MEMORANDUM

To:	Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants
From:	Lisa Wilson-Wright, Lynn Hoefgen (NMR) and Doug Bruch, Bryan Ward (Cadmus)
Subject:	Net-to-Gross Estimates Based on Comparison Area Approach
Date:	March 29, 2015

The PAs and EEAC consultants requested that the Residential Retail Evaluation Team (the Team) estimate net-to-gross (NTG) ratios based on self-reported purchases of CFLs and LEDs gathered in the Spring and Summer of 2014 during on-site visits in Georgia, Eastern Kansas, and Massachusetts (performed primarily for the Market Assessment study). This memorandum describes the steps taken to develop a 2013 NTG value, based on based on 2013 self-reported purchases and 2013 program data. Results are presented based on each comparison state and averaged across the two states. Additionally, unlike the approaches in the other three NTG estimation tasks (i.e., Supplier Interviews, Demand Elasticity Modeling, and Point-of-Sale Data Modeling), we also estimate total net energy savings in order to account for the large number of direct install program bulbs found in Massachusetts homes taking part in the on-site visits. The NTG estimates described here will be integrated (via a mutually agreeable approach) with those from the other three estimates in an overall report to be delivered to the PAs and EEAC consultants as soon as possible.

Key Takeaway: The overall NTG estimate for all products taking both comparison areas into account is 65%. As explained more below, the Team believes this is the most reliable of the estimates developed from this approach, given the small sample sizes of comparison-area households and obvious anomalies in the data. The memorandum below presents ratios for individual products, including standard and specialty CFLs, CFL fixtures, and LEDs (both bulbs and fixtures).

ESTIMATION APPROACH

The comparison area approach represents a quasi-experimental study design in which Massachusetts is compared to one or more "control areas" that are meant to stand in for the Massachusetts' lighting market in the absence of the program. This approach to estimating NTG ratios requires three inputs:

1. Market-level[1] CFL and LED purchases in Massachusetts;

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

2. Market-level CFL and LED purchases in the comparison area, or in this case, areas;
3. Program-supported CFL and LED sales.

As operationalized for this study, the measurement of each of these inputs carries some potential for bias or inaccuracies. The Team obtained the first two inputs, market-level purchases in Massachusetts and comparison areas, through on-site visits to 261 households in Massachusetts (150 "new" visits and 111 "panel visits), 78 households in Georgia, and 67 households in Eastern Kansas.[2] These two inputs potentially suffer from two sources of bias.

First, the social, demographic, and economic characteristics of Eastern Kansas and Georgia differ from those of Massachusetts (e.g., education and income levels, population density, etc.), casting doubt on their suitability as comparison areas to Massachusetts and creating the potential for these differences to bias results. Although not "ideal" comparisons to Massachusetts, the PAs, EEAC consultants, and Team selected Georgia and Kansas as comparison to Massachusetts for the purposes of the Market Assessment and On-Site Saturation studies based on a mixture of demographics, program activity (or lack thereof in the case of Kansas), and access to prior saturation estimates (2009 in both states plus 2010 in Kansas). In short, they served as acceptable comparisons *for the purposes of the Market Assessment Study* based on the overall consideration of these various factors. However, after selecting those areas, the PAs, EEAC consultants, and Team decided to use data collected for the on-sites to develop NTG ratios, even though we recognized that the two states were not perfect "baselines" for Massachusetts for the purposes of calculating net savings. Because the Multistage NTG Study will integrate estimates from multiple methods, we concluded that it made sense to use the comparison areas, despite their shortcomings, to provide more information to the development of the final NTG estimates. To help compensate for these shortcomings, the Team weighted the Georgia and Kansas self-reported purchases to the demographics of Massachusetts (based on education and home ownership) to improve comparability.

The second source of bias and error concerns the method for estimating the first and second. During the on-site visit, the Team asks respondents to estimate when they purchased each CFL and LED found installed or in storage in the home. While we have found this approach to be more reliable than simply asking people how many bulbs they bought in a given time period, the Team recognizes that people still exhibit inaccurate recall of the estimated date of purchase.

For the third input, the Team relied on the PAs' filed estimates of total numbers of CFLs and LEDs supported by the program in 2013. The calculations considered sales of standard and specialty CFLs, screw-base LEDs, CFL fixtures, and LED fixtures. While these estimates provide the most reliable and unbiased of the three inputs, the PAs and Team understand that the lighting program tracking data may have some unrecognized errors (e.g., missing data, inaccurately designated product types, etc.) that could also affect the results.

