

MEMORANDUM

To: MA Cross Cutting NEI Working Group

From: Greg Clendenning and Nicole Rosenberg, NMR; Nate Caron and Novel Stevens, DNV GL

Cc:

Date: March 30, 2018

Re: Market-Rate Multifamily NEI – Phase I Final Memo (MF NEI Matrix and Program Data Analysis)

Executive Summary

This memorandum reports the findings for Phase I of the Market-Rate Multifamily Non-Energy Impacts (NEIs) study. The study seeks to better understand the NEIs associated with retrofits to market-rate “multifamily” (MF) properties (defined as properties with five or more dwelling units) that accrue to the owners and managers of the properties. In the first phase, the team conducted an analysis of the MF NEIs planned for by the PAs in their 2016-18 plan BC models. The following tasks were included in this analysis:

- Analyzed a compilation of the NEIs planned for by the PAs in their 2016-18 plan BC models in the MF sector and the source documents of the NEIs
- Analyzed a compilation of the measures associated with each MF NEI, including, to the extent possible, whether the measure is installed in a common area, a housing unit, or as a central system
- Determined the PA program(s) and initiative(s) associated with these measures for which there is a related NEI. To the extent possible, determined whether these measures are also associated with the “single-family” sector
- Linked the population benefiting from the NEIs (i.e., tenant vs. owner or landlord) to the installed measure(s) and program(s)/initiative(s)
- Identified measures currently not associated with NEIs but installed by PA MF Retrofit initiatives, including if there were any measures installed through the Commercial and Industrial (C&I) MF initiatives that have NEIs but were not being planned for by the PAs in their 2016-18 plan BC models for their C&I MF projects
- Analyzed program data for the PA MF Retrofit initiatives from the 2015 Program Year

This memo also provides an analysis of the NEIs associated with the revised measure lists for the PAs' MF retrofit initiatives (Residential MF Retrofit, Low-income (LI) MF Retrofit, and C&I MF Retrofit). The analysis sought to determine the following:

- 1) Whether any LIMF owner and C&I NEIs not currently included in the PAs 2016-18 plan BC models through the C&I MF Retrofit initiative apply to market rate MF projects
- 2) Whether NEI values differ for MF projects based on the type and ownership of the participating building
- 3) Whether there is overlap or double counting of MF NEIs in the PAs 2016-18 plan BC models

The memo is divided into five parts:

- Residential MF Retrofit initiative review
- Low-income MF Retrofit initiative review
- C&I MF initiative review
- Analysis of recently revised measure lists for the PAs' MF retrofit initiatives
- MF program data analysis

KEY FINDINGS

The key findings from Phase I of this study are as follows:

- All residential MF-specified measures and associated NEIs in the BCR tables were included in the TRM.¹
- NMR confirmed that the residential NEI values in the TRM and BCR models are consistent with the values reported in the original source document.²
- For the most part, the residential MF Retrofit initiative NEI values are quite similar to the HES initiative NEI values. The LIMF Retrofit initiative generally has higher values for the same NEIs and measures, and for some measures – such as air sealing, low-flow showerheads, thermostats, and refrigerators – the LIMF Retrofit initiative has additional NEIs that accrue to the owners and managers of the LIMF facilities.
- At the time of the initial review, the program tracking data did not consistently track whether measures, such as lighting, thermostats, hot water heaters and air conditioners, were installed in common areas or housing units. The PAs now track lighting by location.
- For C&I MF retrofits, the PAs did not consistently use the same NEI values for the same measures in their 2016-18 plan BC models. For example, for lighting, Eversource used the residential value and National Grid used both the residential value and the C&I existing buildings value, while for HVAC measures, Eversource appeared to use the NEI

¹ The evaluation team notes that for LIMF, the TRM does not include lighting-related NEIs for owners and managers that were reported in the 2011 Residential and Low-Income NEI study.

² NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

value for “HVAC – custom” rather than “HVAC-prescriptive” (as reported in the 2012 C&I Retrofit NEI study).³

- The BCR models do not appear to capture the diversity of electric and gas HVAC measures installed in C&I MF retrofit projects and are therefore not attributing all of the NEIs to the C&I MF initiative. The NEIs are attributed to the initiative to which the savings are claimed (the C&I MF Retrofit and C&I RF initiatives, respectively).
- As noted in the NEI Framework Study Report, due to the double counting associated with property values or rental income and the individual non-property value NEIs that are the source of changes in property value or rental income, we recommend that the PAs not count their existing property value NEIs (including “housing unit value” for owners) for those measures with both property and non-property NEIs. But for those measures that only have property value NEIs, such as appliances and low-flow showerheads, we recommend using, in the BCR calculations, the property value NEIs as proxies for the individual NEIs that have not yet been counted.
- From the 2015 program year tracking data for the Residential MF Retrofit initiative and C&I MF Retrofits, lighting accounts for the largest share of electric savings (75%), followed by HVAC measures, while envelope, hot water, and HVAC measures account for the bulk of natural gas savings (40%, 27%, and 18%, respectively).
- A majority of the HVAC electric and therm savings are attributed to major equipment types that are amenable to a life-cycle cost analysis, such as air conditioning, ASHP, and boilers. In contrast, the vast majority of hot water measure savings are attributable to measures such as faucet aerators and low-flow showerheads that are not appropriate for a life-cycle analysis.

RECOMMENDATIONS

Based on these findings, we recommend the following:

- For measures that exist in both the LIMF initiative and market-rate MF initiative (hot water measures, lighting, thermostats, air sealing, refrigerators), the team recommends that the PAs apply the associated LIMF owner NEIs to market rate MF projects (Rental Units Marketability, Reduced Tenant Complaints, Property Durability, Equipment Maintenance and Reliability [thermostats only]). For those MF NEIs that have both occupant and owner values (increased home/property durability), the team recommends applying the owner NEI only. [Appendix B](#) and the accompanying spreadsheet details the measure-level NEI recommendations.⁴
- For common area lighting installed through the residential MF Retrofit initiative, the team recommends applying the C&I lighting O&M NEI value.⁵ The team notes that C&I Retrofit

³ DNV KEMA. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators.

⁴ For LIMF, the team recommends claiming the same non-O&M owner NEIs (Rental Units Marketability, Property Durability. And Reduced Tenant Complaints) for lighting installed in common areas.

⁵ DNV GL and Tetra Tech. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study.” Prepared for the Massachusetts Program Administrators.

NEIs are currently applied to eligible C&I measures installed through the C&I MF Retrofit initiative.⁶

- As shown in [Table 6](#), ensure that the C&I MF NEIs for common area measures (i.e., not in-unit measures) are being applied consistently across the PAs' BCRs and reflect the diversity of the C&I NEIs provided by the source document.

CONSIDERATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Based on these findings, we provide the following considerations and suggestions for future research:

- To the extent possible, the program tracking data should more clearly track whether measures installed in MF sites, particularly lighting measures, are installed in common areas or housing units. This will help ensure that the appropriate NEI can be claimed by the PAs (e.g., C&I NEIs for common areas and residential NEIs for housing units).
- Once the MF retrofit redesign is complete, the team recommends the PAs consider reconciling and re-examining the MF owner/property manager NEIs for both common area and in-unit measures. In addition, the PAs might consider further research for the most commonly installed measures to update NEIs for reduced O&M costs (i.e., through equipment life cycle analyses), increased unit marketability and durability, and reduced tenant complaints and turnover costs.

⁶ For LIMF, the team recommends claiming the same C&I lighting O&M NEI value for lighting installed in common areas

Section 1 Introduction

This memorandum reports the findings for Phase I of the Market-Rate Multifamily Non-Energy Impacts (NEIs) study. The study seeks to better understand the NEIs associated with retrofits to market-rate “multifamily” (MF) properties (defined as properties with five or more dwelling units) that accrue to the owners and managers of the properties. In the first phase, the team conducted an analysis of the MF NEIs planned for by the PAs in their 2016-18 plan BC models. The following tasks were included in the analysis:

- Analyzed a compilation of the NEIs planned for by the PAs in their 2016-18 plan BC models in the MF sector and the source documents of the NEIs
- Analyzed a compilation of the measures associated with each MF NEI, including, to the extent possible, whether the measure is installed in a common area, a housing unit, or as a central system
- Determined the PA program(s) and initiative(s) associated with these measures for which there is a related NEI. To the extent possible, determined whether these measures are also associated with the “single-family” sector
- Linked the population benefiting from the NEIs (i.e., tenant vs. owner or landlord) to the installed measure(s) and program(s)/initiative(s)
- Identified measures currently not associated with NEIs but installed by PA MF Retrofit initiatives, including if there were any measures installed through the Commercial and Industrial (C&I) MF initiatives that have NEIs but were not being planned for by the PAs in their 2016-18 plan BC models for their C&I MF projects
- Analyzed program data for the PA MF Retrofit initiatives from the 2015 Program Year

This memo also provides an analysis of the NEIs associated with revised measure lists for the PAs’ MF retrofit initiatives (Residential MF Retrofit, Low-income (LI) MF Retrofit, and C&I MF Retrofit). The analysis sought to determine the following:

- 1) Whether any LIMF owner and C&I NEIs not currently included in the PAs 2016-18 plan BC models through the C&I MF Retrofit initiative apply to market rate MF projects
- 2) Whether NEI values differ for MF projects based on the type and ownership of the participating building
- 3) Whether there is overlap or double counting of MF NEIs in the PAs 2016-18 plan BC models

The memo is divided into five parts:

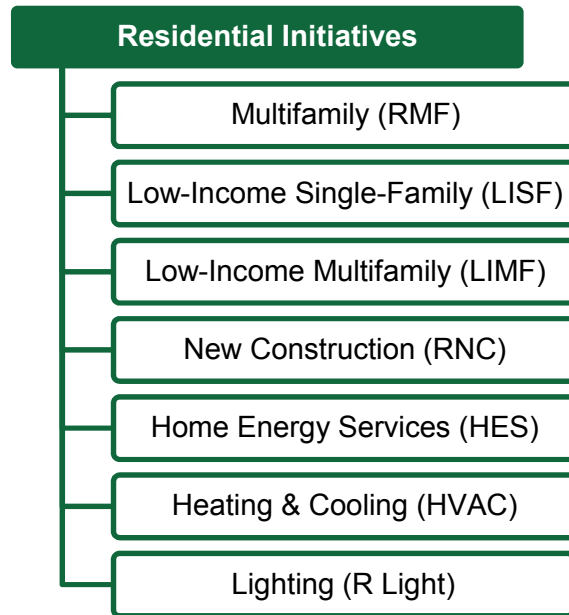
- Residential MF Retrofit initiative review
- Low-income MF Retrofit initiative review
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- Analysis of recently revised measure lists for the PAs’ MF retrofit initiatives
- MF program data analysis

Section 2 Residential Multifamily Initiative Measures and Associated NEIs

2.1 REVIEW THE TRM AND BCR NEI VALUES

The Massachusetts Technical Reference Manual (TRM)⁷ lists the PA initiatives, the measures included in each initiative, and the measures with individual NEI categories. The TRM also provides the NEI values associated with each NEI for each measure and for each initiative. The NEI values are then used as inputs into the PAs’ benefit-cost ratio (BCR) models. Figure 1 lists the initiatives included in the TRM and in the “NEI Lookups” worksheet of the PAs’ 2016-18 plan BC models.⁸

Figure 1: PA Initiatives in TRM and BCR Models



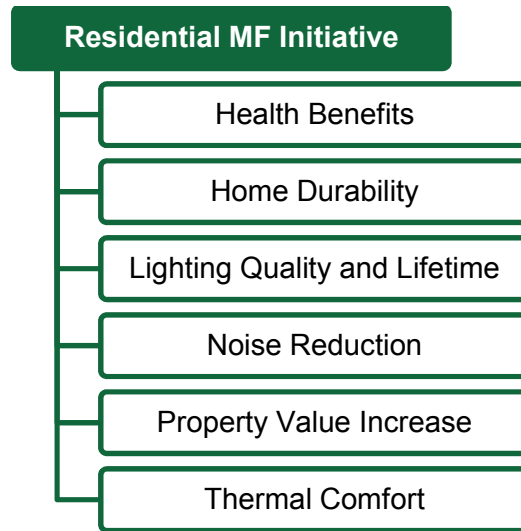
As a first step, the team studied the measures and their associated NEIs that appear in the TRM and the PA BCR NEI Lookup tables provided by the PAs for the residential MF Retrofit initiative.⁹ The NEIs associated with the MF Retrofit initiative are listed in Figure 2 and are limited to NEIs that accrue to the occupant of the retrofitted housing unit. The team found that all residential MF-specified measures and associated NEIs in the 2016-18 plan BC model tables were included in the TRM.

