Multifamily Program Improvement Strategies

Preliminary Results – Summary of Task 2b and 3 Findings

Prepared for:

The Electric and Gas Program Administrators of Massachusetts
Part of the Residential Evaluation Program Area

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EXECUTIVE SUMMARY

Project Background

The goal of the overall *Multifamily Program Improvement Strategies* study is to identify actionable strategies and innovations to improve the multifamily program performance, realization rates, and overall program cost-effectiveness for both the residential and commercial sectors.

The research is intended to provide context for the multifamily program's most recent billing analysis impact evaluation, which resulted in a low realization rate for electric savings[1]. Additionally, the program is struggling to maintain cost-effectiveness while providing comprehensive services equitably across the market to different building sizes, ownership structures, and heating fuel types.

The focus of this report, prepared as the Task 4 *Preliminary Results Memo,* is to identify implementation changes which will result in rapid improvements in program performance. As lighting accounts for 92% of program savings, the lighting end use has been a primary focus of Navigant's research, with the preliminary findings presented in this report emanating from tasks 2b, 3a, and 3b as illustrated in Table 1.

Table 1. RES 42 Multifamily Program Improvement Strategies: Project Task Description and Status

Task	Description	Status
1	Finalize Stage 3 Work Plan and Conduct Kick-off Meeting	Complete
2a	Massachusetts Multifamily Program Documents	Memo, 1/13/2017
2b	**Technical Resource Manual (TRM) Multifamily Measure Characterization**	**Preliminary Findings**
2c	Tailoring Delivery Based Upon Building Science	Memo, 1/13/2017
3a	**Lighting Baseline and Delta Watts**	**Preliminary Findings**
3b	**On-Site Verification**	**Preliminary Findings**
4	**Preliminary Results Memo: Summary of Task 2 & 3 Findings**	**Preliminary Findings**
5	National Literature Review: Innovative Practices	To be developed
6	Peer Utility Program Manager Interviews	To be developed
7a.	Current Program Cost Effectiveness Inputs	To be developed
7b	Projected Program Cost Effectiveness Inputs	To be developed
Opt 7c.	Develop and incorporate fuel switching measures into Projected Program Inputs	To be developed
8	Final Reporting	To be developed
9	Project Management	In progress

A summary of activities incorporated into this report include:

[1] DNV GL (August 3, 2016). *2013 National Grid Multifamily Program Gas and Electric Impact Study.*

- **Task 2b: Technical Resource Manual Multifamily Measure Characterization**[2]. The two primary activities in this task include a review of existing measure characterizations to improve accuracy of multifamily program claimed savings, and to identify opportunities to increase program savings.
- **Task 3a: Project Verification, Lighting Baseline and Delta Watts.** This task analyzed specific direct installation lighting data, as reported to Navigant from implementation contractors (ICs). The reported data (including product location, baseline and efficient wattage) allowed comparison of the on-site project baselines and program activity with deemed values from the Technical Resource Manual (TRM).
- **Task 3b: Project Verification, On-Site Verification**. Navigant conducted ride-along site visits with the Program Administrator (PA) Quality Assurance (QA) Vendor to assess baseline conditions, identify missed opportunities, and confirm reported measure installation.

Concurrent with the research results presented in this report, the Team has developed preliminary findings from Task 2a (Program Research Review) and Task 2c (Tailoring Delivery Based on Building Science). These have been distributed to stakeholders through separate draft memorandums; while not included with this preliminary report, relevant findings have served to inform the research, findings, and suggested strategies contained herein.

Summary of Preliminary Findings and Suggested Multifamily Program Improvement Strategies

The strategies suggested in this report are limited to the results of project tasks 2b and 3. Additional analysis of cost effectiveness and comprehensive impacts will be incorporated as part of Task 7 to inform and formalize the final project recommendations.

Table 2. Preliminary Findings and Suggested Improvement Strategies

Preliminary Findings	Suggested Strategies
• Specific to the non-low-income multifamily program, deemed lighting measure values (hours of use, location, and delta watts) combine to overstate lighting savings by 20%. • In unit lighting hours of use does not reflect partial occupancy for seasonal use properties.	1. **Adjust In-Unit lighting hours of use**. a. Apply the Massachusetts Non-Low-Income Multifamily specific hours of use (HOU) value of 2.2 hours/day from the NERHOU study[3] to in-unit lighting measures. b. Consider using location-specific HOU to improve accuracy of savings estimates. c. Apply an "Occupancy Adjustment Factor" to reduce energy savings in consideration of part time or seasonal use.

[2] The Massachusetts Technical Reference Manual can be found at http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

[3] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*.

• Site specific hours of use can have a significant impact on common area lighting energy savings as compared to deemed hours of use values.	2. **Use site-specific HOU for common area lighting retrofits.** Improve accuracy of common area lighting savings estimates through applying site specific HOU, determined in consultation with on-site staff.
• Low hours of use locations account for 46% of in-unit lighting savings, effectively reducing the average of HOU and savings for installed bulbs.	3. **Continue to explore prioritizing lighting retrofits to high hours of use locations**. Reducing or eliminating light bulb installations in low use areas (such as in-unit hallways, bathrooms, and bedrooms) will increase average HOU and energy savings. The strategy needs to be balanced with resulting reductions in overall project savings; the final recommendation will be informed and updated by the subsequent cost effectiveness analysis, expected in task 7.
• Project documentation and project transfer between the ICs, QA Vendor, and PAs is not sufficient to ensure accurate energy savings estimates are reported, verified, and ultimately claimed by the program. • Verification results are not consistent. • Verification results are not clearly understood by stakeholders. Stakeholders do not rely on a routine or replicable mechanism to address discrepancies or update the PA database based on QA Vendor findings.	4. **Strengthen project reporting and verification procedures**. a. Require Implementation Contractors (ICs) to report to both PA and QA Vendor the specific location for each installed bulb. Standardize project reporting documentation across utilities and vendors to improve documentation clarity and accuracy for all stakeholders. b. Clearly define the definitions of verification results (i.e.: when to use “Pass”, “Pass with Note”, and “Fail”). Standardize expectations for routine follow-up actions based on verification findings for all stakeholders. c. If verified results differ from reported results, the IC should provide documentation or explanation to the QA Vendor, including follow-up on-site visits with both stakeholders as appropriate. QA Vendor should then verify corrected results. d. Update program database to reflect final, verified measures and savings. e. As a method to prioritize verification activities and information flow across stakeholders, PA’s could consider compensating IC’s for results verified by QA Vendor. Note: As a result of the preliminary project reporting and verification findings detailed in this report, the PA’s and MF Working Group is actively updating QA procedures including formalizing data transfer protocols and improving QA access to detailed project tracking data.

• Building owner and property manager expectations are not aligned with program goals to diversify end use measure mix. • Building owners and property managers are not prepared to coordinate residents or facilitate verification visits. • Building owner and property managers are not motivated to engage in projects which do not result in energy savings (due to split incentive) or the work may be disruptive to owner occupants or tenants. Auditors perceive pursuit of additional measures to be not worth their time with these customers.	5. **Shift customer expectations to incorporate additional measures into projects**. Customer outreach and program marketing should target property owners and managers with messaging to build the case for projects with multiple end uses for both common areas and in-units. Ensure customers are aware of the entire project process, including verification site visit expectations. Consider structuring incentives to reward property owners who intentionally increase energy savings per unit.
• Lighting controls are not identified or prioritized for retrofit at time of audit. • HVAC end uses are not prioritized through standard project activities. • Building owner and property manager expectations are not aligned with program goals to diversify end use measure mix.	6. **Reinforce auditor training to identify and complete additional measure types**. To encourage additional, non-light bulb measure installations, prioritize **substantive and regular training** for project teams, specifically auditors. Training should include: a. Programmatic and technical trainings to ensure auditors are knowledgeable about all program offerings, prioritize accurate data entry, and understand how their work affects other aspects of project and program results. b. Sales trainings, to support auditors in promoting program goals and persuading property owners to take additional steps. 7. **Incorporate lighting controls into projects**. When lighting controls exist, ensure HOU reflect the estimated reduction from control use. When lighting controls do not exist, prioritize their incorporation with product incentives and technical training for auditors.

- Measure characterizations in the Technical Reference Manual could be edited to serve fuel oil and propane fuels; incorporate additional measures to diversify the end uses and measures available to the multifamily program, and fine tune savings estimates.

8. **Update Technical Resource Manual**. The edits and adjustments to measures provided in this report will improve accuracy and enhance the multifamily program offerings. Edits include:
   a. Lighting HOU and occupancy adjustment factors.
   b. Incorporate fuel oil and propane into natural gas measures.
   c. Incorporate measures offered by the Low Income Multifamily program into the Non-Low Income Multifamily program to leverage the multifamily program resources already invested in properties, increase end uses and measure diversity; and improve measure consistency across programs.

1. PROJECT VERIFICATION: LIGHTING BASELINE AND DELTA WATTS

Over 90% of multifamily electric savings is derived from lighting retrofits. Due to the very low realization rate[4] for the overall program, lighting must be considered the primary source of discrepancy between reported and verified savings results. The purpose of Task 3a was to analyze project specific lighting data directly from implementation contractors (IC), including installation location, baseline and efficient product watts. Navigant analyzed the reported data to assess delta watts, investigate the impact of retrofit location on program savings, and compare project specific findings to deemed values in the technical reference manual (TRM).

Historical IC data reporting activities to both the program administrators (PAs) and Quality Assurance (QA) Vendor has included only the total quantity of measures installed at a given property (e.g. 600 bulbs were installed across a 100-unit property), with no additional detail. ICs have not specified key measure criteria to verify on-site savings: including the apartment or room of installation; baseline equipment type or wattages; or whether the baseline or efficient fixtures incorporated any control equipment (motion or daylight sensors), etc.

1.1 Methodology

1.1.1 Data Collection

Data reported to the verification vendor includes the type, wattage, and quantity of efficient lighting products, and whether they were installed in a common area or in-unit. As measure level data is not currently available to the PA's or QA vendor, Navigant requested detailed recording and reporting of measure level data for the period of this study. ICs submitted data for each lighting retrofit completed from November 7, 2016 through January 6, 2017. Navigant provided data collection forms to ensure data consistency across utilities, vendors and contractors. The forms were submitted directly to Navigant for data input and analysis. The data collection documents used for this task are provided in Appendix A.

IC on-site representatives recorded and submitted detailed data for each retrofitted light bulb or fixture totaling 12,906 retrofitted light bulbs (or light fixtures)[5] in 1,161 tenant occupied in-unit apartments or condominiums. Additionally, 1,430 retrofitted light bulbs or fixtures were reported in common areas such as hallways, lobbies, stairs, and laundry rooms, etc. A database of the results from all projects submitted over the evaluation period was created for analysis.

A summary of bulb distribution across reported projects, apartments, and common areas is shown in Table 3.

[4] DNV GL (August 3, 2016). *2013 National Grid Multifamily Program Gas and Electric Impact Study.* "Realization rate of 24.4% with a precision of ±49.3% at the 90% confidence interval."

[5] ICs retrofitted both individual bulbs and entire fixtures. The savings analysis compared baseline bulbs to efficient bulbs, regardless of whether an entire fixture was replaced.

Table 3. Summary of Reported Retrofit Projects

Vendor	Projects	Residential Apartments / Condos Reported	Common Areas Reported[6]
CLEAResult	18	504	58
Rise	26	657	29
Total	**44**	**1,161**	**87**

Data collection was gathered and reported by the ICs specifically for this study. The intent of savings estimates developed through the subsequent data analysis are limited to identification of potential discrepancies between on-site conditions and deemed values. The results of this activity are specifically not intended to be compared with program administrator (PA) savings claimed during this period. The research was not intended to confirm that all IC reported bulbs were invoiced to the PAs, and vice versa that all PA invoiced bulbs were reported to the QA Vendor or evaluation team. Additionally, none of the retrofitted bulbs reported by the ICs to Navigant had received verification by the PA QA Vendor as the reporting to Navigant was in advance of, and separate from, IC reporting to the QA Vendor and PA's.

To assess measure and project level savings, IC's used Navigant's data collection form to collect and report data for each bulb including:

- Project information: project name, address, ownership type (condo or rental)
- Retrofit location:
    - Common area room type: e.g. lobby, hallway, stairs, office, mechanical, laundry, etc.
    - In-unit room type: e.g. kitchen, living room, bedroom, hallway, bathroom, exterior door
- Baseline bulb data: type, watts, and quantity
- Replacement efficient bulb data: type, watts, and quantity
- Lighting Controls: presence of existing or installed occupancy sensors or daylighting controls

1.1.2 Data Analysis

Analysis was conducted to assess key on-site conditions which could contribute to the discrepancy between historical reported savings and the recent verified program savings[7]. Key conditions considered include reported delta watts (between baseline and efficient lighting products) and HOU. The analysis was completed at the room level, to align detailed HOU with the IC reported delta watts by room (based on lighting retrofit data reported directly to Navigant for this study by IC's as summarized in Table 3).

