



# **R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall Report**

Final Report

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## Table of Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>I</b>
STUDY OBJECTIVES AND APPROACHES .....	I
FINDINGS .....	II
Net-to-Gross and Net-of-Freeridership Estimates .....	II
Market Assessment Methods and Takeaways .....	
CONCLUSIONS AND RECOMMENDATIONS .....	II
<b>SECTION 1       INTRODUCTION .....</b>	<b>1</b>
1.1   STUDY OBJECTIVES .....	1
1.2   RESEARCH APPROACHES .....	1
<b>SECTION 2       DETAILED APPROACH METHODOLOGIES .....</b>	<b>5</b>
2.1   DEMAND ELASTICITY .....	5
2.1.1   Demand Elasticity Input Data.....	5
2.1.2   Demand Elasticity Model Specification .....	5
2.2   POS DATA MODELING .....	6
2.2.1   POS Modeling Input Data .....	6
2.2.2   POS Model Specification .....	7
2.3   EXAMINATION OF SOCKET SATURATION TRENDS AND COMPARISON AREA RESEARCH .....	7
2.3.1   Prior Connecticut Saturation On-site Methodology.....	8
2.3.2   Comparison Area Data Collection.....	8
2.3.3   Weighting Scheme .....	8
2.4   SUPPLIER INTERVIEWS.....	8
2.4.1   Supplier Interview Weighting .....	9
<b>SECTION 3       NTG AND NET-OF-FREERIDERSHIP ESTIMATES .....</b>	<b>10</b>
3.1   SUMMARY OF NTG AND NET-OF-FREERIDERSHIP RESULTS.....	10
3.2   DEMAND ELASTICITY MODELING.....	10
3.2.1   Benchmarking Net-of-Freeridership.....	13
3.3   POINT-OF-SALE MODELING.....	14
3.4   SUPPLIER INTERVIEWS.....	16
3.5   LOOKING AHEAD TO 2016 – 2018 .....	18
<b>SECTION 4       MARKET ASSESSMENT KEY TAKEAWAYS .....</b>	<b>19</b>
4.1   IMPACT OF THE UPSTREAM LIGHTING PROGRAM .....	19
4.2   SATISFACTION WITH CONNECTICUT PROGRAM.....	21
4.3   FINDINGS RELATED TO THE LED MARKET .....	23
4.4   IMPACTS OF EISA LEGISLATION .....	24

**SECTION 5 STRENGTHS AND LIMITATIONS OF RESEARCH APPROACHES ..... 25**

5.1 STRENGTHS AND LIMITATIONS OF MODELING APPROACHES ..... 27

5.2 STRENGTHS AND LIMITATIONS OF SUPPLIER INTERVIEWS, EXTRAPOLATED SATURATION ESTIMATES, AND COMPARISON AREAS ..... 28

**SECTION 6 CONCLUSIONS AND RECOMMENDATIONS ..... 30**

6.1 RECOMMENDED NTG RATIOS FOR CFLS AND LEDS TO 2013 AND 2014 PROGRAM ACTIVITY ..... 30

6.2 CONTINUE REGULAR ESTIMATION OF NTG USING A MULTI-PRONGED APPROACH..... 30

6.3 CONTINUE THE PRACTICE OF INCREASING SUPPORT FOR LEDS WHILE GRADUALLY REDUCING SUPPORT FOR CFLS..... 31

6.4 CONSIDER SHIFTING SOME INCENTIVE SUPPORT FROM HOME IMPROVEMENT TO OTHER CHANNELS..... 31

6.5 CEASE SPECIALTY CFL INCENTIVES..... 31

6.6 INCREASE CUSTOMER EDUCATION TOWARD LEDS ..... 32

**APPENDIX A DEMAND ELASTICITY DETAILED INFORMATION..... 1**

A.1 INPUT DATA ..... 1

A.1.1 Price Variation..... 1

A.1.2 Mass Marketing..... 1

A.1.3 Promotional Displays ..... 1

A.1.4 Stocking Issues ..... 2

A.1.5 Seasonality Adjustment ..... 3

A.1.6 Model Specification ..... 4

A.1.7 Elasticities ..... 5

A.1.8 Model Outputs and Specifications ..... 8

**APPENDIX B POS MODELING DETAILED INFORMATION..... 1**

B.1 MODEL INPUTS ..... 1

**APPENDIX C EXAMINATION OF SOCKET SATURATION TRENDS DETAILED INFORMATION..... 1**

C.1 WEIGHTING SCHEME ..... 1

**APPENDIX D SUPPLIER INTERVIEW DETAILED INFORMATION ..... 1**

D.1 SUPPLIER INTERVIEW NTG APPROACH..... 1

D.1.1 Weighting the NTG Estimates..... 1

D.1.2 Net-to-Gross Estimates..... 2

**Figures**

**FIGURE 1: CONNECTICUT BULB SATURATION OVER TIME ..... 1**

**FIGURE 2: DEMAND ELASTICITY PREDICTED AND ACTUAL SALES ..... 6**

**FIGURE 3: STATEWIDE CFL AND HALOGEN MARKET SHARE OVER TIME FROM POS DATA..... 17**

**FIGURE 4: EFFICIENT BULB SATURATION OVER TIME ..... 19**

**FIGURE 5: CFL SATURATION OVER TIME BY STATE..... 20**

FIGURE 6: 2014 SATURATION BY BULB TYPE AND STATE ..... 21  
 FIGURE 7: MANUFACTURER AND RETAIL BUYER SATISFACTION WITH CONNECTICUT PROGRAM ..... 22

**Tables**

TABLE 1: EVALUATION OVERVIEW ..... I  
 TABLE 2: NET-OF-FREERIDERSHIP AND NTG ESTIMATES .....  
 TABLE 3: SUMMARY OF EVALUATION ACTIVITIES..... 2  
 TABLE 4: NTG AND NET-OF-FREERIDERSHIP ESTIMATES ACROSS METHODS ..... 10  
 TABLE 5: NET-OF-FREERIDERSHIP ESTIMATES BY UTILITY ..... 11  
 TABLE 6: NET-OF-FREERIDERSHIP RESULTS BY BULB TYPE ..... 11  
 TABLE 7: NET-OF-FREERIDERSHIP BY RETAIL CHANNEL ..... 12  
 TABLE 8: NET-OF-FREERIDERSHIP BY RETAIL CHANNEL AND PRODUCT ..... 13  
 TABLE 9: BENCHMARKING NTG AND INCENTIVE LEVELS ..... 14  
 TABLE 10: NTG RATIOS FROM POS MODELING..... 15  
 TABLE 11: SUPPLIER INTERVIEW NTG RATIOS BY BULB TYPE..... 16  
 TABLE 12: STRENGTHS AND LIMITATIONS OF APPROACHES..... 25  
 TABLE 13: ELASTICITY ESTIMATES BY RETAIL CHANNEL AND BULB TYPE..... 5  
 TABLE 14: MEAN PRICES AND MARKDOWN BY RETAIL CHANNEL AND BULB TYPE ..... 7  
 TABLE 15: MODEL INFORMATION ..... 8  
 TABLE 16: CLASS LEVEL INFORMATION ..... 8  
 TABLE 17: CRITERIA FOR ASSESSING GOODNESS OF FIT..... 9  
 TABLE 18: ANALYSIS OF MAXIMUM LIKELIHOOD PARAMETER ESTIMATES ..... 1  
 TABLE 19: ON-SITE VISITS WEIGHTING SCHEME..... 2  
 TABLE 20: SATURATION ESTIMATES AND CONFIDENCE INTERVALS OVER TIME ..... 1  
 TABLE 21: CHANNEL-SPECIFIC AND PROGRAM-WIDE NTG ESTIMATES FOR STANDARD CFLS ..... 3  
 TABLE 22: CHANNEL-SPECIFIC AND PROGRAM-WIDE NTG ESTIMATES FOR SPECIALTY CFLS ..... 4  
 TABLE 23: CHANNEL-SPECIFIC AND PROGRAM-WIDE NTG ESTIMATES FOR LEDs..... 5



## Executive Summary

This report summarizes the tasks completed to assess the Connecticut (Connecticut) residential lighting market for light emitting diodes (LEDs) and to estimate net-to-gross (NTG) ratios for CFLs and LEDs for the Upstream Lighting Program. We discuss the evaluation methods used, the key research findings and takeaways, and the resulting NTG ratios estimated from relevant approaches. We also present a discussion of the relative strengths and limitations of these approaches in order to assist the Energy Efficiency Board (EEB) and Companies in determining the final NTG ratio to apply to the program and assessing program revisions for the 2016 to 2018 program cycle.

## STUDY OBJECTIVES AND APPROACHES

The main objectives of the R86 LED Market Assessment and NTG Study were to understand consumer reactions to varying efficient bulb types and the Energy Independence and Security Act (EISA), to assess the residential LED market by describing current conditions and exploring future conditions, and to estimate NTG ratios for CFLs and LEDs. Table 1 provides a brief overview of the evaluation activities, which are fleshed out in the body of the report.

**Table 1: Evaluation Overview**

Activity	Summary of Approach
Demand Elasticity Modeling	Estimated the price elasticity of program lighting products with an assessment of sales without the program's incentive, thus providing a net-of-freeridership estimate.
POS Data Modeling (n=44 states)	Modeled the Connecticut program's impact on CFL and LED sales using sales data for 44 states over 5 years, along with lighting program and demographic data. Predicted bulb sales in the presence and absence of program activity to develop NTG ratios.
Examination of Connecticut socket saturation trends (n = 95 in 2009, 100 in 2012, and 90 in 2013)	Used 2012 and 2013 Connecticut saturation data to assess saturation trends, comparing those to Massachusetts and NYSERDA. 2014 Massachusetts data informed likely Connecticut saturation rates. Reporting of this task combined with comparison area research.
Supplier Interviews (n = 12 manufacturers, 3 high-level retail buyers)	Interviewed 12 lighting manufacturers and suppliers and 3 high-level retail buyers from May through June of 2014. Gained their insights into the LED market, predictions for the future market, satisfaction with the Connecticut program, and estimation program impact yielding NTG estimates.

Activity	Summary of Approach
Contribution to regional comparison area data collection (n= 78 in Georgia, 67 in Kansas)	Onsite visits in Georgia and Kansas demonstrated saturation and purchase rates in areas with less program activity. Helped to identify the impact of program activity on the energy-efficient bulb market.
Overall report	Summary report focuses on the key findings and recommendations across tasks.

**FINDINGS**

The findings of the present research are summarized below. We begin by providing the NTG (encompassing both freeriders and spillover) and net-of freeridership estimates (which exclude spillover) before discussing the results of the residential market assessment.

**Net-to-Gross and Net-of-Freeridership Estimates**

The Team utilized three methods for estimating NTG and net-of-freeridership for the Connecticut program. The first two methods were quantitatively-oriented, employing large sets of sales and pricing data to estimate program impacts via statistical modeling. The first of these approaches, demand elasticity modeling, used sales data and bulb promotion information to measure the relationship of price and promotion to sales and to predict sales without the program’s intervention. This allowed for an estimation of freeridership by comparing the modeled baseline sales to the modeled program sales.

An important note regarding demand elasticity is that the models allowed for an estimation of net-of-freeridership but did not take spillover into account, so the results may provide conservative NTG ratios. The Team obtained net-of-freeridership values using the following formula:

$$Net\ of\ FR\ Ratio = \left( \frac{Savings\ with\ Program - Savings\ without\ Program}{Savings\ with\ Program} \right)$$

The second of the two quantitatively-oriented methods for estimating program impact was the point-of-sale (POS) modeling exercise. This approach utilized a large set of sales data across 44 states and five years (2009-2013) to understand how lighting programs across the nation influenced statewide proportions of efficient bulb sales. The Team used a given state’s program lighting budget to quantify program activity. We also collected an extensive set of model inputs including statewide demographics and presence/absence of major lighting retailers to run the series of regression models that ultimately predicted efficient bulb sales. The POS modeling research provided NTG estimates for Connecticut for 2013, but for only a subset of retail channels. This reflects the fact that the sales data in the POS dataset did not represent market-level sales in Connecticut or elsewhere. Instead they captured selected retail channels – grocery, drug, discount, club, and mass merchandiser channels – but exclude home improvement and hardware stores through which Connecticut moves approximately 80% of its program bulbs. It is worth noting that other program states also move a large proportion of their bulbs through home improvement and hardware channels. As such, the associated NTG values should only be considered representative of those channels represented by the data, and not the Connecticut program as a whole. Further, the POS modeling approach also has inherent limitations for assessing the current impact of program activity

on LED sales, which are still relatively new to the lighting market, and almost non-existent at the outset of the POS dataset (2009).

The formula used to estimate NTG from the POS data is shown below:

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

The final method for estimating NTG for the Connecticut program in 2013 relied on responses to questions about program attribution and sales in the absence of the program obtained through in-depth interviews with lighting manufacturers and high-level retail buyers. Interviewees included 12 lighting manufacturers and suppliers accounting for roughly 93% of the sales by manufacturers in the Connecticut program tracking database and three high-level lighting buyers who accounted for over 73% of the program sales. The NTG estimates were calculated by asking interviewees whether or not they believed certain channels sold efficient lighting as a result of the Connecticut program, and whether the Connecticut program positively influenced efficient sales. The extent to which interviewees cited the program as being influential in moving efficient bulb types would lead to higher program impacts.

Table 2 on the next page presents the net-of-freeridership and NTG estimates calculated from these three methods. The Team addresses the recommended NTG ratios in the [Conclusions and Recommendations](#) below.

Table 2: Net-of-Freeridership and NTG Estimates

Measure	Connecticut Currently Assumed	Demand Elasticity	Supplier Interviews	POS Modeling	Simple Average	Range
LED Specialty	100%	71%	74%	87%	70%	49% to 87%
LED Standard		49%				
CFL Specialty	81%	47%	55%	29%	50%	29% to 68%
CFL Standard		51%	68%			
Notes	From the 2014 PSD, Appendix 3; net realization rates are 82% for LEDs and 51% for CFLs. <sup>1</sup>	Net of freeridership, partial or missing data required team to make assumptions for some products, stores	Subject to biases of responding manufacturers and retailers	Partial market estimate, home-improvement/hardware channels not included. Limited applicability for program LEDs.		

<sup>1</sup> The United Illuminating Company and Connecticut Lighting and Power Company. 2014. *Connecticut Program Savings Document: 10<sup>th</sup> Edition for 2015 Program Year*. See page 289.



## Market Assessment Methods and Takeaways

The market assessment portion of this study had three primary purposes:

- Examine trends in LED and CFL socket saturation in Connecticut and comparison areas between 2009 and 2013 and extrapolate 2014 socket saturation rates for Connecticut,
- Assess the state of the LED market, and
- Determine supplier satisfaction with the program

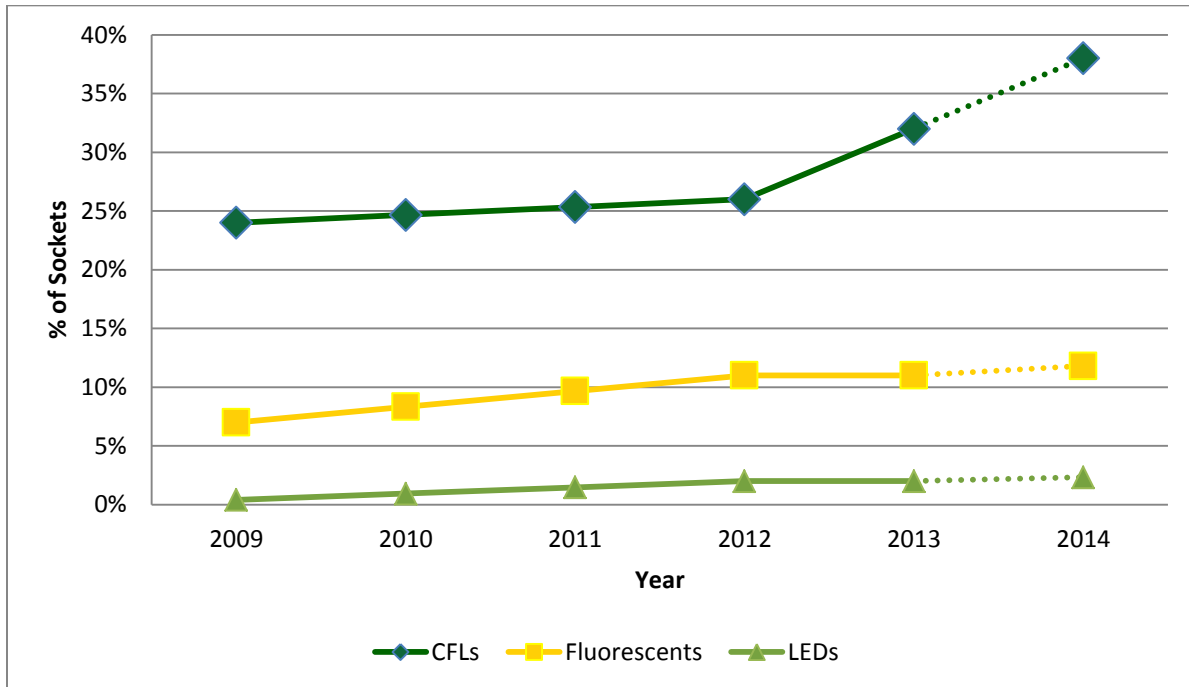
To accomplish this, the Team analyzed lighting saturation data collected in 2009, 2012, and 2013, interpolating and extrapolating data for the years 2010, 2011, and 2014 when no saturation visits occurred in Connecticut. Data from Connecticut was also compared to three other areas of the country, Massachusetts, Georgia, and Kansas, all areas for which the Team had access to prior saturation data, allowing for comparisons in trends over time. The areas also displayed varying levels of program activity, with Massachusetts having a long history of strong program support for CFLs and LEDs, Georgia only recently providing incentives for CFLs and LEDs, and Kansas not having ever provided incentives for efficient lighting. Finally, the suppliers provided assessments of their program satisfaction during the in-depth interviews described above in the NTG section.

