

# Program Administrators of Massachusetts

## Non-Energy Impact Framework Study Report

January 23, 2018



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## TABLE OF CONTENTS

<b>1. Executive Summary</b> .....	<b>1-1</b>
1.1 Overview of Objectives and Approach	1-1
1.2 Framework for Future NEI Research	1-1
1.3 Recommendations	1-3
1.4 Suggestions For Future Research	1-3
<b>2. Introduction</b> .....	<b>2-4</b>
2.1 The State of NEI Research and Application in Massachusetts	2-4
2.2 Research Goal and Objectives	2-6
2.3 Research Questions	2-6
2.4 Overview of Report	2-7
<b>3. Methodology</b> .....	<b>3-8</b>
3.1 Inventory of Residential and C&I NEI Values Claimed by the PAs	3-9
3.2 In-Depth Interviews	3-10
3.3 Literature Review	3-11
3.4 Sensitivity Analysis	3-11
3.5 Framework for Future NEI Research	3-11
<b>4. Summary of Results</b> .....	<b>4-13</b>
4.1 Results of NEI Inventory	4-13
4.1.1 Measure-level Consistency Between PAs/Three-Year Plan	4-18
4.1.2 Consistency Between NEI Source Documents and PAs/Three-Year Plan	4-18
4.1.3 PA Initiatives and Measures with No Claimed NEIs	4-21
4.2 Results of Roundtable Interviews	4-21
4.3 Results of Literature Review	4-22
4.3.1 Residential NEI Findings	4-23
4.3.2 Commercial and Industrial NEI Findings	4-23
4.4 BCR Sensitivity Analysis	4-24
4.4.1 Lighting Sensitivity Analysis	4-24
4.4.2 Lighting and HVAC Sensitivity Analysis	4-25
4.4.3 All-End-Use Sensitivity Analysis	4-25
4.4.4 Sensitivity Analysis Conclusions	4-26
<b>5. Framework for Future NEI Research</b> .....	<b>5-30</b>
5.1 NEI Research Framework—Overall	5-35
5.1.1 Studies for Newly-Identified NEIs	5-40
5.1.2 Studies for NEIs Previously Identified in the Literature	5-43
5.1.1 Study to leverage NEI Research for Selling and Marketing Energy Efficiency Initiatives to C&I Customers	5-47



<b>6. Recommendations and Suggestions for Future Research .....</b>	<b>6-49</b>
6.1 Recommendations	6-49
6.2 Suggestions For Future Research	6-49
<b>APPENDIX A: Theoretical NEI Background .....</b>	<b>6-51</b>
A.1 Hedonic Price Theory—Theoretical Basis for NEIs	6-51
A.2 Approaches to Estimating NEIs	6-51
A.2.1 Self-Report (Survey-Based) Techniques	6-52
A.2.2 NEI Modeling Approaches	6-52
A.3 Potential Issues Estimating NEIs	6-55
A.3.1 Double Counting	6-55
A.3.2 Transfer Payments	6-56
A.3.3 Increased Occupancy Rates	6-56
A.3.4 Implications for Past and Ongoing NEI Research	6-56
<b>APPENDIX B: Inventory of NEIs Claimed by the PAs .....</b>	<b>6-58</b>
B.1 Three-Year Plan Versus BCR Model Consistency	6-62
B.1.1 NEI-level Consistency Between BCR Models	6-62
B.1.2 Measure-level Consistency Between PAs/Three-Year Plan	6-62
B.1.3 Consistency Between NEI Source Documents and PAs/Three-Year Plan	6-63
B.2 PA Initiatives and Measures With No Claimed NEIs	6-71
B.2.1 Residential Sector	6-71
B.2.2 Low-Income Initiatives	6-74
B.2.3 C&I Initiatives	6-74
<b>APPENDIX C: PA Interview and Literature Review Results .....</b>	<b>6-80</b>
C.1 Roundtable Interviews With PA Staff Results	6-80
C.1.1 Applying NEIs	6-80
C.2 Literature Review Results	6-84
C.2.1 Residential NEIs Overview	6-85
C.2.2 Commercial and Industrial NEIs Overview	6-86
C.2.3 Residential NEI Studies	6-87
C.2.4 Multifamily Studies	6-90
C.2.5 General Overview Studies of NEI Research and NEI Values	6-92
C.2.6 Property Value Studies	6-93
C.2.7 Health Impacts of Residential Energy Efficiency Initiatives	6-94
C.2.8 General Overview C&I Studies	6-95
C.2.9 Summary of C&I NEI values	6-97
<b>APPENDIX D: Full BCR Sensitivity Analysis .....</b>	<b>6-102</b>

## 1. EXECUTIVE SUMMARY

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This report presents a framework to guide the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants in planning and conducting future non-energy impact (NEI) research in Massachusetts. The framework is based on research conducted by Tetra Tech and led by DNV GL and NMR (the evaluation team). The report describes the research conducted, explains how we developed the framework, and presents the framework (Chapter 5).

### 1.1 OVERVIEW OF OBJECTIVES AND APPROACH

The primary goal of the study was to develop a strategy and framework for conducting research to evaluate and quantify NEIs for initiatives in the residential, low-income, and C&I sectors.

The study's key objectives were:

- Develop a clear, consistent strategy and plan for conducting future NEI research.
- Ensure coordination to avoid the inadvertent double counting of NEIs across residential and C&I initiatives.
- Identify NEIs that are not currently being claimed by the PAs but could potentially be claimed, and prioritize these for research. NEI beneficiaries from PA activities considered in this study include, but are not limited to, homeowners, multifamily facility owners, condominium owners, landlords, property managers, renters/tenants, condo boards, homeowner associations, C&I customers, employees of C&I customers, and the PAs.
- Outline detailed approaches and steps the PAs can take to update current NEI values, reconcile conflicts in the NEI values used for different purposes, and/or estimate values for potential new NEIs.

The study undertook three foundational research tasks to inform development of the NEI framework. These were:

1. Inventory NEI values claimed by the PAs, and review benefit-cost ratio (BCR) models
2. Conduct in-depth interviews (IDIs) with program staff from seven electric and gas PAs, addressing aspects of NEIs relating to PA initiatives across all sectors
3. Conduct a literature review to identify NEIs resulting from residential, low-income, and C&I sectors that are not currently characterized in the existing MA research

### 1.2 FRAMEWORK FOR FUTURE NEI RESEARCH

The framework portion of this study identified a total of eight NEIs that warrant future research, and prioritized them based on a variety of factors including, but not limited to:

- Whether there is reason believe that NEIs exist that are not being claimed, based on a review of the energy efficiency literature and IDIs with the PAs
- Whether the NEIs were up to date based on a changing mix of measures installed through initiatives



- The outcome of an analysis of the sensitivity of BCR model results to changes in baseline assumptions used for savings estimates.

Table 1 shows the highest-priority NEI research for PAs to consider for the future, based on the scoring system described in Table 13 of Chapter 5, along with the relative costs and benefits of the research. The NEI studies are not listed in any particular order. Table 1 is based on a longer and more detailed list of studies that appears in summary format in Table 15 of Chapter 5.

**Table 1. High-Priority Future NEI Research**

Proposed Research	Sector or PA Initiative	NEI Research Description	Potential NEIs	Cost	Benefit
Multifamily Owner NEI Study <sup>1</sup>	Residential and C&I Multifamily	Determine whether existing low-income multifamily owner NEIs should apply to and be adjusted for owners of Market Rate Multifamily Retrofit projects, or whether primary research is needed. <sup>2</sup> Distinguish and reconcile those NEIs that could be accrued to both owners/landlords and occupant tenants (e.g., equipment maintenance, water and sewer savings).	Equipment O&M, reduced tenant complaints and turnover costs, property durability, and water and sewer savings	Low	Moderate
Non-Lighting—Health and Safety NEIs	Market Rate & Moderate Income Residential—Retrofit and New Construction (single and multifamily)	Expand the values from Low-Income Health and Safety study through empirical studies that apply methods used in the low-income health and safety study	Health and safety NEIs	Moderate	High
Refresh and Expansion of Existing C&I NEI Values	C&I – All Initiatives	Determine whether the existing C&I retrofit or C&I NC NEIs could be applied to the Retrofit, Initial Purchase & End-of-Useful Life, or Upstream initiatives. For existing NEIs, determine whether the values need to be updated based on changing initiative measure mixes.	O&M, health benefits, employee comfort	Moderate	High

<sup>1</sup> There is a market-rate MF retrofit study currently under way and a second stage is under consideration.

<sup>2</sup> Occupant NEIs for market rate multifamily retrofit projects (e.g., improved health, lighting quality and lifetime, noise reduction, thermal comfort, and water and sewer savings) are now largely based on single family NEI values.