[2] For more details on the on-site visits in all three states, see Cadmus, NMR, Tetra Tech, Navigant. 2015. *Results of the Massachusetts On-site Lighting Inventory 2014*. Final delivered to the PAs and EEAC Consultants March 2015. Hereafter referred to as the "On-site Saturation Report" throughout the text.

A few additional caveats must be kept in mind. First, Georgia Power does have a CFL lighting program serving a large portion of the state's population. Until recently the program had focused on marketing and education, coupled with some limited bulb give-aways and promotional events. However, Georgia Power began to provide upstream incentives for standard CFLs in 2013, moving 2,000,000 bulbs through the program in that year. However, at least some of those CFLs would have been purchased in the absence of the program (i.e., they represent freeridership). While an exact freeridership estimate for the Georgia Power program is not available yet, an evaluation team member for the utility suggested assuming a placeholder value of 60% freeridership rate,[3] meaning that 1,200,000 bulbs would have been purchased without the program, while the remaining 800,000 were truly program-induced purchases. Since we are treating Georgia as a non-program baseline for Massachusetts, we subtract the program-induced purchases from the total estimate of CFLs bought in Georgia in 2013, but we leave in the freerider purchases. Eastern Kansas does not have a program, and while neighboring Missouri does, there is little evidence of leakage from Missouri to Kansas, so we make no adjustments to Kansas purchases.

Second, the recent on-site visits to Massachusetts also revealed an important change from previous on-site studies: the proportion of CFLs and LEDs obtained through the PAs' direct install programs increased by a great deal (from 12% of newly obtained bulbs in 2012 to 35% in 2013).[4] While we preferred to adjust for direct installations in our counts of market-level sales, concerns about bias in the weighting scheme (i.e., a few households with very large weights unduly influencing estimates of bulb obtained through direct install programs) led us to adopt an approach that adjusted for direct-install bulbs in a manner that did not rely on evaluation-derived estimates of energy-efficient lighting distributed through the direct install program. We calculated total energy savings from the CFL and LED bulbs and fixtures obtained in homes in 2013 using the assumptions reported in the most recent Technical Resource Manual (TRM) and then subtracted out the energy savings claimed by the PAs for the direct install programs. We then applied the NTG ratio to the savings from bulbs and fixtures obtained through retail stores (or given to the participant by a landlord or acquaintance), yielding an estimate of net savings from the Residential Lighting Program. (We provide a walk-through of this approach later in this memo).

Finally, the Team found it necessary to isolate CFL and LED fixtures due to the extra step taken to calculate net savings, as per-product savings differ between bulbs and fixtures. The Team identified CFL and LED fixtures in two different ways. For CFLs, we counted all pin- and GU-based CFL bulbs as fixtures, assuming 1.5 bulbs per fixture (as the PAs do). For LEDs, as we did not anticipate needing the information, we did not ask on-site technicians to denote integrated fixtures or downlight retrofit kits. However, in some cases we could identify integrated fixtures because they lacked a screw base. We also attempted to estimate retrofit kits for recessed cans through a mixture of on-site and program data, but

[3] Georgia Power only supported standard spiral 60W incandescent bulbs in 2013. The PAs currently assume a freeridership rate of 57% for Massachusetts for such bulbs. Given that this is placeholder value, we rounded to 60%. If the Georgia Power NTG estimate becomes available prior August 1, 2015—the last date the PAs can consider information for the 2016 to 2018 plan—we will update this assumed freeridership rate and take it into account in any recommended NTG ratios for 2016 to 2018.

[4] Please see the On-site Saturation Report for detailed discussions of the reasons for this increase and its implications for energy-efficient socket saturation and use.

the lack of details from the on-sites yielded suspect results.[5]) Therefore, the Team used a placeholder assumption that one-half of the screw-base LEDs installed in recessed cans had been fitted with such kits. While the PAs and EEAC Consultants review this memo, the Team will attempt to see if it can use a mixture of the 2013 and 2014 on-site and program-supported product data to arrive at an empirically informed, reasonable, and believable estimate of market-level integrated LED fixture purchases and will update the savings estimates accordingly in our revisions. (The LED NTG will remain the same, as we calculate it for all LED products together, which matches PA practices and reduces error in designating which on-site LEDs are standard, specialty, or fixture types.)