## Socket Saturation Trends

The analysis of socket saturation trends in Connecticut and comparison areas demonstrated an interesting and, from the perspective of efficiency, optimistic set of findings. Figure 1 displays socket saturation of CFLs, LEDs, and fluorescent tubes in Connecticut over time (the dotted lines from 2013 to 2014 represent the extrapolated 2014 values). The full body of the report provides more detail on saturation trends in Connecticut and beyond. Findings of particular note include the following:

- CFL saturation displayed gains over time, increasing from 24% in 2009 to 26% in 2012, followed by a 6% increase from 2012 (26%) to 2013 (32%) (Figure 1). Due to wide confidence intervals, the saturation levels are not statistically different at the 90% level (see Table 20 in Appendix C).
- Connecticut CFL saturation increased by 8% between 2009 and 2013 compared to 6% in Kansas and 3% in Georgia during the same time period. The difference in saturation was not statistically significant between Connecticut and Kansas but was between Connecticut and Georgia.
- Nine out of ten Connecticut households used at least one CFL (a 90% penetration rate).
- LED saturation in Connecticut more than doubled from less than 1% in 2009 to over 2% in 2013.
- LED penetration increased from 1% of homes in 2009 to 23% of homes in 2013.

Figure 1: Connecticut Bulb Saturation Over Time



### LED Market and EISA Impacts

The current LED market and the impact of EISA were prioritized topics throughout each of the study methods. Although the Team did not interview Connecticut store managers directly, we do draw on insights leveraged from Massachusetts store managers when applicable. Below are some of the key takeaways from all lines of inquiry.

- Market actors expected LED prices to drop, due to both: 1) advances in LED technology; and 2) increased scales of LED production due to greater consumer demand spurred by both utility rebate programs lowering the LED price point and the EISA legislation's phase-out of incandescent bulbs opening up some new market share.. More suppliers thought LED prices would decrease than CFL or halogen prices.
- Respondents indicated strong LED sales in the past year; the majority of store managers classified sales as "excellent" or "good."
- Respondents cited high costs as the factor preventing greater LED lighting sales; the only barrier reported by all three market actor groups.
- Respondents expected LED bulb prices to decrease over the next year, but not LED fixtures.
- Respondents most frequently cited providing larger rebates and customer education for increasing LED bulb sales.
- Every lighting manufacturer and retail buyer reported that EISA contributed to increased sales of LED and halogen bulbs and, to a lesser extent, CFLs.

### Supplier Program Satisfaction

Manufacturers and retailers interviewed for this study voice high levels of satisfaction with both program and implementation staffs and the program overall (ratings of eight or higher on a zero to ten scale). When asked about potential program improvements, comments tended to say that the Connecticut program could be more flexible in its program design and requirements regarding deadlines, ability to modify agreements, and length of memoranda of understanding (MOUs) with the

current MOUs being too short in duration. They respondents preferred three-year contracts to one-year ones.

## CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the current evaluation, the Team offers the following recommendations for the Connecticut Upstream Lighting program, discussed in more detail in Section 6.

- **Recommended NTG estimates for 2013 and 2014; looking ahead to 2016 to 2018:**  
Based on the range of NTG estimates developed for this study and their relative strengths and weaknesses in light of program characteristics, the Team recommends applying a CFL NTG of 51% and LED NTG of 82% for 2013 and 2014. The CFL NTG falls between the estimates developed for this study. The LED NTG is higher than those developed for this study, but each method had shortcomings for addressing LEDs. The team ultimately recommended values because they match the current *net realization rates* from the 2014 PSD, but lower than what the Companies currently assume for NTG (using the equation  $100\% - \text{Free Ridership} + \text{Spillover}$ ), 81% for CFLs and 100% for LEDs. In addition, the rapid changes in the lighting market give these NTG estimates a short self-life. While estimating prospective NTG ratios for 2016 to 2018 is not in this project's scope, the Team believes the CFL NTG ratio will not change much over the next few years, while the LED NTG will remain high through 2016 and then begin to drop off gradually. Exact deemed values should be decided after determining the program design for 2016 to 2018. The main body of the report provides additional justifications for these recommendations.
- **Continue regular estimation of NTG using a multi-pronged NTG approach:** Although we have made recommendations about prospective NTG ratios, the uncertainty in these estimates suggests that the EEB should continue regular measurement of this important impact value. NTG ratios will likely change as consumers set their preferences for light bulbs in the post-incandescent period, and as LED prices fall and the bulbs become more widely adopted by consumers without price supports, suggesting the need to “check-in” with NTG every couple years. Additionally, all approaches to estimating lighting NTG have strengths and limitations, and using different methods allows for triangulation that reduces bias from any single method. The EEB may also consider setting NTG ratios separately for specialty and standard LEDs as well as exploring NTG ratios for CFL and LED adoption among households often considered to be “hard to reach” (e.g., low income, non-English speaking, etc.). To arrive at final values, the EEB may consider supporting a consensus building approach to determining recommended NTG values, similar to one recently used in Massachusetts (report is forthcoming as of June 19, 2015).
- **Continue practice of increasing support for LEDs while gradually reducing support for CFLs:** LEDs show high levels of customer satisfaction and were viewed by suppliers as a bulb type that will continue to be popular, especially when incentivized. NTG and net-of-freeridership values for LEDs are also likely to remain high in the post-incandescent period, suggesting they should remain an important program focus. While the Team supports the current plan to shift program focus toward LEDs, we also believe that CFLs represent a familiar technology, and maintaining some degree of program incentives for them will help offset the concerning trend observed in other states of consumers moving toward less efficient halogens in the absence of CFL incentives (i.e., “backsliding” in efficient bulb sales).
- **Consider shifting some incentive support from Home Improvement to other channels:** Research in Massachusetts and results from the current demand elasticity modeling (and research conducted in other states) reveal that NTG and net-of-freeridership values differ

between various retail channels.<sup>2</sup> In particular home improvement channels tend to receive lower estimates than those serving hard-to-reach customers. Providing increased support in non-home improvement channels, particularly bargain/discount stores, is likely to bring about greater program impacts.

- **Cease specialty CFL incentives:** The present research suggested declining NTG and net-of-freeridership values for specialty CFLs, even more so than standard CFLs. The EEB and Companies should continue their plan of ceasing support for specialty CFLs.
- **Increase customer education toward LEDs:** LEDs are widely considered the future of residential lighting, demonstrating high levels of customer satisfaction, long lifetimes, and strong opportunities for energy savings. In order to promote the bulb for those who have not yet installed LEDs, and to ward off competition from less efficient halogens, the Team suggests educational campaigns toward LEDs to highlight their advantages over other bulb options.

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<sup>2</sup> DNV-GL, NMR, Cadmus. 2015. *Massachusetts Upstream Lighting Program Net-to-Gross Ratio Estimates Using Supplier Self-Report Methodology* Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/Upstream-Lighting-Net-to-Gross-Estimates-Using-Supplier-Self-Report-Methodology.pdf>

# 1

## Section 1 Introduction

The Connecticut Energy Efficiency Board (EEB) commissioned a study to assess the current residential market for light emitting diodes (LEDs) and to estimate net-to-gross (NTG) ratios for standard compact fluorescent lamps (CFLs) and LEDs, including specialty CFLs and LEDs when possible. This report summarizes the tasks completed as part of the study. NMR Group, Inc. led the study together with subcontractors DNV GL and The Cadmus Group

(the Team).

### 1.1 STUDY OBJECTIVES

This study examines aspects of the Residential Lighting component of the Connecticut Energy Efficiency Fund's (CEEF) Retail Products Program. The program has offered incentives on energy-efficient lighting since 2003. While the program initially relied heavily on the use of instant coupons and mail-in rebates to incent CFLs, the Companies shifted their promotion strategy to Negotiated Cooperative Promotions (NCPs), which represents an "upstream" model in which they pay incentives directly to manufacturers and retailers to reduce the price of energy-efficient bulbs on store shelves. The program implementer also works with retailers to provide point-of-purchase (POP) materials that advertise the products and educate consumers about them. While the program initially focused almost exclusively on the promotion of standard, spiral CFLs, the Companies have also added specialty CFLs and LEDs to the mix. Most recently, they have been shifting support increasingly to the promotion of LEDs, which is a response to federal legislation regarding lighting efficiency standards (the Energy Independence and Security Act or EISA) and direction from the Department of Energy and Environmental Protection to reduce support for CFLs and increase support for LEDs.<sup>3</sup>

The R86 LED Market Assessment and NTG Study had three main objectives. These were to:

1. Understand consumer reactions to CFLs, LEDs, and the Energy Independence and Security Act (EISA)
2. Assess the residential LED market by describing current conditions and also exploring future market conditions to the extent that the evaluation activities and budgets allow, and
3. Estimate NTG ratios for CFLs and LEDs, ideally providing estimates for both standard and specialty bulbs as the data allow, also discussing the likely "shelf life" of the NTG ratio(s) for LEDs given current information about the future of the LED market and the Connecticut residential lighting program.

### 1.2 RESEARCH APPROACHES

In determining the research approaches that would best meet the objectives above within the specific budget, the Team worked with the EEB Evaluation Consultant to select evaluation methods that would pull "double duty" by providing both unique information on assessing the LED market and

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<sup>3</sup> Connecticut Department of Energy and Environmental Protection. 2013. *Draft Decision 2013-2015 Electric and Natural Gas Conservation and Load Management Plan*. Available at: [http://www.energizect.com/sites/default/files/2013-2015%20Conservation%20and%20Load%20Management%20Plan%20\(Draft%20Decision\)%208.23.13.pdf](http://www.energizect.com/sites/default/files/2013-2015%20Conservation%20and%20Load%20Management%20Plan%20(Draft%20Decision)%208.23.13.pdf)

yielding estimates of NTG ratios. In order to make efficient use of the evaluation budget, the evaluation leveraged resources with similar tasks being performed in Massachusetts.<sup>4</sup>

Table 3 summarizes the approaches the Team utilized to meet the aforementioned study objectives.

**Table 3: Summary of Evaluation Activities**

Activity	Summary of Approach	Leverage with Massachusetts
Demand Elasticity Modeling*	Using program tracking data, the Team developed a demand elasticity model to estimate the price elasticity of program lighting products. This allowed the Team to estimate sales without the program’s incentive, providing a net-of-freeridership estimate. This estimate lacks spillover so is not a NTG ratio.	No
POS Data Modeling (n=44 states)	The point-of-sale (POS) approach to estimating NTG modeled the Connecticut program’s impact on CFL and LED sales by using POS data for 44 states over 5 years, along with lighting program activity, 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 2013 NTG ratios.	Yes

<sup>4</sup> The Team received permission from the Massachusetts Program Administrators (PAs) and the Energy Efficiency Evaluation Consultants (EEAC) to leverage funds. For joint tasks, Massachusetts allotted at least twice (sometimes greater) the funds to the task as did the Connecticut Energy Efficiency Fund (CEEF) in recognition of the significantly larger programs in Massachusetts. The corresponding Massachusetts reports will be filed with Program Administrator’s annual report.

Activity	Summary of Approach	Leverage with Massachusetts
<p>Examination of Connecticut socket saturation trends (n = 95 in 2009, 100 in 2012, and 90 in 2013)</p>	<p>The Team used 2012 and 2013 saturation data from Connecticut in an assessment of saturation trends, comparing those trends to Massachusetts and NYSERDA. This allowed for an appraisal of the similarities and differences in saturation regionally. The Team used 2014 Massachusetts data to inform likely saturation rates in Connecticut for 2014. This approach lacks an estimate of 2013 market-level sales in Connecticut, so it does not provide a NTG estimate. The Team combines reporting of this task with that of the comparison area research discussed below.</p>	<p>Yes</p>
<p>Supplier Interviews (n = 12 manufacturers, 3 high-level retail buyers)</p>	<p>The Team interviewed 12 lighting manufacturers and suppliers and 3 high-level retail buyers from May through June of 2014 to gain their insights into the current state of the LED market (both prices and sales), their predictions for the future of that market, their satisfaction with the Connecticut program, and their estimation of the impact of the Connecticut program on CFL and LED sales. This approach yields NTG estimates.**</p>	<p>Yes</p>

Activity	Summary of Approach	Leverage with Massachusetts
Contribution to regional comparison area data collection (n= 78 in Georgia, 67 in Kansas)	Connecticut helped offset the cost paid by Massachusetts for of onsite visits in comparison areas (Georgia and Kansas), which informed what energy-efficient saturation and purchase rates are like in areas with less program activity. This helped to identify the impact of program activity on the energy-efficient bulb market. This approach lacks an estimate of 2013 market-level sales in Connecticut, so it does not provide a NTG estimate. The Team combines reporting of this task with that of the Connecticut saturation trend analysis discussed above.	Yes
Overall report	The present summary report focuses on the key findings and recommendations across tasks.	No

\* Massachusetts performed a separate demand elasticity task, but the two programs use different implementer contractors. This leads to variations in program design and the structure of data tracking that precluded partnering on this task.

\*\* Some of the Connecticut interviewees also partnered with the Massachusetts lighting program, and the Team gathered information on both states during the same interview. Other interviewees represented Connecticut only. While interviewees always provided separate estimates of NTG and program satisfaction, for budgetary reasons, the Team did not ask specific questions of interviewees about Connecticut market condition. Instead, we draw on Massachusetts findings to provide information on this topic.



## 2

## Section 2 Detailed Approach Methodologies

In this section we outline in greater detail the different methods utilized to understand the LED market in Connecticut and to estimate NTG ratios by bulb type.

### 2.1 DEMAND ELASTICITY

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

- Quantify the relationship of price and promotion to sales,
- Predict likely sales levels without the program's intervention (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.

The Team calculated savings net of freeridership<sup>5</sup> using the following formula:

$$\text{Net of FR Ratio} = \left( \frac{\text{Savings with Program} - \text{Savings without Program}}{\text{Savings with Program}} \right)$$

#### 2.1.1 Demand Elasticity Input Data

In order to use the demand elasticity approach, the Team first reviewed the program tracking data to make certain that they met the conditions needed for this type of modeling. Importantly, as desired for analysis, sales data did display necessary amounts of price variations, measured within unique part number/retailer location combinations. Therefore, the Team concluded that the available data for the demand elasticity approach were sufficient to support the analysis. Still, the data presented issues that did not preclude the Team from fitting the necessary models, but did require the Team to make reasonable assumptions to address them. These included inconsistent data on bulb prices and rebates, inconsistent use of store IDs, and bulb part/model numbers that appeared incomplete. Others data issues that the Team faced included lacking information on promotional displays, stocking issues, and the necessity of creating seasonality adjustments to separate data variations. These issues and the Team's response to them are discussed in greater detail in Appendix A.