### 1.3 RECOMMENDATIONS

Based on the findings presented in this report, we offer the following recommendations:

1. 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. Rather, in the BCR calculations, the PAs should count the NEI values associated with the individual amenities 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.
2. We recommend that the PAs review the BCR-model-related differences highlighted in this report and determine whether there is a reason for each. If so, the PAs should cite their reason for using those values. If not, the PAs should update their claimed NEI values to match the relevant Massachusetts NEI studies. For the NEIs that apply to measures for some PAs but not others (i.e., price hedging and rate discounts), the PAs should determine if these apply to their measures.
3. In cases where the PAs decide to apply an NEI for one initiative or measure to a different initiative or measure, we suggest providing clear public documentation of how the decision was made, such as via citation of the source of each NEI in the technical reference manual (TRM).

### 1.4 SUGGESTIONS FOR FUTURE RESEARCH

In addition to the recommendations based on the findings presented in this report, we also offer the following suggestions for future research:

1. NEIs are critical to promoting and sustaining the cost-effectiveness of low-income and market rate multifamily programs, particularly for PAs installing electric measures. PAs should prioritize studies that focus on multifamily measures to support the continuation and expansion of their multifamily program offerings
2. Additional NEI research highlighted in the framework should seek to go beyond O&M and other previously quantified savings, and attempt to measure effects such as increases in worker productivity from retro-commissioning or HVAC retrofit projects, improved occupant health and safety resulting from lighting measures, and improved academic performance from energy efficiency upgrades at schools.
3. We recommend that the PAs make their existing NEI research readily available to program implementation staff in a useful and relevant manner. We also recommend that the PAs consider research specific to the sales and marketing of energy efficiency measures based on NEIs. For example, focus group research is one approach for testing the effectiveness of marketing messages. Another possibility is use of controlled experiment to test response to differing marketing channels and social media.

## 2. INTRODUCTION

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### 2.1 THE STATE OF NEI RESEARCH AND APPLICATION IN MASSACHUSETTS

Massachusetts is one of a few states that include a wide range of NEIs when testing the cost-effectiveness of energy efficiency initiatives. Beginning in 2010, the PAs, EEAC Consultants, and the evaluation team embarked on the most comprehensive energy efficiency NEI research effort in the U.S. to date. The objectives of those studies were twofold:

- To quantify NEIs for inclusion in the BCR models for initiatives in the PAs' residential, low-income, and C&I sectors
- To explore how NEIs could be more effectively used in the marketing of energy efficiency initiatives and measures

Based on the existing research, state regulators permit the PAs to claim NEIs in their BCR models. For measures installed in 2016, the total value of these NEIs was about \$408 million (\$263 million for PAs installing electric measures and \$145 million for PAs installing gas measures), or roughly 17% of total portfolio benefits, for the residential, low income, and C&I sectors.<sup>3</sup>

As of June 2017, the evaluation team had completed four NEI research studies and two NEI update memos. Three additional studies evaluating NEIs are in progress, under development, or recently completed: a study of multifamily building NEIs (in progress, with a second phase under consideration), a guidance memo for applying existing NEIs to mini-split heat pumps and ducted heat pumps (completed), and a low income multifamily health and safety study (in progress). The six completed studies include:

1. **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. 2011.<sup>4</sup>
2. **Additional Non-Energy Impacts of Low-Income Programs** (Memo). 2011 Energy Efficiency Annual Report, Appendix C—Study 28. Prepared for: Massachusetts Program Administrators. Prepared by The Evaluation Management Committee. 2011.<sup>5</sup>
3. **Commercial and Industrial Existing Retrofit NEIs.** Final Report—Commercial and Industrial Non-Energy Impacts Study. Prepared for the Massachusetts PAs by DNV GL and Tetra Tech. June 29, 2012.

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<sup>3</sup> We calculated these values by adding up all of the lifetime NEIs for projected measures installed during 2016 across each of the 2016-2018 BCR plan models.

<sup>4</sup>[http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra\\_Tech\\_and\\_NMR\\_2011\\_MA\\_Res\\_and\\_LowLow-income\\_NEI\\_Evaluation\(76\).pdf](http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LowLow-income_NEI_Evaluation(76).pdf)

<sup>5</sup><http://ma-eeac.org/wordpress/wp-content/uploads/Additional-Non-Energy-Impacts-for-Low-Income-Programs-Memo-to-MA-Program-Administrators-from-Evaluation-Management-Committee.pdf>





4. **Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs** (Memo). 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.<sup>6</sup>
5. **Residential Health-Related NEIs**. 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: Three<sup>3</sup> and NMR. August 5, 2016.<sup>7</sup>
6. **Commercial and Industrial New Construction NEIs**. Commercial and Industrial New Construction Non-Energy Impact Study. Prepared for the Massachusetts Program Administrators and EEAC Consultants by DNV GL. March 24, 2016.<sup>8</sup>

In addition to the extensive research efforts to date, there remain opportunities for the PAs to investigate and claim additional NEIs, as well as to apply NEIs to initiatives that currently do not claim them. For example, these opportunities apply to measures/initiatives for which NEI estimates are already quantified for one initiative (C&I O&M cost savings for C&I Existing Building Retrofit), but that have not yet been applied to other initiatives (C&I Initial Purchase & End of Useful Life), as well as NEIs that have not previously been calculated, such as increased employee comfort in C&I facilities.

Additionally, given the magnitude of NEI benefits claimed by the PAs, it is important to review the claimed NEIs to identify and eliminate any possible overlap or double counting for past and future NEI research. Finally, many of the NEIs currently claimed by the PAs from early NEI research reflect the measure mix of initiatives in 2010 and 2011, and are now potentially out of date. Considering NEI research and its corresponding costs, the PAs and EEAC Consultants decided to take a step back and develop a more formalized roadmap for future NEI research.

The PAs are looking to this framework to help prioritize research to ensure that future efforts focus on those NEIs and initiatives that fill identified needs. The NEI Framework Study builds on previous PA-sponsored NEI research to assess the value of future NEI research efforts, and develops a strategy and framework to guide future research to quantify NEIs in the residential, low income, and C&I sectors. This report details the framework, describes how we developed it, and presents:

- An inventory of NEIs currently captured by research in Massachusetts, and opportunities to quantify and apply additional NEIs
- Results from interviews with PA stakeholders
- A literature review of NEI research in other jurisdictions

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<sup>6</sup><http://ma-eeac.org/wordpress/wp-content/uploads/HVAC-Replace-on-Failure-Non-Energy-Impacts-Memo-7.15.13.pdf>

<sup>7</sup><http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf>

<sup>8</sup><http://ma-eeac.org/wordpress/wp-content/uploads/Stage-2-Results%E2%80%94Commercial-and-Industrial-New-Construction-Non-Energy-Impacts-Study%E2%80%94Final-Report.pdf>



- Recommendations
- Suggestions for future NEI research

## 2.2 RESEARCH GOAL AND OBJECTIVES

The primary goal of the study was to develop a strategy and framework for conducting research to evaluate and quantify NEIs associated with measures installed in the residential, low income, and C&I sectors.

The study's key objectives were:

- Develop a clear, consistent strategy and plan for conducting future NEI research.
- Ensure coordination to avoid the inadvertent double counting of NEIs across residential and C&I initiatives, which commonly occurs in multifamily common areas and central systems.
- Identify NEIs that are not currently being claimed by the PAs but could potentially be claimed, and prioritize these for research. NEI beneficiaries from PA activities considered in this study include, but are not limited to, homeowners, multifamily facility owners, condominium owners, landlords, property managers, renters/tenants, boards, homeowner associations, C&I customers, employees of C&I customers, and the PAs.
- Outline detailed approaches and steps the PAs can take to update current NEI values, reconcile conflicts in the NEI values used for different purposes, and/or estimate values for potential new NEIs.

## 2.3 RESEARCH QUESTIONS

The specific research questions that guided this study included:

- What is the current inventory of NEIs claimed by the PAs?
- How important are NEIs in initiative design and marketing?
- How important are NEIs in achieving the cost-effectiveness of the PAs' current and planned initiatives? What, if any, are the other benefits of evaluating and quantifying NEIs in Massachusetts?
- How do the values of the PAs' claimed NEIs compare across different initiatives?
- Are there large disparities in NEI values claimed by different PAs for the same initiatives (e.g., low income vs. market rate multifamily initiatives)? Will some PAs need to further substantiate their claims (i.e., if the NEI values claimed do not match the other PAs' values and the source documents for the NEIs)?



- What are the key PA-claimed NEI sources for C&I, residential, and low-income initiatives, and what NEIs likely remain to be identified and claimed?<sup>9</sup>
- What are the areas of potential NEI overlap—creating a risk of double counting—within and across residential and C&I initiatives?
- What types of NEIs are generally more difficult to assess and quantify?
- What remaining NEI studies will provide the greatest possible return on investment?

