freeridership values, their relative strengths and weakness, and the best information available on future price trends and incremental cost. In this way the "consensus" values represented the agreement of experts on these topics.

Study Overview: Completed Research Tasks

Table 4 summarizes the research tasks and their contributions to each study (we also provide citations to all full reports should reviewers desire more details on any of the relevant methodologies).

Table 4. Studies Providing NTG or Net-of-Freeridership Estimates

Activity	Overview
Supplier Interviews	Through in-depth interviews with manufacturers and high-level retail buyers as well as surveys with retail lighting managers, the Team probed the percentage of the changes in sales for various bulb types that suppliers attribute to the MA program as well as their reasons for providing these estimates. Their responses were combined to provide a NTG estimate for each retail channel for 2013. Additionally, a 2015 supplier interview effort focused on assessing incremental costs (specifically anticipated price and sales trends through 2018, the latter in both program and non-program scenarios). Preliminary results from this effort informed the consensus process for develop prospective NTG ratios for 2016 to 2018.
Point-of-Sale Data Analysis	The point–of-sale (POS) approach to estimating NTG modeled the MA program's impact on CFL and LED sales relative to other states with and without significant program activity by analyzing POS data for 44 states over five years, along with lighting program activity, and demographic, social, and economic data. The Team developed models to predict energy-efficient bulb sales in the presence and absence of program activity, using these estimates together with actual program sales to develop unique 2013 NTG ratios for MA.
Self-reported Market-level Purchase Analysis	This approach compared consumer-based purchases to estimate market-level sales in MA and comparison states, one with a recent history of lighting incentives (GA), one with no history of lighting incentives (KS) and one former program state that recently eliminated lighting incentives (NY). The Team generated 2013 NTG ratios from this method using total self-reported purchases in MA and comparison areas and actual program-supported sales in MA.
Analysis of changes in Socket Saturation	This approach utilized the prior program state of NY (an ideal comparison to MA given similar demographics and past program activity) to compare changes in efficient bulb socket saturation between the states in 2013 and early 2015. This method garnered MA NTG ratios for 2014.
Demand Elasticity	Using program tracking data, the Team developed a demand elasticity model to estimate the price elasticity of program lighting products. The resulting elasticity allowed the Team to estimate sales without the program's incentive, providing a 2013 net-of-freeridership estimate. This estimate lacks spillover so is not a NTG ratio.
Web-based Pricing Modeling	Team members used a web-scraping technique to extract information on LED, CFL, and halogen price trends from major retailers in Massachusetts, which were combined in a statistical modeling exercise with prior data collected from the Washington, DC area (after verifying comparability). Combining the data allowed for adequate statistical power for the exercise. The modeling results yielded estimates of prices and incremental costs for various bulb types through 2018, and this information informed prospective NTG development.

Data Modeling Approaches

This section describes the two most quantitatively oriented tasks—demand elasticity and point-of-sale (POS) data modeling—that the Team undertook to estimate net-of-freeridership and NTG ratios for the MA Residential Lighting Program.

Demand Elasticity Modeling

Demand elasticity is a modeling approach that uses sales and promotion information in order to accomplish the following:

- Quantify the relationship of price and sales,
- Predict likely sales levels without the program's incentives (baseline or counterfactual sales), and
- Estimate freeridership by comparing modeled baseline sales with modeled program sales.

The demand elasticity research produced a statistical model to estimate freeridership for the upstream markdown channel in the 2013 program year. Importantly, demand elasticity models allow for an estimation of freeridership by comparing the model outputs in absence of the program with the actual sales data.[4]

The Team estimated freeridership using the following equation:

$$FR\ Ratio = \frac{\sum_i^n \left(E\left[bulbs_{NOPROG_i}\right] * Gross\ kWh_i\right)}{\sum_i^n \left(E\left[bulbs_{PROG_i}\right] * Gross\ kWh_i\right)}$$

Where:

$E[bulbs_{NOPROGi}]$	=	The expected number of lamps of type 'i' that would be purchased in absence of the program (as predicted by setting the model price to original retail levels)
$Gross\ kWh_i$	=	The gross energy savings for lamp type 'i.'
$E[bulbs_{PROGi}]$	=	The expected number of lamps of type 'i' purchased with program pricing (as predicted by the model)

The strengths of the demand elasticity approach include the fact that this method utilizes actual variation in prices, is not dependent on respondent recall, and can often estimate future net-of-

[4] For more details on the methodology of the demand elasticity modeling see Cadmus & NMR. *Preliminary Lighting Demand Elasticity Findings.* Memorandum delivered to the PAs and EEAC Consultants March 2015.

freeridership levels. The main weakness of the approach is that it does not take spillover or C&I sales into account.

The demand elasticity approach resulted in the following estimates of net-of-freeridership for CFLs in MA (Table 5).

Table 5. Estimated CFL Freeridership

CFL Type	Percent of Sales	Net-of-Freeridership
Specialty	24.7%	44%
Standard	75.3%	61%
Overall	**100%**	**57%**

Point-of-Sale (POS) Modeling

As with the demand elasticity modeling, the purpose of the POS modeling research was to provide estimates of program impacts. However, while demand elasticity modeling led to a net-of-freeridership estimate, the POS modeling research provided actual NTG ratios as it allows for an assessment of spillover (albeit only for selected retail channels).[5] These NTG estimates for CFLs and LEDs (and both bulb types combined) were developed by leveraging nationwide sales data purchased through LightTracker, an initiative of the Consortium for Retail Energy Efficiency Data (CREED), which include bulb purchase data captured at the point of sale for selected retail channels for 44 states across five years (2009-2013).[6] The Team also collected an extensive set of model inputs, including statewide program activity (operationalized as a state's lighting program budget), demographics, and presence/absence of major retailers reporting to CREED, which were used as independent variables in a series of regression models predicting the proportion of statewide bulb sales that were efficient. By utilizing these variables in the same model the Team could identify those that had the greatest impact on the sales of CFLs and LEDs, and in particular the effect of program activity on efficient bulb sales.[7]

To determine these potential influences the Team fit a series of robust random-effects regression models of the following form:

[5] A shortcoming of the POS dataset is that it does not include sales data from Home Improvement and Hardware retail channels, which can account for a substantial proportion of both market-level, and program-level sales.

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

[7] For more details on the POS Modeling research, see Cadmus, NMR, Tetra Tech, Navigant, and DNV GL. *Massachusetts Residential Point-of-Sale Modeling: Final Report*. Final delivered to the PAs and EEAC Consultants February 2015.

$$\log(\%efficient.sales_{i,j}) = \alpha + \beta_{0,i} + \beta_1 \log(cr.sqft_{i,j}) + \beta_2 \log(noncreed.sqft_{i,j}) + \beta_3 avg.electric.price_{i,j} + \beta_4 cost.of.living_i + \sum_{k=1}^{p} \gamma_k dem.var_{i,j,k} + \theta prog_{i,j} + \tau_j + \epsilon_{i,j}$$

Where:

%efficient.sales$_{i,j}$ = Proportion of total CREED-reported bulb sales that were efficient bulbs in state *i* and year *j*. Calculated as *(#CFL*$_{i,j}$ *+ #LED*$_{i,j}$*)/(total bulb sales*$_{i,j}$*)*.

cr.sqft$_{i,j}$ = Number of square feet of major CREED-reporting retailer channels in state *i* and year *j.*

noncreed.sqft$_{i,j}$ = Number of square feet of major non-CREED-reporting retailer channels in state *i* and year *j.*

avg.electric.price = Average cost of electricity in state *i* and year *j.*

cost.of.living = Average cost of living index in state *i.*

dem.var$_{i,j,k}$ = One of *p* demographic variables for state *i*, at time *j*, with *k* ∈ *(1, …, p)*. The following state-level demographic variables were considered: number of households, % of homes built before 1980, % of renters who pay their own utilities, median income, % owner-occupied households, education level, and population. The Team determined which demographic variables to include in each model by selecting the covariate pattern yielding the highest adjusted R^2.

prog$_{i,j}$ = Program activity variable for state *i* in year *j*, defined as the lighting program budget in state *i* in year *j*, as gathered through published reports, internet searches, internal evaluations, or provided directly by Utilities. It should be noted that the program budget variable includes program activity even if it was in retail channels not represented by the POS data. The square root of program-related budgets was used in the models in order to adjust for the skewedness in the distribution of that variable.