#### 2.1.2 Demand Elasticity Model Specification

The Team modeled bulb, pricing, and promotional data using an econometric model, addressing these data as a panel, with a unique bulb model number/store location as the cross-section unit of analysis modeling package quantities over time as a function of prices, promotional events, and retail

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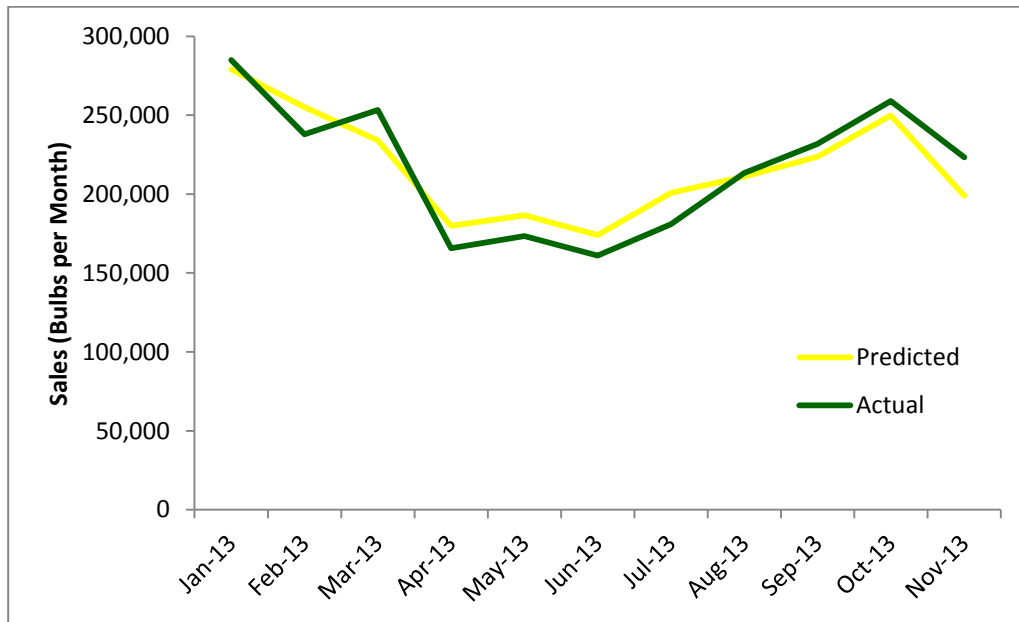
<sup>5</sup> Net of FR are sales net of freeridership, or 1-FR, used to calculate the net-to-gross (NTG) ratio where NTG = 1 - FR + Spillover.

channels. This involved testing a variety of specifications to ascertain price impacts—the main instrument affected by the program—on bulb demand. The final model specification examined the impact of such factors as price, retail channel, bulb type, specialty features, pack size, in-store promotions, and seasonality on the quantity of bulb packs sold.

Appendix A provides details on the model specification, including the model equation.

The Team adjusted the model to correct for missing data on promotional displays and stocking issues. The fit of the model was then examined by comparing the model-predicted sales with the actual sales. Figure 2 reveals that the model-predicted sales matched closely with the actual sales with no persistent bias indicating that the model fit the data well.

**Figure 2: Demand Elasticity Predicted and Actual Sales**



## 2.2 POS DATA MODELING

As with the demand elasticity modeling, the purpose of the POS modeling research was also to provide estimates of program impacts. However, while demand elasticity garnered a net-of-freeridership estimate, the POS modeling research provided a NTG ratio (albeit only for select retail channels: grocery, drug, discount, club, and mass merchandisers, which did not include approximately 80% of Connecticut program sales).<sup>6</sup>

### 2.2.1 POS Modeling Input Data

The provision of these NTG estimates for CFLs and LEDs (and both bulb types combined) was achieved by leveraging nationwide sales data which was purchased through LightTracker, an initiative of the Consortium for Retail Energy Efficiency Data (CREED) and represents bulb purchase data captured at the point-of-sale for select retail channels for 44 states across five

<sup>6</sup> 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.

years (2009-2013).<sup>7</sup> 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 to run a series of regression models predicting the proportion of statewide bulb sales that were efficient. By doing so, the Team identified those model inputs that had the greatest impact upon the percentage of lighting sales for CFLs and LEDs.

## 2.2.2 POS Model Specification

The Team fit regression models to the following three dependent variables: 1) percentage of all bulbs that were energy efficient (i.e., [CFL+LED Sales]/All Bulb Sales); 2) the percentage of all bulb sales that were CFLs only; and 3) the percentage of all bulb sales that were LEDs only as the dependent variable. The main independent variable of interest in the models was the program budget, a continuous variable, though the model also controlled for several demographic and state-specific factors. Because program budgets tended to increase over time and showed a slight correlation with time, models were fitted with a "non-program trend" variable; the average percentage of efficient bulb sales (or CFLs, or LEDs, depending on the model) across the states that did not have any program activity during the time period analyzed (2009 – 2013). In this way, we controlled for the naturally occurring, baseline trend in efficient bulb sales absent program activity.

Additionally, the Team determined that one state was an outlier, imparting a great deal of influence on the regression results in two of the three models. This state had a very large program budget but only moderate CFL and overall efficient bulb sales; therefore, we ultimately present results with that state removed from the model for the all efficient bulbs and CFLs-only models. The state did not appear to be an outlier in the LED model, though, so the results reported for LEDs include all 44 states.

## 2.3 EXAMINATION OF SOCKET SATURATION TRENDS AND COMPARISON AREA RESEARCH

An analysis of lighting saturation data in Connecticut from 2009 through 2013 explored the saturation of energy-efficient residential lighting products over time and provided information relevant to the assessment of the lighting market in general and LED market specifically. The data came from a series of residential lighting on-site studies conducted in Connecticut in 2009, 2012, and 2013.<sup>8 9 10</sup>

<sup>7</sup> 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.

<sup>8</sup> NMR Group Inc., and DNV GL. *Northeast Residential Lighting Hours of Use Study*. Prepared for the Connecticut Energy Efficiency Board (and other Program Administrators in the Northeast). May 2014. Available at: <https://app.box.com/s/o1f3bhbunib2av2wiblu>

<sup>9</sup> NMR Group Inc. *Connecticut Efficient Lighting Saturation and Market Assessment*. Prepared for The Connecticut Energy Efficiency Fund, Connecticut Light and Power, and The United Illuminating Company. October, 2012. Available at:

[http://www.energizect.com/sites/default/files/FINAL%20EISA%20Lighting%20Saturation%20and%20Market%20Assessment%20Report%20100212\\_pdf.pdf](http://www.energizect.com/sites/default/files/FINAL%20EISA%20Lighting%20Saturation%20and%20Market%20Assessment%20Report%20100212_pdf.pdf)

<sup>10</sup> NMR Group Inc. *The Market for CFLs in Connecticut*. Prepared for the Connecticut Energy Conservation Management Board (ECMB), Connecticut Light & Power, and The United Illuminating Company. November 2009. Available at: [http://energizect.com/sites/default/files/ct\\_lighting\\_report\\_11-24-09.doc](http://energizect.com/sites/default/files/ct_lighting_report_11-24-09.doc)

For years when on-site studies were not conducted (2010 and 2011), the Team used straight line interpolation to determine saturation based on the 2009, 2012, and 2013 data, and similarly extrapolated saturation estimates for 2014.

### 2.3.1 Prior Connecticut Saturation On-site Methodology

The Team completed 95 on-site visits in 2009, 100 in 2012, and 90 in 2013. Sampling methods varied slightly across the studies, with the 2013 sample designed to secure comparable numbers of single-family and multi-family homes. During the visits a trained technician walked through each room of the home examining all lighting sockets and gathering data on fixture type, bulb type, bulb shape, socket type, wattage, and specialty characteristics for all installed and stored lighting products and asked the householder specific questions regarding their lighting. Quality assurance measures were also put in place to make sure all technicians collected data in a satisfactory manner.

We recommend the reader examine the original reports for more details on sampling, recruitment, and data collection.

### 2.3.2 Comparison Area Data Collection

The Team also explored the saturation of energy-efficient residential lighting products in Connecticut over time *in reference* to three comparison areas: Massachusetts, Georgia and Kansas. The Team focused on these particular comparison areas for a number of reasons, including the availability of prior saturation estimates that allowed us to look at a time series of data, but also because they display varying levels of lighting program activity. Georgia recently began providing incentives for CFLs and LEDs (earlier it had focused on education and small promotions or bulb-giveaways), whereas Kansas is a non-program activity comparison area, not currently or historically providing incentives for efficient lighting. In this way the Team could consider the impact of differing levels of program support on changes in efficient bulb saturation. The ultimate selection of these areas was decided by Massachusetts, although Connecticut joined the comparison area effort in order to enhance its analysis and subsequent findings and insights while also offsetting Massachusetts's substantial data collection costs for comparison areas. We compare the prior Connecticut data to those collected from these three states between 2009 and 2014. For years when on-site studies were not conducted, the Team interpolated saturation based on the data provided.

### 2.3.3 Weighting Scheme

In order to present a reliable time series of data, it was imperative that the Team develop a consistent weighting scheme that could be applied to data collected for all states in all years. After considering multiple options, the Team ultimately chose to weight by home type and tenure in Connecticut as applied to the other states, as these provided the best fit to the Census data. The one exception was the Northeast state; the team retained its original weighting scheme as we provide the information more as a true comparison of another very active program state in the region than trying to force this area to serve as a stand-in for what Connecticut might be like absent a program. For Connecticut, although the scheme is similar to that used in prior reports, it is not identical, so some of the saturation estimates reported here differ very slightly from those reported in each study. The weighting scheme is presented in Appendix C.

## 2.4 SUPPLIER INTERVIEWS

A key input for understanding both the Connecticut lighting market and the impact of the Connecticut program came from interviews with lighting manufacturers and retail buyers. These interviews were

conducted between May and June of 2014 and focused on program attribution (NTG ratios) for standard CFLs, specialty CFLs, and LEDs in the state, as well as satisfaction with the Connecticut program. Interviewees included:

- 12 lighting manufacturers and suppliers who accounted for roughly 93% of the sales by manufacturers identified in the program tracking databases; and
- 3 high-level lighting buyers who represented large national or regional retailers in the program. Together, they accounted for over 73% of the program sales.

Standard CFLs were defined for the purpose of these interviews as “bulbs that have spiral shapes, are not covered, and which do not have any special features such as dimmability or three-way capability.” We defined specialty CFLs as those “that do not have a spiral shape, like A-shape or globe-shape lamps, or CFLs with special features such as dimmable, 3-way, or reflector CFLs.” [Appendix D](#) provides details on the NTG calculation algorithm.

Note that we also draw some information from a recently completed supplier interview effort in Massachusetts.<sup>11</sup> Massachusetts funded questions asking supplier (manufacturers, high-level buyers, and store managers) to describe the state of the LED market generally. Because their insights focus on the market in general, we believe they also provide useful insights for Connecticut.

#### 2.4.1 Supplier Interview Weighting

The Team used the quantity of bulbs that each respondent sold through the program as a means of weighting their NTG ratios. In channels for which we had estimates from both manufacturers and retail buyers, the approach was to use sales through the program that each market actor category accounted for in order to weight estimates to the channel-wide level. In one case, we used the simple average NTG estimate by weighing each market actor category (manufacturers and retail buyers) equally.

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<sup>11</sup> 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. Available at; <http://ma-eeac.org/wordpress/wp-content/uploads/Supplier-Retailer-Perspectives-on-Residential-Lighting-Market-Summary-of-Year-2014-Interviews-Final-Report-.pdf>

## 3

## Section 3 NTG and Net-of-Freeridership Estimates

This section outlines the various estimates of NTG and net-of-freeridership that the Team calculated from the relevant approach methodologies. We begin by describing the quantitatively oriented values gleaned from the demand elasticity and POS modeling approaches, before moving into the self-reported approaches utilized from the supplier interviews. We also discuss the relevant strengths and limitations of these approaches and their subsequent threats to validity.

### 3.1 SUMMARY OF NTG AND NET-OF-FREERIDERSHIP RESULTS

Table 4 displays the NTG and Net-of-freeridership estimates across all methods utilized throughout the program cycle. These methods and their associated estimates are described individually in more detail below.

**Table 4: NTG and Net-of-Freeridership Estimates Across Methods**

Measure	Connecticut Currently Assumed	Demand Elasticity	Supplier Interviews	POS Modeling
LED Specialty	100%	71%	74%	87%
LED Standard		49%		
CFL Specialty	81%	47%	55%	29%
CFL Standard		51%	68%	
Notes	From the 2014 PSD, Appendix 3; net realization rates are 82% for LEDs and 51% for CFLs. <sup>12</sup>	Net of freeridership, partial or missing data required team make assumptions for some products, stores	Subject to biases of responding manufacturers and retailers	Partial market estimate, home-improvement channel not included

### 3.2 DEMAND ELASTICITY MODELING

The Team estimated the overall net of freeridership for CFLs and LEDs from the demand elasticity models utilizing the formula shown below. Table 5 shows these estimates broken down by utility. The

<sup>12</sup> The United Illuminating Company and Connecticut Lighting and Power Company. 2014. *Connecticut Program Savings Document: 10<sup>th</sup> Edition for 2015 Program Year*. See page 289.

model estimated program-level freeridership to be 49%, and as such the net-of-freeridership or 1-FR to be 51% overall. Note that because these estimates do not include spillover—which increases NTG—the actual NTG ratio is likely higher but we cannot determine by how much.

$$\text{Net of FR Ratio} = \left( \frac{\text{Savings with Program} - \text{Savings without Program}}{\text{Savings with Program}} \right)$$

**Table 5: Net-of-Freeridership Estimates by Utility**

Utility	Net of Freeridership
Eversource	51%
UI	48%
Overall	51%

Table 6 on the next page shows the incentive as a share of the original retail price and the estimated net of freeridership ratio by utility and bulb type for the 2013 program year through November. The proportional price reduction and net of freeridership trends typically correlate, with higher incentives being associated with lower freeridership. In addition, specialty LED sales exhibited a greater response to price changes.

**Table 6: Net-of-Freeridership Results by Bulb Type**

Product	Price Reduction as Percent of Original Price	Net of Freeridership
LED Specialty	39%	71%
LED Standard	30%	49%
CFL Specialty	32%	47%
CFL Standard	31%	51%

One issue the Team encountered with estimating these numbers by bulb type was the prevalence of LED downlights in the data, which accounted for a large percentage of sales. This bulb type does not tend to be as sensitive to price changes as other LEDs. The estimates shown in Table 6 include the downlights within the standard category. However, moving those bulbs into the specialty category did not affect net-of-freeridership estimates for individual categories, or overall. It is worth acknowledging however, that if the program undergoes changes and Connecticut increases support for LEDs, it would be worthwhile to begin tracking NTG or net of freeridership separately for different LED styles.

Another point to note is the lower than anticipated LED Standard and CFL Specialty net-of-freeridership results. The Team explored possible reasons for the lower than anticipated estimate for LED Standards. Excluding downlight bulbs from the category did not change the net-of-freeridership value so we rejected this possibility. Another possible—but not directly tested—explanation centered around the fact that LEDs are still relatively new to the market, and while the unsupported price is still rather high, LED buyers are more likely to be “early adopters” of efficient lighting technology. This status makes them less price sensitive, particularly in the retail channel (DIY) that dominates

the Connecticut program (see Table 7 below). Price sensitivity also provided a possible explanation for specialty CFLs. Prior research has found that these bulbs are less sensitive to price changes than are other product types.<sup>13</sup> In addition, most specialty bulbs are not subject to EISA, making them less susceptible than standard CFLs and LEDs to competition from low-cost halogen bulbs.

Table 7 presents freeridership estimates by retail channel.<sup>14</sup> The retail channels shown in Table 7 are:

- DIY: Do-it-Yourself or home improvement retailers, such as Ace Hardware or Lowe’s
- Discount: bargain retailers, such as Big Lots or Family Dollar
- Mass Market: Volume, non-membership retailers such as Wal-Mart, Stop n Shop, or K-Mart
- Warehouse: Membership retailers, such as Costco

Warehouse stores exhibited the highest net-of-freeridership, followed by discount retailers.

**Table 7: Net-of-Freeridership by Retail Channel**

Retail Channel	Net of Freeridership
DIY	43%
Discount	55%
Mass Market	48%
Warehouse	66%

Table 8 provides the net-of-freeridership estimates by product and pack size for the retail channels shown in Table 7.

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<sup>13</sup> For example, NMR, KEMA, Cadmus, and Tetra Tech. 2011. *Massachusetts ENERGY STAR Lighting Program: 2010 Annual Report*. Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/2010-Annual-Report-Volume-1-Final-Report.pdf>

<sup>14</sup> The Team attempted to keep categories comparable across methodologies but the particular nature of the program design or data required some slight variations. For example the DIY category combines the home improvement and hardware channels and the Mass Market channel includes what other methods call Mass Merchandise and Grocery. This reflects the need to increase the number of stores represented in those categories, limiting the influence of any one retailer which would bias them.