⁷ Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. October 2015.

⁸ The team reviewed 2016-2018 three-year plan BC models provided by Eversource Gas, Eversource Electric, National Grid Gas, and National Grid Electric for this analysis.

⁹ Includes Eversource Gas, Eversource Electric, National Grid Gas, and National Grid Electric. All BCR models used in this analysis were the 2016-2018 three-year plan BC models that we received from the PAs in 2016.

Figure 2: NEIs Reported in the TRM and BCR Models for Residential Retrofit Multifamily Initiative



2.2 LINK THE TRM AND BCR NEI VALUES TO THEIR SOURCES

NMR confirmed that the values in the TRM and BCR models are consistent with the values reported in the original source document (NMR’s 2011 study, Massachusetts Special, and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts Evaluation, [“NMR”]).¹⁰ While the values from the 2011 residential study were derived primarily from a sample of single-family homes (SFH), duplexes, and two-to-four unit buildings (99% of the sample respondents), if the same measure is installed in a MF housing unit, presumably the measure results in the same set of NEIs. While it is not clear whether the NEI values are of the same magnitude for a SFH and a MF home, the team recommends continuing to apply the values from the 2011 NMR study to the residential MF Retrofit initiative until the PAs are able to develop MF-specific values. [Table 1](#) links the residential MF Retrofit initiative measures with their NEIs in the TRM and the BCR NEI tables to the 2011 NMR study.

¹⁰ NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

Table 1: Residential Multifamily Initiative Measures and their Associated NEIs in the TRM and BCR Models

| Multifamily Initiative Measure | Residential MF Initiative | | | | | |
|--------------------------------|---------------------------|-----------------|-------------------------------|-----------------|-------------------------|-----------------|
| | Health Benefits | Home Durability | Lighting Quality and Lifetime | Noise Reduction | Property Value Increase | Thermal Comfort |
| Air Sealing | NMR | NMR | | NMR | NMR | NMR |
| CFL Bulb | | | NMR ¹ | | | |
| Duct Seal | NMR | NMR | | | NMR | NMR |
| Fixtures | | | NMR ¹ | | | |
| Insulation | NMR | NMR | | NMR | NMR | NMR |
| LED Bulb | | | NMR ¹ | | | |
| Low-Flow Showerhead | | | | | NMR | |
| Pipe Wrap | | | | | | |
| Thermostat | NMR | NMR | | | NMR | NMR |
| Refrigerator | | | | | NMR | |

¹ NMR suggested a one-time per unit value range of \$3.00-\$3.50. The TRM and BCR models use \$3.50 for fixture and \$3.00 for CFL bulbs. NMR did not study LED NEIs in 2011, but it appears that the CFL value has been applied to the LEDs.

2.3 COMPARING RESIDENTIAL MULTIFAMILY NEI VALUES ACROSS RESIDENTIAL AND LOW-INCOME INITIATIVES

We compared the NEI values associated with the residential MF Retrofit measures with those of other residential and low-income initiatives included in the TRM. [Table 2](#) lists all residential MF measures, the residential MF NEI values, and any NEI values associated with other initiatives offering the same measures. Nearly all the measures installed in the residential MF retrofit initiative are installed in the individual housing units, with the exception of lighting, which can also be installed in common areas. The NEIs listed in the TRM and BCR models correspond to the occupant NEIs, though the NEIs for lighting measures installed in common areas accrue to the owner of the building.¹¹

In addition, for measures that are also provided under the PAs’ low-income multifamily (LIMF) initiative, [Table 2](#) includes the NEIs associated with owners and managers of LIMF projects. As discussed in more detail in [Section 3](#) of the memo, NEIs that accrue to owners and managers of LIMF projects may theoretically accrue to owners and managers of market-rate MF projects. We note that for LIMF, the TRM does not include lighting-related NEIs for owners and managers that were reported in the 2011 study and the team therefore recommends that the PAs claim the

¹¹ After our initial measure review, the PAs have developed revised BCR models that have additional MF measures, such as faucet aerators, and differentiate between in-unit and common area lighting.

non-O&M NEIs (Rental Units Marketability, Property Durability, And Reduced Tenant Complaints) for lighting installed in common areas.¹²

For the most part, the residential MF Retrofit initiative NEI values are quite similar to the HES initiative NEI values. The LIMF Retrofit initiative generally has higher values for the same NEIs and measures, and for some measures – such as air sealing, low-flow showerheads, thermostats, and refrigerators – the LIMF Retrofit initiative has additional NEIs that accrue to the owners and managers of the LIMF facilities. These additional NEIs include housing-unit value (in addition to property value), tenant complaints, durability, and marketability. It is important to note that there is likely to be substantial overlap between two sets of NEIs: the property value and housing-unit value NEIs, and durability (occupant) and durability (owner). The property value and durability (occupant) NEIs were derived from the tenant survey respondents to the residential and LI NEI study, while the housing-unit property value and durability (owner) values were derived from the owner and manager survey respondents. The beneficiary of two of the NEIs, durability and property value, depends upon the ownership of the unit.¹³ If the occupant owns the unit, the NEIs accrue to the occupant (and occupant NEIs apply), but if the unit is a rental unit, the NEIs accrue to the building owner (and owner NEIs apply).

¹² The 2011 Residential and LI NEI study found several NEIs associated with lighting for owners of LIMF projects, including marketing (\$0.44 per housing unit per year), durability (\$16.95 per housing unit per year), tenant complaints (\$9.02 per housing unit per year) and reduced lighting maintenance (\$86.73 per housing unit per year).

¹³ As discussed in more detail later in the memo, property value and housing unit value should not be counted along with the non-property value NEIs as this results in double counting.

Table 2. NEI Values by Residential Multifamily Measure Types Across All Residential and Low-Income Initiatives

| Measure | Initiative | Occupant NEIs | | | | | | LIMF Owner NEIs | | | | |
|-------------------------|---------------------|----------------------|--------------------------|--|-------------------------------|-------------------------------|---|------------------------------------|-----------------------------|--|--------------------------|---------------------------------|
| | | Health (Annual/Unit) | Durability (Annual/Unit) | Light Quality / Lifetime (One-Time/Unit) | Noise Reduction (Annual/Unit) | Thermal Comfort (Annual/Unit) | Property Value Increase (One-Time/Unit) | Housing Unit Value (One-Time/Unit) | Marketability (Annual/Unit) | Equipment Maint. & Reliability (Annual/Unit) | Durability (Annual/Unit) | Tenant Complaints (Annual/Unit) |
| CFL Bulb ¹ | RMF | | | \$3.00 | | | | | | | | |
| | HES | | | \$3.00 | | | | | | | | |
| | R Light | | | \$3.00 | | | | | | | | |
| | RNC | | | \$3.00 | | | | | | | | |
| LED Bulb ¹ | RMF | | | \$3.00 | | | | | | | | |
| | HES | | | \$3.00 | | | | | | | | |
| | R Light | | | \$3.00 | | | | | | | | |
| | RNC | | | \$3.00 | | | | | | | | |
| Fixtures ¹ | RMF | | | \$3.50 | | | | | | | | |
| | R Light | | | \$3.50 | | | | | | | | |
| Lighting - Prescriptive | C&I MF ¹ | | | \$3.50 | | | | | | | | |
| Refrigerator | RMF | | | | | | \$1.44 | | | | | |
| | LIMF | | | | | | \$26.61* | \$5.96* | \$0.34 | | \$12.90 | \$6.86 |
| | HES | | | | | | \$1.44 | | | | | |
| | LISF | | | | | | \$26.61 | | | | | |
| Low-Flow Showerhead | RMF | | | | | | \$0.03 | | | | | |
| | LIMF | | | | | | \$1.72* | \$0.17* | \$0.01 | | \$0.37 | \$0.20 |
| | HES | | | | | | \$0.03 | | | | | |
| | LISF | | | | | | \$1.72 | | | | | |

MARKET-RATE MULTIFAMILY NEI – PHASE I FINAL MEMO

| Measure | Initiative | Occupant NEIs | | | | | | LIMF Owner NEIs | | | | |
|-------------|------------|----------------------|--------------------------|--|-------------------------------|-------------------------------|---|------------------------------------|-----------------------------|--|--------------------------|---------------------------------|
| | | Health (Annual/Unit) | Durability (Annual/Unit) | Light Quality / Lifetime (One-Time/Unit) | Noise Reduction (Annual/Unit) | Thermal Comfort (Annual/Unit) | Property Value Increase (One-Time/Unit) | Housing Unit Value (One-Time/Unit) | Marketability (Annual/Unit) | Equipment Maint. & Reliability (Annual/Unit) | Durability (Annual/Unit) | Tenant Complaints (Annual/Unit) |
| Air Sealing | RMF | \$0.32 | \$3.95 | | \$4.88 | \$10.13 | \$135.83* | | | | | |
| | LIMF | \$5.69 | \$10.61 | | \$16.39 | \$30.23 | \$144.93* | \$1.19* | \$0.07 | | \$2.58 | \$1.37 |
| | HES | \$0.32 | \$3.95 | | \$4.88 | \$10.13 | \$135.83** | | | | | |
| | LISF | \$5.69 | \$10.61 | | \$16.39 | \$30.23 | \$144.93* | | | | | |
| Duct Seal | RMF | \$0.01 | \$0.06 | | | \$0.16 | \$2.51* | | | | | |
| | LIMF | \$0.13 | \$0.23 | | | \$0.68 | \$5.11* | | | | | |
| | HES | \$0.01 | \$0.06 | | | \$0.16 | \$2.51* | | | | | |
| | LISF | \$0.13 | \$0.23 | | | \$0.68 | \$5.11* | | | | | |
| Insulation | RMF | \$0.80 | \$9.82 | | \$11.54 | \$25.15 | \$378.05* | | | | | |
| | LIMF | \$4.77 | \$8.76 | | \$13.56 | \$25.38 | \$223.63* | | | | | |
| | HES | \$0.80 | \$9.82 | | \$11.54 | \$25.15 | \$378.05* | | | | | |
| | LISF | \$4.77 | \$8.76 | | \$13.56 | \$25.38 | \$223.63* | | | | | |
| Thermostat | RMF | \$0.13 | \$1.33 | | | \$3.99 | \$51.49* | | | | | |
| | LIMF | \$0.92 | | | | \$4.87 | \$34.47* | \$1.87* | \$0.11 | \$3.91 | \$4.05 | \$2.16 |
| | HES | \$0.13 | \$1.33 | | | \$3.99 | \$51.49* | | | | | |
| | LISF | \$0.92 | \$1.68 | | | \$4.87 | \$34.47* | | | | | |
| | RHVAC | \$0.13 | \$1.33 | | | \$3.99 | \$51.49* | | | | | |

Source: Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. October 2015.