The first calculation determined the total reported kWh savings based on deemed delta watts and HOU values from the Technical Reference Manual (TRM). To refine the savings estimate and identify potential sources of discrepancy, subsequent calculation iterations were conducted using the IC reported delta watts per room. These iterations were calculated using HOU-per-room estimates from the Northeast

[6] Definitions of reported common areas varied among ICs. For example, 'Hallway' may have been reported as a short hall with two fixtures in one project, and reported as the combination of three long hallways on three floors of another project. The definition variance in the reported data affects the accuracy of the quantity of common areas, however does not affect the analysis of delta watts. Table 3 reflects the quantity of common area data entries reported by ICs.

[7] DNV GL, (August 3, 2016) *2013 National Grid Multifamily Program Gas and Electric Impact Study*

Residential Hours-of-Use Study[8], and compared to the results of the first calculation which used deemed delta watts, to identify differences in savings estimates.

1.2 In-Unit Lighting Findings

1.2.1 In-Unit: Reported Baseline and Delta Watts

Analysis of IC reported data indicates an average in-unit lighting baseline wattage of 61.1 watts and an average efficient replacement bulb wattage of 10.4 watts, resulting in an average delta of 50.7 watts per bulb (Table 4). The reported delta watts per bulb is within 5% of the TRM deemed delta watts per bulb of 48.3 watts.

Table 4. Average Reported In-Unit Bulb Watts

Average baseline watts per bulb	Average replacement watts per bulb	Average delta watts per bulb
61.1	10.4	50.7

Average in-unit delta watts across most room types are within a narrow band between 52 and 62 watts. The exception is bathroom lighting, with an average of 32 delta watts. The lower delta watts found in bathrooms is due to the presence of vanity light fixtures, which typically have a higher quantity of lower wattage bulbs per fixture. Average delta watts and measure frequency by room type is illustrated in Figure 1.

Figure 1. Average In-Unit Delta Watts / Bulb and Measure Frequency

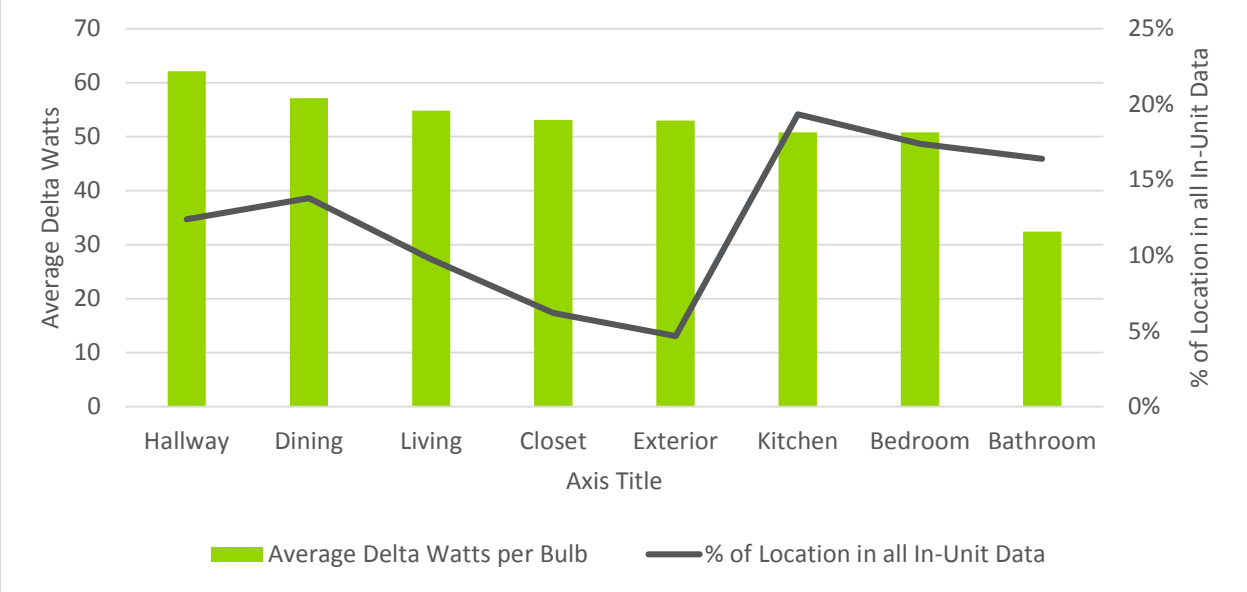
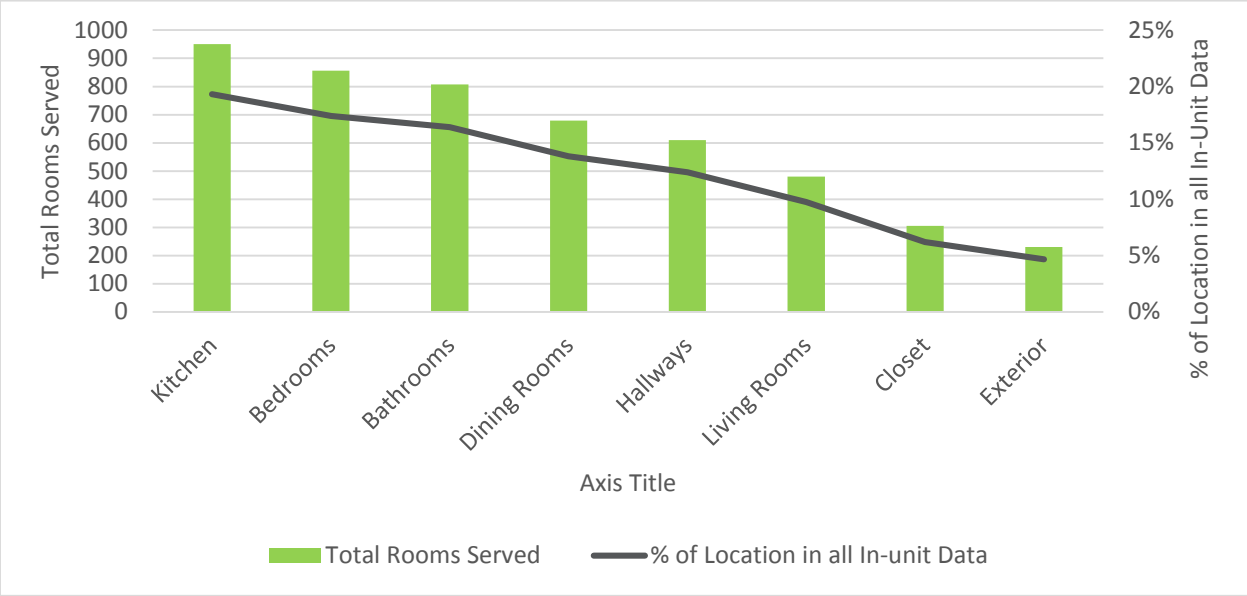


Figure 2 illustrates the variety of in-unit lighting retrofit locations reported by ICs. While exterior fixtures have a high reported delta watts, they account for the smallest percentage of installations.

[8] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*.

Additionally, while rooms such as closets, hallways, and bathrooms with lower HOU account for 35% of combined lighting installations (6.2%, 12.4%, and 16.4% respectively), these locations account for over 46% of all installed bulbs (3.8%, 17.4%, and 25.2% respectively). This percentage of lighting retrofits in low HOU locations has the effect of reducing average installed per/bulb HOU below the current deemed value of 2.7 hours per day (see discussion in section 1.2.3). To the extent this study's findings are representative of recent typical program practices, the findings suggest a partial explanation of the low realization rates found in the recent billing analysis. Since this study commenced, some PAs have directed ICs to cease retrofitting lighting products in low use areas, including closets, hallways and bathrooms.

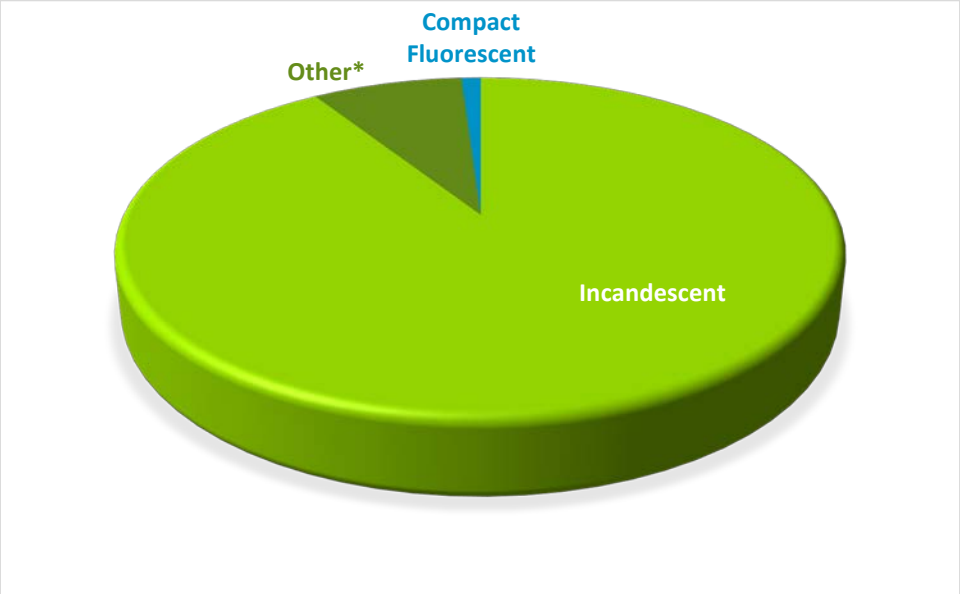
Figure 2. In-Unit Bulb Installation Locations



Existing in-unit bulbs retrofitted by the program were predominantly incandescent (Figure 3). Note this finding is not representative of all existing lighting in multifamily fixtures or the evaluation period for the recent impact evaluation[9]. Rather the baseline product findings represent the retrofitted product data submitted to Navigant for this study. "Other" existing lighting bulbs reported were predominantly 4' linear fluorescent products, located in kitchens; one project in particular was responsible for the majority of this product type. While IC contractors reported replacing some CFLs with LEDs, this accounted for only 1% of retrofits.

[9] DNV GL, (August 3, 2016) *2013 National Grid Multifamily Program Gas and Electric Impact Study*

Figure 3. In-Unit Lighting Products: Replaced Baseline Bulbs



**Predominantly linear fluorescent bulbs, in kitchen areas.*

1.2.2 In-Unit: Reported Lighting Savings Assessment

Four calculations were utilized to estimate savings results from the reported lighting retrofits. The purpose of this analysis was to compare the use of deemed savings methodology with location and delta watts data obtained through IC reported activities. Average, deemed HOU in the TRM are referenced from the Northeast Residential Hours-of-Use Study; the room-specific and adjusted HOU reference results from the same study. The calculations resulted in:

1. A savings estimate based on deemed HOU and deemed delta watts.
2. A savings estimate based on deemed HOU and average of reported delta watts.
3. A savings estimate based on room-specific HOU and reported room-specific delta watts.
4. A savings estimate based on adjusted room-specific HOU and reported room-specific delta watts.

1.2.2.1 In-Unit Savings: Deemed Values

The preliminary savings estimate for all in-unit lighting products was calculated using TRM deemed values for delta watts (48.3 watts) and HOU (2.7 hours / day). Delta watts reported by ICs for the analysis period are 50.7. Comparison of the difference between reported and deemed delta watts, using constant deemed hours-of-use values, indicates program savings would be 5% higher than deemed savings claims. The higher reported delta watts identified and illustrated through calculations 1 and 2 are contradictory to the 2013 impact evaluation[10] results (24.4%realization rate). Further analysis of HOU to address this apparent contradiction are presented through calculations 3 and 4, below. Preliminary savings estimate values are shown in Table 5 for calculations 1 and 2.

[10] DNV GL, (August 3, 2016) *2013 National Grid Multifamily Program Gas and Electric Impact Study*

Table 5. Deemed Savings Analysis

Calc.	Delta Watts: Source	Delta Watts	Total Bulb Quantity	Deemed Hours / Day	Total Estimated Savings (kWh/year)
1	TRM Deemed	48.3	12,906	2.7	614,321
2	Reported Average	50.7	12,906	2.7	644,846
	Difference:	**2.4 (5%)**	*constant*	*constant*	**30,525 (5%)**

1.2.2.2 In-Unit Savings: Reported Delta Watts with Location-Specific Hours of Use

The third estimated savings calculation completed by Navigant is based on analysis of IC reported, location-specific, in-unit delta watts. These reported location-specific delta watts values are applied to location-specific HOU values from the Northeast Residential Hours-of-Use Study. Energy savings results based on location-specific delta watts and HOU (calculation 3) is estimated at 597,498 kWh / year. This represents an estimated savings *reduction* of 3% as compared to historical reporting based on deemed delta watts and deemed HOU (shown in calculation 1).