τ_j = Average proportion of efficient bulb sales across states that had no program activity for the entire study period, 2009 to 2013. Including this term allows the model to account for naturally occurring, non-program influenced, "baseline" trends in efficient bulb sales during the study period, which in turn helps to isolate the effect of program activity on efficient bulb sales as opposed to other outside factors.

α = Overall model intercept term.

$\beta_{0,i}$ = Subject-specific deviation from overall-level intercept, α, as estimated by random-effects specification.

β_1, β_2, γ_k, ϑ = Regression coefficients to be estimated by the model.

$\epsilon_{i,j}$ = Error term.

Strengths of the POS modeling approach include the following:

- Actual sales data
- Not dependent on respondent recall
- Six years of data to assess trends
- Statistically modeled comparison area takes multiple factors into account

Alternatively, the POS modeling approach has the following weaknesses:

- Only some channels are included in the data
- Only includes ~22% of MA program sales
- Stores covered in MA may not be the same as those covered in other states

The POS modeling approach yielded the NTG estimates shown in Table 6.

Table 6: MA NTG Values from POS Modeling

Bulb Type	NTG
All Efficient Bulbs	45.4%
CFLs Only	43.9%
LEDs Only	97.9%

Supplier Interviews

The Team derived NTG ratios from the more qualitatively oriented supplier interview method by utilizing responses to in-depth interview questions with various market actors participating in the 2013 MA program. Interviewees included the following:

- 14 lighting manufacturers (which accounted for 86% of 2013 program bulb sales);
- Four buyers of lighting products for large national or regional retailers participating in the program; and
- 224 managers of stores selling lighting products through the program.

The NTG estimates from lighting manufacturers together accounted for 71% of program sales. Store managers had a higher number of NTG estimators (*i.e.*, respondents providing an estimate) than the other market actors, but the cumulative amount of program sales represented by these estimators ranged from 11% to 19%, depending on bulb types. The four retail buyers from which we could collect NTG estimates accounted for 3% to 34% of program sales, again depending on bulb types.

To estimate NTG, suppliers answered a series of questions about what their sales of each bulb type would have been in the absence of the program, as detailed in the report for this task.[8]

If a given market actor sold multiple types of bulbs (i.e., standard CFLs, specialty CFLs, or LEDs) through the program, they received NTG questions separately for each bulb type. Because lighting manufacturers sold bulbs through multiple retail channels, we asked these NTG questions separately for the retail channels they participated in. However, not all manufacturers provided an estimate for each bulb type/channel combination.

One of the greatest strengths of the supplier interview approach is the very large portion of the market accounted for by the respondents, many of whom have been following the lighting market for years. It's also the only method that directly takes non-residential bulb sales into account. Alternatively, a weakness of this method is the fact that suppliers have an inherent self-interest in the continuation of lighting programs and, as such, may be biased.

The NTG values coming out of the supplier self-reported methodology are shown in Table 7.

Table 7. NTG Ratios by Bulb Type From Supplier Interviews

Bulb Type	Total Bulbs Sold	NTG Ratio
Standard CFLs		
Non-HTR	1,851,587	58%
HTR	918,409	95%
Total	**2,769,996**	**70%**
Specialty CFLs		
Non-HTR	1,303,795	58%
HTR	361,320	99%
Total	**1,665,115**	**67%**
LEDs		
All LEDs	508,085	75%

[8] Cadmus, NMR, Tetra Tech, Navigant, and DNV GL. *Supplier and Retailer Perspectives on the Massachusetts Residential Lighting Market Final Report.* Final delivered to the PAs and EEAC Consultants March 2015.

Onsite Comparison Area Research Approaches

The comparison area approach to estimating NTG represents a quasi-experimental study design in which MA is compared to one or more "control areas" that are meant to stand in for the MA lighting market in the absence of the program. We used two variations on the comparison area approach, one that relied on self-reported purchases in MA and three comparison areas (GA, KS, and NY) and one that relied on saturation estimates (in MA and NY only). Because they represent unique research efforts in two different years, we present results based on GA and KS comparisons first and then in turn, those for NY.

Georgia – Kansas Self-Reported Purchases Approach

The self-report, market-level sales approach to estimating NTG ratios requires three inputs:

- Market-level[9] CFL and LED purchases in MA;
- Market-level CFL and LED purchases in the comparison area(s);
- Program-supported CFL and LED sales in MA.

These inputs were used in the following market-level NTG calculation:

$$NTG = \frac{(Massachusetts\ Market\ Sales - Comparison\ Area\ Market\ Sales)}{Massachusetts\ Residential\ Program\ Sales}$$

The Team obtained the first two inputs—market-level purchases in MA and comparison areas—through on-site visits to 261 households in MA (150 "new" visits and 111 "panel visits), 78 households in GA, and 67 households in Eastern KS.[10] During each on-site visit, the technician would ask the homeowner when they had purchased each CFL or LED installed or in storage: within the past twelve months, or prior to the past twelve months. If a CFL or LED had been purchased within the past year, they also asked the homeowner to identify the store or store type from which they had purchased the bulb.

As with prior methods there are both strengths and weaknesses to using self-reported purchases in comparison areas and MA for calculating NTG ratios. As described in more detail in the task memo[11], strengths include the following:

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9 By market level, the team means total CFL and LED sales in an area for the time period under consideration. This includes products obtained with and without program support through both program partner and non-program partner stores.

10 For more details on the on-site visits in all three states, see Cadmus, NMR, Tetra Tech, Navigant. *Results of the Massachusetts On-site Lighting Inventory 2014*. Final delivered to the PAs and EEAC Consultants March 2015.

11 Cadmus, NMR, Tetra Tech, Navigant, and DNV GL. *Net-to-Gross Estimates Based on Comparison Area Approach*. Final delivered to the PAs and EEAC Consultants March 2015.

- Prior saturation estimates allowed Team to assess trends
- Range of program support in GA and KS provide good comparison areas.

The limitations of the self-reported purchases through the comparison area research method include:

- Being dependent on respondent recall
- Small sample sizes in GA and KS
- GA/KS and MA are different demographically
- Possible non-response bias
- MA Started with higher saturation than GA which could affect future sales
- KS had fewer specialty fixtures than MA
- KS has many more Walmarts per household than MA; Walmart has aggressively promoted CFLs since 2007.

The Team decided to use both comparison areas together in order to balance some of the limitations mentioned above of each state serving as an independent baseline for MA. Averaging the two states' sales and subtracting the Georgia Power program-induced sales, the resulting equation was:

$$NTG = \frac{\left(MA\ Market\ Purchases - \frac{(GA\ market\ purchases - GA\ program\ bulbs) + KS\ market\ purchases}{2}\right)}{Massachusetts\ Residential\ Program\ Sales}$$

Substituting the actual values from the research into this equation led to the following NTG ratio:

$$NTG = \frac{\left(13{,}771{,}035 - \frac{(8{,}096{,}036 - 2{,}000{,}000) + 11{,}317{,}681}{2}\right)}{6{,}842{,}703} = 0.65$$

Using this approach, the overall NTG estimate for all lighting program products, taking both comparison areas into account is 65%. The Team believes this combined comparison area estimate is the most reliable of the estimates developed from the approach, given the small sample sizes of individual comparison-area households and obvious anomalies in the data, such as the ratio of households to Walmarts in KS and low response rates in each comparison area. Table 8 shows the estimates by area and combined.

Table 8. Comparison Area Net-to-Gross Values: MA, GA, and KS

Product	NTG Based on Average of Georgia and Kansas	NTG Based on Only Georgia	NTG Based on Only Kansas
All Products	**65%**	**95%**	**36%**
All CFL Bulbs	**53%**	**87%**	**19%**
CFL Standard	0%*	41%	0%*
CFL Specialty	280%**	266%	294%
CFL Fixtures	**133%**	**142%**	**123%**
All LED Products	**123%**	**130%**	**116%**

* These values are actually negative but the Team interprets the result as indicating consumers in KS, which started with lower efficient bulb saturation than MA, are "catching up" to the sales gains MA consumers made in prior years.