## 2.4 OVERVIEW OF REPORT

The remainder of this report is organized as follows:

- Chapter 3—the methodology we used to conduct the NEI Framework Study
- Chapter 4—the results of the NEI Framework Study tasks
- Chapter 5—the framework for future NEI research developed through this study
- Chapter 6 —recommendations based on the study’s findings
- 6.2APPENDIX A:—background information for the framework, including key theoretical concepts underlying the existence of NEIs and NEI research techniques, and overview of approaches used to estimate NEIs. This section also discusses technical concepts surrounding accurate NEI estimation.
- 6.2APPENDIX B:—an inventory of NEI types claimed by the PAs
- 6.2APPENDIX C:—results from the NEI Framework Study’s IDIs with PA program staff
- 6.2APPENDIX D:—the BCR Sensitivity Analysis

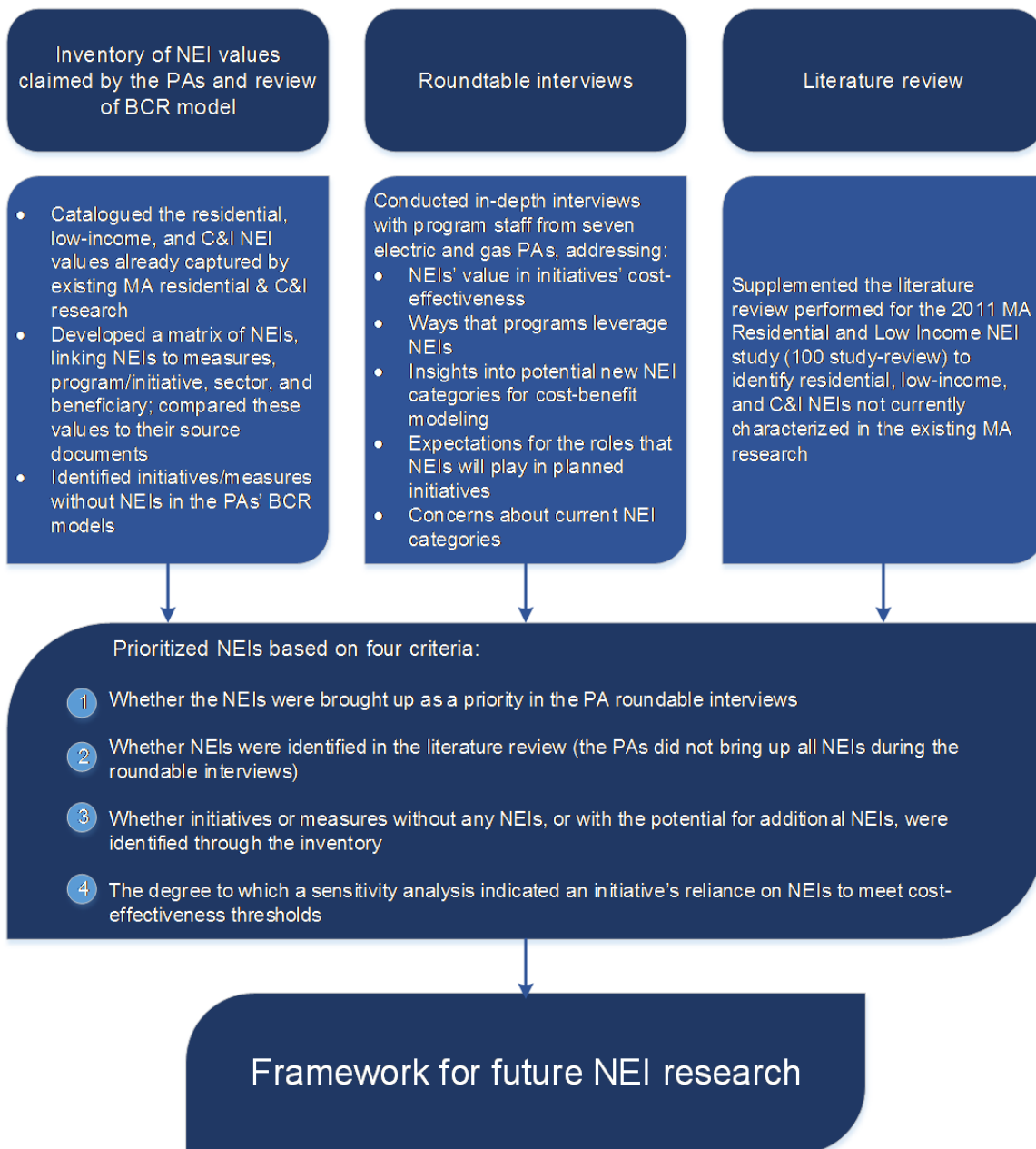
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<sup>9</sup> These questions apply to current programs, initiatives, and measures, as well as to target sub-populations that the PAs are hoping to engage in the future (e.g., multifamily market rate rentals, condominiums, moderate income home energy services [HES], LED lighting).

### 3. METHODOLOGY

This section details the methodology used to develop the NEI Framework. Figure 1 provides a high-level overview of the approaches employed. The framework was guided by three sources of information: (1) an inventory of NEIs currently claimed by the PAs and a review of their application in the BCR models, (2) interviews with the PAs, and (3) a literature review. Each of these sources and the design of the framework are discussed below.

**Figure 1. Methodology Overview**





### 3.1 INVENTORY OF RESIDENTIAL AND C&I NEI VALUES CLAIMED BY THE PAS<sup>10</sup>

The evaluation team cataloged the residential, low-income, and C&I sector NEI values that have been developed from existing Massachusetts research. We focused our work on the NEIs associated with measures included in the BCR models. We then developed a matrix of NEIs, linking NEIs to all relevant measures, initiatives, sectors, and beneficiaries (e.g., occupant or owner/landlord). As a final step, we then contrasted NEIs contained in the literature review with those NEIs not currently being claimed by the Massachusetts PAs, to identify NEIs that the PAs may prioritize for future research. Based on this inventory, potential opportunities to claim additional NEI include:

- LED lighting NEIs for C&I Existing Building Retrofits<sup>11</sup>
- NEIs for the C&I Initial Purchase & End of Useful Life Initiative
- Non-O&M NEIs for C&I New Construction
- NEIs for Residential Health and Safety
- C&I Multifamily Initiative NEIs
- Other C&I measures that are new to the initiatives since the time of the 2012 C&I Retrofit study
- Moderate-income Offering NEIs

We focused our research and review on the NEIs associated with measures included in NEI lookup tables of the PAs' 2016-2018 BCR plan models. For comparison, we compiled into a single repository these NEIs alongside ones currently being claimed by the PAs in the Three-Year Plan and the NEI values from five Massachusetts studies. Table 2 lists the initiatives that currently have NEIs. We include the complete NEI inventory with this report as a supplemental Excel workbook. It is not necessary to review the workbook to understand this analysis, since all differences and opportunities for claiming additional NEIs are reported fully in 6.2 APPENDIX B:.

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<sup>10</sup> The proposed scope of work assumes we will build off the matrix developed for the market rate multifamily study.

<sup>11</sup> Most lighting measures in the 2010 program tracking data used for the 2012 C&I retrofit NEI study were T-5s and T-8s. Since that study, there has been a shift to LEDs.



**Table 2. List of PA Energy Efficiency Initiatives in NEI Inventory**

Initiative
C&I Multifamily Retrofits
C&I New Buildings and Major Renovations <sup>12</sup>
C&I Retrofit
C&I Small Business
C&I Upstream Lighting
Low-Income Multifamily Retrofit
Low-Income Single Family Retrofit
Residential Heating & Cooling Equipment
Residential Home Energy Services
Residential Lighting
Residential Multifamily Retrofit
Residential New Construction

### 3.2 IN-DEPTH INTERVIEWS

In January and February of 2017, the evaluation team conducted IDIs with program staff from seven electric and gas PAs: Berkshire Gas, Cape Light Compact, Columbia Gas, Eversource, Liberty Gas, National Grid, and Unitil. Interviewees included, but were not limited to, residential and/or C&I program managers, implementation contractors, evaluation leads, and marketing staff. The team conducted group interviews with most PAs to address multiple aspects of NEIs that relate to the residential and C&I initiatives. The interviewees' awareness and knowledge of NEIs for use in BCR analysis and initiative marketing varied. Interviewers tailored interview questions to suit the respective interviewees' awareness levels; as such, not all questions were necessarily asked of all PAs.

Topics discussed during these interviews included:

- Perspectives on NEI usefulness in initiatives' cost-effectiveness
- Understanding the ways that the initiatives leverage NEIs
- Insights into and suggestions for potential NEI categories that are not currently incorporated into the BCR modeling
- Expectations for the roles that NEIs will play in planned initiatives

<sup>12</sup> Note that while there is an existing study detailing NEIs for the C&I New Buildings & Major Renovations Initiative, and the correct NEI values are included in the NEI lookup tables, due to timing, these NEIs were not included as part of the cost-effectiveness calculations in the 2016-2018 plan models. They will be included in future years.



- Concerns about current NEI categories

We summarize the results of these interviews in the next chapter, with the full results discussed in APPENDIX C:.

### 3.3 LITERATURE REVIEW

The focus of the literature review was to identify NEIs that are not currently characterized in the existing Massachusetts NEI research. The literature review performed for the 2011 Massachusetts Residential and Low-Income NEI study examined over 100 studies.<sup>13</sup> The current literature review supplements the 2011 review and identifies remaining opportunities to claim additional NEIs that do not exist in the current body of Massachusetts NEI research. As there are several existing reviews of NEI research, the evaluation team conducted a brief review of the most prominent NEI studies by initiative or measure type.