**Table 8: Net-of-Freeridership by Retail Channel and Product**

Bulb Type	Pack Category	Discount	DIY	Mass Market	Warehouse
CFL-Specialty	Multi	28%	14%	20%	54%
CFL-Specialty	One	23%	8%	14%	44%
CFL-Standard	Multi	23%	23%	31%	45%
CFL-Standard	One	19%	15%	24%	38%
LED-Specialty	Multi	65%	36%	n/a	51%
LED-Specialty	One	56%	28%	n/a	44%
LED-Standard	Multi	48%	33%	34%	57%
LED-Standard	One	42%	26%	29%	50%

[Appendix A](#) provides a more detailed discussion of price elasticities and the estimated price markdowns that informed the analysis, as well as the detailed model outputs.

### 3.2.1 Benchmarking Net-of-Freeridership

Table 9 compares net-of-freeridership estimates from several recent evaluations using the elastic model approach. The table also shows the average, sales-weighted original retail price of program bulbs and the incentive as a share of the original price.<sup>15</sup>

The net-of-freeridership estimates for Eversource and UI were within the range of those observed in other programs. However, the incentives for standard bulbs offered by both Connecticut utilities were considerably lower than all of the other programs.

While the elasticity estimates for Eversource and UI were somewhat lower than those observed in other programs, the freeridership was relatively low compared to the level of the incentive shares shown in Table 9. This suggests it is possible Eversource and UI incented a higher proportion of products with a greater price elasticity. Targeting products with a higher elasticity means that, all else being equal, net lift in sales will increase to a greater degree per-dollar spent on incentives.

<sup>15</sup> Results are for standard CFLs. These bulbs are most comparable between programs as the product/retailer mix is not as variable as specialty bulbs or LEDs, making them the best bulb to use for benchmarking.

**Table 9: Benchmarking NTG and Incentive Levels**

Utility	Bulb Type	Markdown per bulb	Regular per Bulb	Incentive Share	Net of Freeridership
Southwest Utility 2	Standard	\$1.37	\$2.18	63%	83%
Mid-Atlantic Utility 1	Standard	\$1.41	\$1.97	72%	73%
Mid-Atlantic Utility 3	Standard	\$1.59	\$2.10	76%	73%
New England	Standard	\$1.00	\$2.11	47%	68%
Mid-Atlantic Utility 2	Standard	\$1.43	\$2.14	67%	65%
Mid-Atlantic Utility 4	Standard	\$1.46	\$2.22	66%	65%
Midwest Utility	Standard	\$1.13	\$1.82	62%	57%
Southwest Utility 1	Standard	\$0.87	\$1.61	54%	55%
Eversource	Standard	\$0.96	\$3.68	26%	53%
Southeast	Standard	\$1.09	\$2.15	51%	52%
UI	Standard	\$0.94	\$3.40	28%	50%

### 3.3 POINT-OF-SALE MODELING

The second model-based approach to estimating the net impact of the program on efficient bulb sales involved the use of a market-level sales database, as described above. Recall that this database does not include sales from hardware or home improvement stores. In fact, the stores reporting sales represented about 19% of Connecticut's program sales. Despite this limitation, the CREED initiative represents the first time that national and state market level lighting sales data—even for only a portion of the market—have been available to lighting program administrators and evaluators to assess the impact of their programs on bulb sales.

After fitting the regression models following the approach described earlier (See [Section 2.2](#)), the Team used the resultant coefficients from the POS models to calculate corresponding 2013 NTG ratios for all efficient bulbs (CFLs + LEDs), CFLs-only, and LEDs-only.<sup>16</sup> As outlined in previous work,<sup>17</sup> these NTG ratios were derived by subtracting a the number of efficient bulbs sold assuming no program activity (as estimated via modeling) from the number of efficient bulbs sold under the program and dividing by the total number of program bulbs sold, as follows:

<sup>16</sup> The POS data did not allow for breaking out CFLs and LEDs by standard and specialty.

<sup>17</sup> NMR Group, Inc., KEMA Inc., The Cadmus Group, Inc., and Tetra Tech. *Massachusetts ENERGY STAR Lighting Program: 2010 Annual Report, Volume 1*. Prepared for the Energy Efficiency Advisory Council Consultants, among others. June, 2011. Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/2010-Annual-Report-Volume-1-Final-Report.pdf>

$$NTGR = \frac{(\# \text{ bulbs sold with program} - \# \text{ bulbs sold with no program})}{\# \text{ of program incented bulbs sold}}$$

The Team calculated the first input to the NTG equation (# of bulbs sold with program) as the actual number of CFL and LED sales represented in the POS data set. We derived the total number of program-incented bulbs sold from the Connecticut program-tracking data, summed the total number of program-supported CFL and LED sales at all retailer channels in Connecticut represented by the data. Table 10 presents the NTG ratios from this method. The CFL NTG of 29% is substantially lower than that currently assumed (81%), while the LED NTG of 87% is also lower than current assumptions (100%).

**Table 10: NTG Ratios from POS Modeling**

Bulb Type	NTG 2013
CFLs and LEDs	30%
CFLs Only	29%
LEDs Only	87%

The results point to some important insights. First, CFLs drove the overall model, mainly because CFL sales remained far greater than LED sales, at both the market and program levels. Second, the NTG ratios differed considerably from those for the Demand Elasticity approach as well as the Supplier Interview Approach below. The Team believes that the divergence reflects a) the nature of the stores included in the POS dataset compared to program partners, and b) the benefit of looking beyond the program and program partners to understand the market more broadly. In other words, at least in the stores included in the dataset, CFL sales were fairly strong with and without program activity<sup>18</sup> while LED sales were more sensitive to program incentives. The team recognizes that this conclusion seemingly contradicts the result from Demand Elasticity Modeling, but one must keep in mind that the retail channels differed between the two datasets. In short, customers who shop at the retailers in the demand elasticity dataset may be more correctly characterized as “early adopters” and less sensitive to price than those shopping at retailers in the POS dataset. Perhaps most importantly, the POS model measures program impact using the program budget, and, compared to some other states, the Connecticut lighting budget (with controls for the number of households) was lower than some (not all) of the states included in the model.

<sup>18</sup> One can certainly—and accurately—make the argument that the existence of long-standing CFL support in states such as Connecticut, Massachusetts, California, New York, and others have had spillover effects that moved the market in states that only recently started to support programs or have lower levels of program support (almost all states, Kansas and a few others being exceptions, have some type of CFL promotional activity). For example, strong sales in program areas may have convinced manufacturers and retailers to carry CFLs in places with less program activity, sometimes even lowering the shelf price without incentives because the upstream incentives offset the prices. Unfortunately, quantifying this cross-state spillover and factoring it into NTG ratios is next to impossible, fraught not only with the challenge of measuring it but also with deciding how to allocate the impact across the many program administrators that have been supporting CFLs since the 1990s and early 2000s. The California investor owned utilities in particular, representing the state with the oldest and largest continuous CFL program (early 1990s to 2013), largest population in the nation, and one of the top ten economies in the world could make a strong argument for claiming a lion’s share of cross-state spillover.

### 3.4 SUPPLIER INTERVIEWS

Table 11 displays the NTG ratios estimated from the supplier interviews, using the methodology described in Section D.1. As with the demand elasticity estimate, the estimated standard CFL NTG ratio (68%) and LED NTG ratio (74%) were lower than currently assumed (81% and 100% respectively). Note that an evaluation in another Northeast State had nearly equivalent NTG ratios for standard CFLs and LEDs but a higher NTG ratio for specialty CFLs, largely due to the fact that they sold some specialty CFLs through channels serving many hard-to-reach customers. These channels achieved higher NTG ratios in the study.

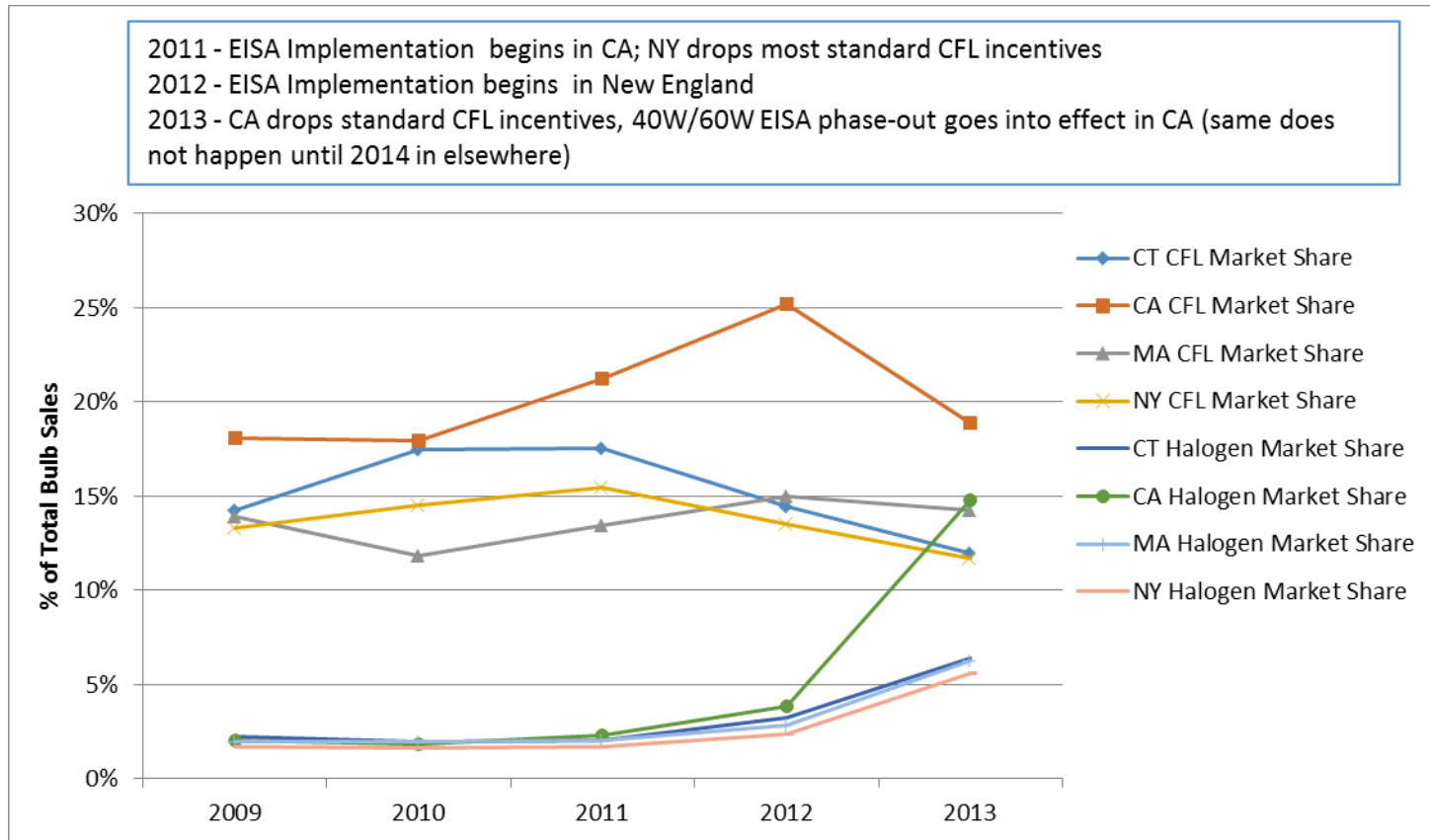
**Table 11: Supplier Interview NTG Ratios by bulb type**

Bulb Type	Connecticut 2013 Program Bulbs Sold	Connecticut NTG	Massachusetts NTG
Standard CFLs	1,877,676	68%	70%
Specialty CFLs	298,147	55%	67%
LEDs	410,233	74%	75%

As with the Demand Elasticity approach, the finding that standard CFLs garnered a higher NTG than specialty CFLs may seem counterintuitive at first. The newer and more expensive lighting technologies, like those used for specialty CFLs, would rely more on program incentives than more mature and inexpensive bulb types like standard CFLs. As mentioned above, the Team believes that there are a number of possible explanations for these findings, some of which were mentioned earlier regarding the similar finding for Demand Elasticity specialty NTG.

- 1) *Small sample size and accompanying lack of reliability.* Although the lighting manufacturers and retail buyers interviewed in this line of research represented a large portion of the Connecticut lighting market, the actual number of interviewees was small. Further, given that their results are weighted by bulb sales, responses from larger manufacturers carry substantial influence on the overall results.
- 2) *Standard CFLs face competition from EISA-compliant halogens.* Interviews with lighting manufacturers and retail buyers revealed that some view program discounts as important for keeping the standard CFLs cost competitive with EISA-compliant halogen bulbs. This is consistent with recent research utilizing the POS data on market share levels across program and non-program states, which show that as standard CFLs incentives disappear (e.g., in California), halogen sales markedly increase (Figure 3 on next page). The halogen is a relatively low-cost bulb that closely resembles the incandescent bulbs it replaces. Halogens are also marketed as energy-efficient bulbs by using incandescents as a baseline comparison. Because most of the EISA-compliant halogens being sold offer no special functionality or shapes, they are less likely to compete with specialty CFLs that offer enhanced performance features three-way capability, or specialty designs such as globes or reflectors. However, they are direct competitors with standards CFLs.

**Figure 3: Statewide CFL and Halogen Market Share Over Time from POS Data**



- 3) *Demand for specialty CFLs has been shown to be more inelastic than demand for standard CFLs.* As mentioned above, a 2011 study of the 2010 Massachusetts ENERGY STAR lighting program found that consumer demand for specialty CFLs was more inelastic than it was for standard CFLs.<sup>19</sup> Such inelastic demand would at least partially explain a lower NTG ratio for specialty CFLs compared to standard CFLs since specialty CFLs customers would be less likely to change their purchasing behavior if the program discounts went away.
- 4) *Specialty CFLs are becoming a more familiar technology.* Specialty CFLs are newer to the market than standard CFLs, but they have been commonly available in retail stores long enough that most customer unfamiliarity barriers have likely been overcome.
- 5) *The Connecticut program sold a higher percentage of specialty CFLs through big box stores.* A slightly higher percentage (97%) of the specialty CFLs in the 2013 Connecticut program were sold through big box retailers compared to standard CFLs (89%). Lighting manufacturers and retail buyers provide higher NTG estimates for bulb sales through discount stores than they do for big box stores.

### 3.5 LOOKING AHEAD TO 2016 – 2018

The scope of this project did not involve estimating prospective NTG ratios for the 2016 to 2018 program cycle. However, the Team recognizes that the Companies are currently engaged in planning for this next cycle and, in response, offers the following considerations to help the Companies, EEB, and regulators decide which deemed values to apply to 2016 to 2018. The final deemed values should be decided after the residential program design is complete.

**CFLs:** Halogen bulbs will continue to compete with standard CFLs for market share, particularly in the face of decreasing program support for CFLs. Therefore, we believe the standard CFL NTG will likely not change a great deal in the next program cycle. Based on what we have observed in other states, if the program still wishes to increase CFL saturation, one probable way to do so over the next few years would be to focus on channels such as drug, grocery, and bargain stores that tend to carry and sell fewer CFLs without program support. In contrast, one could make a strong argument that the large home improvement (do-it-yourself) channel is “transformed” and most support there serves only to increase free ridership.

**LEDs:** LEDs present greater challenges in developing a prospective NTG. There are strong arguments in support of a temporary boost in NTG and equally strong arguments for a steady decrease in NTG over the next few years. On the one hand, LED prices remain higher than those for most bulbs, and most consumers have yet to install them in more than a handful of sockets in their homes. Additionally, the program only supports high-quality ENERGY STAR models that are more expensive than lower-quality models that do not qualify for the ENERGY STAR label. Halogens (and CFLs) will also compete with LEDs for market share. All of these factors suggest that continued program support would result in more LED sales, yielding a high NTG. On the other hand, continued decreasing prices, greater consumer awareness and adoption, and the embracing of LEDs by home improvement and mass merchandise stores would suggest a lower NTG ratio. The Team’s best advice given current information would be to assume a fairly high NTG ratio—in line with current values—for the 2016 and gradually reduce the NTG ratio in 2017 and 2018.