Table 6. Weighted In-Unit Savings Estimate
In-Unit Reported Delta Watts with Location-Specific Hours of Use

Calc.	Room	Total Bulbs Replaced by Room Type	Reported Delta Watts	Location - Specific Hours[11]	Savings (kWh/year)
	Bedroom	1,477	50.8	2.0	54,773
	Bathroom	3,251	32.4	1.8	69,203
	Kitchen	2,437	50.8	4.0	180,747
	Living	1,129	54.8	3.3	74,521
	Dining	1,590	57.2	2.7	89,629
	Exterior	281	53.0	5.5	29,898
	Other: Closet	489	53.1	1.7	16,115
	Other: Hallway	2,252	59.1	1.7	82,584
3	**Average**		**50.7**	**2.7**	
3	**Total**	**12,906**			**597,498**

Location-specific HOU for closets were not established by the Northeast Regional Hours-of-Use Study. Due to the quantity of reported light bulb retrofits in closets, Navigant analyzed closet savings using an estimated .5 hours per day to assess the impact of closet retrofits on overall in-unit lighting savings. Closet light bulbs represent 3.8% of all retrofitted bulbs reported; closet lighting savings is estimated at 4,739 kWh / year using the estimate .5 hours per day, or less than 1% of calculated savings. Using the

[11] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*.

TRM deemed value of 2.7 hours per day, closet lighting savings would be estimated at 25,589 kWh / year, or 3.6% of in-unit lighting savings, as indicated in Table 7.

Table 7. Impact of Closet Hours of Use

Hours of Use Source	Bulb Quantity	Reported Delta Watts	Hours of Use	Estimated Savings (kWh/year)
TRM HOU:	489	53.1	2.7	25,589
NERHOU Study, "Other" category:	489	53.1	1.7	16,112
Navigant estimated HOU:	489	53.1	0.5	4,739
Closet savings reduction between TRM and Navigant estimated HOU:				20,851
Closet savings reduction (20,851 kWh/year) as percentage of TRM deemed values				81.5%
Closet savings reduction (20,851 kWh/year) as percentage of location based HOU (calculation 3):				3.6%

1.2.2.3 In-Unit Savings: Reported Delta Watts with Adjusted Location-Specific Hours of Use

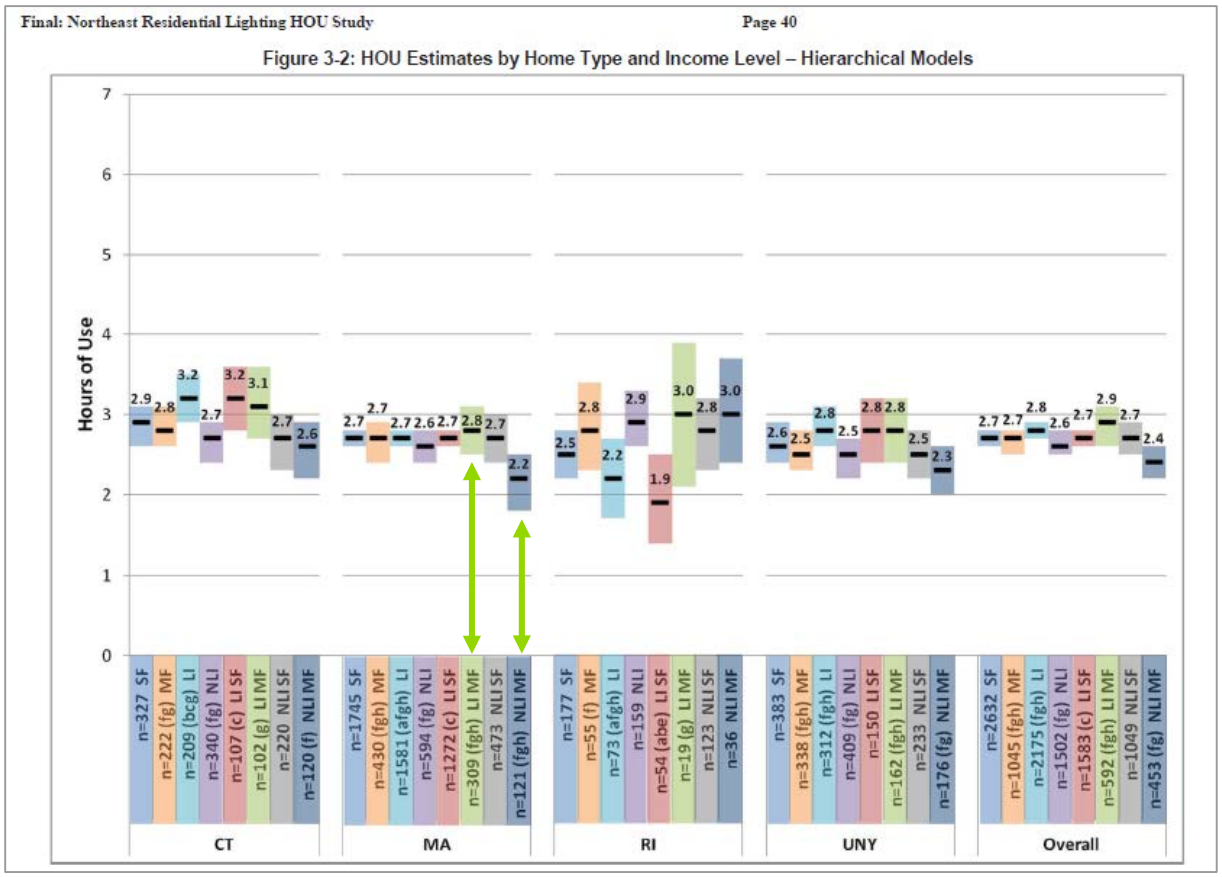
The TRM deemed HOU value is 2.7 for all Massachusetts housing types and income levels. The deemed value is based on the Northeast Residential HOU Study, and applicable for most Massachusetts housing types and income levels (see Figure 4); single family, multifamily, low-income single family and non-low-income single family housing types all rely on an average of 2.7 HOU per day.

However, the HOU Study found that the Massachusetts non-low-income multifamily properties are an outlier with respect to other housing types, and to multifamily housing in other states, averaging just 2.2 hours per day, as illustrated in Figure 4. This difference in the non-low-income multifamily HOU indicates the Massachusetts program may be overstating in-unit lighting savings by 18.5%. The HOU study states:

> *"HOU estimates for non-low-income multifamily households in Massachusetts are significantly lower compared to those for single-family, low income, and low-income single family households in Massachusetts."* [12]

[12] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*, Section 3.3, HOU Estimates by Home Type and Income Level, p. 38

Figure 4. Northeast HOU Study, Figure 3-2:
HOU Estimates by Home Type and Income Levels



For comparison, Navigant adjusted the TRM deemed HOU per specific room location by the findings for Massachusetts non-low-income multifamily housing from the HOU Study. Hours were reduced by 18.5%, as illustrated in Table 8.

Table 8. Adjusted Hours of Use for Massachusetts Non-Low Income Multifamily Housing

Room	TRM Deemed HOU	Adjusted HOU[13]
Bedroom	2.0	1.6
Bathroom	1.8	1.5
Kitchen	4.0	3.3
Living	3.3	2.7
Dining	2.7	2.2
Exterior	5.5	4.5
Other: Closet	1.7	1.4
Other: Hallway	1.7	1.4
Average	**2.7**	**2.2**

[13] Room-specific HOU were reduced by 18.5%, based on comparison of the deemed 2.7 hours/day across all residential uses and building types with the 2.2 hours/day specific to MA Non-Low-Income Multifamily housing from the NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*.

Estimating the energy savings based on IC reported delta watts and the adjusted HOU per location further reduces the in-unit lighting savings. Table 9 illustrates the values used to estimate in-unit lighting savings totaling 489,948 kWh / year for calculation 4, a 20% *reduction* as compared to the deemed values shown in calculation 1.

Table 9. In-Unit Reported Delta Watts with Adjusted Location-Specific Hours of Use

Calc.	Room	Total bulbs replaced by room type	Reported Delta Watts	Adjusted Location - Specific Hours[14]	Savings (kWh / year)
	Bedroom	1,477	50.8	1.6	44,640
	Bathroom	3,251	32.4	1.5	56,401
	Kitchen	2,437	50.8	3.3	147,309
	Living	1,129	54.8	2.7	60,735
	Dining	1,590	57.2	2.2	73,048
	Exterior	281	53.0	4.5	24,367
	Other: Closet	489	53.1	1.4	13,215
	Other: Hallway	2,252	59.1	1.4	67,306
4	**Average**		**50.7**	**2.2**	
4	**Total**	**12,906**			**489,948**

1.2.3 In-Unit Lighting Savings: Summary of Key Findings

Low Hours of Use locations account for 46% of in-unit lighting savings. While lighting accounts for over 90% of program savings, 46% of reported in-unit lighting was installed in locations with low HOU such as closets, hallways, and bathrooms. Eliminating the retrofitting of lighting in low-HOU locations (such as in-unit hallways, bathrooms, and bedrooms) from the program offerings will have the effect of increasing average in-unit lighting savings by 19%. Eliminating these retrofit bulbs removes the low-HOU locations from the average, which would effectively increase the current deemed value from 2.7 hours per day to 3.2 hours per day. Conversely, while increasing average per measure savings, this adjustment will decrease overall program savings by reducing the number of bulbs replaced.

In-Unit lighting savings has been overstated by 18.5% compared to the HOU Study. Applying location-specific, updated non-low-income multifamily hours of use and delta watts reduces claimed savings by 20%. Applying location-specific HOU (as adjusted by the Massachusetts non-low-income multifamily housing type), with the reported location-specific delta watts reduces the estimated deemed savings claim by 20% (Table 10). This reduction is inclusive of the higher delta watts (50.7 watts) identified in through IC reporting to Navigant, in comparison to the deemed value (48.3 watts).

[14] Ibid.

Table 10. Summary of In-Unit Lighting Findings

Calc.	Delta Watts	Delta Watts: Source	Hours / Day	Hours / Day: Source	Total Estimated Savings (kWh/year)
1	48.3	TRM Deemed	2.7	• TRM Deemed	614,321
2	50.7	Reported Average	2.7	• TRM Deemed	644,846
3	32.4-59.1	Reported Average, Location-Specific	0.5 – 5.5, (average 2.7)	• NERHOU Study • Location-Specific	**597,498**
4	32.4-59.1	Reported Average, Location-Specific	0.4 – 4.5, (average 2.2)	• NERHOU Study • Location-Specific • NLIMF Adjusted	489,948
Difference between Calculation 1 *(deemed values)* and Calculation 4 *(location-specific values adjusted for Massachusetts non-low-income multifamily housing)*				**kWh/year**	**124,372**
				Percent	**20%**

1.3 Common Area Lighting Findings

The MA Technical Reference Manual addresses multifamily common area lighting through the residential measures “Lighting – Bulbs” (page 150) and “Lighting - Fixtures” (page 152). Different from the in-unit lighting measures, to estimate savings both measures require custom analysis of pre-retrofit product watts, efficient product watts, and pre and post product quantities. Unlike in-unit lighting, there is no deemed delta watts for multifamily common area lighting.

The TRM recommended default HOU are 12 hours / day for exterior, and 24 hours per day for interior applications, to be used if vendor-estimated values are not available. The TRM directs, “*Operating hours are estimated by the vendor for each facility…Estimates are verified with facility maintenance staff when possible*.”

1.3.1 Common Area: Reported Baseline and Delta Watts

Through this study, ICs reported installing 1,430 retrofitted bulbs/fixtures in 319 individual common areas at 44 project sites. For each retrofitted bulb/fixture the ICs reported to Navigant the baseline and retrofit lighting product quantities, lighting type, and wattage. The reported retrofits indicated that de-lamping occurred frequently; this study did not investigate how (or whether) electric savings from de-lamping was reported to the program[15].

The analysis indicates common area locations with the highest delta wattage are some of the least prevalent retrofit locations, for example, mechanical rooms and exterior parking lots (Figure 5). Conversely, stairways, lobbies, hallways and other locations (including storage, fitness, meeting rooms), were responsible for 80.8% of all installations, with an average 25.2 delta watts.

[15] National Grid reports instances of de-lamping are evident in the tracking data, represented by different pre and post quantities.

Average common area delta watts across room types with the highest installation rates clustered between 20 and 34 watts. The low delta wattage of baseline bulbs in these high use areas is primarily reflective of the efficient baseline equipment, a result of previous retrofits to reduce common area energy costs for owners and managers.

Although installed in minimal quantities, mechanical rooms and elevators had delta watts of 57 and 56 respectively. Exterior fixtures were reported to have a much higher average delta watts (82.3), due to high wattage baseline HID wall packs and parking lot lighting fixtures. However, exterior fixtures only accounted for 11.6% of bulb installations. Figure 5 and Figure 6 illustrate average common area delta watts and installation frequency reported by IC's to Navigant. While stairs accounted for over 40% of reported locations (Figure 5), less than 15% of all bulbs were installed in stair locations. Hallways accounted for almost 50% of all bulb installations (Figure 6).