We summarize the results of the literature review in the next chapter, with the full results of these interviews discussed in APPENDIX C:.

### 3.4 SENSITIVITY ANALYSIS

In our initiative-level sensitivity analysis, we calculated the BCRs of each core initiative both with currently credited NEIs included in the BCRs, and with NEIs removed from the BCRs. We also ran a series of tests on both scenarios, decreasing the energy savings for certain end uses and combinations of end uses by 10%, 20%, 50%, and 100% to simulate shifting baselines.

We performed our analysis of the BCRs at the initiative level, rather than the measure level, since certain initiative costs that factor into these calculations are not directly attributable to individual measures. For example, initiative planning and administration, marketing and advertising, sales, technical assistance, training, and performance incentives each represent substantial costs to the initiatives. This analysis is also highly simplified in that we assume the PAs would continue to incentivize measures and maintain initiative activity at the same level, and thus maintain the same costs, even as energy savings move to 0%, leaving only NEIs.<sup>14</sup>

We present the results of this analysis in the next chapter.

### 3.5 FRAMEWORK FOR FUTURE NEI RESEARCH

This section discusses the final framework for future NEI research that outlines the initiatives, measures, and potential sources of NEIs not presently claimed by the PAs. This framework built on information from the inventory of NEIs, literature review, and PA interviews to identify opportunities for capturing NEIs that are not currently claimed in the existing Massachusetts NEI research, and the range of NEI values that could be expected. This framework is detailed in Chapter 5.

In determining which research to prioritize, we focused on four criteria:

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<sup>13</sup> NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

<sup>14</sup> The Three-Year Plan does not include 2016 program activity.



1. Whether the PA roundtable interviews provided evidence for the existence of certain NEIs, through the interviewees experience with energy efficiency initiatives
2. Whether NEIs were identified in the literature review
3. Whether initiatives or measures without any NEIs, or with the potential for additional NEIs, were identified through the inventory
4. The degree to which a sensitivity analysis indicated NEIs have the potential to make a difference in an initiative's cost-effectiveness thresholds

The final step in the NEI Framework was to assess the potential benefits and costs of further NEI research. Where possible, we presented rough estimates of the expected magnitude of NEI values based on existing literature. We also provided a proxy for the overall study cost to assist in the prioritization of further research in an area. For example, if a topic was cited in the PA interviews as an area of interest, but the literature indicates the expected NEI values are low relative to the cost of the study, the PAs may choose to de-prioritize researching this topic.



## 4. SUMMARY OF RESULTS

This chapter summarizes the results of the NEI inventory, interviews, literature review, and BCR analysis. These results informed the framework presented in Chapter 5.

### 4.1 RESULTS OF NEI INVENTORY

Our NEI inventory cataloged the residential, low-income, and C&I sector NEI values that have been developed from existing Massachusetts research, and appear in the PAs' respective 2016-2018 BCR models.<sup>15</sup> Table 3. Legend for Table 4, Table 5, and Table 6

✓	NEIs claimed in the 2016-2018 PA BCR plan models.
✓★	NEIs related to increase property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○	NEIs identified through PA interviews, literature review, or existing NEIs currently applied to other initiatives in the 2016-2018 PA BCR plan models, that has not yet been quantified or applied to a particular initiative.
○★	Not yet quantified or applied NEIs related to increased property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○◆	Not yet quantified or applied NEIs. Measures installed for the common areas of a multi-family facility or building (e.g., lighting and thermostats) would receive the appropriate C&I retrofit NEI, instead of the NEI specific to residential multi-family.
○•	Not yet quantified or applied NEIs. Assuming most low-income multi-family units are rentals, only the owner/landlord (not the occupant / tenant) NEIs for property value, maintenance, and durability should apply.

Table 4, Table 5, and Table 6 below present matrices where we show the NEIs associated with initiatives in the residential, low-income, and C&I sectors respectively, while Table 3 provides a detailed legend for these tables. We indicate claimed NEIs as a checkmark (✓) in these tables.

Additionally, to identify NEIs that the PAs might wish to prioritize for future research, we contrasted NEIs contained in the literature review and PA interviews with those NEIs currently being claimed by the Massachusetts PAs. We also identified where existing NEIs claimed by certain initiatives might be expanded through additional research to apply to other initiatives. For these NEIs, we believe existing NEI research can serve as a basis from which appropriate NEI values can be constructed with minimal research to develop adjustment factors to account for differences in program offerings. One form of cross-program expansion/transfer might be negotiated adjustments to the values for Program X before applying them to Program Y, based on collaborative reasoning about differences or similarities in target market, technologies, etc. Another form might be empirical studies that frame as hypotheses the existence of the same NEIs found for Program Y in similar Program X, and seeking to confirm or disconfirm those hypotheses. A third form might be empirical studies that seek to apply methods found to be reasonably workable for Program X to Program Y. We indicate these potentially expandable NEIs with a circle (○).

Finally, there are several NEIs in the inventory labeled with a star (✓★ or ○★). These indicate property value NEIs that are currently claimed by the PAs, or that could potentially be claimed.

<sup>15</sup> All BCR models used in this analysis were the 2016-2018 three-year plan models that we received from the PAs in 2016.



We highlight these because it would be double counting to claim these while also claiming the non-property value NEIs for individual measures. The property value NEIs should only be counted when non-property value NEIs cannot be calculated. We discuss this in greater detail in Section 4.3.1.



**Table 3. Legend for Table 4, Table 5, and Table 6**

✓ NEIs claimed in the 2016-2018 PABCR plan models.
✓★ NEIs related to increase property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○ NEIs identified through PA interviews, literature review, or existing NEIs currently applied to other initiatives in the 2016-2018 PABCR plan models, that has not yet been quantified or applied to a particular initiative.
○★ Not yet quantified or applied NEIs related to increased property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○◆ Not yet quantified or applied NEIs. Measures installed for the common areas of a multi-family facility or building (e.g., lighting and thermostats) would receive the appropriate C&I retrofit NEI, instead of the NEI specific to residential multi-family.
○• Not yet quantified or applied NEIs. Assuming most low-income multi-family units are rentals, only the owner/landlord (not the occupant / tenant) NEIs for property value, maintenance, and durability should apply.

**Table 4. Residential Sector NEIs Included in the BCR Models, by Initiative**

NEI	Residential New Construction	Residential Multi-Family Retrofit	Residential Home Energy Services	Residential Behavior/ Feedback	Residential Heating & Cooling Equipment	Residential Consumer Products	Residential Lighting	Moderate-Income Single Family Retrofit
<b>Owner/Occupant Perspective</b>								
Equipment Maintenance	○	○◆	○		✓	○	○	○
Health Benefits	○	✓	✓		✓	○	○	○
Home Durability	○	✓	✓		✓	○	○	○
Improved Safety	○	○◆	○		○	○	○	○
Lighting Quality and Lifetime	✓	✓	✓				✓	○
Noise Reduction	✓	✓	✓		✓	○		○
Property Durability	○	○	○		○	○	○	○
Property Value Increase	✓★	✓★	✓★		✓★	○★	○★	○★
Reduced Tenant Complaints		○						
Rental Unit Increased Property Value		○★						
Rental Units Marketability		○						
Thermal Comfort	✓	✓	✓		✓			○

**Table 5. Low Income Sector NEIs Included in the BCR Models, by Initiative**

NEI	Low-Income Single Family Retrofit	Low-Income Multi-Family Retrofit
<b><i>PA Perspective</i></b>		
Arrearages	✓	✓
Bad Debt Write-offs	✓	✓
Customer Calls and Collections	✓	✓
Price Hedging	✓	✓
Rate Discounts	✓	✓
Safety Related Emergency Calls	✓	✓
Terminations and Reconnections	✓	✓
<b><i>Owner/Occupant Perspective</i></b>		
Equipment Maintenance	✓	✓
Health Benefits	✓	✓
Home Durability	✓	✓
Improved Safety	✓	✓
Lighting Quality and Lifetime	✓	✓
Noise Reduction	✓	✓
Property Durability	○	✓
Property Value Increase	✓★	✓★
Reduced Tenant Complaints		✓
Rental Unit Increased Property Value		✓★
Rental Units Marketability		✓
Thermal Comfort	✓	✓



**Table 6. C&I Sector NEIs Included in the BCR Models, by Initiative**

NEI	C&I New Buildings & Major Renovations	C&I Initial Purchase & End of Useful Life	C&I Existing Building Retrofit	C&I Small Business	C&I Multi-family Retrofit	C&I Upstream Lighting
<b>Owner/Occupant Perspective</b>						
Administrative Costs	○	○	✓	✓		✓
Health Benefits	○	○	○	○	○	○
Home Durability					○	
Improved Academic Performance	○	○	○			○
Improved Aesthetics	○	○	○	○		○
Improved Safety	○	○	○	○	○	○
Lighting Quality and Lifetime					○◆	
Material Handling	○	○	✓	✓		✓
Material Movement	○	○	✓	✓		✓
Noise Reduction	○	○	○	○	○	
O&M	✓	○	✓	✓	○◆	✓
Other Costs	○	○	✓	✓		✓
Other Labor Costs	○	○	✓	✓		✓
Product Spoilage	○	○	✓	✓		✓
Property Durability					○	
Property Value Increase					○★	
Reduced Tenant Complaints						
Rent Revenue	○★	○★	✓★	✓★		✓★
Rental Unit Increased Property Value					○★	
Rental Units Marketability					○	
Rental Unit Quality						
Sales Revenue	○	○	✓	✓		✓
Thermal Comfort	○	○	○	○	○	
Water and Sewer Savings	○	○	✓	○	○◆	
Waste Disposal	○	○	✓	✓	○	✓

#### 4.1.1 Measure-level Consistency Between PAs/Three-Year Plan

The evaluation team reviewed the 2016-2018 BCR plan model used by each PA (BCR model) and compared each of them to the 2016-2018 Massachusetts Joint Statewide Three-Year Plan (Three-Year Plan).<sup>16</sup> Most of the BCR models are consistent with the Three-Year Plan.