** There are far fewer specialty sockets in KS (27%) than in MA (40%) although GA (39%) has comparable proportions of specialty sockets as MA.

New York Self-Reported Purchase Approach[12]

The New York State Energy Research and Development Authority (NYSERDA) ended its support for standard CFLs in 2012 and drastically reduced its support for specialty CFLs and LEDs beginning in June of 2014, tapering off to no support as of December 31, 2014. Therefore, the Team decided to utilize respondent estimates from the past six months preceding the onsite visit, as opposed to the past year, and provide results as an overall CFL and LED combined NTG estimate. During each on-site visit, the technician asked the homeowner when they had purchased each CFL or LED installed or in storage: July 2014 – present, January 2014 – June 2014, or before January 2014. If a CFL or LED had been purchased within the past year, they also asked the homeowner to identify the store or store type from which they had purchased the bulb.

The strengths and weaknesses of using these self-reported purchases for the comparison area NTG calculation utilizing NY are similar to those using GA and KS, and are listed below.

- Strengths:
  - Have prior saturation estimates (2013) to assess trends
  - NY discontinued support for standard CFLs in 2012, providing a good indication of what would have occurred had MA done the same (and thereby the impacts of the MA program)

[12] Note that the team did not deliver an individual report describing the development of estimates based on NY, but instead offered the estimates as part of the background materials to the consensus approach to developing retrospective and prospective NTG estimates. Therefore, we spend more time discussing the details of the NY-based estimates than we do the other approaches.

  - Saturation levels in MA and NY in 2013 were similar
  - NY is demographically similar to MA
- Weaknesses:
  - Only covers the last six months of 2014
  - Depends on respondent recall about when they purchased bulbs
  - Small sample size in NY
  - Possible non-response bias is greater in NY because of lower response rate
  - While comparable to MA in many demographics, NY is not the same as MA.

Table 9 presents the estimated market-level purchases and program sales by product and state (MA and NY) for the six months prior to the study.

Table 9. Net-to-Gross Inputs: MA and NY

Bulb Type	Purchased/Obtained within the Past Six months		MA Direct Install in Past 6 months	NY Direct Install in Past 6 months
	MA (All Visits)	NY		
Total # of CFL bulbs	5,123,290	4,215,166	1,471,541	46,043
# of Twist/Spiral + A-line CFLs	4,435,128	2,993,505	1,155,319	46,043
# of Specialty CFLs	688,161	1,221,661	316,222	0
Total # of LED bulbs	2,841,156	882,069	990,057	0

Similar to the equation used for the GA-KS based estimate, the market-level NTG calculation using NY data utilizes the following equation:

$$NTG = \frac{(MA\ Market\ Sales - NY\ Area\ Market\ Sales)}{MA\ Residential\ Program\ Sales}$$

Table 10 presents NTG ratios for each product based self-reported purchases by NY respondents, although those for the combined CFLs and LEDs are the focus of this research. This method leads to NTG estimates for 2013-2014 of 31% for all CFL bulbs, 55% for standard CFLs, and 218% for all LED bulbs.

Table 10. Estimated NTG Ratios Based on NY

Product	Based on NY
All CFLs	31%
Standard CFLs	55%
All LEDs	218%

New York Saturation-Based Approach

The unique timing and coordination of on-site lighting data collection in 2013 and 2015 and the demographic similarities between MA and NY enabled the team to use a second comparison area approach in NY for estimating NTG. The timing of the visits also coincided nicely with NYSERDA's ramping down of support for energy-efficient bulbs that began in 2012 and continued through 2014—MA continued strong support for CFLs and increased support for LEDs during the same time period, making NY a strong comparator to MA.

Table 11 shows saturation levels in MA and NY in the beginning of 2013 and the beginning of 2015, as well as the change in saturation, for both CFLs and LEDs. Saturation of both CFLs and LEDs began at a slightly higher level in MA than in NY in 2013, and by 2015 MA saturation was substantially higher for both bulb types. NY actually saw a decline in CFL saturation from 2013 to 2015.

Table 11. MA and NY Saturation Levels

Bulb Type	All CFLs		LEDs	
State	**MA**	**NY**	**MA**	**NY**
2013	28%	26%	2%	1%
2015	32%	22%	6%	3%
Difference in Percentage	4%	-4%	4%	2%

Number of Visits: MA 2013 - 150; MA 2015 – 354; NY 2013 – 127; NY 2015 - 101

This resultant NTG estimate is based on the following formula:

$$NTG = \frac{MA\ market\ purchases\ 2013\ and\ 2014 - MA\ market\ purchases\ 2013\ and\ 2014\ assuming\ a\ similar\ change\ in\ Saturation\ and\ Storage\ as\ in\ NY\ from\ 2013\ to\ 2015}{MA\ Program\ Sales\ 2013\ \&\ 2014}$$

The MA-NY saturation based method led to NTG estimates for 2013-2014 of 66% for CFLs, 96% for LEDs, and 72% for CFLs and LEDs combined. As also shown in Table 3, the saturation-based approach has a number of advantages over the self-report approach, most notably that it is not dependent on respondent recall. NY also makes for a nearly ideal comparison area to MA, as the state discontinued support for standard CFLs in 2012, thereby providing an assumption on sales trends without a program in a demographically similar area. The limitations of this approach, however, include the small sample size in NY, and the possible non-response bias in NY brought about by the lower response rate.

Additional Data Sources

In addition to the sources from the research methods described above, the development of prospective NTG estimates were informed by emerging market indicators gleaned from ongoing research. We describe those additional data sources here, and also provide access to the full document that reviewers received to aid in the provision of their own estimates in Appendix A: Materials for NTG Meetings.

- **LED Price Trends from Web Scraping:** As part of the LED Incremental Cost study, the team developed a model to estimate the incremental costs for LEDs relative to incandescent bulbs, halogen bulbs and CFLs from 2015 through 2020 based on historical prices since 2008 (shown in Table 20 in Appendix A: Materials for NTG Meetings). The web-based price extrapolation incorporates price data from a large number of distribution channels including popular home improvement, hardware and mass merchandise stores, which account for nearly 70% of all residential lighting sales. This resource enables the development of historical, current, and forward-looking LED price estimates for a variety of product categories. The data for this model come from the primary retail channels for residential lighting and includes extensive product categories and specifications. The LED price trends helped provide greater context for developing the prospective NTG estimates for LEDs.

- **Suppliers' Price Predictions:** Another component of the LED Incremental Cost Study involved in-depth interviews with lighting manufacturers and high-level retail buyers. These market actors were asked to estimate 2015 retail prices and predict future pricing and market share of LEDs, CFLs, and halogens for 2016, 2018 and 2020. Their preliminary forecasts were used to guide the development of the consensus NTG estimates.

- **2014 POS Data Trends:** The Team also provided the group with estimates of bulb market share for CFLs, LEDs, halogens, and incandescents, across program and non-program states for six years from the POS dataset (the same data utilized for the POS Modeling NTG estimation technique). The states included MA, NY, KS, GA, and CA, and the years covered were 2009-2014 (Table 19). Although the POS data does not capture full market-level sales, the numbers were meant to provide the group with a context of how these bulbs make up differing sales percentages across years and geographic regions, to further assist in their estimation of program impacts.

The Consensus Approach to Developing NTG Estimates

In this section, we summarize the process for developing both the retrospective and prospective NTG estimates for the MA Residential Lighting program. The objective of the consensus-building process was to seek agreement on retrospective NTG estimates for 2014, and prospective NTG estimates to be applied to the 2016-2018 program years based on recent years NTG research and supporting information about past and future sales and price trends. The Team derived these estimates with input from the PAs, the EEAC consultants, and evaluation team members. The process for developing the retrospective and prospective NTG estimates, as well as the estimates themselves, are presented below.