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<sup>19</sup> NMR Group, Inc., KEMA Inc., The Cadmus Group, Inc., and Tetra Tech. *Massachusetts ENERGY STAR Lighting Program: 2010 Annual Report, Volume 1*. Prepared for the Energy Efficiency Advisory Council Consultants, among others. June, 2011. Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/2010-Annual-Report-Volume-1-Final-Report.pdf>

## 4

## Section 4 Market Assessment Key Takeaways

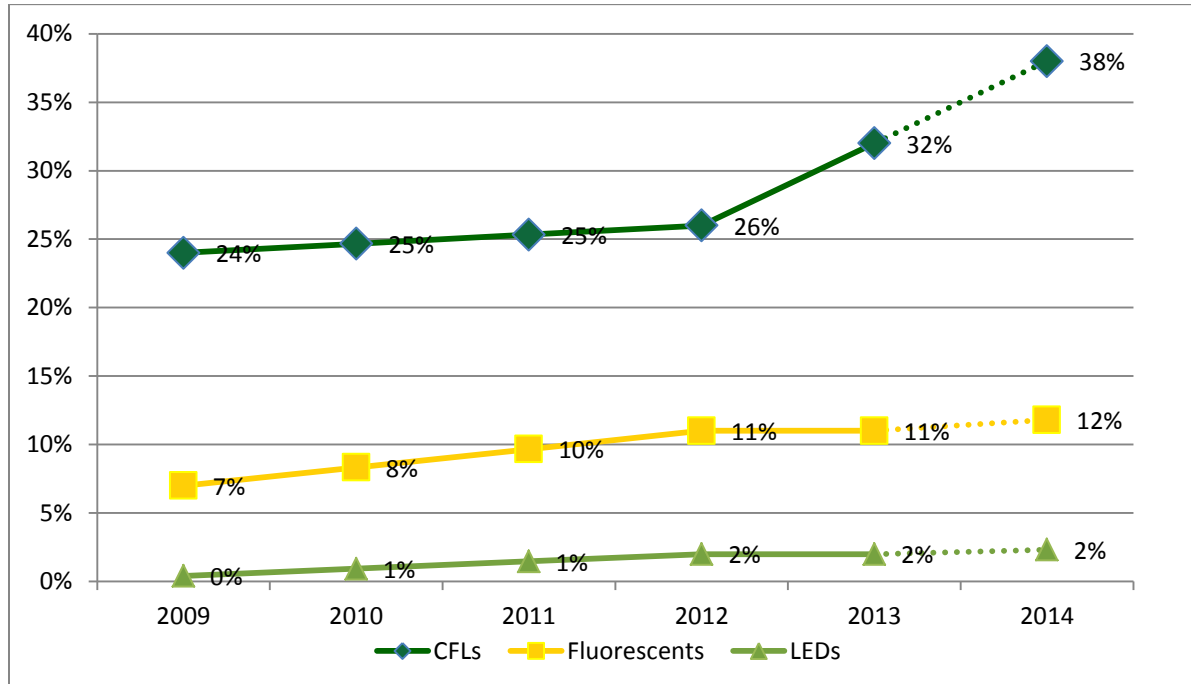
In this section we discuss the key findings from the present research as they relate to assessing the lighting market in Connecticut with a focus on the market for LEDs.

### 4.1 IMPACT OF THE UPSTREAM LIGHTING PROGRAM

Key findings from the analysis of socket saturation trends included:

- Regardless of weighting, the data showed increases in CFL *saturation* (the percentage of sockets filled with CFLs) over time. While CFL saturation increased only 2% from 2009 (24%) to 2012 (26%), there was an increase (6%) in saturation from 2012 (26%) to 2013 (32%) (Figure 4).
- CFL *penetration* (the number of households using at least one CFL) remained high, at over nine out of ten homes in 2013.
- LEDs still represented only a small portion of sockets (about 2%), but this value had more than doubled from less than 1% in 2009 to over 2% in 2014 (Figure 4).
- In contrast, LED *penetration* (the number of households using at least one LED) had increased dramatically from 2009 to 2013. LEDs were only found in 1% of homes in 2009, but were found in nearly one-quarter (23%) of homes in 2013.

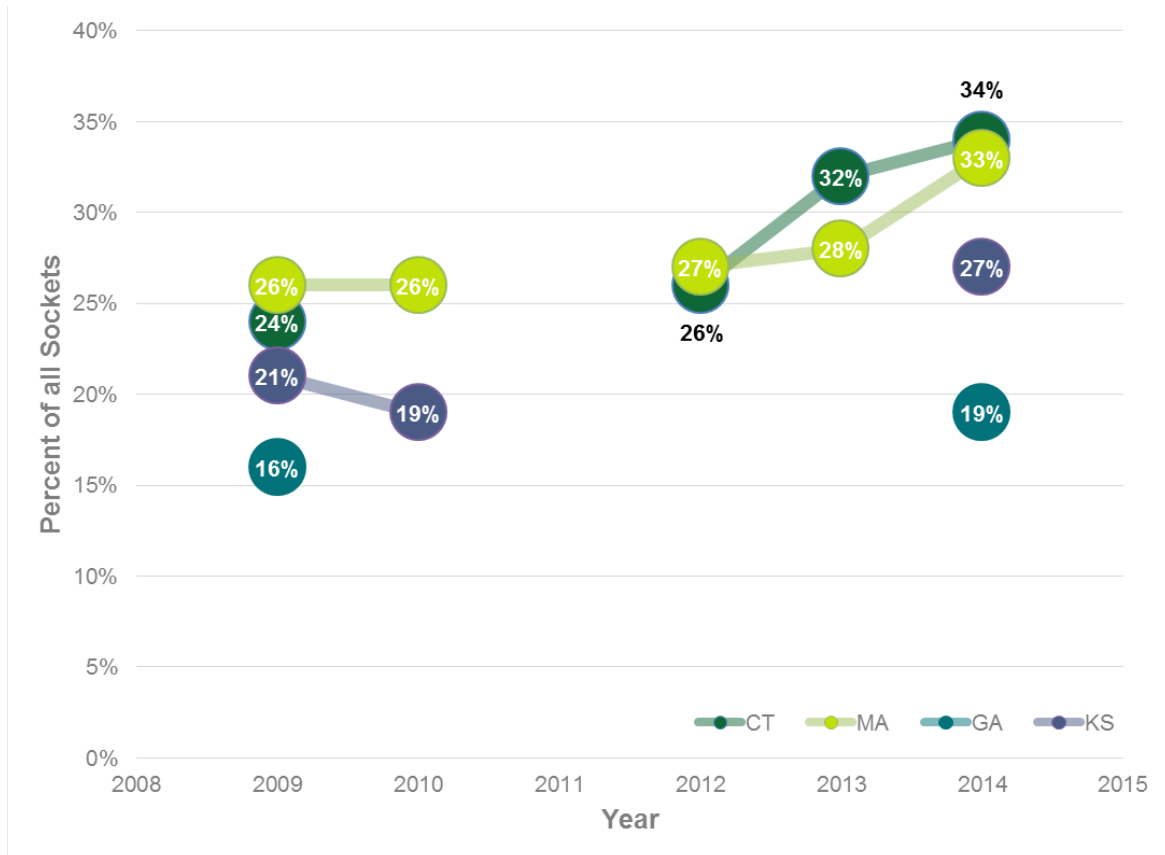
Figure 4: Efficient Bulb Saturation Over Time



The Team found similar results when considering the socket saturation trends in comparison areas as they related to Connecticut. Once again, the data showed increases in CFL saturation over time

in all four areas (Figure 5). However, CFL saturation increased at a slower rate in the comparison areas compared to Connecticut and Massachusetts comparison state. Kansas, which does not have a program, increased CFL saturation more than Georgia, which does have a program, albeit one that is younger and smaller in scope than Connecticut's or Massachusetts'. While CFL saturation increased in all four areas, Connecticut jumped 8% (or 10% to the extrapolated CFL saturation of 34% in 2014) and MA jumped 7% from 2009 to 2013. Kansas increased only 6% and Georgia increased only 3% during the same time period, revealing the continued impact of programs in moving efficient bulbs in both Northeastern states.<sup>20</sup>

**Figure 5: CFL Saturation Over Time by State**



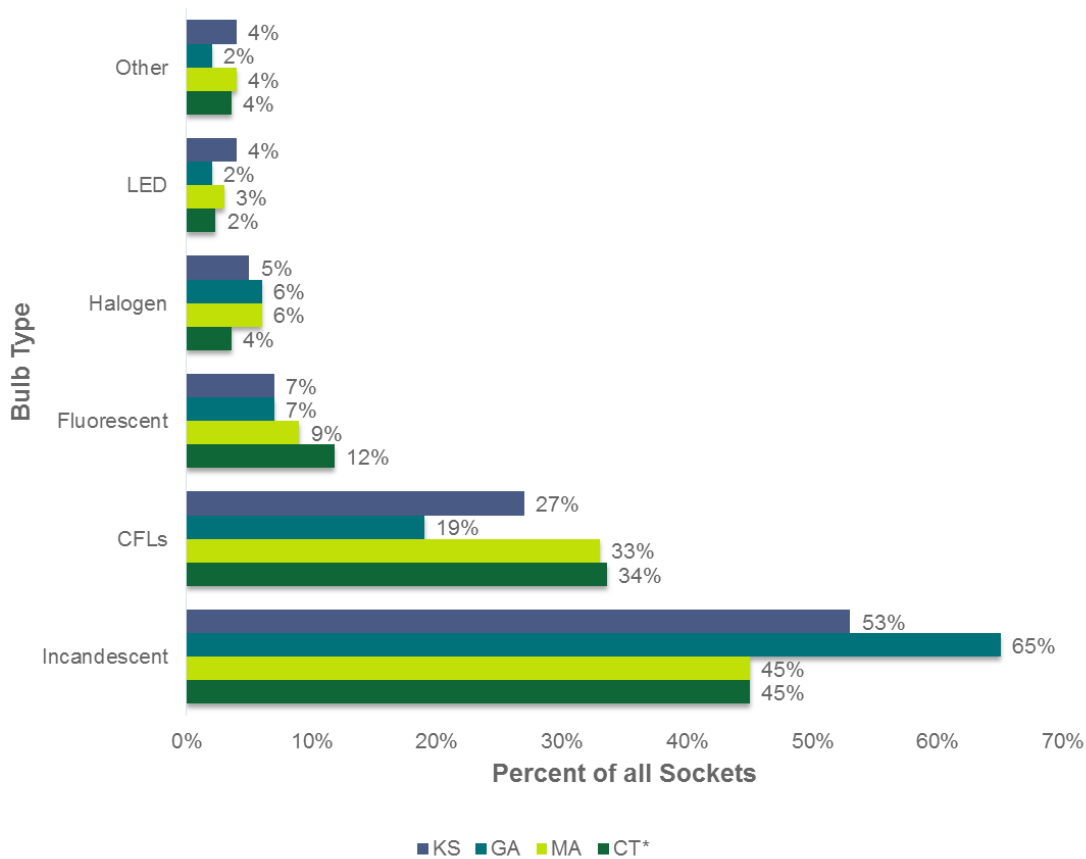
When considering only 2014 (the saturation results from Georgia, Kansas, and Massachusetts on-site visits and the extrapolated results for Connecticut) the saturation rate for *incandescent* bulbs in Connecticut was expected to be less than one-half of all sockets in 2014, while Georgia (which has a small amount of program activity) and Kansas (which has no program activity) were still above one-half (Figure 6). In Connecticut, the extrapolated 2014 penetration rate for CFLs was 92% and for LEDs was 28%; in Massachusetts the 2014 penetration rate for CFLs was 96% and for LEDs was

<sup>20</sup> Given its lack of program activity, the Team acknowledges some surprise at the high saturation rate in Kansas. As explained more in the detailed Massachusetts report, we examined a number of possible explanations for this. None of them could fully explain the reason for the high saturation rate, but the concentration and reliance on Wal-Mart, which has embraced energy-efficient bulbs, most likely played a role. It should also be noted that Kansas has fewer specialty sockets than typically seen in the Northeastern states. See NMR, Cadmus. 2015. *Results of the Massachusetts On-site Lighting Inventory 2014*. Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/On-Site-Lighting-Inventory-Final-Results.pdf>



23%. Again, this points to the importance and impact of the lighting programs in these Northeastern states, and the higher penetration in Connecticut may reflect the state’s earlier start in the shift from CFL to LED support.

**Figure 6: 2014 Saturation by Bulb Type and State<sup>21</sup>**

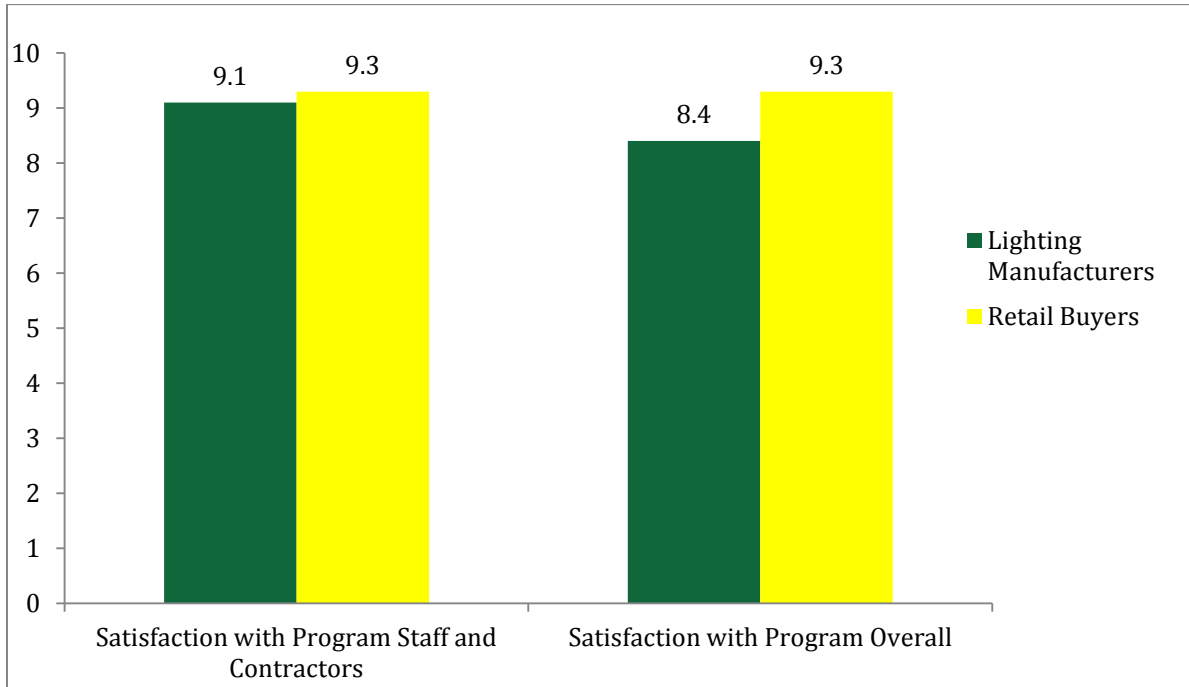


**4.2 SATISFACTION WITH CONNECTICUT PROGRAM**

As part of the supplier interviews, lighting manufacturers and retail buyers answered how satisfied they were with the program managers, implementation contractor, and other staffs involved in delivering the Connecticut program; the Team also probed about their satisfaction with the program in general. Using a scale of 0 to 10 (10 = very satisfied and 0 = very dissatisfied) nine of the 12 participating lighting manufacturers and all three of the participating retail buyers provided satisfaction ratings. Figure 7 demonstrates that these interviewees tended to be very satisfied with the Connecticut program. Lighting manufacturers showed a tendency to be more satisfied with the program staff than they were with the program overall, while retail buyers showed extremely high satisfaction with both aspects of the program.

<sup>21</sup> Data for Connecticut in 2014 are estimated values based on the assumption that saturation trends continue per the relative changes observed between 2009 and 2013. They do not represent actual onsite-verified values.

**Figure 7: Manufacturer and Retail Buyer Satisfaction with Connecticut Program**



The only issues that interviewees raised related to comparative aspects of the Connecticut program design as they related to other states. In particular, some interviewees tended to compare Connecticut to Massachusetts (recall that Connecticut leveraged funds with Massachusetts PAs in order to meet the cost requirements of the supplier interviews), indicating that there were features of the Massachusetts program that were more desirable from their perspective. In their opinions, they perceived that the Massachusetts program had a larger budget for incentives than Connecticut did and offered more flexibility in its design.