#### 4.1.2 Consistency Between NEI Source Documents and PAs/Three-Year Plan

We identified differences between NEI values in the Three-Year Plan and NEI values in the studies that were cited to support the values in the Three-Year Plan. Only the Residential and Low-Income NEIs and C&I Existing Retrofit NEI studies are cited as sources of NEIs in the Three-Year Plan. We found that two NEI update memos that appear to be the basis for several NEI values were not cited as sources. These memos include “Additional Non-Energy Impacts of Low-Income Programs”<sup>17</sup> and “Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs.”<sup>18</sup>

We also found *apparent* differences between the Three-Year Plan and values in the source studies, that ultimately did not turn out to be meaningful. For example, several NEI values for the Low-Income Single-Family Retrofit weatherization measure appear in the Three-Year Plan and BCR models, but do not appear in any of the NEI research cited by the plan, or in the additional NEI update memos referenced above. We learned from subsequent discussion with the PAs that the difference is the result of weatherization measures under the Low-Income Single Family Retrofit initiative being tracked as a combination of insulation and air sealing, rather than the combined weatherization measure listed in the literature.<sup>19</sup>

We found that certain C&I NEIs may be out of date based on changing measure mixes since the original NEI research was conducted. One example that we identified was certain PAs’ application of the C&I retrofit lighting NEI to the C&I upstream lighting initiative, specifically for screw-base LED bulbs. It is the evaluation team’s understanding that NEI values from the 2012 NEI retrofit initiative were not intended to be applied to upstream fluorescent, upstream linear LED, or upstream LED screw-base bulbs. However, the Three-Year Plan and 2016-2018 BCR plan models currently include an NEI value for the upstream LED screw-base measure.

The C&I retrofit lighting NEI is valued at \$.03/kWh saved. The inclusion of this NEI for the upstream screw-based LEDs increases the value of benefits from the upstream lighting

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<sup>16</sup> All references in this document to the Three-Year Plan denote a specific portion of the 2016-2018 Massachusetts Joint Statewide Three-Year Plan, dated October 2015. This portion is Appendix C of the Massachusetts Technical Reference Manual, which is itself Appendix V of the Three-Year Plan.

<sup>17</sup> The Evaluation Management Committee. “Additional Non-Energy Impacts of Low-Income Programs.” 2011 Energy Efficiency Annual Report, Appendix C—Study 28. Prepared for the Massachusetts Program Administrators. 2011.<sup>17</sup>

<sup>18</sup> NMR. “Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs.” 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

<sup>19</sup> Note that this weatherization measure counts both non-property value NEIs and property value NEIs. As we will discuss in section 4.3.1, this property value NEI is double counting the non-property value NEIs, and should be removed from any BCR calculations.



initiative by approximately \$19.9 million, or 16% of total upstream lighting benefits, based on aggregate values across all electric PA BCR models.

Based on conversations with the PAs, it appears that the decision to apply this NEI to upstream lighting was discussed during the writing of the Three-Year Plan. The decision was made to include the NEI, since the measure mix installed by the upstream initiative was like that installed by the retrofit initiative in 2012, although with LEDs displacing fluorescents. In such cases, where the PAs decide to apply an NEI for one measure to a different measure, we suggest providing clear public documentation of how the decision was made. This documentation could include citing the source of each NEI in the TRM, for example.

Aside from the need to document decisions regarding the application of NEIs, the application of the C&I existing building retrofit NEI to the upstream lighting initiative highlights three issues:

- First, the retrofit lighting NEI likely underestimates the true value of the O&M portion of the NEI for applicable upstream lighting measures. This is because the longer life of LED bulbs would result in greater O&M savings than the fluorescent bulbs that comprise most of the retrofit sample.
- Second, the relevance of the non-O&M portion of the retrofit NEI to the upstream initiative is unknown. The delivery mechanism of the initiative is different, and the type of participants, purpose, and location of the installed bulbs may differ from the retrofit NEI sample. These factors are all important in the calculation of impacts such as increased sales, administrative costs, and product spoilage. Without specifically examining the upstream initiative, the evaluation team can't say whether these non-O&M NEIs would add to or subtract from the O&M savings resulting from the bulbs.
- Third, changing measure mixes may affect NEIs for other initiatives and measures.

To investigate whether certain C&I existing building retrofit NEIs may be out of date based on changing measure mixes, we compared the measure mix for C&I lighting in 2011 to the measure mix for C&I lighting in 2016.



Table 7 below shows the results of this comparison. Note that the values in each column do not add up to 100% of lighting offering savings, since we have restricted the list to those measures that make up the greatest percentage of savings. The shades of green shown in the 2011 and 2016 columns indicate the percent of savings accounted for by each measure type. The darker the shade, the greater the savings accounted for by that measure.

Additionally, while we do not present tables for other measures here, there have been other substantial changes in the measure mix from 2011-2016. For instance, under the C&I Existing Building Retrofit HVAC offering, EMS and custom motors made up roughly 50% of electric savings in 2011. The initiative is now dominated by chillers, retro-commissioning (which was not a measure in 2011), and prescriptive motors. These three measures now account for 63% of electric savings.





Table 7. C&I Existing Building Retrofit, Lighting Offering Measure Mix, 2011 and 2016

Project Track	Measure	2011	2016
Custom	Lighting System Retrofit <sup>20</sup>	17%	51%
Prescriptive	CFLs	3%	1%
	Controls	5%	3%
	Other Fluorescent Bulbs	21%	0%
	High Intensity Fluorescent	5%	0%
	LED	12%	31%
	LED-Exit Sign	1%	
	Lighting System Retrofit	16%	1%
	Metal Halides	1%	
	Performance Lighting		0%
	T8 Fluorescent Bulbs	12%	
	T8 LED Bulbs		5%

### 4.1.3 PA Initiatives and Measures with No Claimed NEIs

We identified only four PA initiatives that do not currently claim NEIs:

- Residential Behavior/Feedback Initiative
- Residential Consumer Products Initiative
- C&I New Buildings & Major Renovations<sup>21</sup>
- C&I Initial Purchase & End of Useful Life

## 4.2 RESULTS OF ROUNDTABLE INTERVIEWS

This section presents results from IDIs with PA staff, including initiative evaluation, initiative implementation, and marketing. These interviews explored which NEIs are the most important to the PAs, and why.

The key findings from the IDIs are:

- **Cost-effectiveness testing**—Initiative evaluation staff were generally aware that positive NEIs played an important role in increasing benefits for cost-effectiveness testing. Currently, NEIs have the greatest impact on the cost-effectiveness of low-

<sup>20</sup> This custom measure includes upgrades to lighting systems including fixtures, bulbs, and controls that do not necessarily qualify for prescriptive incentives based on the prescriptive lighting system retrofit application, or that do not meet Design Lights Consortium technical requirements. Instead, the PAs provide incentives based on the expected savings of the custom lighting system compared to the baseline.

<sup>21</sup> While there is existing research detailing NEIs for the C&I New Building & Major Renovations Initiative, these NEIs did not appear in the cost-effectiveness calculations of the 2016-2018 plan models.



income and multifamily initiatives, but additional NEIs could help sustain or improve the BCRs of new construction initiatives.

- **Energy efficiency (EE) sales and initiative marketing**—The PAs distinguish between the use of NEIs for EE sales and for initiative marketing. The former refers to customer-level sales of individual projects, while the latter refers to broader marketing efforts for overall initiative activity.
  - *EE sales*— Most of the PAs report using NEIs in BCR calculations on an individual project level to sell EE solutions to customers. They report that NEIs can often play an important role in determining whether the BCR on a project exceeds 1.0. Implementation staff also indicated occasionally using the qualitative aspects of NEIs (e.g., improved comfort) to sell EE solutions, but were generally unaware of the extensive body of NEI research available to assist them in EE sales. They indicated that to be useful, the research would have to be readily accessible and relevant to individual sales.
  - *Initiative marketing*—The PAs report that there is some NEI information being used for initiative marketing, but that information is derived from statewide marketing efforts and published literature such as ACEEE research. They are not currently using NEIs from the PAs’ evaluation studies to market their initiatives.