Retrospective Estimates for 2014

The Team provided the PAs, EEAC consultants, and evaluation consultants who were participating in the consensus process with a number of resources to help inform their estimates. These resources included the NTG and net-of-freeridership values estimated through the various research methods for each relevant bulb or fixture type, descriptions of the research approaches along with relative strengths and weaknesses, saturation and POS trends for MA and comparison areas, suppliers' price predictions in the future lighting market, and anticipated LED price trends from web-scraping. The materials that the group members reviewed before giving their estimates are provided in Appendix A: Materials for NTG Meetings. Group members reviewed the material the Team provided, identified any additional strengths or weaknesses not already listed, and rated the importance of the results from each method for informing their personal estimate of retrospective NTG using a scale of one to five where one equals not at all important and five equals extremely important. Group members then provided their recommendations for retrospective NTG estimates by product for 2014 and explanations for each of their recommendations. The purpose of developing retrospective estimates was to obtain the necessary recent context on the lighting market to help inform the prospective estimates for 2016-2018. Six evaluation professionals provided responses for the retrospective NTG estimates: two PAs responding on behalf of their companies, two EEAC consultants, and two evaluation firms. NMR collected and compiled responses and facilitated follow-up webinars to review and discuss the results.

Review of Research Methods

After reviewing all the materials provided, including the initial list of strengths and weaknesses provided by the Team, and also considering their own opinions about the relative merits of the approaches, group members generally agreed that the NTG estimates based on differences in CFL and LED saturation in MA and NY (listed below as MA vs. NY Saturation-based 2013 to 2015) served as the strongest approach, as reflected by the highest average ratings (4.2) out of five (where one equals not at all important and five equals extremely important). Other methods that received relatively high ratings included Supplier Interviews (3.3 average) and POS Data Modeling (3.0 average). In general, individuals did not provide high ratings for methods that relied heavily on self-reported data, yet the group felt that it was useful to have a mix of methods to inform their estimates. Table 12 below shows the participants' average ratings for each method as well as the range of values.

Table 12. Research Methods and Levels of Importance

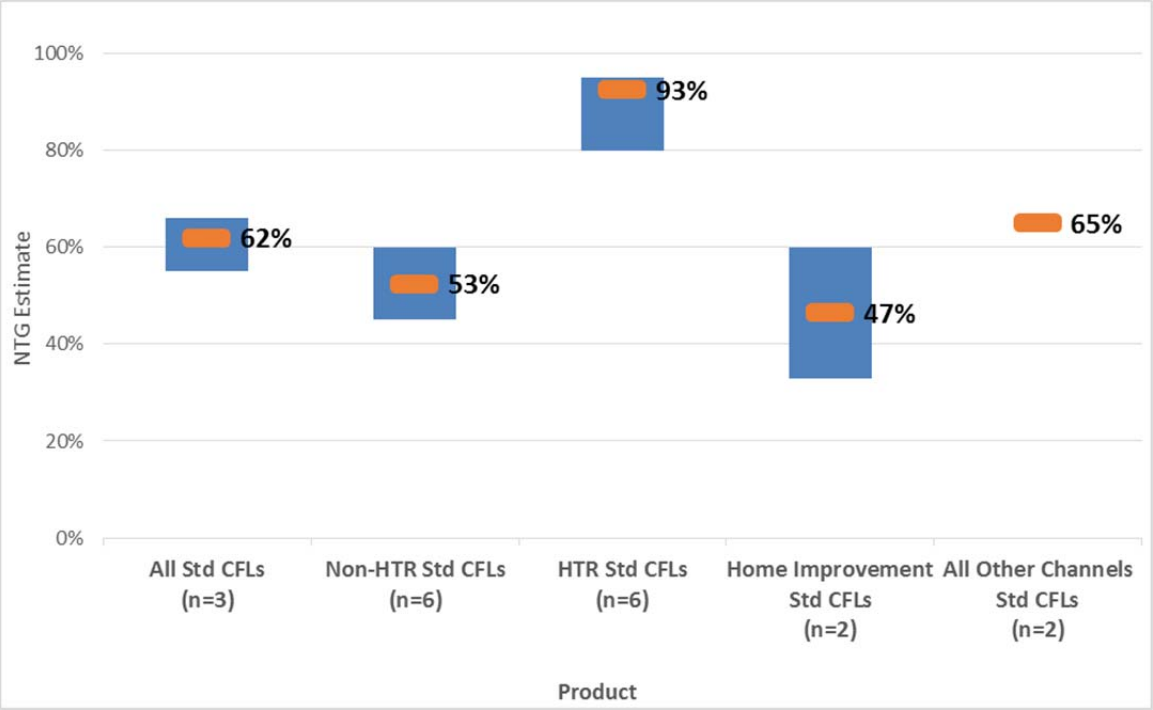
Method	n	Average Rating of Importance	Low	High
MA vs. NY Saturation-based (2013 to 2015)	5	4.2	3	5
Supplier Interviews (2013)	5	3.8	3	4
Supplier Interviews- Alternative Channel Grouping and Weights (2013)	3	3.3	3	4
POS Data Modeling (2009 to 2013)	5	3.0	2	4
MA vs. KS-GA (combined) Self-reported Purchases (2013)	5	2.4	1	4
Demand Elasticity Modeling (2013) [Net of freeriders]	5	2.4	1	4
MA vs. GA Self-reported (2013)	5	2.0	1	4
MA vs. NY Self-reported Purchases (Last six months of 2014)	5	2.0	1	3
MA vs. KS Self-reported Purchases (2013)	5	1.6	1	4

Standard CFL NTG Estimates[13]

Group members provided NTG estimates for five categories of standard CFLs: All standard CFL bulbs, Hard-to-Reach (HTR), Non-HTR, home improvement, and all other channels. In general, there was little variation in the estimates that individuals provided, and for the most part their rationales were very similar. Not all of the group members provided estimates for every category, hence the different sample sizes displayed below; however, everyone in the group provided NTG estimates for Non-HTR standard CFLs and HTR standard CFLs. Considering just these categories, the average NTG estimate (which also became the consensus NTG estimate for all categories of CFLs) for Non-HTR standard CFLs was 53%, with a range from 45% to 60%. The average NTG estimate for HTR standard CFLs was higher at 93%, with a low of 80% and high of 95%. Group members indicated that the scope of these average estimates corresponded with the different estimates from existing research, particularly the NY saturation-based estimates and the supplier interview estimates. They also felt that the proportions of the recommended estimates were consistent with sales estimates indicating the relative amount of HTR and non-HTR is roughly 80% to 20%. Figure 6 shows the group's average (in orange) and range of NTG estimates (in blue) for each of the standard CFL categories.

[13] Although two individuals submitted estimates for specialty CFLs, since the PAs do not have plans to support specialty CFLs in the future the group spent very little time reviewing those estimates and they are not included in this summary.

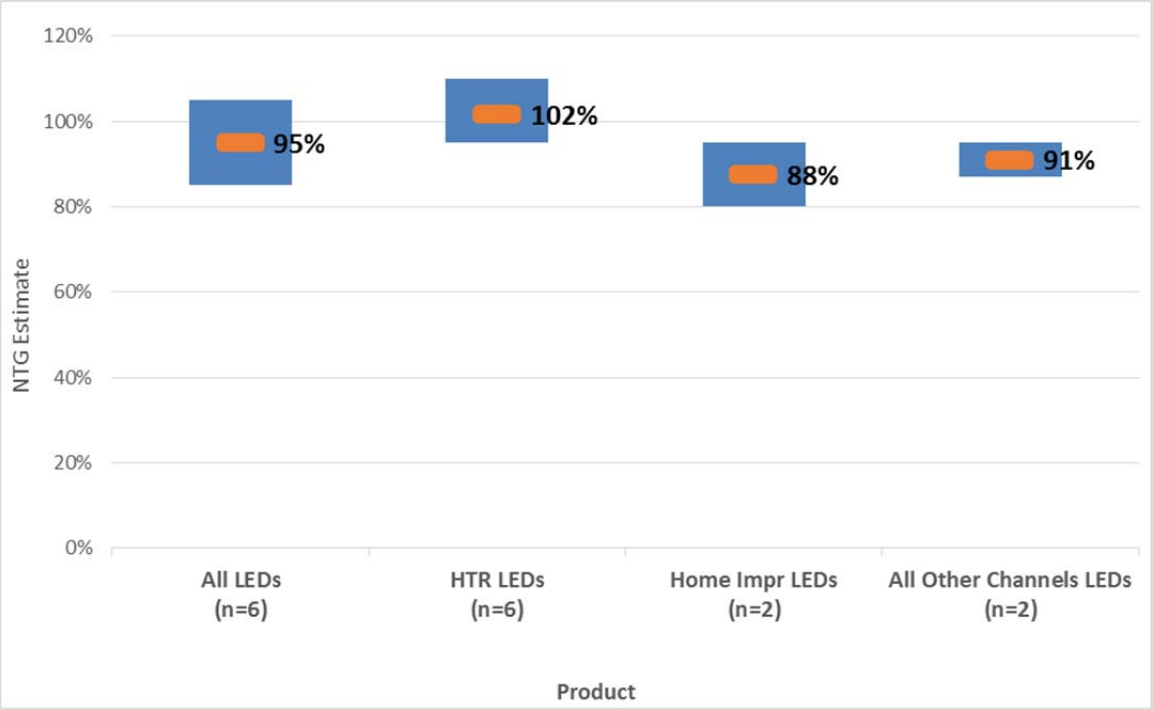
Figure 6. Retrospective (2014) Standard CFL NTG Estimates