Some of their comments concerning their perception of Connecticut's less flexible program design and requirements included:

- “Connecticut is, again, a little more structured, a little more stringent, and we've not always been able to meet their deadlines, and we've had some issues.”
- “The [Connecticut program] processes are a little bit more involved [than Massachusetts]. ... You know, I don't like formal RFPs. I think they create more work that is unnecessary. Don't require formal RFPs. It's the rigidity of the timelines and short dates. It makes it feel like we have one chance to get on the program and one opportunity.”
- “All APT-run programs are designed the same way, and they have some hurdles ... The standard RFP process happens once a year. Modifications to that are difficult. ... Let's just say we run a [national big box retailer's] program and we run out of money in the spring, but we have a planned promotion for the country for the fall. Well, we have to go back to the [Connecticut] utility and ask for more funding. Well, that's not always so easy. Maybe, they don't know if they're going to use all their funding. And then by the time they let us know it's too late for us to ask, because we brought in product on consignment, basically. ... So that model doesn't work great for us. And adding new retailers after the RFP process is very

difficult. That's just the nature of an APT-run utility. We know how to work with it best we can, but it doesn't allow the real-world flexibility that the Mass program does.”

- “Certainly in Connecticut it could be improved to have a longer landscape or longer timeline in terms of the MOUs that you’re awarded. It seems like Massachusetts went to a three-year program from a regulatory perspective, and you do get an annual allocation. I seem to have more security and more time under my belt for Massachusetts in terms of the future. And in Connecticut, it’s every year, it’s: ‘Am I going to get money this year? Am I going to get money this year?’”

Taking their ratings and perspectives into account solely for the Connecticut program, however, their feelings were positive, both with regard to the program staff and contractors, as well as the program overall.

### 4.3 FINDINGS RELATED TO THE LED MARKET

The status of, and changes to, the LED market generally (i.e., at a national level) were a major focus of the supplier interview work in Massachusetts. By agreement with the PAs there, we draw on the findings about the general trends in the LED market as they apply equally to both Connecticut and Massachusetts. Main findings from supplier interviews related to this topic, covered in detail in the Massachusetts supplier interview report, which is now public, were as follows<sup>22</sup>:

- **Lighting market actors expected LED prices to drop, partly due to the future impact of EISA legislation.** A greater percentage of lighting manufacturers and high-level retail buyers thought LED prices would decrease (100% and 75%, respectively) compared to CFLs (29% and 50%) and EISA-compliant halogens (43% and 33%).
- **Respondents deemed LED lighting sales to be healthy.** Most store managers reported sales to be "excellent" or "good" over the past year, with very few managers indicating poor LED sales during this time.
- **Respondents selling LED bulbs mostly commonly cited high costs as the factor preventing greater LED lighting sales.** This was the only barrier reported by all three lighting market actor groups surveyed (e.g., Massachusetts store managers, and nationwide lighting manufacturers, and high-level retail buyers).
- **Respondents expected LED bulb prices to decrease over the next year, but not LED fixtures.** The majority of market actors surveyed anticipated LED bulb prices would decrease in 2015. In contrast, less than one-third thought LED fixture prices would decrease at the same time.
- **Respondents most frequently cited providing larger rebates and customer education for increasing LED bulb sales.** Increased incentives and better customer education were the only suggestions all three lighting market actor groups provided. When surveyed in 2012, retail managers also cited better incentives and customer education.

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<sup>22</sup> 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. Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/Supplier-Retailer-Perspectives-on-Residential-Lighting-Market-Summary-of-Year-2014-Interviews-Final-Report-.pdf>

#### 4.4 IMPACTS OF EISA LEGISLATION

Market actors' key insights about the influence of EISA on the lighting market, as well as their awareness of the legislation are summarized below.

- **Strong awareness of the EISA legislation:** All lighting manufacturers and high-level retail buyers reported being aware of EISA, and reported that EISA has contributed to increased sales of LED and halogen bulbs and, to a lesser extent, CFLs. All lighting manufacturers reported the EISA legislation impacted sales of LED bulbs, and a large majority (82%) reported increased halogen sales due to EISA. In contrast, only 36% reported that EISA led to greater CFL sales.
- **Disagreement about EISA impacts on sales of halogen bulbs.** Eighty-two percent of the manufacturers and 50% of the retail buyers said halogen bulb sales increased due to EISA. Some market actors claimed that lighting program discounts for standard CFLs helped to keep consumers from switching to less expensive and less energy-efficient, EISA-compliant halogen bulbs.
- **Store managers observed changes in consumers' purchasing behaviors in response to new EISA regulations.** Across all channels store managers indicated they had observed changes in purchasing behavior as a result of EISA. Hardware and home improvement store managers most commonly reported these changes in behaviors.

## 5

## Section 5 Strengths and Limitations of Research Approaches

The methods undertaken in the current evaluation cycle, including those utilized to estimate NTG and net-of-freeridership, presented relative strengths and limitations. While all methods used in this study offered pertinent and unique approaches for understanding how the residential lighting market in general and sales in particular were influenced by the Connecticut program, all have limitations, as summarized in Table 12 and discussed below.

**Table 12: Strengths and Limitations of Approaches**

Activity	Strengths of Approach	Limitations of Approach
Demand Elasticity Modeling	<ul style="list-style-type: none"> <li>• Actual variation in prices</li> <li>• Not dependent on respondent recall</li> <li>• When price extrapolations are available allows estimate of future net-of-freeridership levels</li> </ul>	<ul style="list-style-type: none"> <li>• Does not take spillover into account</li> <li>• Some data problems with CFLs but enough good data to develop a net-of-freeridership estimate</li> <li>• Does not take C&amp;I sales into account</li> </ul>
POS Data Modeling	<ul style="list-style-type: none"> <li>• Actual sales data</li> <li>• Not dependent on respondent recall</li> <li>• Have POS data for six years to assess trends</li> <li>• Statistically modeled comparison area takes multiple factors into account</li> </ul>	<ul style="list-style-type: none"> <li>• Only some channels are included in the data - hardware and home improvement channels are not included</li> <li>• Only ~19% of Connecticut program sales are included</li> <li>• The stores covered in Connecticut may not be the same as those covered in other states</li> <li>• Does not take C&amp;I sales into account which generally account for ~7% of residential program purchases</li> </ul>

Activity	Strengths of Approach	Limitations of Approach
Examination of Connecticut socket saturation trends	<ul style="list-style-type: none"> <li>• Utilizing past Connecticut trends and those observed in Massachusetts (a demographically similar state) is likely to be indicative of future trends in Connecticut</li> <li>• Saturation estimates going back to 2009 for Connecticut and comparison area which enables trend assessment</li> <li>• End of program support in comparison area provides a good indication of market transition characteristics</li> <li>• Focus on residential only</li> <li>• Not dependent on respondent recall or bias (actual observed data)</li> <li>• 2013 Connecticut and Massachusetts samples include a large proportion of MF and SF properties, greatly improving data quality</li> <li>• Consistent weighting scheme applied to all years of data</li> </ul>	<ul style="list-style-type: none"> <li>• Potential bias toward individuals who are already more in favor of efficient lighting</li> <li>• Small sample sizes make it difficult to identify statistical differences across regions or over time</li> <li>• Possible non-response bias due to lower response rates</li> <li>• Change in methodology in 2013 to include additional multifamily properties— provides a better picture of Connecticut overall but makes data less comparable to earlier studies (weighting attempts to correct for this)</li> </ul>
Supplier Interviews	<ul style="list-style-type: none"> <li>• A large portion of the market is accounted for by respondents</li> <li>• Many respondents have been following the market for years, in both program areas and non-program areas</li> <li>• Method takes non-residential CFL sales into account, which other studies have estimated make up about 5%-10% of total CFL sales</li> </ul>	<ul style="list-style-type: none"> <li>• Suppliers have an inherent self-interest in the continuation of the program, and hence may be biased</li> <li>• Suppliers are not the ones who actually make the decisions to purchase CFLs for home installation</li> </ul>

Activity	Strengths of Approach	Limitations of Approach
Contribution to regional comparison area data collection	<ul style="list-style-type: none"> <li>• Have prior saturation estimates to assess trends</li> <li>• Range of program support in Georgia and Kansas providing good comparison areas</li> <li>• The estimate is for residential only, not C&amp;I</li> </ul>	<ul style="list-style-type: none"> <li>• Depends on respondent recall about when they purchased bulbs</li> <li>• Small sample sizes in Georgia and Kansas</li> <li>• Georgia/Kansas and Connecticut are different demographically</li> <li>• Possible non-response bias greater in Georgia/Kansas because of lower response rate</li> <li>• Kansas had fewer specialty fixtures than Connecticut</li> <li>• Kansas has many more Walmarts per household than Connecticut, and Walmart has aggressively promoted CFLs since 2007</li> </ul>

### 5.1 STRENGTHS AND LIMITATIONS OF MODELING APPROACHES

The quantitatively-oriented tasks of demand elasticity modeling and POS modeling were advantageous in that they represented (respectively) actual variations in prices seen on participating store shelves and actual sales data captured at the point-of-sale for reporting retailers. Unlike the supplier interviews (and some other approaches NTG not included in this study), neither demand elasticity or POS modeling was susceptible to concerns about the accuracy of respondent recall or the potential agendas that a supplier might display when discussing a program’s impact. Additionally, the POS model incorporated five years’ worth of price and program data, thereby taking into account information not available with methods examining a single point in time or one year of program data. The POS model also took multiple factors into account including demographics and program histories.

Nonetheless, these two methods also had shortcomings. One of the foremost issues for POS modeling is that of generalizability. The sales data that served as the dependent measure for all models and factored heavily into the NTG estimates did not represent full, market-level sales in Connecticut or nationwide. Although many program and non-program bulbs sell through the retail channels included in the dataset, the absence of home improvement and hardware channels means that the models did not account for many of the bulb sales, particularly LEDs which accounted for a small percentage of the market from 2009 through 2013, and were generally sold through non-reporting retail channels. With regard to the NTG estimates from the POS data, the counterfactuals of bulb sales in Connecticut were based not just on data from that state, but also on data from all other states that contributed to the model. Because of the state-level nature of the data, the NTG estimates lacked the specificity that might be obtained from research conducted on a finer scale using data only from Connecticut. While the demand elasticity results had that finer scale, the results did not take spillover (or C&I sales) into account, and data problems required the Team to make assumptions to address these problems that may have had unintended consequences on the

results. These effects would mean that, if anything, the POS and demand elasticity models would tend to underestimate the program influence and, therefore, the NTG ratio.

## 5.2 STRENGTHS AND LIMITATIONS OF SUPPLIER INTERVIEWS, EXTRAPOLATED SATURATION ESTIMATES, AND COMPARISON AREAS

One of the greatest strengths of the supplier interview approach to estimating NTG is the very substantial portion of the market that is accounted for by these interviewees. As discussed, the lighting manufacturers and suppliers accounted for approximately 93% of the sales by manufacturers identified in the program tracking databases, and the high-level lighting buyers represented large program retailers, accounting for over 73% of program sales. These respondents have been intricately involved in, and following the market for years, in both program areas and non-program areas. It is also the only method taking non-residential CFL sales into account.

Nevertheless, this market actor self-report methodology also has its limitations, many of which concern possible biases on the part of the lighting market actors. This could cause interviewees to provide NTG estimates that are higher or lower than what they truly think the program deserves in terms of attribution. For example, market actors could purposely exaggerate how much their lighting product sales would decrease in the absence of the program in order to ensure they continue receiving program discounts or rebates. Conversely, market actors could underestimate how much their sales would drop in the absence of the program based on an inflated confidence in their company's ability to market efficient products. This bias might be considered a variation of the "social desirability bias," a well-known concept in the program evaluation literature on self-reported behavior.

Other limitations with the supplier interviews concern potential gaps in knowledge about the market itself—insufficient knowledge to assess competently what would happen to product sales in the absence of the program. Lighting manufacturers likely have the greatest potential to predict counterfactual sales accurately because these market actors tend to have a practical reason for making such predictions accurately. They submit proposals every year to Upstream Lighting Program managers predicting how many of each product they think they can sell through each retail channel. Overestimating these sales means dealing with unhappy retail partners and program managers, neither of whom like overstocks. Nevertheless, just because lighting manufacturers are qualified to provide accurate predictions of counterfactual sales does not mean they necessarily will.

The saturation extrapolation approach relies on past Connecticut trends and those observed in Massachusetts. Utilizing these past Connecticut trends and those observed in demographically similar neighboring state can provide useful insights into likely future Connecticut trends. Further, having these estimates from 2009 onward allowed for an informative assessment of trends over time. Saturation analyses and extrapolating are also not dependent on respondent recall, and the accompanying validity issues cited earlier.

While this method is likely to be indicative of future trends in Connecticut, the trends could still diverge from the extrapolated values, however. Further, as with most on-site saturation studies, participants tend to be biased towards individuals that favor efficient lighting. This was especially true in Kansas and may partly explain the higher-than-expected CFL adoption rates in this non-program state. Long-standing lighting programs also have the ability to influence markets in other areas, so despite the fact that the Team focused on comparison areas with little or no program activity it may be unfair to consider them a true *baseline* of what would have happened had the Connecticut



program or other programs never existed. Differences in demographic, social, and economic factors also make them imperfect comparators.

## 6

## Section 6 Conclusions and Recommendations

The Team offers the following conclusions and recommendations based on the findings of the current evaluation efforts.

### 6.1 RECOMMENDED NTG RATIOS FOR CFLS AND LEDS TO 2013 AND 2014 PROGRAM ACTIVITY

The NTG ratios developed through the three methods presented in this report all exhibited relative strengths and limitations. In addition, the Connecticut program relied heavily on home improvement stores in the 2013 program year, a characteristic that typically places downward pressure on NTG ratios. Finally, the 2014 PSD (Appendix 3) assumes NTG ratios of 81% for CFLs and 100% for LEDs, but net realization rates of 51% for CFLs and 82% for LEDs. Taking all of this information into account, the Team recommends using the current *net realization rates as NTG ratios for 2013 and 2014*: CFL NTG of 51% and LED NTG of 82% for 2013 and 2014. For CFLs, the 51% falls within the range of results reported here; the 82% for LEDs is higher than study results, but the Team feels that the shortcomings of the approaches for LED NTG estimation should be taken into account. These estimates, however, likely have a very short shelf life considering the rapid and dramatic changes in the lighting market. While estimating prospective NTG ratios for 2016 to 2018 is not in this project's scope, the Team believes that the increased competition of low-cost halogen bulbs, current rates of consumer adoption of CFLs and LEDs, and trends in market prices of LEDs will mean that the CFL NTG ratio will not change much over the next few years, while the LED NTG will remain high through 2016 and then begin to drop off gradually. The EEB, Companies, and regulators will need to decide which deemed values to apply to 2016 to 2018 after factoring in any changes to program design planned for the 2016 to 2018 program cycle.

### 6.2 CONTINUE REGULAR ESTIMATION OF NTG USING A MULTI-PRONGED APPROACH

Although we have made recommendations about prospective NTG ratios, the uncertainty in these estimates suggests that the EEB should continue regular measurement of this important impact value. The year 2014 saw the continued, gradual phase-out of incandescent bulbs. While consumers can still find some of these bulbs on store shelves, their numbers are dwindling as retailers sell through existing stock and cannot legally obtain newly manufactured bulbs for sale. NTG ratios may change rapidly as consumers decide their lighting preferences in a post-incandescent period. Competition from halogen bulbs coupled with decreasing LED prices and increasing LED availability create uncertainty regarding the direction of CFL and LED NTG ratios during the 2016 to 2018 program cycle. Further, as highlighted in Section 5, each of the methods the Team undertook to estimate program impacts had relative strengths and limitations. There is no perfect method for estimating the effect that a program has on the market – every approach has positive and negative attributes. As such, the preferred methodology for arriving at such an estimate is through a triangulation of methods—perhaps with a consensus building component (see forthcoming report from Massachusetts, available in August)—which helps determine whether a single estimate is faulty, as well as where the true net impacts of a program fall. For these reasons, the Team feels that

the EEB should fund a NTG update study, probably by 2017, and continue utilizing a multi-pronged approach for estimating NTG in the future. The EEB may also consider setting NTG ratios separately for specialty and standard LEDs as well as exploring NTG ratios for CFL and LED adoption among households often considered to be “hard to reach” (e.g., low income, non-English speaking, etc.).

### **6.3 CONTINUE THE PRACTICE OF INCREASING SUPPORT FOR LEDs WHILE GRADUALLY REDUCING SUPPORT FOR CFLS**

NTG and net-of-freeridership estimates for LEDs were generally high across the various methodologies, with those that were lower than expected likely a result of data quality issues. The Team expects that NTG ratios for LEDs will remain relatively high during the 2016 to 2018 program cycle. Additionally, forthcoming research in Massachusetts confirms that households using both CFLs and LEDs rate their satisfaction with LEDs higher than CFLs, and that satisfaction—coupled with competitive pricing—will likely move some consumers to use LEDs rather than turning to incandescent halogen bulbs. For these reasons the Team recommends maintaining LED incentives, and generally increasing the program share of incentives toward LEDs and away from CFLs. However, given that CFLs do remain a viable bulb type from the perspective of net savings, and represent a trusted technology that will continue to offer an alternative from the less-efficient halogen, the Team believes that maintaining some degree of support for standard CFLs—particularly in select channels—will help offset the possibility of more consumers moving to halogens.