Figure 5. Average Common Area Delta Watts and Measure Frequency

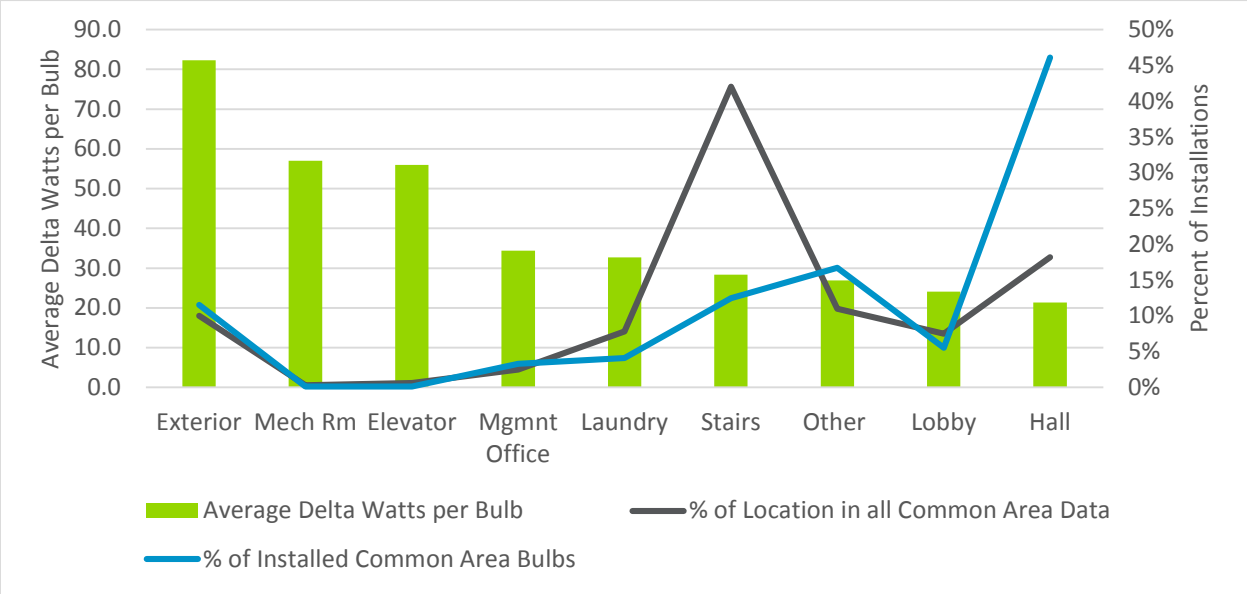
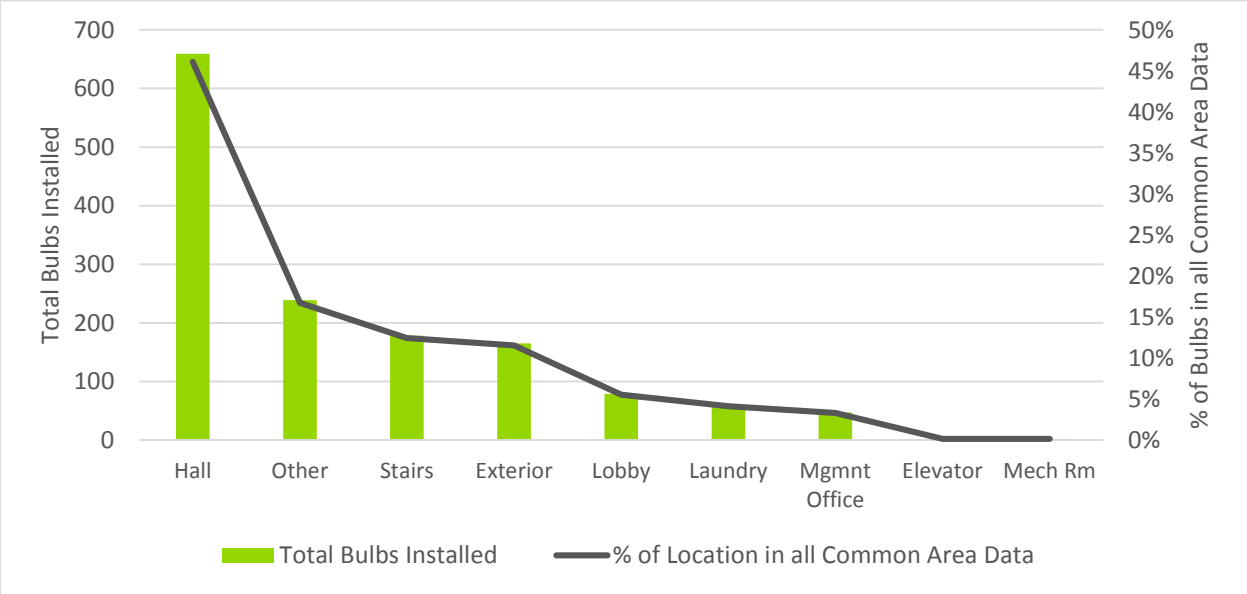
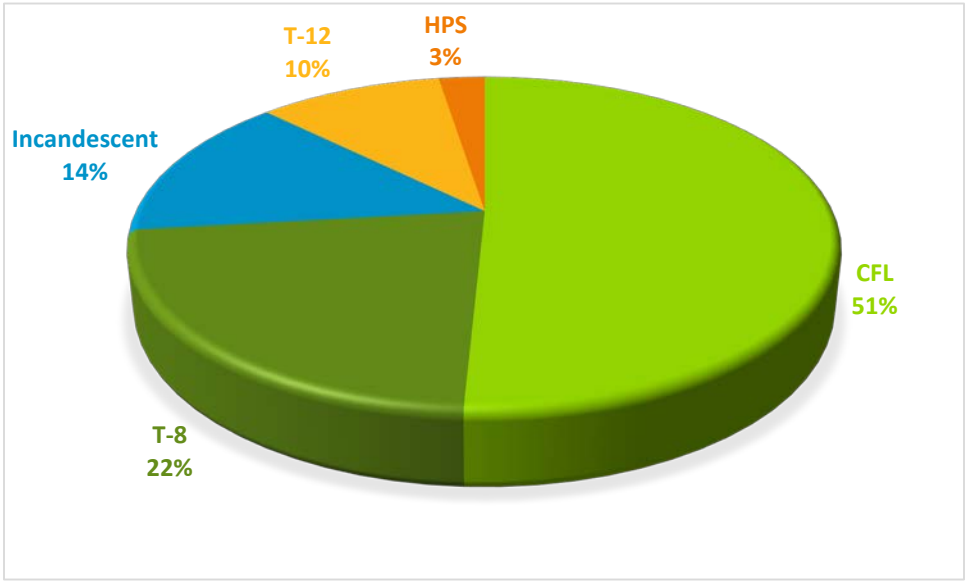


Figure 6. Common Area Measure Installation Locations



Reported common area baseline technologies are shown in Figure 7. The highest percentage of baseline light bulbs is relatively low wattage compact fluorescents, comprising 50.5% of retrofitted products. T-8 linear fluorescent technology is the next largest percentage at 22.3%. High wattage bulbs such as incandescent, T-12 linear fluorescent, and exterior HID bulbs combined comprise 26% of retrofit products.

Figure 7. Existing Common Area Lighting Products: Reported Baseline Bulbs



Virtually no common area projects were reported to have existing lighting controls, either motion or daylighting sensors. ICs reported installing controls in seven common areas. (During Navigant's ride along site-visits, an auditor identified a location for an occupancy sensor, but was unaware that the

program has a lighting control measure, or how to estimate savings for the technology. See the On-Site Verification Section of this report for further discussion).

1.3.2 Common Area: Reported Lighting Savings Assessment

Navigant analyzed the energy savings from all common area bulbs/fixtures based on TRM deemed default HOU values. The calculated savings using deemed HOU was compared to the savings estimated using adjusted HOU values to demonstrate the impacts of utilizing project specific HOU based on-site specific conditions.

The reported baseline and efficient retrofit bulbs indicate that de-lamping occurs; not all baseline bulbs have an equivalent quantity of efficient bulbs (1,534 baseline, 1430 efficient). The analysis was conducted based on total baseline watts in comparison to total retrofitted efficient watts.

1.3.2.1 Common Area: Deemed Values

The preliminary savings estimate for all common area lighting products was calculated using reported delta watts for each location and TRM deemed values for HOU (12 hours / day exterior, 24 hours / day interior). Reported baseline, efficient, and delta watts for each location are illustrated in Table 11, and result in a total estimated savings of 370,420 kWh based on deemed HOU.

Table 11. Reported Delta Watts, Deemed Hours of Use Analysis

Room	Sum of Total Baseline Watts	Sum of Total Replacement Watts	Total Delta Watts	Deemed Hours of Use *(TRM)*	TRM Savings *(kWh/year)*
Common Hall	22,301	7,803	14,498	24	127,002
Elevator	160	48	112	24	981
Exterior	17,625	4,050	13,575	12	59,459
Laundry	2,408	858	1,550	24	13,578
Lobby	3,352	829	2,523	24	22,162
Mechanical Room	420	96	324	24	2,838
Mgmt. Office	2,137	522	1,615	24	14,147
Other	13,682	3,855	9,827	24	86,085
Stairs	7,552	2,510	5,042	24	44,168
			TOTAL ESTIMATED SAVINGS (kWh):		**370,420**

1.3.2.2 Common Area: Reported Delta Watts with Adjusted Location-Specific Hours of Use

The second savings estimate for common area lighting products was calculated using the same reported delta watts for each location as shown in Table 11. For this calculation, Navigant estimated an HOU adjustment for interior areas that may or may not be operational for 24 hours per day to demonstrate the impact of site specific HOU. These areas include laundry rooms, mechanical rooms, management offices, and 'other' rooms such as fitness, storage, and meeting rooms.

Reported baseline, efficient, and delta watts for each location is illustrated in Table 12. Navigant found a total estimated savings of 294,208 kWh based on the adjusted HOU as described. Using HOU adjusted

for facility specific operations as described reduces calculated savings by an estimated 21% (relative to the TRM values[16].

Table 12. Reported Delta Watts, Adjusted Hours of Use Analysis

Room	Sum of Total Baseline Watts	Sum of Total Replacement Watts	Total Delta Watts	Adjusted Hours of Use *(TRM)*[17]	TRM Savings *(kWh/year)*
Common Hall	22,301	7,803	14,498	24	127,002
Elevator	160	48	112	24	981
Exterior	17,625	4,050	13,575	12	59,459
Laundry	2,408	858	1,550	**12**	**6,789**
Lobby	3,352	829	2,523	24	22,162
Mechanical Room	420	96	324	**2**	**237**
Mgmt. Office	2,137	522	1,615	**8**	**4,716**
Other*	13,682	3,855	9,827	**8**	**28,695**
Stairs	7,552	2,510	5,042	24	44,168
			TOTAL ESTIMATED SAVINGS (kWh):		**294,208**

*Common area spaces reported as 'Other' may include fitness, storage, meeting rooms, etc.

1.3.3 Common Area Lighting Savings: Summary of Key Findings

Applying site specific hours of use can have a significant impact on common area lighting energy savings. TRM deemed HOU for interior locations assume 24 hours / day for applications such as common hallways, stairs, etc. If they are not already doing so, ICs should customize HOU in alignment with on-site conditions, determined with the input of knowledgeable site personnel. Navigant's analysis illustrates that site specific HOU for low usage locations can reduce estimated savings by 21% relative to TRM deemed values.

Table 13. Impact of Site Specific Hours of Use

Calculation	Hours of Use Source	Total Common Area Savings Estimate *(kWh/year)*
1	TRM deemed value (12 or 24 hours per day)	370,420
2	Adjustments for low usage locations (estimated)	294,208
Savings reduction:	kWh/year	76,212
	Percent	21%

[16] TRM values are used if vendors do not provide site specific HOU.

[17] Adjusted HOU and location savings are shown in bold.

Over 80% of common area lighting installations have an average 25.2 delta watts. The research does not determine how the average reported delta watts compares with common area savings projections. Program planners are encouraged to use the reported common area average delta watts specific to each location (illustrated in Figure 5) to project future program savings and costs.

Lighting controls can provide additional savings to the program. None of the projects reported to Navigant included existing lighting controls in common areas, either occupancy or daylighting. Only one project reported controls installation. This lack of reported controls is found despite the 24 hours per day deemed value for all interior common areas.

2. PROJECT VERIFICATION: ON-SITE VERIFICATION

Navigant conducted verification-site visits of multifamily building audits and post project installations with the PA Quality Assurance (QA) Vendor, CMC Energy Services. Site visits occurred between November 9, 2016 and January 11, 2017.

Results of this task were intended to confirm the results of the Project Verification Lighting Baseline and Delta Watts analysis, and inform the RES43 (Multifamily Census) database results.

Navigant was unable to visit the intended sample of 100 apartments for verification activities; there were insufficient projects being verified at the time of the data collection period. Specifically, comprehensive projects were significantly under-represented; the visited units did not provide an adequate sample to verify the concurrent research activities. However, the site visits identified opportunities to improve project reporting from ICs to the QA Vendor and overall management of the QA Vendor's activities. These findings lead to suggested implementation strategies which will improve quality control of multifamily program implementation methods, and ultimately better align estimated savings with verified savings.

2.1 Methodology

Navigant collaborated with the QA Vendor, CMC Energy Services, to coordinate site visits. There are three tiers of verification-site visits conducted by the QA Vendor:

Tier 1. Audit – QA Vendor is on-site with the IC Auditor; confirms the auditor identifies appropriate project opportunities.