Calculation and Estimates of Net-to-Gross

The market-level NTG calculation relies on the equation:

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

A few notes about this equation: First, because it represents market-level sales (i.e., every bulb obtained by residences in the three states), it accounts for both free ridership and spillover *but cannot isolate either of these NTG components*. Second, we calculate NTG ratios treating Kansas as the baseline, Georgia as the baseline (after subtracting the Georgia Power program-induced sales [800,000]), and then both together. This last approach theoretically balances some of the weaknesses of each state serving as a baseline for Massachusetts. When we use both together, we average their sales, again subtracting the Georgia Power program-induced sales.

[5] Some approaches estimated that the PAs sold more fixtures than households said they purchased in 2013; others suggested that every recessed can in the home was filled with a newly purchased program-supported downlight or retrofit kit. Neither of these seems like a realistic scenario. Therefore, without sufficient information, none of these approaches improved upon using a placeholder value.

Table 1 presents the estimated market-level purchases and program sales by product and state. It also lists the stored bulbs for Massachusetts by product, which we use later in the calculation of net energy savings.

Table 1. Net-to-Gross Inputs (plus Stored Bulbs for Energy Savings Calculations)

Bulb Type	Purchased/Obtained within the past year			Program Supported Bulbs in MA	GA Power Program-induced Purchases	MA Stored Bulb Obtained in Past Year
	Massachusetts	Georgia	Kansas			
Total # of CFL	11,649,842	7,182,786	10,274,021	5,916,119	800,000	3,309,942
# of Twist/Spiral CFLs/A-line	7,996,116	5,862,120	8,882,260	4,542,089	800,000	2,568,474
# of Specialty CFLs	3,349,489	1,320,666	1,351,726	1,160,063	0	712,209
# of CFL Fixtures	304,237	0	40,035	213,967	0	29,259
Total # of all LEDs	2,121,193	913,250	1,043,660	926,584	0	412,415
# A-line LEDs	644,530	886,596	106,640	365,996	0	242,466
# Other LEDs (mostly spot/flood)	1,191,579	26,654	664,329	311,501	0	154,541
# LED fixtures	285,084	0	272,691	249,087	0	15,408
All Products	13,771,035	8,096,036	11,317,681	6,842,703	800,000	3,722,357

Table 2 presents all of the calculated NTG ratios, showing an extremely large range from a low of zero (for standard CFLs in Kansas) to a high of 294% (for specialty CFLs in Kansas). The most complicated NTG calculation is the one for all products, so we use it to provide an example.

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

$$NTG = \frac{13{,}771{,}035\ - \frac{(8{,}096{,}036 - 800{,}000) + 11{,}317{,}681}{2}}{6{,}842{,}703} = 0.65$$

We found some unexpected results—namely, high self-reported purchases of standard CFLs in Kansas (4.1 per household compared to 3.1 for Massachusetts and 2.7 for Georgia), and low specialty CFL purchase rates in both Georgia (0.7 per household) and Kansas (0.6) compared to Massachusetts (1.0); each of these results has a clear impact on the resulting NTG ratios as described below.[6] Some of these results may stem from greater than expected variance due to low sample sizes of on-site households in Georgia (n=78) and Kansas (n=68).[7] The low specialty CFL purchase rates stem at least in part from the small proportions of specialty sockets found in the participating homes in Kansas. Another factor partially explaining the high self-reported purchases in Kansas may be the greater presence of Walmart stores, which, since 2007, have aggressively promoted efficient lighting. This retailer has a much stronger presence in Kansas than in Georgia and Massachusetts as discussed in more detail in the On-site Saturation Report. Additionally, the savings calculations described below incorporate the gross savings reported by the PAs for both the residential retail and direct install programs; the numbers provided to the Team do not differentiate between products. Considering each of these factors, the Team believes that the strongest estimate is the one that takes all products and both states into account, or a NTG ratio of 65%. Note that we are **not recommending** this value, as the values presented here will be taken into consideration together with those developed from the other three estimation methods when the PAs, EEAC consultants, and Team devise a method to integrate the NTG ratios resulting from all four research tasks.