### 4.3 RESULTS OF LITERATURE REVIEW

The literature review identified NEIs that are not currently characterized in the existing Massachusetts NEI research. These findings are discussed in more detail below. Table 8 summarizes potential NEIs identified in the literature review.

**Table 8. Summary of Potential NEIs from the Literature Review**

Sector	Potential NEI
<b>Multifamily</b>	Reduced tenant turnover resulting in reduced vacancy rates and tenant turnover costs, including maintenance and repair costs and marketing and advertising costs
<b>Low-income/Residential/Multifamily</b>	Improved health effects
<b>C&amp;I</b>	Decreased O&M costs for replace-on-failure measures
	Health-related NEIs
	Improved aesthetics
	Improved academic performance for education facilities
	Improved safety
	Improved employee comfort
	Resource-based NEIs



### 4.3.1 Residential NEI Findings

The residential multifamily NEI literature that we reviewed identifies several non-energy benefits not currently claimed by the PAs—such as improved rental unit quality, reduced turnover costs, reduced marketing costs, reduced tenant turnover, and reduced vacancy rates—that contribute to a relatively small number of monetized NEIs. These monetized NEIs include increased rental income, reduced O&M costs, and increased property values.

It is important to recognize that increased rental income and property value can lead to double counting of NEIs. The potential increase in property values or rental income due to improvements to housing attributes should reflect the cumulative benefits of energy efficiency measures. These should include any amenities or health impacts, and the net present value of energy bill savings. However, the increased amenities that would lead to increased prices are reflected in NEI estimates of health and well-being that are, for the most part, already counted by the PAs. Individual NEIs reflecting increases to residential occupants' well-being can be recognized either by a price change at the point of sale or rent negotiation, or through the sum of monetized non-property value benefits calculated in NEI studies. Since counting both the rent or price change and the individual NEIs is double counting, the PAs should count *either* the individual NEIs *or* the rent or price increase. See Appendix 6.2A.3.1 for additional detail.

Two of the multifamily studies reviewed found substantial reduced maintenance costs, of \$171 to \$363 per housing unit.

Two recent studies documenting the potential health effects of residential energy efficiency projects suggest that further research on health NEIs may be warranted for single-family and multifamily market rate and low-income initiatives.

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 do not count their existing property value NEIs for those measures with both property-value NEIs and other individual NEIs. Rather, in any BCR calculations, the PAs should count the values associated with 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.

### 4.3.2 Commercial and Industrial NEI Findings

The PAs already capture all the O&M cost and revenue NEIs contained in the literature for retrofit measures offered under the C&I Existing Building Retrofit Initiative. However, we found some opportunities for additional sources of C&I NEIs based on the PA interviews and literature review:

- Health-related NEIs
- Improved aesthetics
- Improved academic performance for education facilities



- Improved safety
- Improved employee comfort
- Resource-based NEIs

Additionally, some initiatives, such as C&I Initial Purchase & End of Useful Life, and C&I Multifamily Retrofit do not currently claim any NEIs, and may benefit from both an expansion of NEIs currently claimed by other initiatives to their measures, as well as application of the NEIs enumerated above. Further, there may be an opportunity to study non-O&M NEIs for the C&I New Buildings and Major Renovations initiative, as the existing literature only details O&M NEIs for this initiative.

#### 4.4 BCR SENSITIVITY ANALYSIS

To help in prioritizing future NEI research for the NEI framework in Chapter 5, we undertook sensitivity analyses of the PAs' BCR models. These analyses identify the PA initiatives that are most reliant on NEIs, and where additional NEIs would most make a difference in keeping an initiative viable, should the energy savings per measure be reduced in the future by various levels due to factors such as shifting baselines or changes in realization rates.

It is important to note two caveats in examining this sensitivity analysis:

1. The analysis examines the effect of shifting conditions on benefit-cost ratios up to the point that an initiative has experienced a 100% decrease in its energy savings. It is likely that the PAs would redesign their initiatives given such a change, and not try to make up for the difference with NEIs.
2. Since we performed this analysis at the statewide level, overall BCRs are likely higher than they would be for the smaller PAs alone, since the smaller PAs have fixed program delivery costs comprising a greater proportion of total costs than the larger PAs.

In this section, we present three analyses: Lighting, Lighting and HVAC, and All End Uses. Sensitivity analysis tables for other end uses can be found in 6.2APPENDIX D:.

##### 4.4.1 Lighting Sensitivity Analysis

We tested the BCR sensitivity analysis for lighting because of issues raised during the round-table interviews about the shifting lighting baselines and initiative cost-effectiveness. Table 9 below shows the results of the analysis. For gas measures, all the core initiatives are cost-effective regardless of the inclusion of NEIs in the BCRs. In contrast, for electric measures certain initiatives are not cost-effective even with NEIs. These initiatives include the Residential Multifamily Retrofit initiative and the Residential Heating & Cooling Equipment initiative. The C&I Multifamily Retrofit initiative is just barely cost-effective. The only initiatives that cease to be cost-effective without NEIs are the C&I Multifamily Retrofit and Low-Income Multifamily Retrofit initiatives.

The simulated shifting lighting energy savings scenarios presented in Table 9 also show that decreased per-unit savings from lighting end-uses can be expected to influence the BCRs of many electric initiatives. For the multifamily and low-income initiatives, such a savings



decrease would cause the initiative to no longer be cost-effective, but the other initiatives would remain cost-effective overall.

Since shifting values for lighting savings alone did not push most initiatives' BCRs below 1 even when the shift was substantial, we re-ran the analysis on several other end uses (6.2APPENDIX D:). None of the sensitivity analyses that we performed on other individual end uses had a greater effect than the one on lighting, so we performed additional analyses using a combination of end uses. We discuss these analyses in the next two sections.

#### **4.4.2 Lighting and HVAC Sensitivity Analysis**

Table 10 shows the effects of changing baselines, reducing the energy savings from both lighting and HVAC end uses. In contrast to the lighting-only analysis, the simulated reductions in energy savings affect the BCR of both electric and gas initiatives only when energy savings are reduced by 50% or more. If NEIs are excluded from the BCR and energy savings from gas HVAC end-uses are reduced by 50%, the HVAC Gas Residential Heating & Cooling Retrofit initiative would remain cost-effective.

#### **4.4.3 All-End-Use Sensitivity Analysis**


Since reductions in energy savings from individual or small groups of measures did not cause the BCR to drop below 1 until 50% or more of energy savings were lost, we ran a final sensitivity analysis with all end uses in the BCR models. Table 11 shows the results of this analysis.

This analysis shows that when energy savings are reduced across all measures, smaller reductions in savings produce a greater number of initiatives that fail to achieve a BCR that is just above 1. For example, the Electric Residential Consumer Products initiative would no longer be cost-effective after a 50% across-the-board cut in energy savings, while the Electric Residential Home Energy Services initiative would only be marginally cost-effective without NEIs.

Given the simulated reductions in energy savings, some initiatives would no longer be cost-effective without NEIs. These include the Electric Low-Income Multifamily Retrofit, which would not be cost-effective without NEIs after a 20% reduction in energy savings, but would remain barely cost-effective with NEIs. Similarly, Gas Residential Multifamily Retrofit, Gas Low-Income Single-Family Retrofit, Electric C&I Existing Building Retrofit, and Electric C&I Small Business Retrofit would all not be cost-effective without NEIs after a 50% across-the-board reduction in energy savings.

#### 4.4.4 Sensitivity Analysis Conclusions

Based on the complete sensitivity analysis, the evaluation team identified four items that the PAs should consider in setting their NEI research agenda:



**For NEI Research**

- 1** Even with the current set of NEI values applied to the various energy efficiency initiatives and programs, the residential and C&I multifamily retrofit initiatives are not cost-effective. As PA staff noted in the roundtables interviews, multifamily programs are costly for several reasons. NEI research conducted in the immediate future should focus on researching NEIs that may improve the cost-effectiveness of these programs.
- 2** With a 50% across-the-board reduction, Electric C&I Existing Building Retrofit, Electric C&I Small Business Retrofit, and Low-Income Single-Family Retrofit would no longer be cost-effective.
- 3** The additional of new NEIs from the 2016 Low-Income Single-Family Health and Safety NEI study will likely bolster the cost-effectiveness of the Low-Income Single Family Retrofit Initiative.
- 4** The PAs might consider a refresh of the C&I retrofit NEIs to buffer C&I retrofit initiatives against potential drops in energy benefits, especially given that the mix of lighting measures currently installed is quite different from what was installed in 2012, and could result in much higher O&M cost savings due to the long life of LED bulbs.