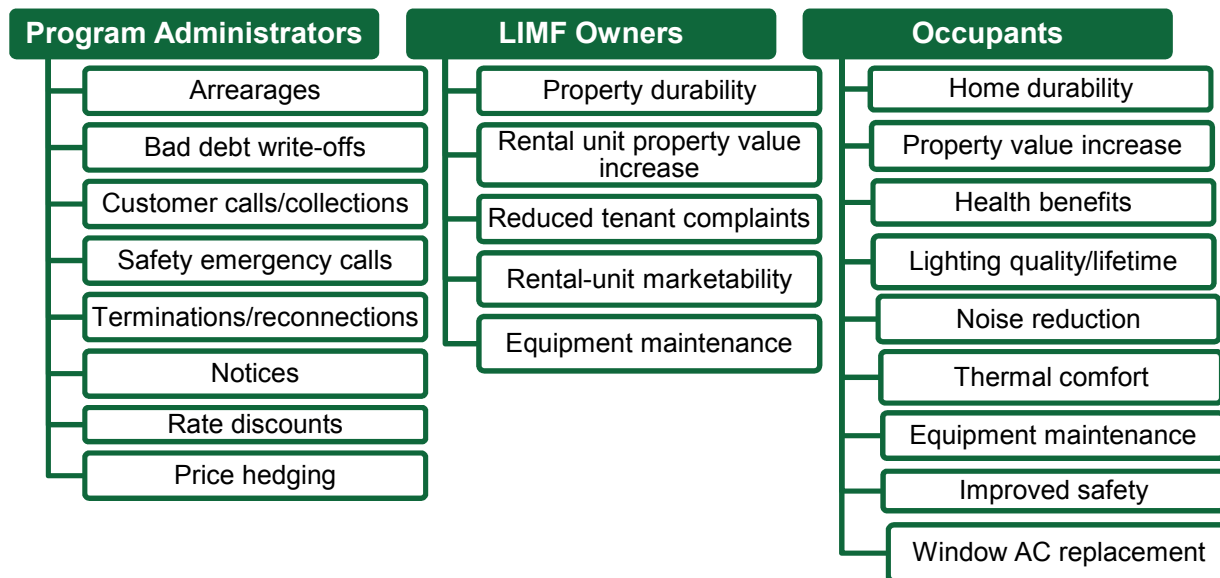
¹The 2011 Residential and LI NEI study also found several NEIs associated with lighting for owners of LIMF projects that were not included in the TRM, including marketing (\$0.44 per housing unit per year), durability (\$16.95 per housing unit per year), tenant complaints (\$9.02 per housing unit per year), and reduced lighting maintenance (\$86.73 per housing unit per year).

* As noted in the NEI Framework Study Report, due to the double counting associated with property values and the individual non-property value NEIs that are the source of changes in property value, we recommend that the PAs not count their existing property value NEIs (including “housing unit value” for owners) for those measures with both property and non-property NEIs. Rather, in the BCR calculations, the PAs should count the NEI values associated with the non-property NEIs, such as improved comfort, health, home durability, reduced O&M costs, reduced tenant complaints, etc. For those measures that only have property value NEIs, such as appliances and low-flow showerheads, we recommend using, in the BCR calculations, the property value NEIs as proxies for the individual NEIs that have not yet been counted.

Section 3 Low-Income MF NEI Values

The LIMF Retrofit initiative includes NEIs that accrue to multiple beneficiaries: the PAs, the owners of the buildings (LIMF owner), and the occupants of the housing units. Figure 3 organizes the NEIs by beneficiary. The beneficiary of two of the NEIs, durability and property value, depends upon the ownership of the unit.¹⁴ If the occupant owns the unit, the NEIs accrue to the occupant, but if the unit is a rental unit, the NEIs accrue to the building owner (i.e., the LIMF owner NEIs apply). But because ownership details of MF projects are not tracked to the individual housing unit, in cases where a measure has an identical occupant and owner NEI category, such as durability, the team recommends that the PAs claim the owner NEI.¹⁵ In addition, for lighting measures, the LIMF Retrofit initiative was only claiming the occupant NEI at the time of our initial review. If lighting measures are installed in common areas, the C&I O&M NEIs for this common area lighting accrue to the LIMF owner.

Figure 3. NEIs Reported in the TRM and BCR Models for Low-Income Multifamily Initiative, by Beneficiary



In the following tables, we report the LIMF NEIs by beneficiary (occupants, building owners, PAs), and the measures associated with the NEIs.

Table 3 reports the LIMF NEIs that accrue to occupants. As with the residential MF NEIs reported in Table 2, the occupant NEI values were derived from a sample of predominantly non-

¹⁴ As discussed in more detail later in the memo, property value should not be counted along with the non-property NEIs as this results in double counting.

¹⁵ The team recommends the owner NEIs in these cases for several reasons. First, the owner NEI survey addressed a much smaller set of measures so that their estimate of NEIs are likely more accurate for a given measure and NEI combination. Second, the owners arguably have a more accurate assessment of the durability costs and benefits of their properties than a tenant. Third, the occupant NEI survey sample was composed of primarily single-family home occupants.

MF respondents (4% of the sample resided in buildings with five or more units). LIMF occupants accrue the same set of NEIs as non-LI occupants, plus two additional NEIs of improved safety and a set of NEIs associated with window AC replacements.

The NEI values in the BCR models and TRM matched those reported and recommended in the 2011 NEI report, with the exception of lighting quality and price hedging, which relied on a supplemental memo prepared by the Evaluation Management Committee to the PAs.

- Lighting quality: The value was recommended in a memo from the Evaluation Management Committee to the PAs. The memo recommended adopting the lighting quality and lifetime value estimated in the 2011 study through the survey of low-income initiative participants (\$56 per participant).¹⁶
- Price hedging: The value was recommended in a memo from the Evaluation Management Committee to the PAs. Price hedging is a metric of the benefit of minimizing initiative participants' exposure to energy price increases, based on a study from Lawrence Berkeley National Lab that quantified the value that wind power provides as a hedge against volatile natural gas prices.¹⁷

In addition, the reviewed BCR models and TRM appear to have transposed the NEI values for equipment maintenance and home durability for heating system retrofits. The value for equipment maintenance should be \$27.43, and durability should be \$9.72 for heating system retrofits.

¹⁶ Evaluation Management Committee. 2012. Additional Non-Energy Impacts for Low Income Programs. Prepared for the Massachusetts Program Administrators. July 25, 2012.

¹⁷ Evaluation Management Committee. 2012. Additional Non-Energy Impacts for Low Income Programs. Prepared for the Massachusetts Program Administrators. July 25, 2012.

Table 3. Low-Income Multifamily Initiative NEIs in the TRM and BCR Models - Occupants

| Measure | Health (Annual/ Unit) | Improved Safety (One-Timer/ Unit) | Equipment Maintenance (Annual/unit) | Light Quality / Lifetime (One-Time/ Household) | Noise Reduction (Annual/ Unit) | Thermal Comfort (Annual/Unit) | Property Value Increase (One-Time/ Unit) | Home Durability (Annual/ Unit) | Window AC Replacement (Annual/ Unit) |
|-----------------------------------|-----------------------|-----------------------------------|-------------------------------------|--|--------------------------------|-------------------------------|--|--------------------------------|--------------------------------------|
| Air Sealing | \$5.69 | | | | \$16.39 | \$30.23 | \$144.93 | \$10.61 | |
| Duct Seal | \$0.13 | | | | | \$0.68 | \$5.11 | \$0.23 | |
| Faucet Aerator | | | | | | | \$26.61 | \$0.37 | |
| Freezer Replacement | | | | | | | \$26.61 | | |
| Heating System Retrofit | \$5.27 | \$45.05 | \$9.72 ¹ | | | \$28.01 | \$249.20 | \$27.43 ¹ | |
| Insulation | \$4.77 | | | | \$13.56 | \$25.38 | \$223.63 | \$8.76 | |
| Low-flow Showerhead | | | | | | | \$1.72 | \$0.37 | |
| Pipe Wrap (Heating/Water Heating) | \$1.05 | | | | | \$5.56 | \$5.00 | | |
| Programmable Thermostat | \$0.92 | | | | | \$4.87 | \$34.47 | \$1.68 | |
| Refrigerator Replacement | | | | | | | \$26.61 | | |
| Water Heater | | | | | | | \$1.65 | \$0.20 | |
| Window AC Replacement | | | | | | | | | \$49.50 ² |
| Lighting ³ | | | | \$56.00 | | | | | |

Source: Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. October 2015.

¹ The NEI values for equipment maintenance and home durability for heating system retrofits are transposed; the value for equipment maintenance should be \$27.43, and durability should be 9.72.

² The window replacement NEI is an annual participant benefit that includes comfort, safety, and health effects for window AC replacements. The value was estimated from the evaluation of National Grid’s 2003 Appliance Management Program (AMP), a pilot program that replaced inefficient air-conditioning units in low-income households (Quantec and SERA. 2005. Evaluation of National Grid’s 2003 Appliance Management Program: Room Air Conditioning Metering and Non-Energy Benefits Study. National Grid USA Service Company.)

³ Reported as “participant” in the TRM and BCR models.

Table 4 presents the TRM and BCR NEI values for the LIMF Retrofit initiative that accrue to owners of the LIMF buildings. The NEI values in the BCR models and TRM matched those reported and recommended in the 2011 NEI report, with the exception of an additional NEI value of \$0.005 per kWh (one-time) for rental-unit property value increase for low-flow showerheads in the NSTAR electric BCR model (the team does not know the source of the NEI value). As noted previously, the team does not recommend counting property value NEIs for measures that include non-property value NEIs. In addition, the TRM does not include lighting-related NEIs for owners and managers that were reported in the 2011 study. For lighting measures installed in common areas, the team recommends that the PAs claim the non-O&M NEIs (Rental Units Marketability, Property Durability, and Reduced Tenant Complaints), as well as the C&I O&M NEIs.¹⁸ It is important to note that the NEIs are applied per housing unit, not per measure. And for measures such as lighting that include multiple types that can be installed in the same facility (i.e., common area fixtures, exterior fixtures, common area bulbs, etc.), the NEIs should be claimed a single time for all lighting measures associated with a MF facility.

Table 4. Low-Income Multifamily Initiative NEIs in the TRM and BCR Models -- Owners

| Measures | Property Durability (Annual/ Unit) | Rental-Unit Property Value Increase (One-Time/ Unit) | Tenant Complaints (Annual/ Unit) | Rental-Unit Marketability (Annual/Unit) |
|--------------------------------------|------------------------------------|--|----------------------------------|---|
| Air Sealing | \$2.58 | \$1.19 | \$1.37 | \$0.07 |
| Faucet Aerator | | \$0.17 | \$0.20 | \$0.01 |
| Freezer Replacement | \$12.90 | \$5.96 | \$6.86 | \$0.34 |
| Low-Flow Showerhead | \$0.37 | \$0.17 ¹ | \$0.20 | \$0.01 |
| Programmable Thermostat ² | \$4.05 | \$1.87 | \$2.16 | \$0.11 |
| Refrigerator Replacement | \$12.90 | \$5.96 | \$6.86 | \$0.34 |
| Water Heater | \$0.37 | \$0.17 | \$0.20 | \$0.01 |

Source: Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. October 2015.

¹ The NSTAR BCR models include an additional, one-time NEI value of \$0.005 per kWh.

² Programmable Thermostats have an additional annual NEI of equipment maintenance and reliability of \$3.91/ housing unit.

Table 5 presents the TRM and BCR NEI values for the LIMF Retrofit initiative that accrue to PAs. For each participating household, the LIMF Retrofit initiative produces several annual NEIs that accrue to the PAs: arrearages, bad-debt write-offs, terminations and reconnections, customer calls and collections, and notices. For each LIMF measure installed, the TRM applies

¹⁸ The team recommends claiming the same set of NEIs for lighting measures with unknown location. The team recommends using the C&I lighting O&M NEI rather than the LIMF owner NEI of “reduced lighting maintenance” because we feel it is a more accurate estimate O&M NEIs for building owners.

rate discount and price hedging values; the measures for which they apply include air sealing, CFLs, duct sealing, faucet aerators, fixtures, freezer replacements, heating system retrofits, insulation, LEDs, low-flow showerheads, pipe wraps, thermostats, water heaters, waterbeds, and window AC replacements. The NEI values in the BCR models and TRM matched those reported and recommended in the 2011 NEI report.

The BCR models appropriately included rate discounts and price hedging NEIs for a number of measures installed by the initiative but not included in the TRM: air source heat pumps, appliance removal, custom measures, demand circulators, duct insulation, smart strips, torchieres, and variable frequency drives.¹⁹

Table 5. Low-Income Multifamily Initiative NEIs in the TRM and BCR Models - Program Administrators

| NEI | Annual per Participating Household | Per Measure (All Measures) | | |
|--------------------------------|------------------------------------|----------------------------|-------------------------------|------------------|
| | | Annual per kWh | Annual per Therm ¹ | One-Time per kWh |
| Arrearages | \$2.61 | | | |
| Bad-Debt Write-offs | \$3.74 | | | |
| Terminations and Reconnections | \$0.43 | | | |
| Customer Calls and Collections | \$0.58 | | | |
| Notices | \$0.34 | | | |
| Rate Discounts | | \$0.03 | | |
| Price Hedging | | | \$0.13 | \$0.01 |

Source: Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures: 2016-2018 Program Years – Plan Version. October 2015.