[6] Note that the LightTracker Point-of-Sale data confirm high purchases in Kansas.

[7] As outlined in the On-site Saturation Report, the Team wanted to visit 100 homes in each area, but we experienced difficulties in recruiting households for the on-sites, resulting in the lower than desired sample sizes in each comparison state.

Table 2. Estimated NTG Ratios

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

* These values are actually negative but the Team interprets the result as indicating KS consumers are "catching up" to the sales MA consumers made in prior years.

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

Calculation and Estimates of Gross and Net Savings

As mentioned above, when calculating NTG ratios, the Team had to consider the best way to address the numerous bulbs that Massachusetts households reported obtaining from direct install programs in 2013. Of the 11.7 million CFLs and LEDs obtained by Massachusetts on-site participants, our estimation methods suggested that 4.0 million CFLs and 690,000 LEDs had been obtained through direct install programs (based on where households told us they had obtained the bulbs). In reality, the PAs distributed only about 1.8 million CFLs (including bulbs and fixtures) and 157,000 LEDs (also including both bulbs and fixtures), so clearly our approach overestimates the products obtained through direct install programs.

The root of the problem with the weighting scheme is that some households obtaining large numbers of direct install bulbs (i.e., the program replacing every inefficient bulb installed in the home with a CFL) also received large weights due to either a relatively low education level, because they rented, or both. Although the Team is currently engaged in a process of improving this weighting scheme, the one we used for the current evaluation is comparable to the scheme we have been using since 2009. Therefore, rather than scrap the weighting scheme (recalling that comparability to prior years was essential for the Market Assessment and Saturation Stagnation studies), the Team decided to keep the direct install bulbs from Massachusetts in the calculation of NTG ratios but adjusted for these bulbs through the calculation of net savings for the retail program.

To accomplish this, we first calculated the energy savings resulting from all 2013 CFL and LED bulb and fixture purchases using inputs from the recent TRM (Table 3).

Table 3. Assumptions for Energy-savings Calculations

PA assumptions for the Residential Lighting Program Savings Calculations	ΔkWh 2014 in TRM assuming 1022 annual op hours
CFL bulbs	52.1
Aline LED bulbs	44.3
CFL fixtures	76
LED fixtures	66

The PAs provided us with lighting-derived gross and net savings for 2013 for each of the residential programs that distributed lighting products in that year (Table 4).

Table 4. 2013 Gross and Net Savings Claimed from Residential Programs

Program	Sum of Gross kWh Savings	Sum of Annual Net MWh Savings
Low-Income Multi-Family Retrofit	14,394,165	14,233
Low-Income New Construction	460,557	919
Low-Income Single Family Retrofit	8,237,457	7,824
Residential Home Energy Services	61,823,525	46,923
Residential Multi-Family Retrofit	21,420,113	25,623
Residential New Construction	7,322,715	7,486
Direct Install Only	***113,658,532***	***103,008***
Residential Lighting	***346,732,451***	***199,857***
GRAND TOTAL	**460,390,983**	**302,866**

The final steps involved the actual calculation of gross and net savings. After subtracting 2013 purchases found in storage, we multiplied the products obtained by Massachusetts on-site households (as reported in Table 1) by the appropriate TRM values in Table 3. This yielded the first-year gross savings of all installed 2013 purchases found in the home (Row 1, Table 5). Second, we subtracted the gross savings claimed for the direct install programs (Row 2), yielding the gross savings for the all installed 2013 CFL and LED purchases found in the on-site homes (Row 3). In the final step, we applied the NTG ratio for all products, yielding net savings pf 266,841 MWh for all residential products found in the home (Row 4 in kWh and Row 5 in MWh). This final estimate of savings is about 67,000 MWh more than claimed by the PAs for the Residential Lighting Program (199,857 MWh), which is fairly close considering the biases found in the data and the necessity of using placeholder values in both the NTG and energy savings estimations.

Table 5: Calculating Net Savings

Savings Calculations - based on TRM	CFLs	LED	All Products
Row 1. Gross Savings for Installed Products	441,080,764	81,550,835	522,631,599
Row 2. Gross Savings Claimed for Direct Install			113,658,532
Row 3. Gross Savings from Retail Program, Market Purchases			408,973,067
Row 4. Application of Overall NTG = 65%			266,813,853
Row 5. Converted to MWh		n/a	266,841