LED NTG Estimates

The categories for providing NTG estimates for LEDs were similar to those for standard CFLs: All LED bulbs, HTR, home improvement, and all other channels. The exception was the non-HTR LED category which was not included on the template completed by the group because the residential lighting program currently draws no distinction between non-HTR and HTR LEDs. Additionally, the PAs explained that the program may start to promote LEDs in stores serving HTR customers, similar to their HTR CFL approach. The group took this into consideration during the review but ultimately decided that given the design of the 2014 program, including a retrospective non-HTR LED estimate was not appropriate. The group feels that the "all LEDs" estimate is the most suitable value to use for 2014. Figure 7 displays the average and range of retrospective LED NTG estimates that group members submitted. The dialogue regarding Non-HTR and HTR LEDs acknowledged the need for considerably higher incentives to make LED bulbs affordable for HTR populations. The average NTG estimate for all LEDs was 95%, and for HTR LEDs (which also became the consensus estimate) was 102% with a range from 95% to 100%.

Figure 7. Retrospective (2014) LED NTG Estimates



Prospective Estimates

After negotiating retrospective NTG estimates, which were the simple averages of group members' recommended retrospective values as agreed upon by the group, and discussing the different factors to consider for the prospective estimates, the group then went through a similar process for the 2016-2018 estimates. Eight evaluation professionals submitted estimates for prospective NTG values, including three PAs, two EEAC consultants, and three evaluation firms. The prospective NTG estimates focused on the following categories:

- Non-HTR standard CFLs
- HTR standard CFLs
- Non-HTR LEDs
- HTR LEDs
- All LEDs (if non-HTR and HTR bulbs are not differentiated)
- CFL fixtures
- LED fixtures

In addition to the retrospective estimates, the group also relied on additional sources of information such as past saturation trends, POS sales trends, and LED price extrapolations from both web-scraping and suppliers' price predictions, to help guide their decision-making. Note that throughout the sections

that follow the sample sizes differ across different bulb estimates based on how many people provided their own personal estimates for each bulb type.

Standard CFL NTG Estimates

Similar to the retrospective NTG estimates for standard CFLs, group members provided relatively lower NTG estimates for Non-HTR CFLs compared to HTR CFLs. The average prospective NTG estimates for Non-HTR standard CFLs, which also became the consensus estimates, were 54% (for 2016), 53% (for 2017) and 53% (for 2018). The average prospective NTG estimates for HTR CFLs for 2016-2018 were higher at 93%, 92%, and 91% (see Table 13). The fairly consistent NTG estimates for standard CFLs reflect the stable prices that are expected to continue for CFLs in the near future. Figure 8 below shows group members' average NTG estimates for 2016.

Figure 8. 2016 Standard CFL NTG Estimates

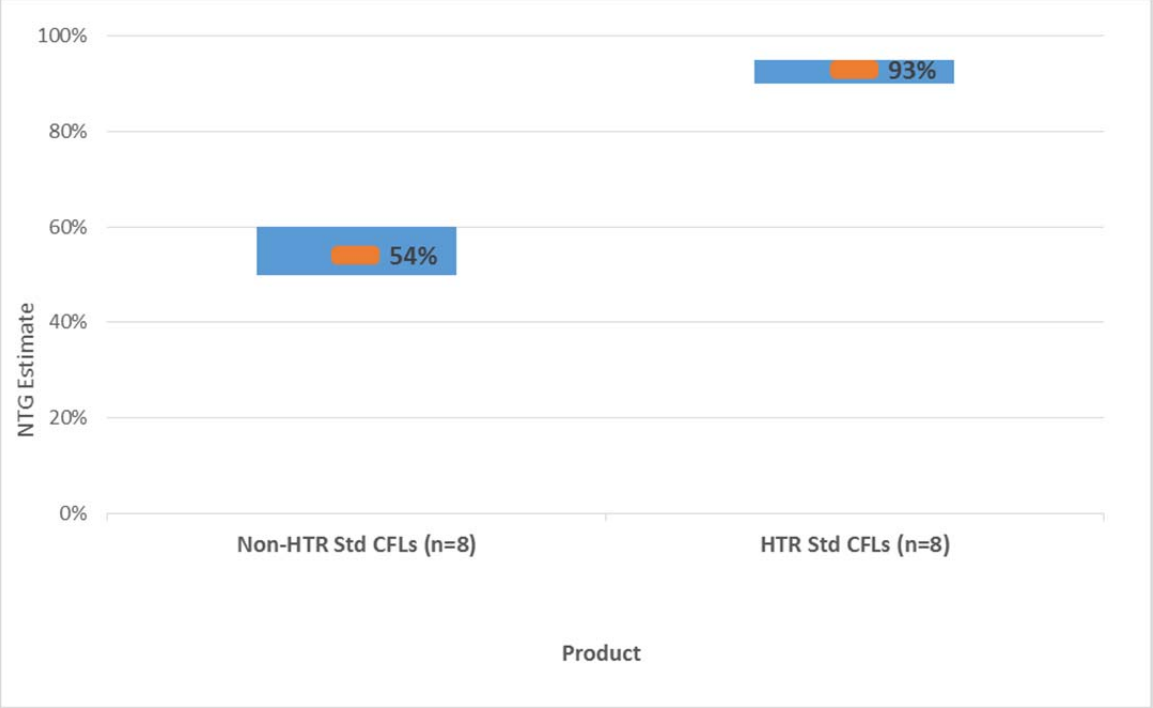


Table 13. Standard CFL NTG estimates, 2016-2018

Year	Product	N	Average	Low	High
2016	Non-HTR Std CFLs	8	54%	50%	60%
	HTR Std CFLs	8	93%	90%	95%
2017	Non-HTR Std CFLs	8	53%	50%	55%
	HTR Std CFLs	8	92%	85%	97%
2018	Non-HTR Std CFLs	8	53%	50%	55%
	HTR Std CFLs	8	91%	75%	95%