¹ Excludes electric-only measures (e.g., lighting and appliances).

¹⁹ The team agrees with applying rate discounts and price hedging NEIs to all LIMF measures.

Section 4 C&I MF Initiative Measures and Associated NEIs

As part of Task 2, for the PAs C&I MF initiatives, the team reviewed the NEIs planned for by the PAs in their 2016-18 plan BC models and reviewed the 2015 C&I MF Retrofit initiative data. The following tasks were completed:

- Reviewed and compared TRM and the NEI tables in the PAs' 2016-18 plan BC models provided by the PAs²⁰ for the C&I MF initiative
- Compared the TRM and BCR NEI values to their source, DNV GL's 2012 study, *Commercial and Industrial Non-Energy Impacts Study*²¹
- Reviewed 2015 program data and determined the following to the extent possible:
 - Whether the measure was installed in a housing unit, was installed in a common area, or is a central system
 - Whether there were any measures not associated with NEIs but installed by PA MF initiatives, including if there were any measures installed through the C&I MF initiatives that have NEIs but were not being planned for their C&I MF projects by the PAs' BCR models

The review process was complicated by several factors:

- 1) The TRM reports NEI values for only a limited subset of measures installed by the C&I MF Retrofit initiative: one electric measure (lighting) and four gas measures (duct insulation, pipe wrap, thermostats, and custom measures).
- 2) The electric and gas and BCR models are organized differently.
 - a. The electric BCR models do not include set values for the C&I MF measures listed in the NEI lookups tab. Instead, the BCR models draw upon values in the NEI lookups tab associated with the same measures listed under the residential multifamily retrofit initiative (lighting) or the C&I Existing Buildings Retrofit initiative (lighting, HVAC, and hot water measures). In addition, the electric BCR models report NEIs only by broad measure groups, such as HVAC, but the models do not define the individual measures included in the measure groups. In contrast, the gas BCR models do include NEI lookups for all measures and are generally reported for individual measures, such as "pipe wrap" and "duct insulation," rather than broad measure groups, with the exception of custom HVAC, hot water, and heating measures.
- 3) The BCR models and TRM do not consistently follow the organization of the C&I retrofit NEI study.
 - a. The C&I Retrofit NEI study reports NEIs by broad measure categories, such as building envelope, HVAC, and water heating, and report different values for prescriptive and custom applications within each of these measure groups. For

²⁰ Includes Eversource Gas, Eversource Electric, National Grid Gas, and National Grid Electric. All BCR models used in this analysis were the 2016-2018 three-year plan models that we received from the PAs in 2016.

²¹ DNV KEMA. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators.

reference, we report the NEI values from the 2012 C&I Retrofit NEI study in [Appendix A](#).

- 4) At the time of the evaluation team’s review, the PAs did not consistently use the same NEI values for the same measures. For example, for lighting, Eversource planned for the residential value, and National Grid planned for both the residential value and the C&I existing buildings value.

4.1 REVIEW OF THE TRM, BCR MODEL, AND C&I RETROFIT REPORT NEI VALUES

[Table 6](#) presents the C&I Multifamily measures and the NEI values from the BCR models and the TRM; it compares them to the C&I NEI Retrofit study and offers our assessment of the information. We first present electric measures and then gas measures. The team assumed that the measures identified in the BCR models and the C&I NEI Retrofit report are measures installed in common areas or central systems and that the NEIs accrue to the building owners, with the exception of lighting and programmable thermostats, which could also be installed in housing units. However, at the time of our review, the program tracking data did not track where lighting measures and thermostats were installed.

Table 6. C&I Multifamily Initiative NEIs in the TRM and BCR Models

| Measure | BCR | | TRM | | | NEI Report | | Assessment |
|------------------------------|--|---------------------------------------|------------------|---------------------|-----------|---------------------------------|------------------|---|
| | National Grid, per kWh/ Therm of Savings | Eversource, per kWh/ Therm of Savings | Initiative | Measure | NEI Value | Measure Name | NEI Value | |
| Electric | | | | | | | | |
| HVAC - Multifamily | 0.097 | 0.024 | C&I Retrofit | HVAC - Prescriptive | 0.097 | E - HVAC - Prescriptive | 0.097 | Eversource appears to be planning for the NEI value “HVAC – custom” rather than “HVAC-prescriptive.” |
| Hot Water - Multifamily | 0.056 | - | C&I Retrofit | Process - Custom | 0.056 | E - Water Heater - Prescriptive | \$0 (Not St Sig) | NEI value should be \$0 as water heater NEIs were not statistically significant in the DNV study, rather than planning the “Custom-Total” value from the NEI report. |
| Lighting - Multifamily | 0.027 ¹ | - ¹ | C&I MF Retrofits | Lighting | 0.027 | E - Lighting - Prescriptive | 0.027 | National Grid is claiming both the residential one-time lighting NEI value and the C&I NEI value, while Eversource is planning for the residential NEI value. The initiatives should differentiate between common area lighting (C&I NEIs) and in-unit lighting (Res NEIs). |
| HVAC Custom-Multifamily | 0.024 | 0.024 | C&I MF Retrofits | HVAC - Custom | 0.024 | E - HVAC - Custom | 0.024 | All sources match. |
| Hot Water Custom-Multifamily | 0.056 | - | C&I Retrofit | Process - Custom | 0.056 | E - Water Heater - Custom | Not St Sig | NEI value should be \$0. |

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| Measure | BCR | | TRM | | | NEI Report | | Assessment |
|-----------------------------|--|---------------------------------------|------------------|-------------------|-----------|----------------------------|-----------------------|--|
| | National Grid, per kWh/ Therm of Savings | Eversource, per kWh/ Therm of Savings | Initiative | Measure | NEI Value | Measure Name | NEI Value | |
| Lighting Custom-Multifamily | 0.059 | 0.059 | C&I MF Retrofits | Lighting - Custom | 0.059 | E - Lighting - Custom | 0.0594 | All sources match, assuming this is lighting installed in common areas. |
| Gas | | | | | | | | |
| Building Shell - Custom | 0.25 | 0.25 | C&I MF Retrofits | Custom | 0.25 | G - Envelope - Custom | 0.477 | The BCR appears to be using the “Gas-Custom-Total” NEI rather than the envelope value. The PAs should claim the envelope -specific NEI rather than the ‘total’ value for “Gas-Custom.” |
| HVAC - Custom | 0.25 | 0.25 | C&I MF Retrofits | Custom | 0.25 | G - HVAC - Custom | 0.229 | The BCR appears to be using the “Gas-Custom-Total” NEI rather than the HVAC value. The PAs should claim the HVAC -specific NEI rather than the “total” value for “Gas-Custom.” |
| Heating - Custom | 0.25 | 0.25 | C&I MF Retrofits | Custom | 0.25 | G - HVAC - Custom | 0.229 | The BCR appears to be using the Gas-Custom-Total NEI rather than the HVAC value. The PAs should claim the HVAC -specific NEI rather than the “total” value for “Gas-Custom.” |
| Hot Water - Custom | 0.25 | 0.25 | C&I MF Retrofits | Custom | 0.25 | G - Water Heater - Custom | Not St Sig | NEI value should be \$0. |
| Duct Insulation | 1.35 | - | C&I MF Retrofits | Duct Insulation | 1.35 | G - HVAC - Prescriptive OR | 1.35 if prescriptive; | Determine if the measure is prescriptive or custom and |

| BCR | | | TRM | | | NEI Report | | Assessment |
|---------------------------|--|---------------------------------------|------------------|------------|-----------|---|--|---|
| Measure | National Grid, per kWh/ Therm of Savings | Eversource, per kWh/ Therm of Savings | Initiative | Measure | NEI Value | Measure Name | NEI Value | |
| | | | | | | Custom | 0.23 if custom | claim the appropriate NEI value. |
| Pipe Wrap (Water Heating) | 1.35 | - | C&I MF Retrofits | Pipe Wrap | 1.35 | G - Water heater - prescriptive OR Custom | Not St Sig | NEI value should be \$0. |
| Pipe Wrap (Heating) | 1.35 | - | C&I MF Retrofits | Pipe Wrap | 1.35 | G - HVAC - Prescriptive OR Custom | 1.3464 if prescriptive; 0.2291 if custom | Determine if the measure is prescriptive or custom and claim the appropriate NEI value. |
| Programmable Thermostat | 1.35 | - | C&I MF Retrofits | Thermostat | 1.35 | G - HVAC - Prescriptive | 1.35 | Thermostats were included in the C&I NEI study as “HVAC-Prescriptive” (resulting in O&M savings). |

¹ The BCR model also included a one-time \$3.50 per lighting measure.

4.2 REVIEW OF THE 2015 C&I MF PROGRAM DATA

As a next step, the team reviewed C&I MF Retrofit NEI data from the 2015 program year for the following purposes:

- To determine if the measure was installed in a housing unit, installed in a common area, or is a central system
- To identify measures currently not associated with NEIs but installed by PA MF Retrofit initiatives, including whether there were any measures installed through the C&I MF Retrofit initiative that have NEIs but that were not being included in the PAs 2016-18 plan BC models for their C&I MF projects.

The program data does not track the location of a measure, so we were not able to definitively determine whether a measure was installed in a housing unit or a common area. Unless noted, the team assumed that the measures were either central systems or were installed in common areas (and therefore have NEIs that accrue to the owners of the MF buildings).

Table 7 presents a summary of the measures that the team could not definitively link to the C&I MF Retrofit initiatives in the BCR models (and therefore the models did not appear to be crediting the MF initiative with the corresponding NEI values). Overall, the BCR models do not appear to capture the diversity of electric and gas HVAC measures installed in C&I MF retrofit projects. We have identified several electric HVAC measures because the electric BCR models only include a single measure ID for HVAC and we assumed the single measure ID does not encompass all of the HVAC measures included in the program data.²² We have also identified a number of prescriptive gas HVAC measures because the gas BCR models appear to only include custom HVAC measures.²³ Overall, it appears that the NEIs are being claimed by the initiative where the savings are being claimed (the C&I MF Retrofit and C&I RF initiatives, respectively).

²² The program data did not include BCR measure IDs, so we cannot be certain whether the NEIs for these measures are included in the PAs 2016-18 plan BC models for the C&I MF Initiatives.

²³ The PAs may want to consider creating a lookup list of C&I measures for each NEI measure category, based on the sampling from the C&I retrofit study, to help assign NEI values.

Table 7. C&I Multifamily Measures Not Attributed to the C&I MF Initiative in the PA BCR Models

| Measure Name (Tracking Data) | Measure Name (C&I RF BCR) | NEI Value (C&I RF BCR) | Measure Name (C&I Retro. NEI Report) | NEI Value (C&I Retro. NEI Report) |
|------------------------------|---------------------------|------------------------|--------------------------------------|-----------------------------------|
| Electric | | | | |
| Custom - CHP | CHP systems | -0.015 | E - CHP - Custom | -0.015 |
| Prescriptive- CHILLER | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- EMS | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- HVAC-CONTROLS | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- HVAC-HEATPUMP | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- HVAC-MOTORS | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- HVAC-CONTROLS | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Prescriptive- HVAC-MOTORS | HVAC - Prescriptive | 0.10 | E - HVAC - Prescriptive | 0.10 |
| Custom - PROCESS | Process - Custom | 0.06 | E - Other - Custom | 0.06 |
| Custom - SPRAY-VALVE | Other - Custom | 0.00 | E - Other - Custom | 0.06 ¹ |
| Custom - PROCESS | Other - Custom | 0.00 | E - Other - Custom | 0.06 ¹ |
| Gas | | | | |
| Custom - STEAM TRAPS | Steam Trap - Custom | 1.35 | HVAC - Custom | 0.23 ² |
| Prescriptive- HVAC | HVAC - Prescriptive | 0.00 | HVAC - Prescriptive | 1.35 |
| Prescriptive- HVAC-EQUIPMENT | HVAC - Prescriptive | 0.00 | HVAC - Prescriptive | 1.35 |
| Prescriptive- BOILER-RESET | Boiler reset controls | 1.35 | HVAC - Prescriptive | 1.35 |
| Prescriptive- CONDENSING | HVAC - Prescriptive | 0.00 | HVAC - Prescriptive | 1.35 |
| Prescriptive - Custom | Other - Prescriptive | 0.00 | Total - Prescriptive | 0.83 ³ |

¹ From the DNV report, the custom-electric “other” reporting category included the building envelope, compressed air, process, and other end uses.