### **6.4 CONSIDER SHIFTING SOME INCENTIVE SUPPORT FROM HOME IMPROVEMENT TO OTHER CHANNELS**

Research in Massachusetts and results from the current demand elasticity modeling (and research conducted elsewhere) reveals that NTG and net-of-freeridership values differ depending on the retail channel in which program bulbs are sold.<sup>23</sup> In particular, discount and bargain channels, often considered to serve “hard-to-reach” customers (e.g., those with lower levels of education, income, or ability to speak English) tend to show heightened NTG ratios compared to lighting specific stores and larger home improvement channels. The Connecticut program, which moves most program bulbs through home improvement stores, may see improved NTG ratios and diversified adoption of bulbs by shifting some CFL and LED incentives from home improvement to bargain and discount channels, among other types of stores.

### **6.5 CEASE SPECIALTY CFL INCENTIVES**

Results of the present research demonstrated low or declining NTG and net-of-freeridership values for specialty CFLs, even when compared to standard CFLs. Given the lower NTG ratios—and what other studies have shown to be lackluster satisfaction with these bulbs—the Team recommends that the EEB and Companies continue in their consideration to cease support for specialty CFLs.

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<sup>23</sup> DNV-GL, NMR, Cadmus. 2015. *Massachusetts Upstream Lighting Program Net-to-Gross Ratio Estimates Using Supplier Self-Report Methodology* Available at: <http://ma-eeac.org/wordpress/wp-content/uploads/Upstream-Lighting-Net-to-Gross-Estimates-Using-Supplier-Self-Report-Methodology.pdf>

## 6.6 INCREASE CUSTOMER EDUCATION TOWARD LEDS

The Team supports the current Connecticut program move of focusing lighting incentives primarily on LEDs. The bulbs display high levels of customer satisfaction, have long lifespans, and present great opportunities for energy savings compared to halogens and remaining incandescents. However, consumer awareness and comfort with LEDs is critical for the bulb continuing to grow in use and popularity, particularly in the face of strong competition from incandescent halogen bulbs. In order to promote greater adoption of LEDs, the Team suggests increasing educational campaigns, in-store events, and instructive information toward LEDs.

# A

## Appendix A Demand Elasticity Detailed Information

This appendix provides more detail on the methods, and related data issues, with the demand elasticity research.

### A.1 INPUT DATA

As the demand elasticity approach relies exclusively on program data, a model's robustness depends on data quality. Overall, available data achieved a sufficient quality to support the analysis; however, the data also presented several issues of note:

- 1 Inconsistent data on bulb prices and/or rebates.
- 2 Inconsistent use of store IDs, requiring the Team to match bulb sales data to stores based on addresses; and
- 3 Bulb part/model numbers that appeared incomplete or to have data entry errors (e.g., transposed characters).

It was necessary for the Team to make the most reasonable assumptions possible when preparing the data to support the analysis (e.g., assessing whether two retailer addresses with different formats and level of detail were the same). Where a bulb's original retail price did not equal the target price plus program/other rebates, the Team assumed data entry errors occurred in the rebate amount and adjusted accordingly. All of these changes went through several rounds of internal review with the EEB Evaluation Consultants at Apex to ensure data quality.

#### A.1.1 Price Variation

As desired for analysis, sales data displayed relatively high amounts of price variations. Variation was measured within unique part number/retailer location combinations, that is, a given bulb model within a unique retail location. While only 25% of these combinations exhibited price variation, this corresponded to 63% of total records and 75% of total sales.

#### A.1.2 Mass Marketing

The program implementer (APT) provided information relating to the mass marketing efforts of Eversource and United Illuminating (UI). This included data on the timing and outlets of print, radio, and online advertising campaigns. Except for Eversource's Google Pay-Per-Click advertising, which ran from May to December 2013, all marketing campaigns took place during Fall 2013 and covered most of Eversource's and UI's service areas. As the timing coincided with seasonal trends in consumer behaviors, the Team could not separate the marketing's effect from other confounding factors. In the future, varying the timing, duration, and geographic areas of the mass marketing could increase the likelihood of estimating separate effects for mass marketing.

#### A.1.3 Promotional Displays

APT also provided records of product displays collected by its field staff when they visited stores to ensure compliance with contractual agreements negotiated with retailers. Field staff verified prices, product placement, and shelf signs indicating products included in the program. They also collected

data tracking whether or not program bulbs were displayed in prominent, promotional displays (e.g., clip strips, end caps, pallet displays).

Data provided at the storefront level included the following:

- 1 Retailer name
- 2 Store address
- 3 Date of store visit
- 4 Display type

The tracking data on promotional displays did not include every participating storefront in every week of the program, but instead included a sample of stores within a given week. Given this timing, some weeks there were no records indicating whether products were displayed. Through consultations with APT, the Team verified that the sample listed in the tracking system within a given week reflected stores visited at random.

Consequently, the Team imputed values for the weeks lacking product display information by assuming that, until another observation indicated a change in displays within a given storefront, the previous observation would hold true. That is, if a given storefront used an end cap display in week five and did not display the product in week eight, the display remained in place between week five and week seven (until the observed change in week eight). Similarly, if the data missed weeks nine and 10, analysis assumed display did not occur (an assumption continued until data observed for another week again indicated a display's presence).

Given that display data were collected for only a subset of stores, it was not possible to include a variable in the full elasticity model controlling for displays. To correct for potential omitted variable bias, the Team developed a separate model using only the subset of observations with display data in which we included a variable controlling for the proportion of products in a promotional display in order to estimate the impact.

Upon estimating the coefficient for the displays, the Team calculated the mean proportion of stock keeping units (SKUs) on display across all stores. This assumed the subset of observations with displays represented the program as a whole. The Team multiplied the display coefficient by the mean proportion of SKUs displayed to calculate a bias-adjustment factor. The bias adjustment was then added to predicted sales for each product in the program.

#### A.1.4 Stocking Issues

In preparing to model the sales data, the Team observed inexplicable, dramatic sales drops that did not correspond to programmatic activity:

For two retailer sales for several different SKUs dropped in October, November, and December 2013, from sales per month of several hundred to less than 10.

- Several bulbs sold at within one retailer experienced precipitous sales drops in March before disappearing from the program, indicating they had been phased out or replaced on the shelves.

The Team's model implicitly assumed supply would meet demand at the given price. The Team screened the data for any instances where this assumption did not appear to be true, for instance where price and sales were positively correlated. The Team closely reviewed any products where potential issues were identified. This assumption proved true for virtually all products in the analysis other than the instances stated above.

In the few cases that stocking issues arose for bulbs, however, available data precluded separating these effects from the influence of program factors. Therefore, the analysis excluded these bulbs for the months in which they appeared to be low or out of stock: including these data would bias any elasticity estimates downward. In total these bulbs represented roughly 5% of program sales.

### A.1.5 Seasonality Adjustment

In economic analysis, it is critical to separate data variations resulting from seasonality from those resulting from relevant external factors. For example, suppose prices had been reduced on umbrellas at the beginning of the rainy season. Any estimate of this price shift's impact would be skewed if the analysis did not account for the natural seasonality of umbrella sales.

To adjust for seasonal variations in sales, the Team used a monthly seasonal trend provided by APT. This represented national sales from a major lighting products manufacturer. Ideally, a trend would derive from historical data on aggregate sales of lighting products (e.g., inefficient and efficient, program and non-program). Such data would represent overall trends in lighting product sales and would not suffer from potential confounding with programmatic activity to the same degree as CFL sales.<sup>24</sup> However, the trend provided represented aggregated, nationwide CFL sales for a specific manufacturer.

Presumably, the trend includes some activity from various programs across the nation which could affect the sales trend, potentially leading to underestimated program impacts. However, we assume that program activity is somewhat random across all of the programs that could be included in the sales data used to develop the trend. In that case, program activity would be spread through the year and the variation between months would be driven primarily by non-program factors. Nevertheless, not controlling for seasonal variations could lead to program impact being overestimated by falsely attributing seasonal trends to price impacts (to the degree that they co-varied), or vice versa.

For example, July tends to be a month with lower sales (presumably due to longer daylight hours) so if program activity increased sales in July not controlling for seasonal variation would underestimate the program's impact. October, on the other hand, is a month with higher sales, and no control for seasonality would likely overestimate the impact of program activity occurring in that month.

The Team considered another option to account for seasonality using monthly fixed effects to control for differences between months and compared results to the model using the trend. In the fixed effects case, however, a substantial number of price changes occurred within the same month, and using fixed effects attributed program impacts to monthly averages, therefore underestimating the program impacts.

The trend provided by APT, given the national aggregation level, covered non-program products and areas without programs, therefore limiting the degree that the trend correlated with program activity. Absent a better alternative, the Team estimated model and subsequent freeridership ratios using APT's trend.

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<sup>24</sup> This assumes aggregate lighting sales did not change due to promotions; that is, customers simply substituted an efficient product for an inefficient one. While bulb stockpiling could occur during programmatic periods, this should smooth out over time, as the program would not affect the number of sockets in the home.

### A.1.6 Model Specification

The Team modeled bulb, pricing, and promotional data using an econometric model, addressing these data as a panel, with a cross-section of program package quantities modeled over time as a function of prices, promotional events, and retail channels. This involved testing a variety of specifications to ascertain price impacts—the main instrument affected by the program—on bulb demand. The Team estimated the following basic equation for the model (for bulb model  $i$ , in month  $t$ ):

$$\begin{aligned} \ln(Q_{it}) = & \sum_{\pi} (\beta_{\pi} ID_{\pi,i}) \\ & + \sum_{\theta} (\beta_{\theta 1} [\ln(P_{it}) * (Retail\ Channel_{\theta,i})]) + \sum_{\theta} (\beta_{\theta 2} [\ln(P_{it}) * (Bulb\ Type_{\theta,i})]) \\ & + \sum_{\theta} (\beta_{\theta 3} [\ln(P_{it}) * (Specialty_{\theta,i})]) + \sum_{\theta} (\beta_{\theta 4} [\ln(P_{it}) * (Pack\ Size_{\theta,i})]) \\ & + \beta_{\theta 5} [In\ Store\ Promotion] + \alpha Seasonal\ Trend_t + \varepsilon_i + \gamma_t \end{aligned}$$

Where:

- $\ln$  = Natural log
- $Q$  = Quantity of bulb packs sold during the month
- $P$  = Retail price (after markdown) in that month
- Retail Channel = Retail category (DIY, discount, mass market, or warehouse)
- Bulb Type = Product category (CFL or LED)
- Specialty = Dummy variable equaling 1 for specialty bulbs and 0 for standard
- Pack Size = Dummy variable equaling 1 for single bulb pack and 0 for multipacks
- In Store Promotion = Proportion of in-program bulbs receiving in-store promotion
- ID = Dummy variable equaling 1 for each unique retail channel and SKU; 0 otherwise
- Seasonal Trend = Quantitative trend representing the impact of secular trends not related to the program<sup>25</sup>
- $\varepsilon_{it}$  = Cross-sectional random-error term

The model specification assumed a negative binomial distribution, which served as the best fit of the plausible distributions (e.g., lognormal, poisson, negative binomial, or gamma). The negative binomial distribution provides accurate predictions for a small number of high volume sale bulbs, while the other distributions under predict sales for those bulbs.

The Team adjusted the model to correct for the three factors discussed earlier in this memo:

- Seasonality: To account for baseline lighting sales tending to follow a seasonal pattern, unrelated to price or promotion, by inserting a seasonal trend into the model
- Adjustment for missing data on promotional displays: Display data were based on random visits to stores by field representatives rather than on continuous information, so the Team made use of an omitted variable bias adjustment to estimate the impact on sales of promotional displays at stores without data.

<sup>25</sup> The time trend for this analysis represented shifts in sales due to nonprogram-related seasonality.



- Stocking issues: The model assumed supply would always meet demand; after verifying situations where this did not occur, the Team dropped a small number of observations from the analysis.

Using the following criteria, the Team ran numerous model scenarios to identify the one with the best parsimony and explanatory power:

- Model coefficient p-values (keeping values less than <math><0.1</math>);<sup>26</sup>
- Explanatory variable cross-correlation (minimizing where possible);
- Model Akaike’s Information Criteria (AIC) (minimizing between models);<sup>27</sup>
- Minimizing multicollinearity; and
- Optimizing model fit.

### A.1.7 Elasticities

The net-of-freeridership ratios derive from the estimate of a price elasticity of demand. Price elasticity of demand measures the percent change in the quantity demanded, given a percent change in price. Due to the model’s logarithmic functional form, these simply represented the coefficients for each price variable. In previous, similar analyses, the Team has seen elasticities range from -1 to -3 for CFLs, meaning a 10% drop in price leads to a 10% to 30% increase in the quantity sold. As shown in Table 13, elasticity estimates fell a little below the expected ranges, with some estimates less than one, though on average, the estimates were within the expected range.

It is important to note that some of the studies estimating elasticities in the range of -1 to -3 did not include data for merchandising displays. It is possible that some elasticities are slightly overestimated (which means the Eversource and UI elasticities would be more comparable) as merchandising and price changes often occur simultaneously, which means that some of the merchandising effect could be included in the price elasticity estimates when merchandising is not controlled for separately.

**Table 13: Elasticity Estimates by Retail Channel and Bulb Type**

Store Type	Bulb Type	Pack Category	Elasticity
Discount	CFL-Specialty	Multi	-1.1156
Discount	CFL-Specialty	One	-0.9012
Discount	CFL-Standard	Multi	-1.2693
Discount	CFL-Standard	One	-1.0549
Discount	LED-Specialty	Multi	-1.5784
Discount	LED-Specialty	One	-1.364
Discount	LED-Standard	Multi	-1.7321

<sup>26</sup> Where a qualitative variable had many states (such as bulb types), the Team did not omit variables if one states was not significant, but rather considered the joint significance of all states.

<sup>27</sup> The Team used AIC to 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.

Store Type	Bulb Type	Pack Category	Elasticity
Discount	LED-Standard	One	-1.5177
DIY	CFL-Specialty	Multi	-0.4802
DIY	CFL-Specialty	One	-0.2658
DIY	CFL-Standard	Multi	-0.6339
DIY	CFL-Standard	One	-0.4195
DIY	LED-Specialty	Multi	-0.943
DIY	LED-Specialty	One	-0.7286
DIY	LED-Standard	Multi	-1.0967
DIY	LED-Standard	One	-0.8823
Mass Market	CFL-Specialty	Multi	-0.759
Mass Market	CFL-Specialty	One	-0.5446
Mass Market	CFL-Standard	Multi	-0.9127
Mass Market	CFL-Standard	One	-0.6983
Mass Market	LED-Specialty	Multi	-1.2218
Mass Market	LED-Specialty	One	-1.0074
Mass Market	LED-Standard	Multi	-1.3755
Mass Market	LED-Standard	One	-1.1611
Warehouse	CFL-Specialty	Multi	-1.1737
Warehouse	CFL-Specialty	One	-0.9593
Warehouse	CFL-Standard	Multi	-1.3274
Warehouse	CFL-Standard	One	-1.113
Warehouse	LED-Specialty	Multi	-1.6365
Warehouse	LED-Specialty	One	-1.4221
Warehouse	LED-Standard	Multi	-1.7902
Warehouse	LED-Standard	One	-1.5758

### A.1.7.1 Program Price Impacts

Table 14 shows the sales-weighted mean sale price, the original price, and the markdown within the program, broken out by retail channel and bulb type. The table also shows the markdown as a share of the original price.