**Table 9. Lighting NEI Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.41	2.39	2.31	2.18	2.26	2.23	2.21	2.13	2.01
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.93	0.89	0.78	0.58	0.80	0.76	0.72	0.60	0.40
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.63	2.57	2.41	2.14	2.29	2.23	2.18	2.02	1.75
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.01	1.98	1.88	1.71	1.57	1.54	1.52	1.43	1.29
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.29	1.23	1.05	0.76	0.93	0.88	0.84	0.69	0.46
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.99	2.91	2.65	2.21	3.08	2.99	2.91	2.65	2.21
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Electric	C2a - C&I Existing Building Retrofit	2.41	2.32	2.23	1.94	1.48	1.86	1.80	1.73	1.53	1.20
Electric	C2b - C&I Small Business	2.14	1.97	1.80	1.28	0.42	1.73	1.59	1.45	1.02	0.32
Electric	C2c - C&I Multifamily Retrofit	1.07	1.00	0.94	0.74	0.42	0.81	0.77	0.72	0.58	0.35
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.52	3.51	2.76	2.76	2.75	2.75	2.74
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.44	2.42	2.00	2.00	1.99	1.98	1.97
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
Gas	C2a - C&I Existing Building Retrofit	4.33	4.33	4.33	4.33	4.33	3.62	3.62	3.62	3.62	3.62
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 10. Lighting and HVAC Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.23	2.02	1.40	0.37	2.26	2.05	1.85	1.23	0.19
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.93	0.88	0.75	0.52	0.80	0.75	0.71	0.57	0.34
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.58	2.49	2.19	1.70	2.29	2.19	2.09	1.80	1.31
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.92	0.84	0.63	0.28	0.93	0.86	0.79	0.57	0.22
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	1.93	1.81	1.46	0.88	1.57	1.46	1.35	1.02	0.48
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.26	1.17	0.92	0.48	0.93	0.86	0.78	0.57	0.21
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.91	2.74	2.24	1.40	3.08	2.91	2.74	2.24	1.40
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	3.88	3.67	3.03	1.96	4.10	3.88	3.67	3.03	1.96
Electric	C2a - C&I Existing Building Retrofit	2.41	2.29	2.16	1.78	1.14	1.86	1.77	1.67	1.39	0.91
Electric	C2b - C&I Small Business	2.14	1.96	1.78	1.24	0.34	1.73	1.58	1.44	1.00	0.27
Electric	C2c - C&I Multifamily Retrofit	1.07	0.97	0.87	0.57	0.07	0.81	0.74	0.66	0.43	0.04
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.52	3.51	2.76	2.76	2.75	2.75	2.74
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.64	2.63	2.60	2.55	1.93	1.92	1.91	1.88	1.83
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.38	2.31	2.11	1.76	2.00	1.93	1.86	1.65	1.31
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.07	1.91	1.42	0.60	1.96	1.80	1.63	1.14	0.32
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.85	1.82	1.72	1.54	1.45	1.42	1.39	1.29	1.12
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.28	3.22	3.03	2.72	2.11	2.05	2.00	1.82	1.53
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.17	5.78	4.59	2.61	6.57	6.17	5.78	4.59	2.61
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	4.75	4.38	3.27	1.43	5.12	4.75	4.38	3.27	1.43
Gas	C2a - C&I Existing Building Retrofit	4.33	4.06	3.79	2.98	1.63	3.62	3.39	3.15	2.44	1.26
Gas	C2b - C&I Small Business	5.18	4.96	4.73	4.04	2.90	5.08	4.86	4.64	3.99	2.90
Gas	C2c - C&I Multifamily Retrofit	2.37	2.31	2.25	2.07	1.77	2.07	2.02	1.98	1.83	1.59





**Table 11. All Measure Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.21	1.98	1.31	0.18	2.26	2.03	1.81	1.13	0.00
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.89	0.81	0.57	0.18	0.80	0.72	0.64	0.40	0.00
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.45	2.22	1.54	0.39	2.29	2.06	1.83	1.14	0.00
Electric	A1e - Residential Behavior/Feedback Program	2.10	1.89	1.68	1.05	0.00	2.10	1.89	1.68	1.05	0.00
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.89	0.80	0.52	0.06	0.93	0.84	0.74	0.46	0.00
Electric	A2b - Residential Consumer Products	1.51	1.35	1.20	0.75	0.00	1.51	1.35	1.20	0.75	0.00
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	1.88	1.71	1.20	0.36	1.57	1.41	1.26	0.79	0.00
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.24	1.13	0.80	0.25	0.93	0.84	0.74	0.46	0.00
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.77	2.46	1.54	0.00	3.08	2.77	2.46	1.54	0.00
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	3.69	3.28	2.05	0.00	4.10	3.69	3.28	2.05	0.00
Electric	C2a - C&I Existing Building Retrofit	2.41	2.17	1.93	1.21	0.00	1.86	1.68	1.49	0.93	0.00
Electric	C2b - C&I Small Business	2.14	1.93	1.72	1.07	0.00	1.73	1.56	1.38	0.87	0.00
Electric	C2c - C&I Multifamily Retrofit	1.07	0.96	0.85	0.53	0.00	0.81	0.73	0.65	0.41	0.00
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.26	2.98	2.16	0.78	2.76	2.48	2.21	1.38	0.00
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.46	2.26	1.69	0.72	1.93	1.73	1.54	0.96	0.00
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.25	2.05	1.45	0.45	2.00	1.80	1.60	1.00	0.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	3.99	3.55	2.22	0.00	4.44	3.99	3.55	2.22	0.00
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.04	1.84	1.26	0.28	1.96	1.76	1.57	0.98	0.00
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.74	1.58	1.12	0.36	1.45	1.31	1.16	0.73	0.00
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.12	2.90	2.22	1.10	2.11	1.90	1.69	1.06	0.00
Gas	C1a - C&I New Buildings & Major Renovations	6.57	5.91	5.26	3.29	0.00	6.57	5.91	5.26	3.29	0.00
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	4.60	4.09	2.56	0.00	5.12	4.60	4.09	2.56	0.00
Gas	C2a - C&I Existing Building Retrofit	4.33	3.89	3.46	2.16	0.00	3.62	3.26	2.90	1.81	0.00
Gas	C2b - C&I Small Business	5.18	4.67	4.15	2.59	0.00	5.08	4.57	4.06	2.54	0.00
Gas	C2c - C&I Multifamily Retrofit	2.37	2.13	1.89	1.18	0.00	2.07	1.87	1.66	1.04	0.00

## 5. FRAMEWORK FOR FUTURE NEI RESEARCH

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In the preceding chapters of this report, the evaluation team identified a number of NEIs associated with the PAs initiatives that may warrant further research. In this section we (1) present a summary of these NEIs and the initiatives with which they are associated, (2) prioritize the NEIs for possible future research, and (3) briefly describe research approaches for the higher-priority NEIs for consideration by PAs.

Table 12 summarizes the NEIs that may warrant further investigation, the data source(s) that identified each NEI, and the PA program, initiative, or offering to which each NEI is applicable. We organized the NEIs by the PAs' initiatives or offerings because NEI research is generally organized in this way, and the NEIs can be further linked to individual measures incentivized by the initiative or offering.



**Table 12. NEIs Identified for Consideration for Future NEI Research**

Identified NEIs	Data Source(s) Identifying Need for Research				Applicable PA Program, Initiative or Offering
	Literature review	PA interviews	Cost-effectiveness sensitivity analysis	NEI Inventory	
Multifamily Owner NEIs – O&M savings	X	X	X	X	Residential Multifamily and C&I Multifamily Initiatives
Non-lighting Health and Safety NEIs - Residential	X	X	X	X	Residential Whole House, Residential Heating & Cooling Equipment, Moderate income program offering
Lighting Health and Safety NEIs - Residential	X	X			Residential Lighting, Low-Income Whole House
Moderate Income Program NEIs		X		X	Moderate income program offering
Residential NEIs Identified but not quantified in 2011 Residential and Low-Income NEI Study	X				Low-Income Whole House, Residential Whole House, Residential Products
Improved Academic Performance - Lighting and Other Energy Efficiency Improvements	X <sup>22</sup>	X			C&I New Buildings & Major Renovations, C&I Existing Building Retrofit, C&I Initial Purchase and End of Useful Life, C&I Upstream Lighting
Refresh Existing C&I NEI Values		X		X	C&I Existing Building Retrofit
Expansion of Existing C&I NEI Values to Other Initiatives		X		X	C&I New Buildings & Major Renovations, C&I Multifamily Retrofit, C&I Initial Purchase and End of Useful Life, C&I Upstream Lighting
Health and Safety NEIs – C&I	X	X			C&I New Buildings & Major Renovations, C&I Existing Building Retrofit, C&I Multifamily Retrofit, C&I Initial Purchase and End of Useful Life, C&I Upstream Lighting

<sup>22</sup> This potential NEI was found during a supplemental search of the literature after the PAs identified it during their interviews, and does not appear in our full literature review. We discuss this source later in this section (5.1.1b).