Tier 2. Lighting Verification – the QA Vendor verifies lighting installations. While these projects may be a component of a larger, comprehensive project, on-site QA staff activities are limited to verification of the lighting component. QA staff do not have insight into other aspects of the project during Tier 2 visits.

Tier 3. Comprehensive - the QA Vendor verifies non-lighting installations, such as insulation, thermostats, water conservation devices, pipe insulation, etc. While these projects may be a component of a larger project with lighting measures, on-site QA staff activities are limited to verification of the non-lighting measures. QA staff do not have insight into other aspects of the project during Tier 3 visits.

Table 14 shows the number of projects and apartments/units visited by Navigant in each verification tier. The two Tier 3 verifications represent the only Tier 3 verifications available to the QA Vendor during the evaluation period.

Table 14. Summary of Site Visits by Tier

Projects by Verification Tier	Projects Visited	Units Visited
1. Audit	7	24
2. Lighting Verification	9	39
3. Comprehensive Verification	2	5
Total	**18**	**68**

2.1.1 Verification Site Visit Coordination

Navigant coordinated with the QA Vendor to gain access to project properties. The QA Vendor's procedures were tailored to project status, as identified by verification Tier.

- Tier 1: ICs inform the QA Vendor when their auditors expect to visit a property and conduct an audit. The QA Vendor chooses which Tier 1 (Audit site-visit) projects to attend, coordinating directly with the IC auditor.
- Tier 2 and 3: The QA Vendor is required to verify installations in 10% of all completed units. Because it is difficult to access dwelling units, the QA Vendor attempts to verify as many projects as possible to achieve their required 10% of units. When practical, the QA Vendor attempts to verify more than 10% of units in a given project, as it may not be possible to access 10% in another project. ICs are responsible for providing on-site contact information and project details (measures, quantities, etc.) for verification activities. The QA Vendor contacts the on-site personnel directly to coordinate post installation inspections of common areas and in-unit measures. Typically, IC representatives are not present at Tier 2 and 3 verification-site visits.

For this research project, the QA Vendor informed Navigant of their weekly schedule on Monday of each week. Navigant attended scheduled visits as summarized in Table 14, observed staff interactions and recorded pertinent conditions.

2.2 On-Site Verification Findings

2.2.1 Customer Expectations

1. **Building owner and property manager expectations are not aligned with program goals to diversify end use measure mix**. Customers are not aware of how a comprehensive retrofit, including both the energy savings benefits and actual implementation work, may impact them or their tenants.

   Customers Navigant spoke with were primarily interested in having Mass Save retrofit their lighting at no charge. When asked why they called Mass Save, several reported being repeat customers who are happy with work at their other properties.

   In response to customer expectations, auditors have grown accustomed to meeting customers' basic needs (lighting upgrades). Auditors perceive pursuit of additional opportunities to be not worth their time with these customers. Conversely, customers are not motivated to engage in those opportunities where they may not receive energy saving benefits (due to split incentive) or the work may be disruptive to owner occupants or tenants. Combined, these factors result in the high percentage of program savings from lighting measures. and missed opportunities to diversify the measure mix and increase savings (see Section 2.2.3 Program Savings Opportunities).

2. **Customers are not prepared to coordinate residents or facilitate verification visits**. Customers (including building owners, property managers, or maintenance staff) are not aware of program verification requirements, and are often surprised to discover that an additional contractor requires access to their properties and tenant spaces when they understood the project was complete.

   Additionally, at verification-site visits, the on-site customer staff are not necessarily aware of the project's scope, including which units have received services, which did not, what services were delivered, or when services were delivered.

Both of these issues cause fundamental challenges to successful program verification. The QA contractor does not have access to project units consistent with the IC activity, and often struggles to align reported installations with on-site conditions. The ramifications of this are magnified on more complicated projects (for example in the case of 100+ units spread over a number of individual buildings), leading to potential inaccuracies in project verification.

2.2.2 Project Reporting and Verification

2.2.2.1 Data Transfer

Project documentation and project transfer between the ICs, QA Vendor, and PAs is not sufficient to ensure accurate energy savings estimates are reported, verified, and ultimately claimed by the program.

1. **Project documentation is insufficient to result in accurate project verification**. The QA contractor receives multiple types of project documentation from the various MF program contractors, ranging from a spreadsheet print-out to a bulleted list of measures. However, none of the documents reviewed by Navigant identifies the location of installed products. Navigant staff observed the following situations (see example verification documentation in Table 15 and Table 16, below):
    a. A verification document indicated that dozens of one bulb type and hundreds of other bulb types were installed in a 100-unit property. There is no indication whether the installations were conducted in kitchens, bathrooms, or living rooms – or which units received the lighting products.
    b. Some project documentation used on-site by the QA Vendor appears to be work orders developed at the audit stage, rather than final installed quantities. This is manifested through documentation of product quantities rounded to 3 digits (i.e.: 200 12 watt bulbs).
    c. Measure installation quantities indicated inconsistently in text and numerical format. (i.e., "*Furnish and Install PRO1 755 thermostats. Six (4) Thermostats*"). QA contractors do not have insight into which value to verify. When Navigant enquired, the QA Vendor directed us to the IC; the discrepancy was not addressed in the verification report.
2. **A system of checks and balances does not exist to confirm that projects submitted to the PAs for payment and savings upload are concurrently and consistently provided to QA Vendor**. ICs are contracted to the PAs. The QA Vendor is also contracted through the PAs. Appropriate for a verification activity, there is no agreement or formal relationship between the IC and QA Vendor.

    ICs are expected to transfer completed projects to the QA contractor. The QA contractor is expected to verify 10% of all completed units. There is no mechanism to confirm that all completed IC units are provided to the QA contractor. Additionally, there is no mechanism to confirm that the QA contractor has verified 10% of all units completed by the IC.
3. **Project savings estimates are not updated in the PA database when verification findings identify inaccuracies or problems with reported project measures.** QA vendor findings are reported to the PA's for resolution. Measures identified by the QA vendor with a 'Fail' finding are referred by the PA to the installing IC to remedy; they are not subsequently re-verified by the QA vendor. Several projects visited by Navigant staff resulted in questionable reported findings which were not corrected in the program database, resulting in inaccurate accounting of project savings.

2.2.2.2 Information Technology / Data Entry

1. **The information technology (IT) reporting system is cumbersome for auditors.** When inputting proposed measures, the options presented to the auditor either do not properly represent the desired measures, and/or the system presents too many measure options. As a result, auditors make inaccurate measure choices as they do not have the time (or patience) to identify the actual required product.

   Auditors indicate making a selection that best represents the existing and proposed measure in terms of wattage only; e.g. a 21 watt LED wall pack is entered into the system when a vanity fixture containing three, 7-watt LED bulbs totaling 21 watts is the intended proposed/installed measure. As such, in this example while measure energy savings may be accurate, the number and cost of each proposed measure will be incorrect – inconsistencies which propagate through the project verification process.

   Feedback from IC's and PA staff indicates cataloging and data entry of individual measures is laborious and costly to the program. The PAs are actively working to update tracking tools and processes to streamline data inputs and data availability between the IC's and QA vendor.

2. **The involved parties do not fully understand the entire project process.** Neither the IC auditor nor the QA vendor fully understood the flows of information between the various contractors and PAs. As a result, they are not aware of what impact their work (including data entry errors identified above and verification results) might have downstream for the QA Vendor or PA (development of realization rates, for example).

2.2.2.3 Project Verification Results

Verification results are not consistent. Different QA staff produce inconsistent verification results. The following example as a comparison of two verified projects should be considered emblematic of inconsistencies between individual projects.

Example 1. Project "BT"

QA staff passed all the measures despite noting discrepancies in the estimated number of measures found during the inspection, and results from sampled apartments that did not agree with reported installations.

1. Of the measure quantities the QA staff was able to count, they noted that one of the BR30s had been removed, thus suggesting that the verified quantity is not correct.
2. Of the apartments in the verification sample, QA staff recorded identified installations, and passed the project based on the sampled results. However, extrapolating the sampled unit results across all apartments in the property results in an overall significant *excess* in installed lighting products. The installed quantity cannot be captured through a limited sample of units and buildings when the QA contractor does not have insight into which units received which products.

Table 15. Project "BT" Reported Findings. Status: *Pass*

Measure	Installed Quantity Reported by IC	Quantity Verified by QA	Estimated Installed Quantity - Extrapolated from Sampling of Inspected Apt.'s
Shower	152	152	151
Thermostat	161	161	168

10W Omni	301	301	370
5W Candelabra	6	6	*(Fully counted by QA)*
9.5W BR30	22	22	*(Fully counted by QA, although 1 was noted as 'removed')*
10W Omni	51	51	63
11" LED Drum	170	170	240

Project "BT" verification narrative: *"…has 30 buildings with 168 units. Ten units were inspected along with ten building common areas."*

Example 2: Project "AL"

The QA staff failed two measures on this site – for the first measure, the QA staff counted only 19 rather than 20 outdoor 30W Blazers; for the second measure, a LED Wall Pack could not be located. In either case, the difference was only a single fixture. We note, while these failures are legitimate, they are inconsistent with Project BT in example 1, where there were significant discrepancies in "installed" vs "estimated or counted" measures, but no failures.

While the project was "failed", QA staff for the project "AL" passed all in-unit lighting measures. While on-site, QA staff did not take notes with respect to how many units were visited, and what the results were per unit. Navigant observes the quantity of lighting products numbered by the hundreds (e.g. 100, 200, 300, etc., see Table 16), suggesting that they were estimated by the IC for a ~100-unit property. Had these reported quantities been actual installs, we presume the results would not be quantities (apparently) rounded to the nearest 100.

Table 16. Project "AL" Reported Findings. Status: Fail

Measure	Installed Quantity Reported by IC	QA Result	QA Comment
1. TCP Blazer35 30w LE	20	Fail	*Only 19 Located*
2. 14W Maxlite LED Flood	19	Pass	
3. Maxlite LED Wall pack	1	Fail	*None Found*
4. LED 6W Ceiling	16	Pass	
5. LED 6W Ceiling	201	Pass	
6. Cree CR6 LED Res-Do	42	Pass	
7. TCP Blazers35 30W LE	100	Pass	
8. LED 6W Ceiling	100	Pass	
9. LED 12W Ceiling	100	Pass	
10. LED 6W Ceiling	300	Pass	
11. PRM LED_1100.0172_1	300	Pass	
12. LED 6W Ceiling	200	Pass	
13. TCP Blazers25 20W LE	200	Pass	

14. LED 6W Ceiling	400	Pass	

Project "AL" verification narrative: *"…consists of 96 one and two bedroom apartments in four buildings and a common building. Units are individually metered. Ten apartment units, common interior and common exterior were inspected.*"

2.2.2.4 Actions Taken on Verification Findings

Verification results are not clearly understood by stakeholders. Stakeholders do not rely on a routine or replicable mechanism to address discrepancies or update the PA database based on QA Vendor findings.

1. **Terminology of QA Vendor results is misunderstood and/or misinterpreted by PA staff**. QA Vendor uses three terms to describe the outcome of verification activities: "Pass", "Pass with Note", and "Fail". Both "Pass" and "Pass with Note" are viewed by PA representatives as acceptable outcomes (as the prefix 'pass' implies). "Pass with Note" findings are not investigated to clarify discrepancies between reported and verified savings.

   Pass with Note is used by the QA Vendor to describe situations where the sample of visited units and measure quantities differ from the reported quantities. The verification report for project "PS", in Table 17 indicates that 4 of 6 units were inspected. Measures received a "Pass with Note" finding when the QA verification results did not match reported installations.

Table 17. Project "PS" Reported Findings. Status: Pass

Measure	Installed Quantity Reported by IC	QA Result	QA Comment
1. Cellulose 8" R-30	2450	Pass	
2. AIRSEAL	18	Pass	
3. Thermostat	6	Pass With Note	*Only 2 installed.*
4. AERATOR - REGULAR	12	Pass With Note	*Only 4 installed.*
5. SHOWERHD	6	Pass	

Project PS verification narrative: "…*one building with 6 units. Four units inspected. Electric is individually metered. One gas meter for all units*."

2. **PAs forward QA "Fail" findings to ICs for follow up investigations**. When measures receive a "Fail" (as in Table 16), PAs request the IC to address the result. ICs review the QA Vendor findings, and return to the site to either (a) confirm the original installation exists, or (b) rectify the "Fail" finding. IC follow-up actions do not receive follow-up QA verification.

   Based on project documentation provided to the QA Vendor by the IC, and the QA Vendor's results, it is not clear how the IC Vendor can adequately confirm or rectify the issue. Where the documentation does not provide sufficient detail to describe measure location, and the QA Vendor results do not indicate where on a property the measures were (or were not) identified, it strains credibility to assume "Failed" or missing measures are always fully remedied.

3. **PA databases are not updated to reflect inaccuracies found by QA Vendor**. In the case where either measures are "Fail" or "Pass with Note", the PA database is not updated to reflect

QA Vendor findings. As a result, IC reported savings may be overstated or understated and not corrected to reflect verified on-site conditions.