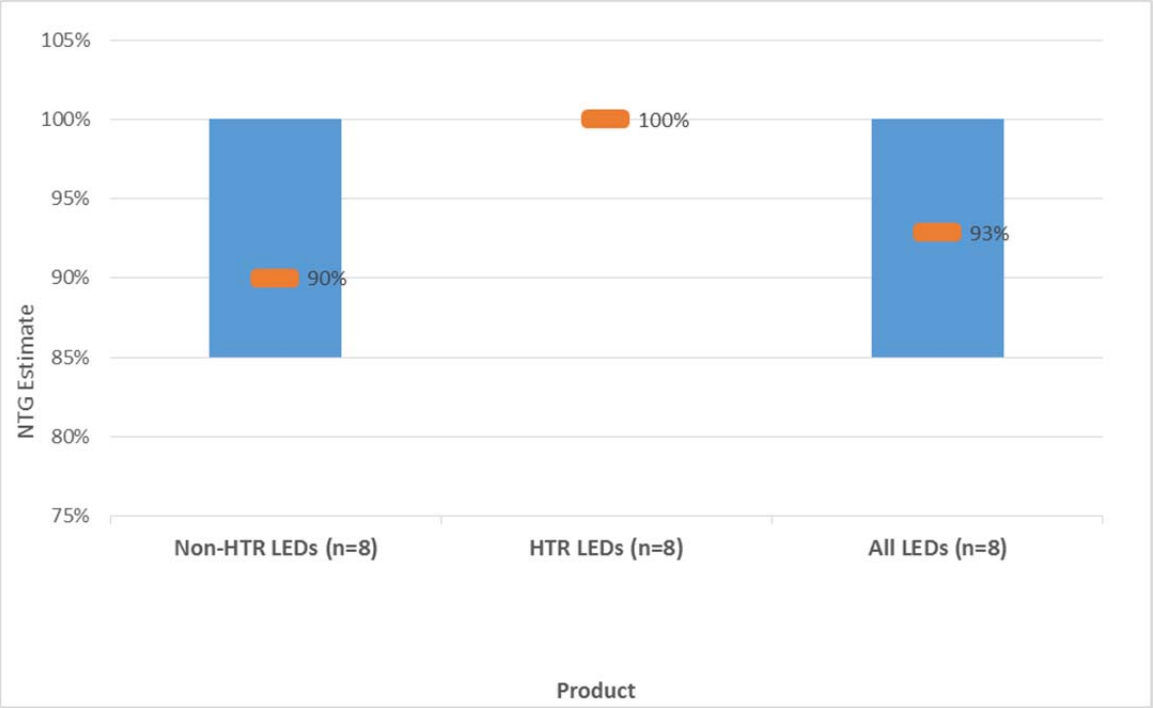
LED NTG Estimates

The individual LED NTG estimates were slightly more variable than standard CFLs due to a number of uncertainties in the rapidly changing LED market. The discussion focused primarily on expected LED price trends (especially how quickly they would decrease), consumer satisfaction with LEDs (telephone surveys in MA suggest it is higher than for CFLs, but this could be an artifact of early adoption), and LED quality (mostly assumed to be superior to CFLs but recent low-quality, non-ENERGY STAR bulbs have entered the market with shorter lifetimes and dimmability issues, confusing consumers).[14] Individual's perceptions of these issues influenced their opinions about the continuing influence of PA incentives and, therefore, prospective LED NTG from 2016 to 2018.

Figure 9 below displays the 2016 NTG estimates that group members provided for LEDs. Looking at 2016-2018, despite a somewhat large range, the group members' prospective non-HTR NTG estimates drop over time, as NTG is likely to be influenced by declining LED prices (Table 14). The consensus non-HTR LED NTG values of 90% for 2016, 80% in 2017, and 70% in 2018 were the only values across all prospective estimates that differed from the simple averages of group members' prospective values. The group was not able to reach consensus in the initial set of discussions on this topic. However, after conducting a follow-up call specifically to address the non-HTR LED prospective estimates and considering various sources of information on expected price and market share trends, product quality, and past experiences with CFLs, the group did agree that the 90%, 80% and 70% estimates were appropriate for this bulb category. In contrast to non-HTR LEDs, the group believed NTG for HTR LEDs was likely to remain high and only decrease by small amounts. Group members expected that price declines would not be adequate to make these bulbs readily available to HTR customers. The average NTG estimates for HTR LEDs were expected to be 100% in 2016, 99% in 2017, and 98% in 2018.

[14] Cadmus, NMR, Tetra Tech, Navigant, and DNV GL. *Massachusetts Spring 2014 Survey Results: FINAL Report*. Final delivered to the PAs and EEAC Consultants January 2015.

Figure 9. 2016 LED NTG estimates



Note: Group members provided NTG estimates for the All LEDs category in the event that future programs do not differentiate between non-HTR and HTR LED bulbs.

Table 14. LED NTG estimates, 2016-2018

Year	Product	n	Averages	Negotiated	Low	High
2016	Non-HTR LEDs	8	91%	90%	85%	100%
	HTR LEDs	8	100%	100%	100%	100%
	All LEDs	8	93%	93%	85%	100%
2017	Non-HTR LEDs	8	84%	80%	60%	95%
	HTR LEDs	8	99%	99%	91%	100%
	All LEDs	8	85%	85%	60%	96%
2018	Non-HTR LEDs	8	77%	70%	45%	90%
	HTR LEDs	8	98%	98%	85%	100%
	All LEDs	8	78%	78%	45%	92%

CFL and LED Fixtures NTG

Based on the group's responses, average NTG values for CFL fixtures will likely remain steady at 96% throughout 2016-2018 (Table 15); the range of estimates were from 90% to 100%. The average NTG estimates for LED fixtures starts at 98% in 2016 and gradually declines each year to 93% in 2017 and 89% in 2018. It is worth noting that the expected greater consumer satisfaction and acceptance of LED

fixtures underlies the lower NTG ratios for this product compared to CFL fixtures. Figure 10 below shows the consensus 2016 NTG estimates for CFL and LED fixtures.

Figure 10. 2016 CFL and LED Fixture NTG estimates

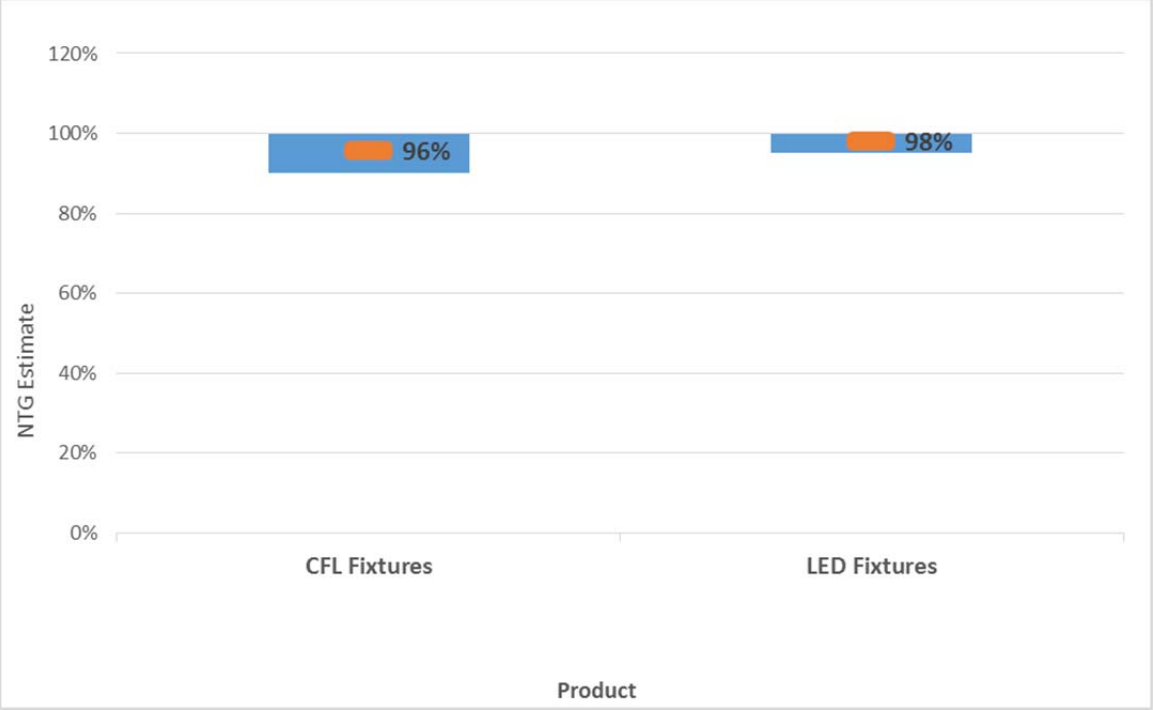


Table 15. CFL and LED Fixture NTG estimates, 2016-2018

Year	Product	N	Average	Low	High
2016	CFL Fixtures	6	96%	90%	100%
	LED Fixtures	5	98%	95%	100%
2017	CFL Fixtures	6	96%	90%	100%
	LED Fixtures	5	93%	90%	95%
2018	CFL Fixtures	6	96%	90%	100%
	LED Fixtures	5	89%	85%	95%

Table 16 below shows the full listing of NTG estimates by product for 2016-2018, as well as the previously discussed retrospective estimates for 2014.