² From program data details, this appears to be an HVAC measure.

³ Recommend using the Total-prescriptive value.

In addition, the program data included three electric measures that are not associated with C&I electric NEIs but do have residential NEIs; the team recommends claiming the LIMF owner NEIs for the following measures:

- Thermostats²⁴
- Low-flow showerheads
- Faucet aerators.

The team examined the energy savings included with the program data and estimated that 21% of the electric savings and 9% of the gas savings are associated with measures that do not appear to be linked to the C&I MF Retrofit initiatives in their BCR models. In other words, the PAs may not be attributing NEIs to the C&I MF initiative for measures responsible for 21% of electric savings and 9% of gas savings to MF retrofits (Table 8).

Table 8. C&I MF Program Tracking Energy Savings, Summarized by Initiatives with which the Measures are Associated with in the BCR Models

| Initiative Measures are Identified With | Savings (kWh) | Savings (therms) | Percent of Savings (kWh) | Percent of Savings (Therms) |
|---|---------------|------------------|--------------------------|-----------------------------|
| C&I Multifamily Retrofit | 8,484,673 | 514,971 | 79% | 91% |
| C&I Existing Building Retrofit | 2,304,314 | 53,584 | 21% | 9% |
| Residential | 5,649 | 0 | 0.1% | 0% |
| Grand Total | 10,794,636 | 568,555 | 100% | 100% |

²⁴ Thermostats have C&I gas NEIs associated with them but not electric NEIs. Assuming that the thermostats are typically installed in housing units in MF retrofit projects, the team recommends claiming the LIMF owner NEIs.

Section 5 Analysis of Revised Multifamily Measure Lists

As part of task 2, the team identified measures currently not associated with NEIs but installed by PA MF Retrofit initiatives. This section of the memo provides an analysis of the NEIs associated with the recently revised measure lists for the PAs' MF retrofit initiatives (Residential MF Retrofit, Low-income [LI] MF Retrofit, and C&I MF Retrofit). There are three aspects of the analysis:

- 1) Determine if any LIMF owner and C&I NEIs not included in the PAs 2016-18 plan BC models in the C&I MF Retrofit initiative apply to market rate MF projects.
- 2) Determine if NEI values differ for MF projects based on the type and ownership of the participating building.
- 3) Determine if there is overlap or double counting of MF NEIs included in the PAs 2016-18 plan BC models.

5.1 APPLICABILITY OF LOW-INCOME MULTIFAMILY OWNER AND C&I NEIs TO MARKET RATE MULTIFAMILY PROJECTS

Based on the literature review included in the *NEI Framework Study Report*, there appears to be a wide range of NEIs that apply to owners of market-rate MF projects, including condominiums.²⁵ Several recent studies have examined NEIs accruing to owners and managers of MF housing that are currently not included in the PAs 2016-18 plan BC models. These NEIs include, but are not limited to, improved rental unit quality, reduced turnover costs, reduced maintenance costs, reduced marketing costs, and reduced tenant turnover, which in turn contribute to a relatively small number of monetized NEIs. These monetized NEIs include increased rental income, reduced O&M costs, and increased property values.²⁶

Because of the evidence from the recent literature, as well as evidence from the 2011 residential NEI study,²⁷ for the measures that overlap between the LIMF initiative and market-rate MF initiative (hot water measures, lighting, thermostats, air sealing, and refrigerators), the team recommends that the PAs claim the following LIMF owner NEIs for

²⁵ DNV GL and NMR. 2018. NEI Framework Study Report. Prepared for Massachusetts Program Administrators.

²⁶ As noted in the NEI Framework Study Report, due to the double counting associated with property values or rental income and the individual non-property value NEIs that are the source of changes in property value or rental income, we recommend that the PAs not count their existing property value NEIs for those measures with both property and non-property NEIs. Rather, in the BCR calculations, the PAs should count the NEI values associated with the non-property value NEIs, such as improved comfort, health, home durability, reduced O&M costs, reduced tenant complaints, etc.

²⁷ NMR. 2011. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators.

their market rate MF projects (as listed in the PAs’ BCR models and reported earlier in Table 4).²⁸

- Rental Units Marketability
- Reduced Tenant Complaints
- Property Durability
- Equipment Maintenance Reliability Due to Thermostats

In cases in which a measure has an identical occupant and owner NEI category, such as durability, the team recommends that the PAs claim the owner NEI.²⁹

If Phase II of the project goes forward, the PAs could use the results of the market-rate owner IDIs to adjust the LIMF NEIs for market-rate projects.

In addition, for common area lighting installed through the residential MF Retrofit initiative, the team recommends applying the C&I lighting O&M NEI value.³⁰ The team notes that C&I Retrofit NEIs were included in the 2016-18 plan BC models for eligible C&I measures installed through the C&I MF Retrofit Initiative.

5.2 MULTIFAMILY NEI VALUES THAT DIFFER BY OWNERSHIP CHARACTERISTICS

Because of the complex nature of ownership and management of MF condominiums, the question arises as to whether building owner NEIs apply to condominiums. LIMF owners can realize several NEIs related to reduced operations and maintenance (O&M) costs, including reduced marketing costs, reduced equipment maintenance (including lighting), increased durability of the property, and reduced tenant complaints.

We differentiate MF condominiums from MF rental properties by the ownership of the individual housing units. MF condominiums are defined as a type of homeownership in which the housing units in a building or development are individually owned, but the common areas are jointly owned and managed.³¹ Individual condominium units may be owner-occupied, rented to long-term tenants, or leased as short-term vacation rentals. In

²⁸ The Team recommends applying the same LIMF owner NEI values to market rate MF projects, rather than scaling the values. The literature is very limited and does not provide evidence to suggest scaling the LIMF owner NEIs either higher or lower for market rate projects.

²⁹ The team recommends the owner NEIs in these cases for several reasons. First, the owner NEI survey addressed a much smaller set of measures so that their estimate of NEIs are likely more accurate for a given measure and NEI combination. Second, the owners arguably have a more accurate assessment of the durability costs and benefits of their properties than a tenant. Third, the occupant NEI survey sample was composed of primarily single-family home occupants.

³⁰ The team recommends using the C&I lighting O&M NEI rather than the LIMF owner NEI of “reduced lighting maintenance” because we feel it is a more accurate estimate of O&M NEIs for building owners. The team recommends claiming the same set of NEIs for lighting measures with unknown location. See DNV GL and Tetra Tech. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study.” Prepared for the Massachusetts Program Administrators.

³¹ <http://www.census.gov/housing/soma/about/definitions.html>

contrast, an entire MF rental building or development (housing units and common areas) has a single owner and the housing units are rented to long-term tenants.

While there may be differences in the magnitude of the owner NEIs by the ownership characteristics, the team is unaware of any research estimating MF owner NEIs by ownership characteristics. Therefore, as noted in the previous section, the team recommends that the PAs claim the LIMF owner NEIs for their market rate MF projects. Future research may want to consider examining differences in owner NEIs by ownership characteristics.

5.3 DOUBLE COUNTING OF MULTIFAMILY NEIS INCLUDED IN THE PAs 2016-18 PLAN BC MODELS

As noted in the NEI Framework Study Report, due to the double counting associated with property values or rental income and the individual non-property value NEIs that are the source of changes in property value or rental income, we recommend that the PAs not count their existing property value NEIs (including “housing unit value” for owners) for those measures with both property and non-property NEIs. Rather, in the BCR calculations, the PAs should count the NEI values associated with the non-property NEIs, such as improved comfort, health, home durability, reduced O&M costs, reduced tenant complaints, etc. For those measures that only have property value NEIs, such as appliances and low-flow showerheads, we recommend using, in the BCR calculations, the property value NEIs as proxies for the individual NEIs that have not yet been counted.

Section 6 Program Data Analysis: PA MF Retrofit Initiatives

As part of Task 2, the team analyzed data from the 2015 program year for all MF retrofit projects from the Residential MF Retrofit initiative and all MF projects included in the tracking data for the C&I Retrofit initiatives. The team examined the measures installed by the initiatives and the associated energy savings.

Table 9 reports the measures installed by the Residential MF Retrofit initiative and C&I MF Retrofit and the associated energy savings. Lighting accounts for the largest share of electric savings (75%), followed by HVAC measures. Envelope, hot water, and HVAC measures account for the bulk of natural gas savings (40%, 27%, and 18%, respectively).

Table 9. Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofit initiatives

| End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|----------------|-------------------|------------------|------------------|--------------------|--------------------|---------------|
| CHP | 765,512 | 1.2% | 0 | 0.0% | 2 | 0.0% |
| Comprehensive | 3,540,076 | 5.7% | 231,985 | 9.8% | 14 | 0.0% |
| Compressed Air | 257,809 | 0.4% | 0 | 0.0% | 17 | 0.0% |
| Envelope | 2,323,370 | 3.7% | 948,469 | 40.0% | 6,731 | 11.4% |
| Food Service | 9,688 | 0.0% | 586 | 0.0% | 2 | 0.0% |
| Hot Water | 412,838 | 0.7% | 646,199 | 27.3% | 4,725 | 8.0% |
| HVAC | 5,117,241 | 8.2% | 421,050 | 17.8% | 1,944 | 3.3% |
| Lighting | 46,779,915 | 75.1% | 0 | 0.0% | 34,378 | 58.5% |
| Motors | 506,959 | 0.8% | 0 | 0.0% | 6 | 0.0% |
| N/A | 187,677 | 0.3% | 0 | 0.0% | 274 | 0.5% |
| Other | 300,871 | 0.5% | 60,564 | 2.6% | 5,804 | 9.9% |
| Process | 1,031,930 | 1.7% | 50,001 | 2.1% | 3,528 | 6.0% |
| Refrigeration | 343,031 | 0.6% | 0 | 0.0% | 121 | 0.2% |
| Unknown | 690,694 | 1.1% | 9,485 | 0.4% | 1,261 | 2.1% |
| Overall | 62,267,611 | 100.0% | 2,368,339 | 100.0% | 58,807 | 100.0% |

Because of the interest in potentially conducting a life-cycle cost analysis to quantify O&M NEIs associated with equipment measures, the team further examined the HVAC and hot water measures to determine the magnitude of savings associated with equipment, such as air conditioners, heat pumps and water heaters, that could potentially be part of a life-cycle cost analysis. As reported in Table 10 and Table 11, a majority of the HVAC electric and therm savings are attributed to major equipment, such as air conditioning, ASHP, and boilers, while the vast majority of hot water measure savings are attributable to measures

that are not appropriate for a life-cycle analysis, such as faucet aerators and low-flow showerheads.