2.2.2.5 PA Updates

As a result of the findings outline in this Data Reporting and Verification section, the PAs indicate that they are actively taking steps to improve project quality assurance and data processes in advance of this report completion and distribution. Evaluation of the steps taken by PA's in response to these findings should be included in follow up research activities. For example, regarding data transfer, the ICs indicate they are actively developing software solutions to reduce the data burden and improve the content of the data shared with the QA vendor. Furthermore, an additional layer of quality assurance has been enacted to ensure the accuracy of project verification results until such software solutions are active and reliable. The PAs are also working to clarify the definitions and actions taken upon verification findings. Finally, it should be noted that the data used for project verification by the QA vendor is not the data that is used by the PAs to report savings; rather, that data comes directly from the IC and is subjected to PA review prior to claiming the savings.

2.2.3 Program Savings Opportunities

It is well documented and understood that the Massachusetts non-low-income multifamily program relies primarily on light bulb and / or fixture savings to meet its program goals. Through this research project, Navigant has observed that customer expectations are not aligned with program goals to increase savings and diversify the measure mix. Additionally, IC auditors are not managed or compensated to identify, promote, and 'close' (sell) comprehensive measures.

2.2.3.1 Lighting Controls

Lighting controls are not identified or prioritized at time of audit. Virtually none of the lighting installations reported to Navigant were indicated to have had existing lighting controls at time of installations. Just one project reported lighting controls as an installed measure.

If one concludes that the IC contractors simply did not report existing lighting controls to Navigant, we assume that existing lighting controls were not incorporated into the HOU reported to the PA database, resulting in overstatement of energy savings. If one concludes that lighting controls did not exist on-site, we assume there is a clear opportunity for the program to advance additional savings and diversify reported energy savings through lighting controls.

During a ride along audit, an IC auditor indicated they were unaware that lighting controls were an available measure to the program or how to incorporate a lighting control measure.

2.2.3.2 HVAC End Uses

HVAC end uses are not prioritized through standard project activities. By providing free audits and product installations, the program invests significant resources into individual projects. These resources have developed relationships with the customer, educated the customer about energy efficiency, and persuaded the customer to take advantage of some energy efficiency opportunities. Additional savings are available from HVAC end uses, but they are not prioritized by ICs as the base heating, cooling and domestic hot water measures are funded and managed outside of the multifamily program.

Navigant observed project documentation at a Tier 3 (Comprehensive) verification-site visit which included photographs of an atmospherically vented gas boiler with an indirect domestic hot water tank. This old equipment appeared close to the end of its useful life, with only rudimentary controls. The QA Vendor staff did not know what the purpose of the photograph was in the verification documentation, and was not inclined to investigate. At the request of Navigant staff, the mechanical room was inspected, and found to be identical to the project verification documentation photo. On-site building staff did not know what the plan was for upgrading the mechanical system.

This scenario illustrates how the program fails to prioritize and manage comprehensive solutions for customers. The property owner took advantage of the free audit, project management and lighting product installation; however additional sources of savings at the property were referred to another program for service. The original project team that developed the customer relationship has moved on, leaving another program to follow through with developing next steps, re-educating the customer, and persuading the customer to take additional action.

3. TECHNICAL RESOURCE MANUAL MULTIFAMILY MEASURE CHARACTERIZATIONS

Navigant conducted a targeted review of the Massachusetts Technical Reference Manual (TRM) for program years 2016-2018, published in October 2015. The review assessed the accuracy and relevance of multifamily measure baseline conditions (incorporating both residential and C&I measures as appropriate). Additionally, natural gas measures have been identified that should be adopted to integrate fuel oil and propane fuels into the program.

Table 18 summarizes measures identified through the review that could be edited to serve fuel oil and propane fuels, incorporate additional measures to diversify the end uses and measures available to the multifamily program, and in some instances, fine tune savings estimates. Subsequent sections go into greater depth on suggested adjustments for each measure. Suggested edits are illustrated in red underline and ~~strikeouts~~ as appropriate.

Table 18. Summary of TRM Measures for Adjustment

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
BUILDING SHELL- AIR SEALING	50	Residential, Low Income	Retrofit	1,2,3,4
BUILDING SHELL- INSULATION	56	Residential, Low Income	Retrofit	1,2,3,4
HVAC- BOILER RESET CONTROL	107	Residential	Retrofit	5,9,10
HVAC- BOILER RETROFIT	132	Low Income	Retrofit	4,10,11
HVAC- HEATINGSYSTEM	136	Low Income	Retrofit	4
LIGHTING- CFL BULBS	138	Residential, Low Income	Lost Opp., Retrofit	1,3,5,6,7,10
LIGHTING- LED FIXTURES	147	Residential, Low Income	Lost Opp., Retrofit	1,3,6,10
LIGHTING- BULBS	150	Residential, Low Income	Retrofit	1,3
LIGHTING-FIXTURES	152	Residential, Low Income	Retrofit	1,3
LIGHTING-OCCUPANCY SENSORS	155	Residential	Retrofit	1,3
WATER HEATING- HEAT PUMP WATER HEATER (ELECTRIC)	193	Residential	Lost Opp.	3,8,10
WATER HEATING- WATER HEATING SYSTEM	195	Low Income	Retrofit	4
HVAC- ENERGY MANAGEMENT SYSTEM	243	C&I	Retrofit	12,13,14

*Core Initiatives	
1: Electric Multifamily Retrofit	8: Electric Residential Cooling and Heating
2: Gas Multifamily Retrofit	9: Gas Residential Heating and Cooling
3: Electric Low Income Multifamily Retrofit	10: Electric Low Income Single Family Retrofit
4: Gas Low Income Multifamily Retrofit	11: Gas Low Income Single Family Retrofit
5: Electric Residential Home Energy Services	12: C&I New Construction
6: Residential Lighting	13: C&I Existing Building Retrofit
7: Residential New Construction	14: C&I Small Business

3.1 Lighting Measures

3.1.1 Hours of Use

Deemed hours of use (HOU) in the TRM are based on research and findings from the Northeast Residential Lighting Hours of Use Study.[18] According to the *HOU Study,* the average HOU for all residential lighting within a household is 2.7 hours per day.

The value referenced in the TRM of 2.7 hours per day is based on the average across all residential building types, income levels, and jurisdictions within the HOU Study. However, within the HOU Study report[19], non-low-income multifamily buildings in Massachusetts were found to have an average 2.2 HOU, an 18.5% reduction compared to the entire population. The HOU Study recommends programs use the average 2.7 hours per day, regardless of residential housing type, income, or location. Where the Massachusetts multifamily program is targeted solely at housing types, incomes, and location consistent with the reduced hours per day usage, Navigant recommends applying the 18.5% reduction to lighting measures utilized by the Electric Multifamily Retrofit core initiative. Table 19 shows a comparison of average lighting HOU per room for overall households to the recommended adjusted non-low-income Massachusetts Multifamily sector. Navigant recommends applying the adjusted HOU to the five (5) lighting measures identified in Table 20 that serve the Electric Multifamily Core Initiative.

Table 19. Average Hours of Use per Room

Room	Average for all Residential Housing	18% Adjustment for Massachusetts Non-Low Income Multifamily
Bedroom	2.1	1.7
Bathroom	1.8	1.4
Kitchen	4.0	3.3
Living Space	3.3	2.7
Dining Room	2.8	2.3
Exterior	5.7	4.6
Other	1.7	1.4
Household	**2.7**	**2.2**

[18] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*

[19] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study,* Table 3-2: HOU Estimates by Home Type and Income Level – Hierarchical Models

Table 20. Measures that Qualify for Non-Low Income Multifamily HOU Standard

Measure Specific Name	TRM Page Number	Sector	Market	*Core Initiative
LIGHTING- CFL BULBS	138	Residential, Low Income	Lost Opp., Retrofit	1,3,5,6,7,10
LIGHTING- LED FIXTURES	147	Residential, Low Income	Lost Opp., Retrofit	1,3,6,10
LIGHTING- BULBS	150	Residential, Low Income	Retrofit	1,3
LIGHTING-FIXTURES	152	Residential, Low Income	Retrofit	1,3
LIGHTING-OCCUPANCY SENSORS	155	Residential	Retrofit	1,3

*Core Initiatives
1: Electric Multifamily Retrofit
3: Electric Low Income Multifamily Retrofit
5: Electric Residential Home Energy Services
6: Residential Lighting
7: Residential New Construction
10: Electric Low Income Single Family Retrofit

3.1.1.1 Lighting- CFL Bulbs

Navigant recommends adjusting measure HOU based on the HOU Study for Massachusetts non-low-income multifamily properties. The change should apply to the Hours section on page 139 as illustrated below:

> *Average annual operating hours for efficient bulbs in the Res Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year). Average annual operating hours for all bulbs in the HES, RNC, LI Retrofit 1-4, ~~MF Retrofit~~ and LI MF Retrofit programs are 985.5 hours/year (2.7 hours/day * 365 days/year). Average annual operating hours for all bulbs in the MF Retrofit programs are 803 hours/year (2.2 hours/day * 365 days/year).*

3.1.1.2 Lighting- LED Fixtures

Navigant recommends adjusting measure HOU based on the HOU Study for Massachusetts non-low-income multifamily properties. The change should apply to the Algorithm and Hours sections on pages 147-148 as illustrated below:

> *Hours = Annual hours of use: 1,200 for Res Lighting, ~~and 985.5~~ 803 for MF Retrofit and 985.5 LIMF Retrofit*
>
> *Average annual operating hours for efficient bulbs in the Res Lighting program are 1,200 hours/year ((93%*2.9 hours/day + 7% *8.46 hours/day)* 365 days/year). The average annual operating hours for efficient bulbs in ~~MF Retrofit~~ and LI MF Retrofit is 985.5 (2.7 hours/day *365 days/year). Average annual operating hours for all bulbs in the MF Retrofit programs are 803 hours/year (2.2 hours/day * 365 days/year).*

3.1.1.3 Lighting- Bulbs and Lighting- Fixtures

Navigant recommends adjusting measure HOU for both the Bulb and Fixtures measures based on the HOU Study for Massachusetts non-low-income multifamily properties. The change should apply to the Hours section on page 151 and 153 as illustrated below:

> *Operating hours are estimated by the vendor for each facility. Typical assumptions are 24 hours/day for common area lighting, 12 hours/day for exterior lighting, ~~and~~ 2.7 hours/day for Electric Low Income Multifamily Retrofit in-unit lighting, and 2.2 hours/day for Electric Multifamily Retrofit, but may be adjusted based on type of housing. Study-determined hours of use by room type may also be applied. Estimates are verified with facility maintenance staff when possible.*

3.1.1.4 Lighting- Occupancy Sensors

Navigant recommends adjusting measure HOU based on the HOU Study for Massachusetts non-low-income multifamily properties. The change should apply to the Hours section on page 155-156 as illustrated below:

Deemed values for hours may be used if auditor does not collect information.

Zone	Usage Category	Hours/Day (Calc.)
Common Area (Exterior)	Exterior	10.3
Common Area (Interior)	Extended Hours & 24/7	24
Common Area (Interior)	Low Usage	3.4
Common Area (Interior)	Medium Usage	12.5
Common Area (Interior)	Non-Area Specific	16.2
Dwelling Unit	Unit, Electric Low Income Multifamily Retrofit	2.7
Dwelling Unit	Unit, Electric Multifamily Retrofit	2.2

3.1.2 Occupancy Adjustment Factor

Some properties served by the multifamily program are seasonal in nature. For example, weekly vacation condominium rentals on Cape Cod may have typical HOU in the summer, but reduced HOU in the winter. Navigant recommends applying an “Occupancy Adjustment Factor” (OAF) to deemed HOU, effectively reducing energy savings by the percent of time the unit or building is unoccupied. Table 21 lists the lighting measures that qualify to utilize an OAF.

Table 21. Lighting Measures that Qualify for Occupancy Adjustment Factor

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
LIGHTING- CFL BULBS	138	Residential, Low Income	Lost Opp., Retrofit	1,3,5,6,7,10
LIGHTING- LED FIXTURES	147	Residential, Low Income	Lost Opp., Retrofit	1,3,6,10
LIGHTING-BULBS	150	Residential, Low Income	Retrofit	1,3
LIGHTING-FIXTURES	152	Residential, Low Income	Retrofit	1,3
LIGHTING-OCCUPANCY SENSORS	155	Residential	Retrofit	1,3

*Core Initiatives
1: Electric Multifamily Retrofit
3: Electric Low Income Multifamily Retrofit
5: Electric Residential Home Energy Services
6: Residential Lighting
7: Residential New Construction
10: Electric Low Income Single Family Retrofit

3.1.3 Occupancy Adjustment Factor Calculations

To utilize the Occupancy Adjustment Factor, ICs are expected to develop a percent of occupancy by collaborating with the property owner or building representatives to determine approximately how many months per year the property is occupied. This number should be reported to the PA and applied to the savings equation, as described below. In Equation 1 through Equation 4 below, the original savings equation for four multifamily lighting measures are shown, followed by the recommended adjustments to incorporate the Occupancy Adjustment Factor.