**Table 14: Mean Prices and Markdown by Retail Channel and Bulb Type**

Store Type	Bulb Type	Mean Sale Price/Bulb	Mean Original Price/Bulb	Mean Markdown/Bulb	Percent Markdown
Discount	CFL-Standard	\$4.07	\$4.95	\$0.88	18%
Discount	CFL-Specialty	\$6.86	\$9.10	\$2.24	25%
Discount	LED-Standard	\$30.81	\$42.76	\$11.94	28%
Discount	LED-Specialty	\$14.64	\$24.64	\$10.00	41%
DIY	CFL-Standard	\$1.91	\$2.98	\$1.07	36%
DIY	CFL-Specialty	\$4.99	\$7.17	\$2.18	30%
DIY	LED-Standard	\$24.59	\$35.19	\$10.60	30%
DIY	LED-Specialty	\$15.53	\$24.86	\$9.33	38%
Mass Market	CFL-Standard	\$1.84	\$2.77	\$0.93	34%
Mass Market	CFL-Specialty	\$4.98	\$6.76	\$1.77	26%
Mass Market	LED-Standard	\$29.77	\$39.77	\$10.00	25%
Warehouse	CFL-Standard	\$1.69	\$2.55	\$0.86	34%
Warehouse	CFL-Specialty	\$3.08	\$5.66	\$2.58	46%
Warehouse	LED-Standard	\$14.43	\$21.36	\$6.93	32%
Warehouse	LED-Specialty	\$9.26	\$13.44	\$4.18	31%

Discount retail channels exhibited the lowest markdowns, with warehouse retailers presenting the highest incentives. Mass market and DIY stores fell between those levels, although all stores were around 30% for most bulb types. Notably, warehouse CFL specialties exhibited unusually high markdowns in comparison with the rest of the group.

### A.1.7.2 Sales Impact from Promotional Displays

The Team also determined elasticity for promotional displays at 2.6%; substantially more than the associated price elasticity. This value represented the degree that demand changed—without a change in price—in response to APT working with participating retailers to relocate program CFLs/LEDs to prominent displays (such as end caps or wing stacks). Similar to price change-based elasticities, this value can be interpreted as the percent change in demand due to a 1% change in the proportion of products relocated to special displays. In this instance the displays appear to have a greater impact on sales for a given percent change in program activity. This suggests that merchandising may be a cheaper option for boosting sales. However, retailers often have restrictions

on which products are eligible for merchandising displays, as the products need to meet certain sales thresholds, which means it is unlikely that the 2.6% would hold for every product.

For example, if a retailer increased the proportion of CFLs/LEDs in special displays by 10%, model-predicted sales would increase by more than that amount (26%) in a given DIY store. Notably, these promotional location or display elasticities did not account for changes in price and therefore should be considered additive (above and beyond) the model’s price-based elasticity estimates. Consistent with marketing and consumer theory, these results indicated moving the product to a more visible location meaningfully affected programs sales.

**A.1.8 Model Outputs and Specifications**

**Table 15: Model Information**

Criterion	Specification
Distribution	Negative Binomial
Link Function	Log
Dependent Variable	Packs Per Month
Number of Observations	34,569

**Table 16: Class Level Information**

Class	Levels	Values
Analysis ID Stores	8,811	1 3 4 5 6 7 8 10 11 12 13 14 15 16 17 18 19 20 21 22 23 27 28 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 50 51 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 79 80 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 103
Store Type	4	DIY, Discount, Mass Market, Warehouse
Monthly	11	2013-01-01 2013-02-01 2013-03-01 2013-04-01 2013-05-01 2013-06-01 2013-07-01 2013-08-01 2013-09-01 2013-10-01 2013-11-01

**Table 17: Criteria for Assessing Goodness of Fit**

<b>Criterion</b>	<b>DF</b>	<b>Value</b>	<b>Value/DF</b>
Deviance	2.60E+04	28,205.82	1.0954
Scaled Deviance	2.60E+04	2,8205.82	1.0954
Pearson Chi-Square	2.60E+04	26,434.82	1.0266
Scaled Pearson Chi-Square	2.60E+04	26,434.82	1.0266
Log Likelihood		37,14786	
Full Log Likelihood		-97,429.3	
AIC		212,500.6	
AICC		218,545.5	
BIC		287,044.4	

Table 18: Analysis of Maximum Likelihood Parameter Estimates

Parameter		DF	Estimate	S.E.	Wald 95% Confidence Limits		Wald Chi Square	Pr < Chi Square
Intercept		0	0	0	0	0	.	.
logRetailP*StoreType	DIY	1	-0.6712	0.0436	-0.7566	-0.5858	237.29	<.0001
logRetailP*StoreType	Discount	1	-1.265	0.2451	-1.7453	-0.7847	26.65	<.0001
logRetailP*StoreType	Mass Market	1	-0.9155	0.0978	-1.1072	-0.7238	87.6	<.0001
logRetailP*StoreType	Warehouse	1	-1.3635	0.0889	-1.5377	-1.1892	235.17	<.0001
logRetailPrice*LED		1	-0.5113	0.2356	-0.9731	-0.0494	4.71	0.03
logRetailP*Specialty		1	0.2233	0.0477	0.1297	0.3169	21.88	<.0001
logRetailPri*OneBulb		1	0.21	0.2246	-0.2303	0.6503	0.87	0.3498
trend		1	0.2536	0.0391	0.1771	0.3302	42.18	<.0001
logRetailPrice*trend		1	-0.0164	0.0187	-0.053	0.0202	0.77	0.3792
Dispersion		1	0.1356	0.0016	0.1325	0.1388		

# B

## Appendix B POS Modeling Detailed Information

This section provides more detail on the methods and results of the POS Modeling research.

### B.1 MODEL INPUTS

To determine the influence of state-level program activity the Team fit a series of robust random-effects regression models of the following form:

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

Where:

- $\%efficient.sales_{i,j}$  = Proportion of total CREED-reported bulb sales that were efficient bulbs in state  $i$  and year  $j$ . Calculated as  $(\#CFL_{i,j} + \#LED_{i,j}) / (\text{total bulb sales}_{i,j})$ .
- $cr.sqft_{i,j}$  = 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  $k \in (1, \dots, p)$ . 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.
- $\tau_j$  = 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.
- $\alpha$  = Overall model intercept term.

- $\beta_{0,i}$  = Subject-specific deviation from overall-level intercept,  $\alpha$ , as estimated by random-effects specification.
- $\beta_1, \beta_2, \gamma_k, \theta$  = Regression coefficients to be estimated by the model.
- $\epsilon_{i,j}$  = Error term.





# C

## Appendix C Examination of Socket Saturation Trends Detailed Information

This section provides more detail on the Team's examination of socket saturation trends.

### C.1 WEIGHTING SCHEME

In order to present a reliable time series of data, it was imperative that the Team develop a consistent weighting scheme that could be applied to data collected in 2009, 2012, and 2013. After considering multiple options, the Team ultimately chose to weight by home type and tenure as these provided the best fit to the Census data. The weighting scheme is presented for each year in Table 19 on the next page.

**Table 19: On-site Visits Weighting Scheme**

Area / Year	Tenure and Home Type	Households	Sample Size	Proportionate Weight
Connecticut 2009	<i>Total</i>	1,326,092	95	
	Owner-Occupied	917,097	76	0.86
	Renter-Occupied			
	Single Family	76,331	10	0.55
	Multifamily	332,664	9	2.65
Connecticut 2012	<i>Total</i>	1,355,973	100	
	Owner-Occupied			
	Single Family	821,275	81	0.75
	Multifamily	95,799	6	1.18
	Renter-Occupied			
	Single Family	87,430	7	0.92
	Multifamily	351,469	6	4.32
Connecticut 2013	<i>Total</i>	1,355,973	90	
	Owner-Occupied			
	Single Family	821,275	34	1.60
	Multifamily	95,799	14	0.45
	Renter-Occupied			
	Single Family	87,430	11	0.53
	Multifamily	351,469	31	0.75
Georgia 2014	<i>Total</i>	2,454,498	78	
	Owner-Occupied	1,736,344	59	0.94
	Renter-Occupied	718,154	19	1.20
Kansas 2014	<i>Total</i>	2,454,498	67	
	Owner-Occupied	1,736,344	45	1.05
	Renter-Occupied	718,154	22	0.89

The Team also examined the trends in socket saturation across the various states under examination over time. These are presented in Table 20 below.

**Table 20: Saturation Estimates and Confidence Intervals over Time**

State	2009	2010	2012	2013	2014
Connecticut	24% (20%, 26%)		26% (22%, 30%)	32% (27%, 37%)	
Massachusetts	26% (22%, 30%)	26% (22%, 30%)	27% (24%, 30%)	28% (24%, 32%)	33% (29%, 37%)
Georgia	16% (13%, 19%)				19% (16%, 22%)
Kansas	21% (17%, 25%)	19% (15%, 23%)			29% (25%, 33%)



## Appendix D Supplier Interview Detailed Information

This section provides more detail on the supplier interviews, including how responses were used to calculate NTG ratios.

### D.1 SUPPLIER INTERVIEW NTG APPROACH

To estimate NTG, manufacturers and retail buyers answered a series of questions about what their sales of each bulb type would have been in the absence of the program. The relevant questions from the manufacturer interviews were as follows:

- Q1. During 2013 the Connecticut energy-efficient lighting program provided average buydown discounts of about [DISCOUNT AMOUNT] for every [BULB TYPE] bulb sold through the program. Are there any retailers or retailer categories that you worked with through the 2013 Connecticut lighting program that you think would not have been selling any [BULB TYPE] products if these discounts had not been available?
  - [IF YES] Which retailers or retailer categories?
- Q2. If these program buydown/markdown discounts and program promotional materials had not been available during 2013, do you think your sales of these types of bulbs through [RETAILER CHANNEL] stores in Connecticut would have been about the same, lower, or higher?
- Q3. By what percentage do you estimate your Connecticut sales of these [BULB TYPE] bulbs through [RETAILER CHANNEL] would be lower during 2013 if these program buydowns/markdowns and program promotional materials had not been available?
- Q4. I want to make sure I understand you correctly. You estimate that your sales would have been [% FROM QUESTION 3] lower without the program support. So if you actually sold 100 [BULB TYPE]s in a given week, you think you'd only have only sold about [100 - (% FROM QUESTION 3 \* 100)] in that period if the buydowns/markdowns hadn't been available?

If respondents said “Yes” to question one – that they would not have sold any of a particular bulb type within a particular retail channel the absence of the program – then we assumed that their NTG ratio for that bulb-channel combination was 100 percent and skipped following question. No respondents said their sales would be the same or larger without the program.

If a given market actor sold multiple types of bulbs (i.e., standard vs. specialty CFLs, or LEDs) through the program, then we asked this battery of 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 they participated in.

#### D.1.1 Weighting the NTG Estimates

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

In channels for which we had estimates from manufacturers and retail buyers, our default approach was to use sales through the program that each market actor category accounted for in order to

weight estimates to the channel-wide level. For example, if the sales-weighted NTG estimate from manufacturers accounted for 100,000 standard CFL sales, and the sales-weighted NTG estimate from retailer buyers accounted for 50,000 standard CFL sales, the manufacturer estimate would carry twice the weight of the retail buyer estimate.

In one case, we used the simple average NTG estimate by weighing each market actor category (manufacturers and retail buyers) equally

### D.1.2 Net-to-Gross Estimates

This section shows the net-to-gross estimates for the various lighting technologies sold through the Connecticut program.

The tables below show “recommended” program attribution for the “discount” and “other” retail channels were 100 percent for each bulb type. While this is a high number, we feel that these estimates are reasonable. Sales through the discount channel were predominantly in dollar stores and thrift stores, which would not have been able to sell these lighting products without the program, and sales through the “other” channel (mobile stores set up in places such as schools, malls, businesses, and at events such as fairs) would not have occurred without coordination by the program.

#### D.1.2.1 Standard CFLs

This subsection shows our calculated NTG ratios for standard CFL bulbs. Standard CFLs were the overwhelming focus of the program during this evaluation period, comprising almost three quarters (73%) of all program sales in Connecticut. The manufacturer and retail buyer estimates accounted for 82 percent and 21 percent, respectively, of the total sales of these bulbs.

Table 21 shows the channel-specific and program-wide NTG estimates for standard CFLs sold in Connecticut during the evaluation period. More than 60 percent of those sales came through the home improvement channel, with all other retail channels except for membership club and mass merchandise accounting for less than five percent of the total. The overall program-wide recommended NTG estimate for these bulbs was 68 percent.

**Table 21: Channel-Specific and Program-Wide NTG Estimates for Standard CFLs**

Retail Channel	Sales Represented by Estimates in Channel	# of Unique Estimates	NTG Estimates (Weighted by Program Sales)		
			Manufacturers*	Retail Buyers*	Recommended NTG
Discount	76,720	3	100%	100%	100%
Drug	3,165	1	80%	None	80%
Grocery	26,843	1	20%	None	20%
Hardware	3,783	2	40%	None	40%
Home Improvement	1,155,559	1	65%	None	65%
Mass Merchandise	167,180	2	50%	None	50%
Membership Club**	359,687	2	74%	74%	74%
Other***	84,739	1	None	100%	100%
All Channels	<b>1,877,676</b>	13			<b>68%</b>

\* Manufacturer estimates represented 82%, and retail buyer estimates represented 21%, of total sales.

\*\* Manufacturer and retail buyer estimates for the membership club channel came from representatives from the same company

\*\*\* "Other" channel includes events/fairs, schools, office buildings, malls, etc.

### D.1.2.2 Specialty CFLs

This subsection shows our calculated NTG ratios for specialty CFL bulbs. Specialty CFLs were the lowest-selling bulb type through the program, with just over 11 percent of total program sales. The manufacturer and retail buyer estimates accounted for 85 percent and 29 percent, respectively, of the total sales of these bulbs.

Table 22 shows the channel-specific and program-wide NTG estimates for specialty CFLs sold in Connecticut during the evaluation period. Sales of specialty CFLs were even more concentrated than standard CFLs, with over 90% coming through two retail channels (home improvement and membership club). The overall program-wide recommended NTG estimate for these bulbs was 55 percent. This number is smaller than our findings from evaluations of similar programs, and can be explained by an unexpectedly low estimate (40%) from the manufacturers selling to the home improvement channel (which made up more than half of total sales). It may be the case that, due to specialty CFLs' small program sales volume, their special application, and the relative lack of alternatives (as opposed to standard CFLs, which compete with a wider variety of technologies), these manufacturers feel that buyers of specialty CFLs would be likely to still purchase these bulbs without the program discounts.

**Table 22: Channel-Specific and Program-Wide NTG Estimates for Specialty CFLs**

Retail Channel	Sales Represented by Estimates in Channel	# of Unique Estimates	NTG Estimates (Weighted by Program Sales)		
			Manufacturers*	Retail Buyers*	Recommended NTG
Discount	4,591	2	100%	100%	100%
Grocery	1,579	1	20%	None	20%
Hardware	800	2	85%	None	85%
Home Improvement	168,924	2	40%	None	40%
Mass Merchandise	15,421	2	55%	None	55%
Membership Club**	103,645	2	75%	75%	75%
Other***	3,187	2	None	100%	100%
<b>All Channels</b>	<b>298,147</b>	<b>13</b>			<b>55%</b>

\* Manufacturer estimates represented 82%, and retail buyer estimates represented 21%, of total sales.

\*\* Manufacturer and retail buyer estimates for the membership club channel came from representatives from the same company

\*\*\* "Other" channel includes events/fairs, schools, office buildings, malls, etc.

### D.1.2.3 LEDs

This subsection shows our calculated NTG ratios for LED lamps. LED sales were slightly larger than those of specialty CFLs, accounting for almost 16 percent of total program sales. LED sales were the most concentrated of the three bulb types, with 98 percent of sales coming through the home improvement and membership club. The manufacturer and retail buyer NTG estimates accounted for 47 percent and 49 percent, respectively, of the total sales of these bulbs.

Table 23 shows the channel-specific and program-wide NTG estimates for LED lamps sold through the program during the evaluation period. It should be noted that for membership club, we used a simple average NTG estimate as our "recommended" ratio due to the retail buyer estimate being a surprisingly low number. Overall, the program-wide recommended NTG estimate was 74 percent, the highest of the three bulb types.

**Table 23: Channel-Specific and Program-Wide NTG Estimates for LEDs**

Retail Channel	Sales Represented by Estimates in Channel	# of Unique Estimates	NTG Estimates (Weighted by Program Sales)		
			Manufacturers*	Retail Buyers*	Recommended NTG
Grocery	2,170	None	None	None	None
Home Improvement	203,828	1	100%	None	100%
Lighting & Electronics	416	2	96%	None	96%
Membership Club**	196,437	3	75%	20%	47%
Other***	7,382	2	100%	100%	100%
All Channels	<b>410,233</b>	8			<b>74%</b>

\* Manufacturer estimates represented 82%, and retail buyer estimates represented 21%, of total sales.

\*\* Manufacturer and retail buyer estimates for the membership club channel came from representatives from the same company

\*\*\* "Other" channel includes events/fairs, schools, office buildings, malls, etc.