Table 16. Consensus Retrospective and Prospective NTG Estimates

Product	Retrospective	Prospective		
	2014	2016	2017	2018
Non-HTR Standard CFLs	53%	54%	53%	53%
HTR Standard CFLs	93%	93%	92%	91%
Non-HTR LEDs	-*	90%	80%	70%
HTR LEDs	102%	100%	99%	98%
All LEDs*	95%	93%	85%	78%
CFL Fixtures	NA	96%	96%	96%
LED Fixtures	NA	98%	93%	89%

*The Team feels that the All LEDs category is the proper estimate to use for 2014 retrospective values because the program did not target LEDs to specific channels in 2014.

Conclusions and Recommendations

This report provides the team's recommended retrospective (for 2014) and prospective (for 2016 to 2018) NTG ratios for CFLs and LEDs (Table 16). The report also summarizes the methods used to calculate various NTG and net-of-freeridership estimates in individual tasks and describes the process of integrating those results into agreed-upon values.

The prospective NTG estimates are based on the best information available to the PAs, EEAC consultants, and evaluation team in the Spring of 2015. Any number of market changes or new information could call for significant revisions to the team's estimates. Three of the most likely factors that could lead to a need for revised estimates include the following:

1. Unexpected changes in the LED price trends;
2. Introduction of new efficient lighting technologies; and
3. Overturning or otherwise negating the EISA lighting efficiency standards to be implemented in 2020—only CFLs and LEDs currently meet the standard.

Evaluation Contractor Recommendation to Policy-Makers

The evaluation contractor team is an independent third party; while we seldom do so, this status provides us the freedom to make recommendations to policy makers, in addition to the more common recommendations regarding program operations, data, and future evaluations. The Team recognizes that recommendations to policy makers must come solely from the evaluation contractor team and must not be influenced by the PAs or the EEAC Consultants. With this perspective in mind, the Team offers the following recommendation to policy makers.

We agree with and applaud the effort to look for opportunities to define NTG values prospectively. There are many products and technologies for which the body of research, market experience, and

trends are substantial and stable enough to make reasonable forecasts of NTG given consistent program design and implementation. Lighting, in contrast, is not such a technology. The lighting market has been undergoing rapid transformation stemming from technology change and increased federal efficiency standards. As a result, any attempt to project NTG beyond a year – even in the face of consistent program design and implementation – goes beyond the typical expectations and responsibilities of an independent third-party evaluation.

As physicist Neils Bohr said, "Prediction is very difficult, especially about the future." In the end, it is impossible to know the future. Nevertheless, while the team feels confident about the validity of the retrospective NTG estimates for residential lighting and, to an extent, the one-year (2016) prospective estimates, we are less confident about the two-year (2017) and three-year (2018) prospective estimates, which are based on conjecture as much as on evidence.. Given the reliance of the residential portfolio on lighting savings and the uncertainty of prospective estimates in a rapidly changing market and policy environment, the PAs run the risk of either exceeding or falling short of the savings targeted in the 2016-2018 plan, especially toward the end of the period. The Team strongly believes that the PAs should closely monitor the market, and periodically revisit and potentially revise the 2016-2018 NTG estimates. If these NTG estimates change substantially, moreover, the Team recommends that the PAs be allowed to apply the new NTG estimates to develop revised savings targets for the 2016-2018 period.

Appendix A: Materials for NTG Meetings

Instrument for Estimating Prospective (2016-2018) Net-to-Gross Ratios for CFLs and LEDs

The aim of this instrument is to obtain your prospective estimates of Net-to-Gross ratios (NTG) for CFLs and LEDs for the years 2016, 2017, and 2018.

The following pages in this Word document labeled "2014 NTG Estimates," "Saturation Trends," "POS Trends," and "LED Price extrapolations" are for informational purposes only, but they may help you develop your 2016-2018 NTG estimates. "2014 NTG Estimates" shows the NTG estimates the group developed by consensus on our April 8 conference call. "Saturation Trends" shows saturations of different bulb types over the years for Massachusetts, New York, Kansas, Georgia, and California. "POS Trends" shows sales of different types of light bulbs in certain channels—EXCLUDING HOME IMPROVEMENT AND HARDWARE—for the years 2009 through 2014. "LED Price Extrapolations" shows extrapolated LED prices through 2018. As separate files, we have also attached the spreadsheet you worked with the other day, "2013 and 2014 NTG Estimates," and "Summary of 2013-2014 NTG estimates for webinar," which summarizes all of your ratings of NTG methods and your NTG estimates.

After you are finished, please **save this Word file** with your last name as part of the file name, and email **BY COB THURSDAY, APRIL 9** to anaim@nmrgroupinc.com. We will compile and distribute responses by COB Friday, April 10 so you can review them before the NTG Integration meeting that is scheduled for 12:00 Noon-1:00 PM on Monday, April 13. If you have any questions about how to fill out this instrument, please call or email Lynn Hoefgen at 617-284-6230 x6, lhoefgen@nmrgroupinc.com, or Lisa Wilson-Wright at 617-284-6230 x15, lwilson-wright@nmrgroupinc.com. We will discuss people's 2016-2018 NTG estimates and associated ratings and rationales during our call on April 13.

Please fill out the yellow cells on the last page of this document, under "**Your 2016-2018 NTG Estimates."** In this case, please estimate NTG levels for 2016, 2017, and 2018 comparing the with-program scenario to the no-program scenario for the entire 2016-2018 period, without taking spillover from pre-2016 programs into account. In other words, assume either that there will be a program or that there will be no program for the entire 2016-2018 period, but in either case that the program will have existed through 2015. Please keep in mind that EISA outlawed the manufacture and import of 100W incandescents in 2012, 75W incandescents in 2013, and 60W and 40W incandescents in 2014, and that the schedule in California was accelerated by one year. The next phase of EISA, if implemented, will outlaw the sale of inefficient bulbs in these lumen ranges—including most of today's halogen bulbs—in 2020. Also, current plans are to promote LEDs and standard CFLs, **NOT specialty CFLs**, in 2016-2018. Again, **BY COB THURSDAY, APRIL 9**, please **save this file** with your last name as part of the file name, and email to anaim@nmrgroupinc.com.

These estimates of NTG for 2014 were developed through negotiation during the April 8 conference call.

Table 17. 2014 NTG Estimates

Category	NTG Estimate
Non-HTR Standard CFLs	53%
HTR Standard CFLs	93%
All LEDs (if HTR and non-HTR not differentiated)	95%
Non-HTR LEDs	95%
HTR LEDs	100%

Table 18. Saturation Trends

Sockets Containing	Massachusetts						New York (Upstate)				Kansas			Georgia		California	
	2009	2010	2012	2013	2014	2015	2009	2010	2013	2015	2009	2010	2014	2009	2014	2009	2012
Sample Size	*100*	*150*	*151*	*150*	*261*	*354*	*203*	*200*	*127*	*101*			*67*		*78*	*1,232*	*1,987*
Incandescent	62%	57%	53%	55%	45%	43%	65%	57%	53%	51%			51%		65%	56%	49%
CFLs	26%	26%	27%	28%	33%	32%	19%	24%	26%	22%	21%	19%	29%	16%	19%	22%	30%
Fluorescent	6%	9%	8%	9%	9%	9%	10%	12%	11%	12%			6%		7%	12%	11%
Halogen	5%	7%	11%	5%	6%	6%	5%	6%	4%	8%			6%		6%	8%	9%
LEDs	<1%	<1%	1%	2%	3%	6%	1%	1%	1%	3%			3%		2%	<1%	1%
Other	<1%	1%	-	2%	4%	4%	<1%	<1%	5%	5%			5%		2%	1%	<1%
CFLs + LEDs	26%	26%	28%	30%	36%	38%	20%	25%	27%	25%			32%		21%	22%	31%
CFLs + LEDs + Fluorescents	32%	35%	36%	39%	45%	47%	30%	37%	38%	37%			38%		28%	34%	42%
Any specialty bulb	30%	31%	48%	38%	40%	42%	33%	48%	38%	37%			27%		39%		
Any specialty CFL	4%	7%	8%	8%	11%	10%	8%	5%	6%	5%			3%		4%		
Any specialty CFL (not including A-line CFLs)	-	-	7%	6%	9%	8%	-	-	5%	4%			3%		3%		
Incandescents + Halogens	67%	64%	64%	60%	51%	49%	70%	63%	57%	59%			57%		71%	64%	58%