Table 10. HVAC Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofit Initiatives

| End Use | Sub End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|----------------|---------------------|------------------|------------------|----------------|--------------------|--------------------|---------------|
| HVAC | Air Conditioning | 2,917,833 | 57.0% | 111,699 | 26.5% | 207 | 10.6% |
| | ASHP | 1,009,696 | 19.7% | | 0.0% | 43 | 2.2% |
| | Boiler | - | 0.0% | 98,902 | 23.5% | 103 | 5.3% |
| | Duct Sealing | 2,990 | 0.1% | 6 | 0.0% | 34 | 1.7% |
| | Ductless Mini-split | - | 0.0% | | 0.0% | 29 | 1.5% |
| | ECM | 187,518 | 3.7% | 57 | 0.0% | 35 | 1.8% |
| | Furnace | 98 | 0.0% | 399 | 0.1% | 8 | 0.4% |
| | Heating | - | 0.0% | 41,207 | 9.8% | 22 | 1.1% |
| | Other HVAC | 169,092 | 3.3% | 76,907 | 18.3% | 75 | 3.9% |
| | Thermostat | 797,066 | 15.6% | 91,873 | 21.8% | 1,386 | 71.3% |
| | VSD | 32,947 | 0.6% | | 0.0% | 2 | 0.1% |
| Overall | | 5,117,241 | 100.0% | 421,050 | 100.0% | 1,944 | 100.0% |

Table 11. Hot Water Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofit Initiatives

| End Use | Sub End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|-----------|------------------------|-------------|------------------|---------------|--------------------|--------------------|---------------|
| Hot Water | Faucet Aerator | 199,723 | 48.4% | 131,759 | 20.4% | 1,867 | 39.5% |
| | Heat pump water heater | - | 0.0% | | 0.0% | 20 | 0.4% |
| | Other hot water | 20,340 | 4.9% | - | 0.0% | 19 | 0.4% |
| | Pipe wrap | 10,320 | 2.5% | 253,055 | 39.2% | 642 | 13.6% |
| | Showerhead | 181,459 | 44.0% | 152,627 | 23.6% | 1,993 | 42.2% |
| | Spray valve | - | 0.0% | 1,554 | 0.2% | 11 | 0.2% |
| | Water heater | 996 | 0.2% | 107,204 | 16.6% | 173 | 3.7% |
| | Overall | | 412,838 | 100.0% | 646,199 | 100.0% | 4,725 |

Table 12 compares the measure savings of MF retrofits participating in the C&I Retrofit and Residential MF Retrofit initiatives. Both are heavily reliant on lighting savings, but the C&I Retrofit initiative accounted for the majority of the HVAC electric savings.

Table 12. Comparing Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofit Initiatives

| Sector | End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|-------------------------|-------------------|---------------|------------------|---------------|--------------------|--------------------|---------------|
| C&I Multifamily | CHP | 765,512 | 1.2% | | 0.0% | 2 | 0.0% |
| | Comprehensive | 3,540,076 | 5.7% | 231,985 | 9.8% | 14 | 0.0% |
| | Compressed Air | 257,809 | 0.4% | | 0.0% | 17 | 0.0% |
| | Envelope | | 0.0% | 397,155 | 16.8% | 161 | 0.3% |
| | Food Service | 9,688 | 0.0% | 586 | 0.0% | 2 | 0.0% |
| | Hot Water | 996 | 0.0% | 353,743 | 14.9% | 350 | 0.6% |
| | HVAC | 3,965,471 | 6.4% | 371,035 | 15.7% | 504 | 0.9% |
| | Lighting | 25,252,527 | 40.6% | | 0.0% | 8,470 | 14.4% |
| | Motors | 506,959 | 0.8% | | 0.0% | 6 | 0.0% |
| | N/A | 187,677 | 0.3% | | 0.0% | 274 | 0.5% |
| | Other | 22,988 | 0.0% | 25,701 | 1.1% | 9 | 0.0% |
| | Process | 341,407 | 0.5% | 50,001 | 2.1% | 19 | 0.0% |
| | Refrigeration | 319,890 | 0.5% | | 0.0% | 61 | 0.1% |
| Overall | 35,171,000 | 56.5% | 1,430,206 | 60.4% | 9,889 | 16.8% | |
| Residential Multifamily | Envelope | 2,323,370 | 3.7% | 551,314 | 23.3% | 6,570 | 11.2% |
| | Hot Water | 411,842 | 0.7% | 292,456 | 12.3% | 4,375 | 7.4% |
| | HVAC | 1,151,770 | 1.8% | 50,016 | 2.1% | 1,440 | 2.4% |
| | Lighting | 21,527,388 | 34.6% | - | 0.0% | 25,908 | 44.1% |
| | Other | 277,883 | 0.4% | 34,862 | 1.5% | 5,795 | 9.9% |
| | Process | 690,523 | 1.1% | - | 0.0% | 3,509 | 6.0% |
| | Refrigeration | 23,141 | 0.0% | - | 0.0% | 60 | 0.1% |
| | Unknown | 690,694 | 1.1% | 9,485 | 0.4% | 1,261 | 2.1% |
| Overall | 27,096,611 | 43.5% | 938,133 | 39.6% | 48,918 | 83.2% | |
| Overall | 62,267,611 | 100.0% | 2,368,339 | 100.0% | 58,807 | 100.0% | |

Table 13 further illustrates that C&I MF Retrofits accounted for the majority of HVAC electric savings attributable to major equipment, such as air conditioners and ASHPs, while most HVAC savings in the residential initiative are attributable to thermostats.

Table 13. Comparing HVAC Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofits

| End Use | Sector | Sub End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|----------------|-------------------------|---------------------|------------------|------------------|----------------|--------------------|--------------------|---------------|
| HVAC | C&I Multifamily | Air Conditioner | 2,683,011 | 52.4% | 111,699 | 26.5% | 186 | 9.6% |
| | | ASHP | 1,009,696 | 19.7% | | 0.0% | 43 | 2.2% |
| | | Boiler | | 0.0% | 98,456 | 23.4% | 100 | 5.1% |
| | | ECM | 187,518 | 3.7% | 57 | 0.0% | 28 | 1.4% |
| | | Furnace | | 0.0% | 399 | 0.1% | 7 | 0.4% |
| | | Heating | | 0.0% | 41,207 | 9.8% | 21 | 1.1% |
| | | Other HVAC | 48,894 | 1.0% | 76,037 | 18.1% | 37 | 1.9% |
| | | Thermostat | 3,404 | 0.1% | 43,180 | 10.3% | 80 | 4.1% |
| | | VSD | 32,947 | 0.6% | | 0.0% | 2 | 0.1% |
| | | Overall | 3,965,471 | 77.5% | 371,035 | 88.1% | 504 | 25.9% |
| | Residential Multifamily | Air Conditioner | 234,822 | 4.6% | - | 0.0% | 21 | 1.1% |
| | | Boiler | - | 0.0% | 446 | 0.1% | 3 | 0.2% |
| | | Duct Sealing | 2,990 | 0.1% | 6 | 0.0% | 34 | 1.7% |
| | | Ductless Mini-Split | - | 0.0% | | 0.0% | 29 | 1.5% |
| | | ECM | - | 0.0% | | 0.0% | 7 | 0.4% |
| | | Furnace | 98 | 0.0% | - | 0.0% | 1 | 0.1% |
| | | Heating | - | 0.0% | - | 0.0% | 1 | 0.1% |
| | | Other HVAC | 120,198 | 2.3% | 870 | 0.2% | 38 | 2.0% |
| | | Thermostat | 793,662 | 15.5% | 48,693 | 11.6% | 1,306 | 67.2% |
| | | Overall | 1,151,770 | 22.5% | 50,016 | 11.9% | 1,440 | 74.1% |
| Overall | | | 5,117,241 | 100.0% | 421,050 | 100.0% | 1,944 | 100.0% |

Demonstrating the complexity of tracking and identifying the savings attributable to MF Retrofits, [Table 14](#) reports the measure-level savings attributable to projects participating in the Residential MF Retrofit initiative, the C&I Retrofit initiative, and projects that participated in both, which account for 20% of electric savings and 10% of all therm savings. The team also notes that there are another 15,971,888 kWh and 353,312 therms of savings in MF projects participating in other residential initiatives (Residential Consumer Products, Residential Cooling & Heating Equipment, Residential Heating & Water Heating, Residential Home Energy Services, Residential Lighting, and Residential New Construction).

Table 14. Comparing Measures and Associated Energy Savings Installed Through Residential and C&I MF Retrofit Initiatives

| Participant Type | End Use | kWh Savings | % of kWh Savings | Therm Savings | % of Therm Savings | Number of Measures | % of Measures |
|---------------------------------|-------------------|-------------------|------------------|----------------|--------------------|--------------------|---------------|
| Residential Initiative Only | Envelope | 2,260,738 | 3.6% | 548,859 | 23.2% | 6,539 | 11.1% |
| | Hot Water | 385,525 | 0.6% | 290,637 | 12.3% | 4,145 | 7.0% |
| | HVAC | 1,134,808 | 1.8% | 50,016 | 2.1% | 1,411 | 2.4% |
| | Lighting | 19,368,887 | 31.1% | - | 0.0% | 24,621 | 41.9% |
| | Other | 277,883 | 0.4% | 34,862 | 1.5% | 5,566 | 9.5% |
| | Process | 632,695 | 1.0% | - | 0.0% | 3,264 | 5.6% |
| | Refrigeration | 23,141 | 0.0% | - | 0.0% | 60 | 0.1% |
| | Unknown | 690,694 | 1.1% | 9,485 | 0.4% | 1,218 | 2.1% |
| | Overall | 24,774,371 | 39.8% | 933,859 | 39.4% | 46,824 | 79.6% |
| C&I Initiative Only | CHP | 464,065 | 0.7% | | 0.0% | 1 | 0.0% |
| | Comprehensive | 2,049,233 | 3.3% | 157,435 | 6.6% | 10 | 0.0% |
| | Compressed Air | 201,935 | 0.3% | | 0.0% | 15 | 0.0% |
| | Envelope | | 0.0% | 376,931 | 15.9% | 133 | 0.2% |
| | Food Service | | 0.0% | 586 | 0.0% | 1 | 0.0% |
| | Hot Water | 996 | 0.0% | 272,735 | 11.5% | 294 | 0.5% |
| | HVAC | 2,201,174 | 3.5% | 314,843 | 13.3% | 348 | 0.6% |
| | Lighting | 18,898,803 | 30.4% | | 0.0% | 6,712 | 11.4% |
| | Motors | 502,434 | 0.8% | | 0.0% | 5 | 0.0% |
| | N/A | 105,771 | 0.2% | | 0.0% | 193 | 0.3% |
| | Other | 22,988 | 0.0% | 16,553 | 0.7% | 7 | 0.0% |
| | Process | 289,871 | 0.5% | 48,861 | 2.1% | 10 | 0.0% |
| | Refrigeration | 252,572 | 0.4% | | 0.0% | 50 | 0.1% |
| Overall | 24,989,842 | 40.1% | 1,187,944 | 50.2% | 7,779 | 13.2% | |
| Residential and C&I Initiatives | CHP | 301,447 | 0.5% | | 0.0% | 1 | 0.0% |
| | Comprehensive | 1,490,843 | 2.4% | 74,550 | 3.1% | 4 | 0.0% |
| | Compressed Air | 55,874 | 0.1% | | 0.0% | 2 | 0.0% |
| | Envelope | 62,632 | 0.1% | 22,679 | 1.0% | 59 | 0.1% |
| | Food Service | 9,688 | 0.0% | | 0.0% | 1 | 0.0% |
| | Hot Water | 26,317 | 0.0% | 82,827 | 3.5% | 286 | 0.5% |
| | HVAC | 1,781,259 | 2.9% | 56,192 | 2.4% | 185 | 0.3% |
| | Lighting | 8,512,225 | 13.7% | - | 0.0% | 3,045 | 5.2% |
| | Motors / Driv | 4,525 | 0.0% | | 0.0% | 1 | 0.0% |
| | N/A | 81,906 | 0.1% | | 0.0% | 81 | 0.1% |
| | Other | - | 0.0% | 9,148 | 0.4% | 231 | 0.4% |
| | Process | 109,364 | 0.2% | 1,140 | 0.0% | 254 | 0.4% |
| | Refrigeration | 67,318 | 0.1% | | 0.0% | 11 | 0.0% |
| | Unknown | - | 0.0% | - | 0.0% | 43 | 0.1% |
| | Overall | 12,503,398 | 20.1% | 246,535 | 10.4% | 4,204 | 7.1% |
| Overall | 62,267,611 | 100.0% | 2,368,339 | 100.0% | 58,807 | 100.0% | |

Appendix A Summary of C&I Retrofit NEI Values

This appendix reports the results of the C&I Retrofit NEI study (Table 15) and details about the measures included in some of the measure categories (Table 16).