Equation 1. LIGHTING- CFL BULBS

Original Equation

$$\Delta kW = \frac{\Delta watts}{1000}$$
$$\Delta kWh = \Delta watts * hours$$

Where:
$\Delta kW = Average\ kW\ reduction$
$hours = hours\ of\ use$

Recommended Occupancy Adjustment Factor:

1. Identify site-specific occupancy, in months / year.
2. Multiply original equation by the ratio (R) of months occupied by months in a year.

$$\Delta kW = \frac{\Delta watts}{1000}$$
$$\Delta kWh = \Delta watts * hours * R$$

Where:
$\Delta kW = Average\ kW\ reduction$
$hours = hours\ of\ use$
$$R = \frac{\text{"}\boldsymbol{number\ of\ months\ building\ is\ occupied\ per\ year}\text{"}}{12\ months\ in\ a\ year}$$

Equation 2. LED FIXTURES

Original Equation

$$\Delta kW = Bulbs * Save_{kW}$$
$$\Delta kWh = \Delta kW * hours$$

Where:
Bulbs = Average # of bulbs per unit for indoor is 1.49 and for outdoor it is 2.0
$Save_{kw}$ = Average kW savings per bulb: See Lighting – LED Bulbs[20]
Hours = Annual hours of use: 1,200 for Res Lighting and 985.5 for MF Retrofit and LI MF Retrofit

Recommended Occupancy Adjustment Factor:

1. Identify site-specific occupancy, in months / year.
2. Multiply original equation by the ratio (R) of months occupied by months in a year.

$$\Delta kW = Bulbs * Save_{kW}$$
$$\Delta kWh = \Delta kW * hours * R$$

Where:
Bulbs = Average # of bulbs per unit for indoor is 1.49 and for outdoor it is 2.0
$Save_{kw}$ = Average kW savings per bulb: See Lighting – LED Bulbs[21]
Hours = Annual hours of use~~: 1,200 for Res Lighting and 985.5 for MF Retrofit and LI MF Retrofit~~[22]

$$R = \frac{\text{"number of months building is occupied per year"}}{12 \text{ months in a year}}$$

[20] NMR Group (2015). *Baseline Sensitivity Analysis Spreadsheet, 2016-2018 Plan Version.* Prepared for the Massachusetts PAs.
[21] Ibid
[22] Note that HOU for this measure are redundant in the equation as they are specified in the HOU description. Navigant recommends HOU description adjustment separately, in Section 3.1.1.2, above.

Equation 3. LIGHTING- BULBS & LIGHTING- FIXTURES

Original Equation

$$\Delta kWh = \frac{[(QTY_{PRE} * Watts_{PRE} * Hours_{PRE}) - (QTY_{EE} * Watts_{EE} * Hours_{EE})]}{1000 * 52}$$

$$\Delta kW = \frac{\Delta kWh * kW}{kWh}$$

Where:
QTY_{PRE} = Quantity of pre-retrofit fixtures/bulbs
QTY_{EE} = Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$ = Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$ = Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$ = Weekly hours of operation for pre-retrofit case lighting fixtures/bulbs
$Hours_{EE}$ = Weekly hours of operation for efficient lighting fixtures/bulbs
52 = Weeks per year
kW/kWh = Average kW reduction per kWh reduction: 0.00030 kW/kWh

Recommended Occupancy Adjustment Factor:

1. Identify site-specific occupancy, in months / year.
2. Multiply original equation by the ratio (R) of months occupied by months in a year.

$$\Delta kWh = \frac{[(QTY_{PRE} * Watts_{PRE} * Hours_{PRE}) - (QTY_{EE} * Watts_{EE} * Hours_{EE})]}{1000 * 52} * R$$

$$\Delta kW = \frac{\Delta kWh * kW}{kWh}$$

Where:
QTY_{PRE} = Quantity of pre-retrofit fixtures/bulbs
QTY_{EE} = Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$ = Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$ = Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$ = Weekly hours of operation for pre-retrofit case lighting fixtures/bulbs
$Hours_{EE}$ = Weekly hours of operation for efficient lighting fixtures/bulbs
52 = Weeks per year
kW/kWh = Average kW reduction per kWh reduction: 0.00030 kW/kWh

$$R = \frac{"number\ of\ months\ building\ is\ occupied\ per\ year"}{12\ months\ in\ a\ year}$$

Equation 4. LIGHTING OCCUPANCY SENSORS

Original Equation

$$\Delta kWh = \frac{(Watts_{Controlled}) * Hours * svg}{1000}$$

Where:
Watts controlled = Connected load wattage controlled by Occupancy Sensor
Hours = Assumed run time of fixture (before the installation of occupancy sensors) (Auditor Input)
svg = Percentage of annual lighting energy saved by occupancy sensor is 30%

Recommended Occupancy Adjustment Factor:

1. Identify site-specific occupancy, in months / year.
2. Multiply original equation by the ratio (R) of months occupied by months in a year.

$$\Delta kWh = \frac{(Watts_{Controlled}) * Hours * svg}{1000} * R$$

Where:
Watts controlled = Connected load wattage controlled by Occupancy Sensor
Hours = Assumed run time of fixture (before the installation of occupancy sensors) (Auditor Input)
svg = Percentage of annual lighting energy saved by occupancy sensor is 30%

$$R = \frac{\text{"number of months building is occupied per year"}}{12 \text{ months in a year}}$$

3.2 Building Shell Measures

Two natural gas measures were identified that can be edited to incorporate fuel oil and propane into the non-low income multifamily program. The measures in Table 22 should be changed to include fuel oil and propane, as shown:

***Primary Energy Impact**: Electric, Natural Gas (Residential Heat), Fuel Oil, Propane*

Table 22. Measures Recommended for Oil and Propane Conversion Adjustment

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
BUILDING SHELL- AIR SEALING	50	Residential, Low Income	Retrofit	1,2,3,4
BUILDING SHELL- INSULATION	56	Residential, Low Income	Retrofit	1,2,3,4

*Core Initiatives
1: Electric Multifamily Retrofit
2: Gas Multifamily Retrofit
3: Electric Low Income Multifamily Retrofit
4: Gas Low Income Multifamily Retrofit

3.2.1 Incorporating Fuel Oil and Propane

The existing measure characterizations for air sealing and building insulation support the addition of oil and propane fuels, without any changes. Fuel oil and propane savings will be calculated to result in MMBtu savings. Project auditors are responsible to estimate the heating system efficiency ($\eta_{heating}$), consistent with the current process for natural gas savings. All other variables and assumptions remain equivalent. Equation 5 and Equation 6 below illustrate the existing equations.

Equation 5. BUILDING SHELL- AIR SEALING

$$\Delta kWh = \frac{Vol * \Delta ACH * 0.018 * HDD * \left(\frac{24}{\eta_{heating}}\right)}{3413}$$

$$\Delta MMBtu = \frac{Vol * \Delta ACH * 0.018 * HDD * \left(\frac{24}{\eta_{heating}}\right)}{1{,}000{,}000}$$

$$\Delta kW = \Delta kWh * \frac{kW}{kWh}$$

Where:

Vol = [ft^3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)

ΔACH = [ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)

HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below.

$\eta_{heating}$ = [AFUE, COP, thermal efficiency (%)] Efficiency of the heating system, as determined on-site (Auditor Input)

24 = Conversion factor: 24 hours per day

0.018 = [Btu/ft^3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density of air (0.075 lb/ft^3)

1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu

3413 = Conversion factor: 3413 Btu/kWh

kW/kWh = Average kW reduction per kWh reduction: 0.00050 kW/kWh

Equation 6. BUILDING SHELL- INSULATION

$$MMBtu_{annual} = \frac{\left(\left(\frac{1}{R_{exist}}\right) - \left(\frac{1}{R_{new}}\right)\right) * HDD * 24 * Area}{1{,}000{,}000 * \eta_{heat}}$$

$$kWh_{annual} = MMBtu_{annual} * 293.1$$

$$kW = kWh_{annual} * \frac{kW}{kWh_{heating}}$$

Where:
R_{exist} = Existing effective R-value (R-Existing Insulation + R-Assembly), ft²-°F/Btuh
R_{new} = New total effective R-value (R-Proposed Measure + R-Existing Insulation + R-Assembly), ft²-°F/Btuh
Area = Square footage of insulated area
η_{heat} = Efficiency of the heating system (AFUE or COP)
293.1 = Conversion constant (1MMBtu = 293.1 kWh)
24 = Conversion for hours per day
HDD = Heating Degree Days; dependent on location, see table below
1,000,000 = Conversion from Btu to MMBtu
kW/kWh $_{heating}$ = Average annual kW reduction per kWh reduction: 0.00050 kW/kWh

3.3 Domestic Hot Water

There are existing measures serving the Low Income Multifamily Retrofit program which could be added to the Non-Low Income Multifamily program to improve measure diversity, increase program impact, and implementation consistency. Additionally, the natural gas measure should be adjusted to incorporate propane, to provide auditors and property owners flexibility when natural gas is not the fuel source.

3.3.1 Water Heating Measures for Multifamily Retrofit Program

The measures in Table 23 are currently part of the Low Income Multifamily Retrofit program. Navigant recommends incorporating these measures into the Non-Low Income Multifamily Retrofit programs, as shown below.

Table 23. Measures Recommended for Multifamily Retrofit

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
WATER HEATING- HEAT PUMP WATER HEATER (ELECTRIC)	193	Residential	Lost Opportunity	3, 8, 10
WATER HEATING- WATER HEATING SYSTEM	195	Low Income	Retrofit	4

*Core Initiatives
3: Electric Low Income Multifamily Retrofit
4: Gas Low Income Multifamily Retrofit
8: Electric Residential Cooling and Heating
10: Electric Low Income Single Family Retrofit

WATER HEATING- HEAT PUMP WATER HEATER (ELECTRIC): Add Electric Multifamily Retrofit to the Core Initiative on page 193 as shown:

> ***Core Initiative:*** *Electric - Residential Cooling & Heating Equipment, Electric - Low-Income, Single Family Retrofit, Electric - Low Income Multi-Family Retrofit, Electric Multifamily Retrofit*

WATER HEATING- WATER HEATING SYSTEM: Add Electric Multifamily Retrofit and Gas Multifamily Retrofit to the Core Initiative on page 195 as shown:

> ***Core Initiative:*** *Gas - Low-Income Multi-Family Retrofit, Electric Multifamily Retrofit, Gas Multifamily Retrofit*

3.3.2 Water Heating Measures Applicable for Propane

There is one existing natural gas domestic water heating measure which should incorporate propane, as shown in Table 24.

Table 24. Measures for Propane

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
WATER HEATING- WATER HEATING SYSTEM	195	Low Income	Retrofit	4

*Core Initiatives
4: Gas Low Income Multifamily Retrofit *(Note: Navigant recommends incorporating the Electric and Gas Multifamily Retrofit into this measure as discussed above.)*

The Water Heating Systems measure should be adjusted to incorporate propane fuel into the measure by adding it as a Primary Fuel on page 195:

> ***Primary Energy Impact:*** *Natural Gas (Residential DHW), Propane*

The existing Water Heating System measure characterization calculation supports the addition of propane fuels without any changes. Propane savings will be calculated to result in MMBtu savings. Project auditors are responsible to estimate the energy factor for baseline and efficient products (EF_{BASE}, EF_{EE}), consistent with the current process for natural gas savings. All other variables and assumptions remain equivalent. Equation 7 illustrates the existing Water Heating System equation.

Equation 7. WATER HEATING- WATER HEATING SYSTEM

$$\Delta MMBtu = Units * \frac{18\ MMBtu}{Unit} * \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EE}}\right)$$

Where:
Unit = Total number of dwelling units utilizing the water heater
18 MMBtu/Unit = Average annual water heating energy demand per dwelling unit
EF_{BASE} = Energy Factor for the baseline water heater
EF_{EE} = Energy Factor for the new efficient water heater

3.4 HVAC Measures

The measures listed in Table 25 should be incorporated into the Non-Low Income Multifamily Retrofit program. Currently HVAC- BOILER RETROFIT and HVAC- HEATING SYSTEM are already provided to projects through the Low Income Multifamily program. Additionally, the measures should incorporate fuel oil and propane fuel savings.

Table 25. Measures for Gas Multifamily Retrofit Core Initiative

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
HVAC- BOILER RETROFIT	132	Low Income	Retrofit	4,10,11
HVAC- HEATING SYSTEM	136	Low Income	Retrofit	4

*Core Initiatives
4: Gas Low Income Multifamily Retrofit
5: Electric Residential Home Energy Services
8: Electric Residential Cooling and Heating
9: Gas Residential Heating and Cooling
10: Electric Low Income Single Family Retrofit
11: Gas Low Income Single Family Retrofit

HVAC- BOILER RETROFIT: Add Gas and Electric Multifamily Retrofit to the Core Initiative on page 132 as shown. The measure already incorporates natural gas, fuel oil and propane fuels.

> **Core Initiative:** Electric – Low-Income Single Family Retrofit, Gas – Low-Income Single Family Retrofit, Gas- Low-Income Multi-Family Retrofit*, Electric Multifamily Retrofit, Gas Multifamily Retrofit*

HVAC- HEATING SYSTEM: Add fuel oil and propane to the Primary Energy Impact. Add Electric Multifamily Retrofit and Gas Multifamily Retrofit to the Core Initiative on page 136 as shown:

> ***Primary Energy Impact:*** *Natural Gas (Residential Heat)*, *Fuel Oil, Propane*
>
> ***Core Initiative:*** *Gas- Low-Income Multi-Family Retrofit*, *Electric Multifamily Retrofit, Gas Multifamily Retrofit*

The algorithms for both of these measures already calculate MMBtu savings based on project specific inputs identified by the project auditor.