Table 19. Point of Sale Trends

CFLs	Massachusetts	New York	Kansas	Georgia	California
2009	14%	14%	18%	15%	19%
2010	12%	15%	18%	16%	18%
2011	14%	16%	20%	18%	20%
2012	13%	14%	18%	16%	21%
2013	14%	12%	12%	12%	17%
2014	17%	13%	14%	15%	17%
LEDs	**Massachusetts**	**New York**	**Kansas**	**Georgia**	**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%	1%	1%	0%	1%
CFLs + LEDs	**Massachusetts**	**New York**	**Kansas**	**Georgia**	**California**
2009	14%	14%	18%	15%	19%
2010	12%	15%	18%	16%	18%
2011	14%	16%	20%	18%	20%
2012	13%	14%	18%	16%	21%
2013	14%	12%	13%	13%	18%
2014	19%	14%	14%	16%	18%
Incandescents	**Massachusetts**	**New York**	**Kansas**	**Georgia**	**California**
2009	71%	72%	68%	72%	64%
2010	73%	70%	70%	72%	66%
2011	73%	71%	69%	71%	63%
2012	72%	72%	69%	72%	58%
2013	64%	69%	67%	70%	45%
2014	44%	53%	54%	52%	34%
Halogens	**Massachusetts**	**New York**	**Kansas**	**Georgia**	**California**
2009	2%	1%	2%	2%	2%
2010	2%	1%	2%	2%	2%
2011	2%	2%	2%	2%	3%
2012	4%	3%	3%	3%	6%
2013	9%	7%	8%	8%	21%
2014	24%	20%	20%	21%	31%
Incandescents + Halogens	**Massachusetts**	**New York**	**Kansas**	**Georgia**	**California**
2009	73%	73%	70%	74%	66%
2010	75%	72%	71%	74%	67%
2011	75%	73%	71%	73%	66%
2012	75%	75%	72%	75%	64%
2013	72%	76%	76%	77%	66%
2014	68%	73%	74%	73%	65%

Table 20. LED Price Extrapolations

LED Lamp Type	2014	2015	2016	2017	2018	Annual Price Decline (%)
A-Type	$11.73	$9.01	$6.92	$5.32	$4.08	23%
PAR38	$29.38	$24.93	$21.16	$17.96	$15.24	15%
Downlight Retrofit	$29.53	$23.45	$18.63	$14.80	$11.75	21%

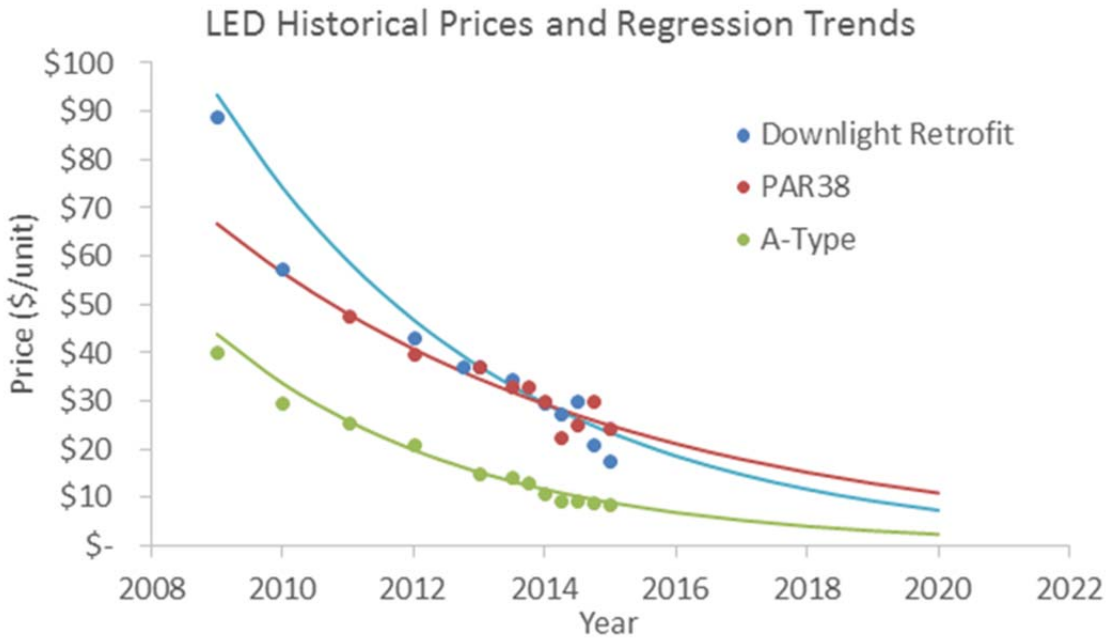


Table 21. Average Predicted Retail Prices from Manufacturers and Retailers

Bulb Type	Estimated 2015 Average MA Retail Price	Avg Predicted 2016 Retail Price	Avg Predicted 2018 Retail Price	Avg Predicted 2020 Retail Price	n=
A-line medium screw base LEDs	$7.04	$6.16	$4.78	$3.98	20
Reflector LEDs	$13.85	$12.24	$10.27	$9.20	20
CFLs					
Standard spiral medium screw base CFLs	$1.66	$1.64	$1.66	$1.77	17
Covered A-line CFLs	$4.01	$3.58	$3.26	$2.93	11
CFL reflectors	$7.78	$7.42	$7.95	$7.53	16
Halogens					
A-line medium screw base halogens	$1.59	$1.72	$1.55	$1.52	8
Halogen reflectors	$6.56	$5.71	$6.48	$6.44	9

* Numbers are weighted by bulb counts except in the case of halogens which are unweighted due to no program tracking data for weighting

Your 2016-2018 NTG Estimates

Please estimate NTG levels for 2016, 2017, and 2018 comparing the with-program scenario to the no-program scenario for the entire 2016-2018 period, without taking spillover from pre-2016 programs into account.

	Non-HTR Standard CFLs		HTR Standard CFLs	
YEAR	WHAT IS YOUR RECOMMENDED NTG FOR NON-HTR STANDARD CFLS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR NON-HTR STANDARD CFLS?	WHAT IS YOUR RECOMMENDED NTG FOR HTR STANDARD CFLS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR HTR STANDARD CFLS?
2016				
2017				
2018				

YEAR	Non-HTR Specialty CFLs		HTR Specialty CFLs	
	WHAT IS YOUR RECOMMENDED NTG FOR NON-HTR SPECIALTY CFLS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR NON-HTR SPECIALTY CFLS?	WHAT IS YOUR RECOMMENDED NTG FOR HTR SPECIALTY CFLS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR HTR SPECIALTY CFLS?
2016				
2017				
2018				

YEAR	Non-HTR LEDs		HTR LEDs		All LEDs (if HTR and Non-HTR not Differentiated)	
	WHAT IS YOUR RECOMMENDED NTG FOR NON-HTR LEDS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR NON-HTR LEDS?	WHAT IS YOUR RECOMMENDED NTG FOR HTR LEDS? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR HTR 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						

YEAR	CFL Fixtures		LED Fixtures	
	WHAT IS YOUR RECOMMENDED NTG FOR CFL FIXTURES? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL FOR CFL FIXTURES?	WHAT IS YOUR RECOMMENDED NTG FOR LED FIXTURES? (Enter a value from 0% to 200%)	WHY DO YOU RECOMMEND THIS NTG LEVEL LED FIXTURES?
2016				
2017				
2018				