Table 15. C&I Multifamily NEI Results

| Measure Category | Prescriptive | | Custom | |
|-------------------|----------------|----------------|---------------|----------------|
| | Electric | Gas | Electric | Gas |
| Building Envelope | Not Stat. Sig. | 3.6151 | No value | 0.4774 |
| CHP/Cogen | Not Stat. Sig. | Not Stat. Sig. | -0.0147 | Not Stat. Sig. |
| HVAC | 0.0966 | 1.3464 | 0.024 | 0.2291 |
| Lighting | 0.0274 | Not Stat. Sig. | 0.0594 | Not Stat. Sig. |
| Motors/Drives | 0.0043 | Not Stat. Sig. | 0.0152 | Not Stat. Sig. |
| Refrigeration | 0.0013 | Not Stat. Sig. | 0.0474 | Not Stat. Sig. |
| Water Heater | Not Stat. Sig. | 0.2604 | | 0.1824 |
| Other (varies) | 0.0039 | | 0.0562 | 0.5253 |
| TOTAL | 0.0274 | 0.8344 | 0.0368 | 0.2473 |

Source: DNV KEMA. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators.

Table 16. Details of Measures Included in the C&I Multifamily NEI Study

| Fuel and Type of Measure | Measure Category | Measure Details |
|--------------------------|-------------------|---|
| Prescriptive Electric | HVAC | AC, air handling units, chillers |
| Prescriptive Electric | Other | Comprehensive and compressed air end uses |
| Prescriptive Gas | Building Envelope | Insulation, windows, doors |
| Prescriptive Gas | HVAC | Gas boilers, furnaces, chiller |
| Prescriptive Gas | Water heater | Also includes spray valve and faucet aerator measures |
| Custom Electric | HVAC | AC, air handling units, chillers and includes thermostats |
| Custom Electric | Other | Includes building envelope, compressed air, process and other end uses. |
| Custom Gas | HVAC | Includes thermostats |
| Custom Gas | Other | Includes process and other end uses |

Source: DNV KEMA. 2012. Final Report – Commercial and Industrial Non-Energy Impacts Study. Prepared for Massachusetts Program Administrators.

Appendix B Recommended Market-Rate MF Owner NEIs

Table 17 and Table 18 present the measure-level NEI recommendations for market-rate MF retrofits. The team used the 2017 BC models as a starting point. Recommended additions are in green font and recommended deletions, due to potential double counting, are in red, strike-through font. The tables are included in the embedded spreadsheet, along with recommended changes to LIMF NEIs and the heat pump NEIs.



TXC29 Market-rate
MF NEIs 03MAR2018.xlsx

Table 17. Recommended Electric Measure Market-rate Multifamily NEIs

| Initiative | Measure | NEI | Annual per Unit | One Time per Unit | Annual per kWh | One Time per kWh | Annual per Therm | One Time per Therm |
|---|----------------------------|--|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| A1b - Residential Multi-Family Retrofit | Air Sealing | | 19.35 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Thermal Comfort | 10.13 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Noise Reduction | 4.88 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Home Durability | 3.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Health Benefits | 0.32 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | | | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Rental Units Marketability | 0.07 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Reduced Tenant Complaints | 1.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Property Durability | 2.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Property Value Increase | | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | | 47.31 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Thermal Comfort | 25.15 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Noise Reduction | 11.54 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Home Durability | 9.82 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Health Benefits | 0.8 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Property Value Increase | | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | | 0.23 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Thermal Comfort | 0.16 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Home Durability | 0.06 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Health Benefits | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Property Value Increase | | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | | 0.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Rental Units Marketability | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Reduced Tenant Complaints | 0.2 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Property Durability | 0.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Property Value Increase | | | 0.03 | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | | 0.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Rental Units Marketability | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Reduced Tenant Complaints | 0.2 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Property Durability | 0.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | | 14.35 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Thermal Comfort | 3.99 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Home Durability | 1.33 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Health Benefits | 0.13 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Rental Unit Marketability | 0.11 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Equipment Maintenance Reliability Due to Thermostats | 3.91 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Property Durability | 4.05 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Reduced Tenant Complaints | 2.16 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Property Value Increase | | | | | | |
| A1b - Residential Multi-Family Retrofit | Refrigerator | | 20.1 | | | | | |
| A1b - Residential Multi-Family Retrofit | Refrigerator | Rental Units Marketability | 0.34 | | | | | |
| A1b - Residential Multi-Family Retrofit | Refrigerator | Property Durability | 12.9 | | | | | |
| A1b - Residential Multi-Family Retrofit | Refrigerator | Reduced Tenant Complaints | 6.86 | | | | | |
| A1b - Residential Multi-Family Retrofit | Refrigerator | Property Value Increase | | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting * | | 26.41 | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | O&M | | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Rental Units Marketability | 0.44 | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Property Durability | 16.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Reduced Tenant Complaints | 9.02 | | | | | |
| A1b - Residential Multi-Family Retrofit | In-Unit Bulb | | | | 3 | | | |
| A1b - Residential Multi-Family Retrofit | In-Unit Fixtures | Lighting Quality and Lifetime | | | 3.5 | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | | 26.41 | | | 0.027 | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | O&M | | | | 0.027 | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Rental Units Marketability | 0.44 | | | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Property Durability | 16.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Reduced Tenant Complaints | 9.02 | | | | | |

* Common Area Lighting NEIs should be counted only once for each participating facility

Table 18. Recommended Gas Measure Market-rate Multifamily NEIs

| Initiative | Measure | NEI | Annual per Unit | One Time per Unit | Annual per kWh | One Time per kWh | Annual per Therm | One Time per Therm |
|---|--|--|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| A1b - Residential Multi-Family Retrofit | CFL Bulb (in unit) | Lighting Quality and Lifetime | | | 3 | | | |
| A1b - Residential Multi-Family Retrofit | LED Bulb (in unit) | Lighting Quality and Lifetime | | | 3 | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | | 47.31 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Thermal Comfort | 25.15 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Noise Reduction | 11.54 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Home Durability | 9.82 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Health Benefits | 0.8 | | | | | |
| A1b - Residential Multi-Family Retrofit | Insulation | Property Value Increase | | | 378.05 | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | | 19.35 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Thermal Comfort | 10.13 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Noise Reduction | 4.88 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Home Durability | 3.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Health Benefits | 0.32 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Rental Units Marketability | 0.07 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Reduced Tenant Complaints | 1.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Property Durability | 2.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Air Sealing | Property Value Increase | | | 135.83 | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | | 0.23 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Thermal Comfort | 0.16 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Home Durability | 0.06 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Health Benefits | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Duct Sealing | Property Value Increase | | | 2.51 | | | |
| A1b - Residential Multi-Family Retrofit | Thermostat (per house receiving tstat) | | 14.35 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostat (per house receiving tstat) | Thermal Comfort | 3.99 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostat (per house receiving tstat) | Home Durability | 1.33 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostat (per house receiving tstat) | Health Benefits | 0.13 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Rental Unit Marketability | 0.11 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Equipment Maintenance Reliability Due to Thermostats | 3.91 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Property Durability | 4.05 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostats | Reduced Tenant Complaints | 2.16 | | | | | |
| A1b - Residential Multi-Family Retrofit | Thermostat (per house receiving tstat) | Property Value Increase | | | 51.49 | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | | 0.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Rental Units Marketability | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Reduced Tenant Complaints | 0.2 | | | | | |
| A1b - Residential Multi-Family Retrofit | Showerhead | Property Durability | 0.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Low-Flow Showerhead | Property Value Increase | | | 0.03 | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | | 0.58 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Rental Units Marketability | 0.01 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Reduced Tenant Complaints | 0.2 | | | | | |
| A1b - Residential Multi-Family Retrofit | Aerator | Property Durability | 0.37 | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting * | | 26.41 | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | O&M | | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Rental Units Marketability | 0.44 | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Property Durability | 16.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Common Area Lighting | Reduced Tenant Complaints | 9.02 | | | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | | 26.41 | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | O&M | | | 0.027 | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Rental Units Marketability | 0.44 | | | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Property Durability | 16.95 | | | | | |
| A1b - Residential Multi-Family Retrofit | Lighting, unknown location | Reduced Tenant Complaints | 9.02 | | | | | |

* Common Area Lighting NEIs should be counted only once for each participating facility

Appendix C Non-Energy Impacts (NEIs) for Heat Pumps

MEMORANDUM

To: Beth Delahajj, National Grid

From: Greg Clendenning, NMR Group

Cc:

Date: October 31, 2017

Re: Non-Energy Impacts (NEIs) for Heat Pumps

C.1 BACKGROUND AND OBJECTIVES

Because the number of heat pump projects has increased recently and because there are multiple data sources (four) for NEIs that apply to heat pump projects, the Massachusetts Program Administrators (PAs) asked the Cross-Cutting Evaluation Team to provide guidance on the NEIs that apply to heat pump projects for several building types:

- Low-income (LI) multifamily (MF) buildings
- Market rate MF buildings
- LI single family (SF) buildings

In addition to general guidance on heat pump NEIs, the PAs asked for answers to the following questions:

- Are there differences in applying existing NEIs to mini-split heat pumps versus ducted heat pumps?
- Are there differences in NEIs among projects in which the heat pump replaces existing electric resistance heat or electric furnaces (with and without existing air conditioning) or existing oil, gas, or propane heating systems?
- Do the heat pump NEIs apply to multifamily retrofit projects that include multi-head heat pump systems in which a single exterior unit serves multiple individual housing units (with each housing unit receiving an interior unit)?

Below, we present a summary of the recommended heat pump NEI values. This is followed by detailed information about the data sources for the current heat pump NEI values and guidance for each of the building types.

C.2 SUMMARY OF RECOMMENDED HEAT PUMP NEI VALUES

Table 19 provides a summary of the NEI recommendations from this memo.

Table 19: Summary of Heat Pump NEIs

| Initiative | Measure | NEI | Annual per Unit | One Time per Unit | Annual per kWh | One Time per kWh |
|---|--|------------------------|------------------------|--------------------------|-----------------------|-------------------------|
| A1b - Residential Multifamily Retrofit | Heat Pump | Total | \$5.70 | | | |
| <i>A1b - Residential Multifamily Retrofit</i> | <i>Heat Pump</i> | <i>Noise Reduction</i> | <i>\$2.50</i> | | | |
| <i>A1b - Residential Multifamily Retrofit</i> | <i>Heat Pump</i> | <i>Home Durability</i> | <i>\$1.17</i> | | | |
| <i>A1b - Residential Multifamily Retrofit</i> | <i>Heat Pump</i> | <i>Thermal Comfort</i> | <i>\$1.96</i> | | | |
| <i>A1b - Residential Multifamily Retrofit</i> | <i>Heat Pump</i> | <i>Health Benefits</i> | <i>\$0.07</i> | | | |
| A1b - Residential Multifamily Retrofit | Heat Pump (Early Replacement Only) | Equipment Maintenance | \$9.42 | | | |
| A1b - Residential Multifamily Retrofit | Ductless Mini-Split | Total | \$5.98 | | | |
| A1b - Residential Multifamily Retrofit | Ductless Mini-Split | Noise Reduction | \$1.41 | | | |
| A1b - Residential Multifamily Retrofit | Ductless Mini-Split | Home Durability | \$1.96 | | | |
| A1b - Residential Multifamily Retrofit | Ductless Mini-Split | Thermal Comfort | \$2.53 | | | |
| A1b - Residential Multifamily Retrofit | Ductless Mini-Split | Health Benefits | \$0.08 | | | |
| B1a - Low-Income Multifamily Retrofit | Heat Pump & Ductless Mini-Split | Total | \$123.91 | | Varies by PA | \$0.005 |
| <i>B1a - Low-Income Multifamily Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Home Durability</i> | <i>\$9.72</i> | | | |
| <i>B1a - Low-Income Multifamily Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Thermal Comfort</i> | <i>\$28.01</i> | | | |
| <i>B1b - Low-Income Multifamily Retrofit</i> | <i>Heat Pump &</i> | <i>Health Benefits</i> | <i>\$5.27</i> | | | |