3.5 Commercial and Industrial Measures

The C&I HVAC Energy Management System measure can be used in larger multifamily buildings with central HVAC systems to reduce energy consumption and improve building performance. Navigant recommends including the Multifamily Retrofit program as a Core Initiative and incorporating propane as a secondary energy impact.

Table 26. Measure for Multifamily Retrofit & Propane

Measure Specific Name	TRM Page Number	Sector	Market	Core Initiative*
HVAC- ENERGY MANAGEMENT SYSTEM	243	C&I	Retrofit	12,13,14

*Core Initiatives
12: C&I New Construction
13: C&I Existing Building Retrofit
14: C&I Small Business

HVAC- HEATINGSYSTEM: Add fuel oil and propane to the Primary Energy Impact. Add Electric Multifamily Retrofit and Gas Multifamily Retrofit to the Core Initiative on page 136 as shown:

Primary Energy Impact: Electric

Secondary Energy Impact: Gas, Oil*, Propane*

Core Initiative: C&I New Construction, C&I Existing Building Retrofit, C&I Small Business*, Electric Multifamily Retrofit, Gas Multifamily Retrofit*

The HVAC- ENERGY MANAGEMENT SYSTEM characterization is largely a custom measure, with inputs from custom analysis tools. No further adjustments are necessary to incorporate the additional fuel type and initiative. The following text describes the measure savings estimate procedures from the "Algorithms for Calculating Primary Energy Impacts", on page 243 of the TRM:

> *"Gross energy and demand savings for energy management systems (EMS) are custom calculated using the PA's EMS savings calculation tools. These tools are used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment and efficiency and points controlled."*

APPENDIX A. LIGHTING VERIFICATION DATA FORM

Form completion instructions
Complete property information for each building.
Use one row for each type of bulb in a given area. Use as many rows per area as needed.
Location: Choose one location per line, if 'Other', please indicate the type of space.
Pre-existing: Indicate the type of bulb removed, quantity, and wattage. Indicate wired or wireless controls, if applicable. Indicate quantity of lamps / fixtures: indicate 8 fixtures with 2 T-8 lamps each as 8 / 2L under the T-8 fluorescent column.
Efficient / Replacement Product: Indicate the type of bulb installed, quantity and wattage. Indicate wired or wireless controls, if applicable.
Efficient / Replacement Products' entries will be compare to the pre-existing bulb section to assess pre and post conditions. For example, if controls are indicated in the Efficient / Replacement Products, and not part of the Pre-existing bulb, it is assumed the project added controls for all of the bulbs indicated on that row. If 8 bulbs are indicated as existing, and 10 bulbs as replaced, it is assumed that there were 2 existing bulbs missing at time of installation.

Example data collection forms are shown in Appendix A.1 and A.2.

A.1 Common Area Data Collection Form

COMMON AREA LIGHTING DATA COLLECTION = EXAMPLE = PAGE: 1 of 4

Date:	11-4-2016	Contractor:	ABC DIRECT INSTALL	Building Reference (if needed)	FRONT BLDG A
Property Name:	THE PUBLIC HOUSE				
Property Address:	25 MAIN STREET			Property Town:	SPRINGFIELD
Number of units:	50			Electric Utility:	XYZ POWER
Occupants (circle one):	CONDO OWNER	RENTAL		Meter (circle one):	MASTER INDIVIDUAL

Common Area Reference	Location									Pre-existing fixture / bulb detail									Efficient/Replacement Products					
	Lobby	Common Hall	Stairs	Mgmt Office	Laundry	Elevator	Mechanical Room	Other (storage, meeting, fitness)	Exterior	Incandescent(#)	CFL (#)	LED (#)	T-8 Linear Fluorescent	T-12 Linear Fluorescent	Other (#)	Wired Controls	Wireless Ctrls	Watts / Bulb	CFL (#)	LED (#)	High Perf. T-8	Wired Controls	Wireless Ctrls	Watts / Bulb
1ST FLOOR	X										10							18		10				10
	X												16-2L	MP				34			16-2L			25
		X												16-2L				40			16-2L			25
			X										4-2L					34			4-2L			25
				X										2-2L				40			2-2L			25
								MTG					12-2L					34			12-2L	X		25
							X			10								60			10			10
					X								6-2L					34			6-2L	X		25
2ND FLOOR		X											20-2L					34			20-2L			25
			X										4-2L					34			4-2L			25
3RD FLOOR			X										4-2L					34			4-2L			25
		X											20-2L					34			20-2L			25
					X								6-2L					34			6-2L	X		25
							INDICATE FIXTURES & LAMPS / FIXTURE										INDICATES			CONTROLS	ADDED			

A.2 In-Unit Data Collection Form

IN-UNIT LIGHTING DATA COLLECTION = EXAMPLE = PAGE: 3 of 4

Date:	11-4-16	Contractor:	ABC DIRECT INSTALL
Property Name:	THE PUBLIC HOUSE	Building Reference (if needed)	FRONT BUILDING A
Property Address:	25 MAIN STREET	Property Town:	SPRINGFIELD
Number of units:	50	Electric Utility:	XYZ POWER
Occupants (circle one):	CONDO OWNER / (RENTAL)	Meter (circle one):	(MASTER) / INDIVIDUAL

Unit Reference	Location										Pre-existing fixture / bulb detail								Efficient/Replacement Products					
	Kitchen	Dining	Living	Hallway	Bathroom	Closet	Bedroom 1	Bedroom 2	Bedroom 3	Exterior	Incandescent(#)	CFL (#)	LED (#)	Other (#)	Specialty (vanity candelabra etc)	Wired Controls	Wireless Ctrls	Watts / Bulb	CFL (#)	LED (#)	Specialty (vanity candelabra etc)	Wired Controls	Wireless Ctrls	Watts / Bulb
15	X										2				X			60		2				10
		X									5				X			25		5	X			5
							X					2						14						
				X							1							60		1				10
										X	1							60		1		X		10
			X								2							60		2				10
			X									2						13						
		X									3							75		3				12
17	X										3							60		3				12
							X				2							60		2				10
										X	1							60		1		X		10
20																								

APPENDIX B. MULTIFAMILY PROGRAM EVALUATION CONTEXT

This supplemental appendix has been developed by the Program Administrators. It has been included here to provide context for the overall multifamily program evaluation activities.

MULTIFAMILY PROGRAM EVALUATION CONTEXT

Several completed and ongoing evaluations in 2016 focused on the Mass Save® Multifamily Retrofit Program, a direct installation program that promotes both electric and gas energy efficiency measures. The purpose of this Appendix is to provide a brief context and associated timeline to assist the Department and other stakeholders in interpreting the purposes and findings of these evaluations.

A billing analysis was completed in October, 2016 by DNV-GL, entitled, "*2013 National Grid MultiFamily Program Gas and Electric Impact Study*." The goal of this study was to provide 2013 program level gas and electric realization rates. This study found a realization rate for natural gas measures, including insulation and air sealing, of 86.2% (Executive Summary (ES) Table 2). The electric realization rate was determined to be 24.4% (ES Table 2). The DNV-GL study recommended, "Given the difficulty in observing lighting savings due to its low savings signature, consider other evaluation methods in subsequent studies of this program when predominate [*sic*] savings is from lighting."

To further explore the poor electric realization rate and factors that may contribute to this finding, the PAs directed Navigant to conduct a new multifamily study. The goal of this study, entitled "*Multifamily Program Improvement Strategies,"* is to "identify actionable strategies and innovations to improve the multifamily program performance, realization rates, and overall program cost-effectiveness for both the residential and commercial sectors." Of particular relevance here, this research is intended to provide additional context for the aforementioned billing analysis impact evaluation's low electric realization rate.

The *Multifamily Program Improvement Strategies* study is an ongoing study with active research tasks. Several tasks have been completed to-date; these are summarized in the 2016 Term Year Report: "*Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings*." While formal program recommendations will be included in the final report to be completed later this year, the current findings from the completed tasks have already been put to use. First, these findings informed the negotiated realization rates to be applied retrospectively for 2016 savings and prospectively for 2017 savings; these realization rates are detailed below. Second, the findings have been used to inform several process improvements that are actively underway. These include the quality assurance processes, data tracking and sharing processes between the implementation contractor and the quality assurance vendor, and tools to encourage comprehensive energy efficiency assessments.

Program evaluators will remain heavily involved in assessing the multifamily program throughout 2017 and into early 2018. The remaining tasks and final report from the "*Multifamily Program Improvement Strategies"* will be completed. A separate impact and process evaluation will be initiated to provide rapid feedback upon the improvements to the quality assurance process and data tracking procedures, develop electric in-service rates and realization rates for 2017 and beyond, and assess the impact of net to gross factors upon realization rates.

MULTIFAMILY PROGRAM REALIZATION RATES

The Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC) Consultants collaboratively developed the following realization rates based upon the best available information, which is described briefly in this Appendix and in detail in the reports. This section of the Appendix documents the specific realization rates and in-service rates that will be applied to multifamily program savings for 2016, 2017 and beyond, until superseded by new evaluation findings.

Natural Gas

Fuel	End Use	Realization Rate	In-Service Rate	Year(s)	Source	Agreement Date
Gas	Envelope	86.2%	100%	2016 and beyond	*2013 National Grid MultiFamily Program Gas and Electric Impact Study. DNV-GL, October 2016.*	October 7, 2016
Gas	Hot Water					
Gas	HVAC					
Gas	ISM[23]	100%	100%			

Electric

Fuel(s)	Measure	Realization Rate	In-Service Rate	Year(s)	Source	Agreement Date
Electricity, Oil, Other	Envelope	86.2%	100%	2016 and beyond	*2013 National Grid MultiFamily Program Gas and Electric Impact Study. DNV-GL, October 2016.*	October 7, 2016
Electricity, Oil, Other	Hot Water					
Electricity, Oil, Other	HVAC					
Electricity, Oil, Other	ISM[23]	100%	100%			
Electricity	In Unit Lighting[2]	100%	80%	2016	*Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings. Navigant, March 2017.*	February 16, 2017
Electricity	Common Area Lighting[3]	Vendor HOU or 79%	80%	2016		

Electric continued

Fuel(s)	Measure	Realization Rate	In-Service Rate	Year(s)	Source	Agreement Date
Electricity	In Unit Lighting[4]	100%	80%	2017	Placeholder based upon *Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings. Navigant, March 2017.* [4]	February 16, 2017
Electricity	Common Area Lighting[4]	60%	80%	2017		

[23] ISM are Instant Savings Measures. These include thermostats, showerheads and faucet aerators.

1. 2016 In Unit Lighting: The PAs will use the Massachusetts multifamily-specific hours of use (HOU) from the Northeast Residential HOU Study[24] with the delta watts from the 2016 lighting Market Adoption Model. This is detailed below in Table 8 taken from the "*Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings.*"

Table 27. Adjusted Hours of Use for Massachusetts Non-Low Income Multifamily Housing

Room	Current TRM Deemed HOU	Adjusted HOU
Bedroom	2.0	1.6
Bathroom	1.8	1.5
Kitchen	4.0	3.3
Living	3.3	2.7
Dining	2.7	2.2
Exterior	5.5	4.5
Other: Closet	1.7	1.4
Other: Hallway	1.7	1.4
Overall Average	**2.7**	**2.2**

2. 2016 Common Area Lighting: Projects that utilized deemed HOU values from the TRM for common areas will apply the 79% realization rate. Projects that used site-specific, vendor-calculated HOU will calculate their 2016 average HOU and adjust their realization rate to reflect deviation of vendor-input HOU from the HOU recommended in the Navigant "*Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings*" report, as shown below.

Deemed and Adjusted Hours of Use Analysis[26]

Room	Current TRM Deemed HOU	Adjusted HOU
Common Hall	24	24
Elevator	24	24
Exterior	12	12
Laundry	24	**12**
Lobby	24	24
Mechanical Room	24	**2**
Mgmt. Office	24	**8**
Other*	24	**8**
Stairs	24	24

[24] NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*. http://ma-eeac.org/wordpress/wp-content/uploads/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf

[25] Room-specific HOU were reduced by 18.5%, based on comparison of the deemed 2.7 hours/day across all residential uses and building types with the 2.2 hours/day specific to MA Non-Low-Income Multifamily housing from the NMR Group, Inc. (2014) *Northeast Residential Lighting Hours-of-Use Study*.

[26] Deemed Hours of Use are from Table 11 and Adjusted Hours of Use are from Table 12 in the *Multifamily Program Improvement Strategies Preliminary Results – Summary of Task 2b and 3 Findings*.

3. 2017 Realization Rates and In-Service Rates will be determined through a new evaluation that will provide rapid feedback upon the data tracking and QA/QC processes and will establish new RR/ISRs to be applied to 2017. This evaluation will be completed in time for filing with the 2017 term year report.