| Initiative | Measure | NEI | Annual per Unit | One Time per Unit | Annual per kWh | One Time per kWh |
|--|--|--|-----------------|-------------------|---------------------|------------------|
| | <i>Ductless Mini-Split</i> | | | | | |
| <i>B1b - Low-Income Multi-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Equipment Maintenance</i> | \$27.43 | | | |
| <i>B1b - Low-Income Multi-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Improved Safety</i> | \$45.05 | | | |
| <i>B1b - Low-Income Multi-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Safety Related Emergency Calls (PA NEI)</i> | \$8.43 | | | |
| <i>B1b - Low-Income Multi-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Rate Discounts</i> | | | <i>Varies by PA</i> | |
| <i>B1b - Low-Income Multi-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Price Hedging</i> | | | | \$0.005 |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | Total | \$310.82 | | <i>Varies by PA</i> | \$0.005 |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Home Durability</i> | \$9.72 | | | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Thermal Comfort</i> | \$33.24 | | | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Health Benefits</i> | \$213.13 | | | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Equipment Maintenance</i> | \$27.43 | | | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Improved Safety</i> | \$18.87 | | | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Safety Related Emergency Calls (PA NEI)</i> | \$8.43 | | | |
| <i>B1a - Low-Income Single-Family</i> | <i>Heat Pump &</i> | <i>Rate Discounts</i> | | | <i>Varies by</i> | |

| Initiative | Measure | NEI | Annual per Unit | One Time per Unit | Annual per kWh | One Time per kWh |
|--|--|-------------------------|-----------------|-------------------|----------------|------------------|
| <i>Retrofit</i> | <i>Ductless Mini-Split</i> | | | | <i>PA</i> | |
| <i>B1a - Low-Income Single-Family Retrofit</i> | <i>Heat Pump & Ductless Mini-Split</i> | <i>Price Hedging</i> | | | | <i>\$0.005</i> |
| B1a - Low-Income Single-Family Retrofit | Smoke Detectors | Total (Improved Safety) | \$5.51 | | | |
| B1a - Low-Income Single-Family Retrofit | CO Detectors | Total (Improved Safety) | | \$183.50 | | |
| B1a- Low-Income Single-Family Retrofit | Heat Pump & Ductless Mini-Split (LI Window AC Replacement) | Total | \$42.75 | | | |
| B1b - Low-Income Multi-Family Retrofit | Heat Pump & Ductless Mini-Split (LI Window AC Replacement) | Total | \$42.75 | | | |

C.3 CURRENT HEAT PUMP NEI VALUES

There are currently four data sources for NEIs that apply to heat pump projects:

- 1) A number of NEIs for residential and low-income heating systems and heating and cooling systems, which include heat pumps, are reported in the 2011 Residential and Low-Income NEI report.³² These NEIs include home durability, thermal comfort, health benefits, property value, equipment maintenance, improved safety, safety related emergency calls, and rate discounts.
- 2) The HVAC-related NEIs from the 2011 report were later updated for market-rate residential programs in the 2013 Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs Memo.³³ The 2013 memo provides adjusted NEI values based on differences in NEIs for residential heating and cooling equipment that is early replacement compared to replace on failure. Low-income values were not adjusted because low-income program measures are considered early replacement measures.
- 3) Updated health and safety-related NEIs for LISF homes are reported in the 2016 Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study.³⁴
- 4) The NEI of “Price Hedging,” applicable to low-income program measures, is reported in the 2011 Additional Non-Energy Impacts of Low-Income Programs memo.³⁵

³² NMR. 2011. Residential and Low-Income NEIs. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators by NMR. [http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation\(76\).pdf](http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation(76).pdf)

³³ NMR. 2013. Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement compared to Replace on Failure. Prepared for Pam Rathbun and Marie Abdou by NMR. July 15, 2013. <http://ma-eeac.org/wordpress/wp-content/uploads/HVAC-Replace-on-Failure-Non-Energy-Impacts-Memo-7.15.13.pdf>

³⁴ Three3 and NMR. 2016. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for the Massachusetts Program Administrators and EEAC Consultants. Massachusetts Special and Cross-Cutting Research Area. August 5, 2016 <http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf>

³⁵ Evaluation Management Committee. 2011. Additional Non-Energy Impacts of Low-Income Programs (Memo). 2011 Energy Efficiency Annual Report, Appendix C – Study 28. Prepared for: Massachusetts Program Administrators. <http://ma-eeac.org/wordpress/wp-content/uploads/Additional-Non-Energy-Impacts-for-Low-Income-Programs-Memo-to-MA-Program-Administrators-from-Evaluation-Managment-Committee.pdf>

C.3.1 Market Rate Multifamily

For market-rate MF retrofit projects, NMR recommends using the values reported in the 2013 Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs Memo, with the exception of property values (Table 20).³⁶

Table 20: Market Rate MF Heat Pump NEIs*

| Measure | NEI | Overall NEI value (\$ / Year per system installed)** |
|---------------------|-----------------|--|
| Heat Pump | Noise Reduction | \$2.50 |
| | Home Durability | \$1.17 |
| | Thermal Comfort | \$1.96 |
| | Health Benefits | \$0.07 |
| Ductless Mini-Split | Noise Reduction | \$1.41 |
| | Home Durability | \$1.96 |
| | Thermal Comfort | \$2.53 |
| | Health Benefits | \$0.08 |

* Source: NMR. 2013. Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement compared to Replace on Failure. Prepared for Pam Rathbun and Marie Abdou, July 15, 2013

** The NEI values apply when the heat pump replaces an existing heating system serving an individual housing unit (including multi-head heat pump systems in which a single exterior unit serves multiple individual housing units). Home Durability would accrue to owners/landlords (not the occupants) of rental units.

In addition, if the heat pump measures are considered early replacement measures, the equipment maintenance value from the 2011 report, \$9.42 per unit per year, could be applied.³⁷

C.3.2 Low-Income Single and Multifamily

For low-income MF retrofit projects for which the heat pump measures serve as a heating system, including ductless mini-split systems that replace existing electric resistance heat or electric furnaces, NMR recommends using the values reported in the 2011 Report for heating systems, including improved safety, safety related emergency calls, rate discounts, and price hedging (but not property values) (Table 21).³⁸ For low-income single-family home retrofit projects for which the heat pump measures serve as a heating system, NMR recommends the

³⁶ As noted in the draft NEI Framework Report, the Evaluation Team recommends that for those measures with both property value NEIs and non-property NEIs, such as improved comfort and health, only the non-property NEIs, and not the property value NEIs, be counted in any benefit cost calculations.

³⁷ The 2013 memo notes that the PAs determined that the equipment maintenance NEI should only be applied to non-oil-to-gas early replacement heating, cooling, or heating and hot water system measures.

³⁸ As noted in the draft NEI Framework Report, the Evaluation Team recommends that for those measures with both property value NEIs and other individual NEIs, such as improved comfort and health, only the individual NEIs, and not the property value NEIs, be counted in any benefit cost calculations.

same set of NEIs, but recommends using health and safety related NEIs estimated in the 2016 Health and Safety NEI report in place of the same NEIs from the 2011 report.³⁹

Table 21: Low-Income Single-Family and MF Heat Pump NEIs

| NEI | Multifamily* | Single-Family** |
|---|----------------------|----------------------|
| Home Durability | \$9.72* | \$9.72* |
| Thermal Comfort | \$28.01* | \$33.24** |
| Health Benefits | \$5.27* | \$213.13** |
| Equipment Maintenance | \$27.43* | \$27.43* |
| Improved Safety | \$45.05* | \$18.87** |
| Safety Related Emergency Calls (PA NEI) | \$8.43* | \$8.43* |
| Rate Discounts | Varies by PA* | Varies by PA* |
| Price Hedging | \$0.005 (per kWh)*** | \$0.005 (per kWh)*** |

* Source: NMR. 2011. Residential and Low-Income NEIs. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators. With the exception of Rate Discounts and Price Hedging, the NEIs values apply when the heat pump replaces an existing heating system serving an individual housing units (including multi- head heat pump systems in which a single exterior unit serves multiple individual housing units). Home Durability and Equipment Maintenance would accrue to owners/landlords (not the occupants) of rental units.

** Source: Three3 and NMR. 2016. Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for the Massachusetts Program Administrators and EEAC Consultants. Massachusetts Special and Cross-Cutting Research Area.

*** Source: Evaluation Management Committee. 2011. Additional Non-Energy Impacts of Low-Income Programs (Memo). 2011 Energy Efficiency Annual Report, Appendix C – Study 28. Prepared for: Massachusetts Program Administrators.

In addition, if smoke detectors and CO detectors are installed with the heat pumps in single-family homes, the PAs could claim the safety NEIs associated with each (\$5.51 per year and \$183.30 one-time, respectively).⁴⁰

C.3.2.1 Room Air Conditioner Replacement

The PAs currently claim an annual participant NEI of \$49.50 for window AC replacement in Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit programs. The NEI includes multiple individual NEIs, including comfort, safety, and health effects. The value is based on an evaluation of National Grid’s 2003 Appliance Management Program (AMP), a pilot program that replaced inefficient air-conditioning units in low-income households.⁴¹

³⁹ Except for the new LISF health and safety NEIs, the PAs have been using the same values for LISF and LIMF projects. The PAs are in the process of initiating a new study to re-assess health and safety NEIs for LIMF projects.

⁴⁰ These safety NEIs are to be studied in the low-income multifamily study currently being planned.

⁴¹ Quantec and Skumatz Economic Research Associates (SERA). 2005. Evaluation of National Grid’s 2003 Appliance Management Program: Room Air Conditioning Metering and Non-Energy Benefits Study. National Grid USA Service Company.

The team reviewed the NEIs that comprise the claimed NEI and assessed whether the currently claimed NEI was applicable to a heat pump replacement of an inefficient window air conditioner or double counted NEIs already claimed (Table 22). The team recommends claiming all of the individual NEIs except for equipment maintenance, which is already claimed for heat pumps, and applying the same 25% discount in order to adjust for the specialized population served by the program in the study (which is the basis of the NEI value).

Table 22: Low-income NEIs: Window AC Replacement

| NEI* | Annual NEI Value per AC* | Applicable to HP? | Rationale for Determining Applicability of the NEI |
|-----------------------|--------------------------|-------------------|---|
| Equipment Maintenance | \$11 | No | PAs already claim an equipment maintenance NEI for HPs. Assumes there are no additional maintenance savings. |
| Equipment Performance | \$14 | Yes | Assumes the efficient HP has better performance than a standard efficiency window AC (no comparable NEI currently being claimed). |
| Equipment Lifetime | \$8 | Yes | Assumes the efficient HP has better lifetime than a standard efficiency window AC (no comparable NEI currently being claimed). |
| Comfort | \$14 | Yes | Assumes a cooling-related comfort value that is independent of the heating system comfort. |
| Noise | \$11 | Yes | Assumes the efficient HP is quieter than a standard efficiency window AC. |
| Safety | \$3 | Yes | Assumes a cooling-system related safety benefit. |
| Health Effects | \$5 | Yes | Assumes a cooling-related health benefit that is independent of the heating system health benefit. |
| Total | \$57 | | |
| 25% Discount** | \$42.75 | | Discounted because of specialized low-income population in Quantec & SERA study. |

* Source: Quantec and Skumatz Economic Research Associates (SERA). 2005. Evaluation of National Grid’s 2003 Appliance Management Program: Room Air Conditioning Metering and Non-Energy Benefits Study. National Grid USA Service Company.

** Source: NMR. 2011. Residential and Low-Income NEIs. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators

C.3.3 Additional Considerations

For heat pumps installed in multifamily buildings, there may be additional NEIs that accrue to the owners or building managers. However, the interviews with low-income building owners and property managers from the 2011 study did not include projects with heat pumps, so no NEI estimates are available for building owners or managers at this time. The PAs may want to

consider examining the heat pump NEIs accruing to building owners and managers in future NEI research.

In addition, if the HVAC measures or the proportion of early replacement, replace on failure, and new HVAC measures has changed since the 2013 memo, the PAs may want to consider revisiting and recalculating the adjusted NEI values for market-rate residential HVAC measures.

Finally, if heat pumps become a larger proportion of the HVAC measure-mix, the PAs may want to consider further research on potential health impacts of heat pumps.