We prioritized the NEIs for research based on the following criteria:

**Figure 2: Factors in Prioritizing NEIs for Research**

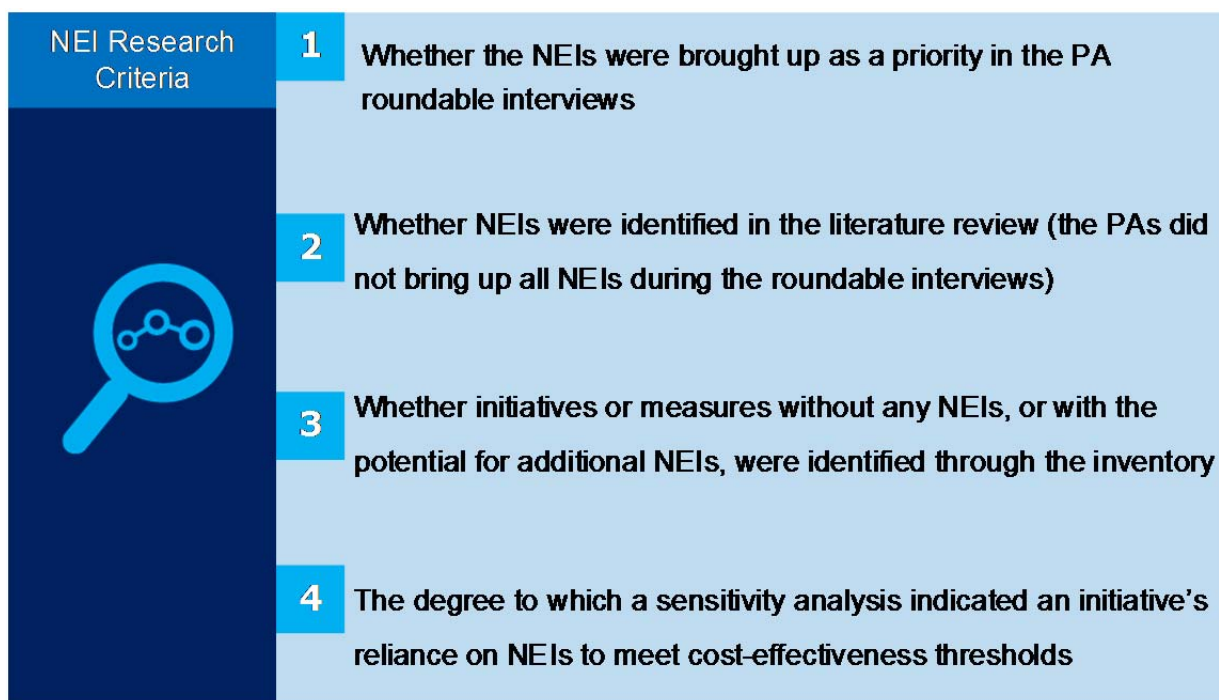


Table 13 shows the scoring matrix we developed to determine the priority of each NEI. More detailed descriptions of the NEIs and the rationale for their study are presented in Section 5.1.1.

In determining the priority for NEI research, there is no single factor that dictates the most appropriate order of priority. With the exception of the BCR sensitivity analysis, we have no evidence that any one of the criteria shown in Figure 2 above is more accurate than any other to prioritize NEI research, and so we weight all but the BCR sensitivity analysis factors equally. We have given additional weight to the BCR sensitivity analysis when NEIs have the potential to make a difference in an initiative's cost-effectiveness given current program conditions.

As detailed in the figure above, to determine the priority of an NEI or group of NEIs, we assigned a score for each category based on whether the category was true or false:

- If the PAs brought up an NEI as a priority during their roundtable interviews, then the "Interviews Reported" category receives a score of one. Otherwise, it receives a score of zero.
- If we identified an NEI in the literature review as potentially applying to one of the PAs' initiatives, the "Literature Cited" category receives a score of one. Otherwise, it receives a score of zero.
- If we identified an initiative or measure without claimed NEIs in the inventory, the "Measures without NEIs" category receives a score of one. Otherwise, it receives a score of zero.



- If we identified an initiative or measure with potentially outdated NEI values based on a change in measure mix, then the “Outdated NEI” category receives a score of one. Otherwise, it receives a score of zero.
- If we identified an initiative in the BCR model sensitivity analysis that showed a need for NEIs in order to be cost-effective given existing program energy savings, the “BCR Model” category receives a score of two.
- If we identified an initiative in the BCR model sensitivity analysis that did not show a need for NEIs in order to be cost-effective given existing program energy savings, but did show a need if program energy savings were reduced, the “BCR Model” category receives a score of one. Otherwise, it receives a score of zero.

After assigning a value to each of the categories in the scoring matrix for each of the NEIs or groups of NEIs, we then summed the scores to arrive at a final priority. We designated those NEIs with a total score greater than or equal to 3 as high priority, those with a total score of two as medium priority, and those with a total score of less than two as low priority.

**Table 13. Matrix for Prioritization Calculation for Future NEI Research**

NEI	Sector, Initiative, or Offering	Measures without NEIs (1/0)	Outdated NEI (1/0)	Interviews Reported (1/0)	BCR model (need without sensitivity=2; Need w/sensitivity =1)	Literature cited (1/0)	Total Score	Priority
Multifamily Owner NEIs	Residential and C&I Multifamily	1	0	0	2	1	4	High Priority
Refresh and Expansion of Existing C&I NEI Values	C&I – all initiatives	1	1	0	1	1	4	High Priority
Non-Lighting Health and Safety NEIs	Market Rate and Moderate Income Residential – Retrofit and New Construction	0	0	0	2	1	3	High Priority
Health and Safety NEIs	C&I – all initiatives	1	0	0	0	1	2	Medium Priority
Lighting - Health and Safety NEIs	Residential	0	0	1	0	1	2	Medium Priority
Academic Performance - Lighting and Other Energy Efficiency Improvements	C&I	0	0	1	0	1	2	Medium Priority
Moderate Income Offering NEIs	Moderate Income	1	0	1	0	0	2	Medium Priority
NEIs identified but not quantified in the 2011 Residential and Low-Income Study (product performance, availability of hot water)	Residential – Market Rate and Low-Income	0	0	0	0	1	1	Low Priority

## 5.1 NEI RESEARCH FRAMEWORK—OVERALL

In this section, we describe possible future research for each NEI for the PAs to consider.<sup>23</sup> The purpose of the proposed studies is to yield estimates of the full value of non-energy benefits associated with the PAs' energy efficiency programs and initiatives. In some cases, the studies could provide information to buffer initiatives against possible future losses in energy savings, based on our analysis of the effect of NEIs on cost-effectiveness in Chapter 4.

Table 14 below presents a list of the highest priority future NEI research based on the prioritization matrix.

**Table 14. High-Priority Future NEI Research**

Proposed Research	Sector or PA Initiative	NEI Research Description	Potential NEIs	Cost	Benefit
Multifamily NEI Study	Residential and C&I Multifamily <sup>24</sup>	Determine whether existing low-income multifamily owner NEIs should apply to and be adjusted for owners of market rate multifamily retrofit projects. <sup>25</sup> Distinguish and reconcile those NEIs that could be accrued to both owners/landlords and occupant tenants	Equipment O&M, Improved safety, reduced tenant complaints and turnover costs, property durability	Low	Moderate
Non-Lighting—Health and Safety NEIs	Market Rate and Moderate Income Residential—Retrofit and New Construction	Expand the values from Low-Income Health and Safety study through empirical studies that apply methods used in the low-income health and safety study.	Health and safety NEIs	Moderate	High
Refresh and Expansion of Existing C&I NEI Values	C&I – All Initiatives	Determine whether the existing C&I retrofit or C&I NC NEIs could be applied to Retrofit, Initial Purchase & End-of-Useful Life, or Upstream initiatives. For existing NEIs, determine whether the values need to be updated based on changing initiative measure mixes.	O&M, health benefits, employee comfort, etc.	Moderate	High

<sup>23</sup> The framework does not include the low-income multifamily health and safety study that is currently being planned with the PAs.

<sup>24</sup> There is a market-rate MF retrofit study currently under way and a second stage is under consideration.

<sup>25</sup> Occupant NEIs for market rate multifamily retrofit projects are now largely based on single family NEI values.



Table 15 provides an overview of all NEI research studies for the PAs to consider, prioritized based on the scoring matrix (Table 13). In addition to the research descriptions and priority, we also provide an estimate of the costs and benefits of undertaking the research. We derive these costs in the detailed research descriptions in Section 5.1.1.

One area of investigation that does not appear in the framework table involves leveraging NEI research for selling and marketing energy efficiency initiatives to C&I customers, since it is not based around specific NEIs, and several of the criteria used in the scoring matrix are not applicable to a marketing study. We discuss this potential study in detail in Section **Error! Reference source not found.**

**Table 15. Framework of Future NEI Research**

NEIs	Sector or Initiative	NEI Research Description	Cost	Annual Benefit	Reason for Research	Detailed Study Description	NEI Priority from Table 13
Multifamily Owner NEIs	Residential and C&I Multifamily	Determine whether existing low-income multifamily owner NEIs should apply to market rate multifamily retrofit projects. <sup>26</sup>	\$150k-\$300k	\$150k-\$600k	Multifamily initiatives are either not cost-effective, or barely cost-effective with existing NEIs. This is a critical area of NEI research identified in PA interviews, the literature review, and cost-effectiveness sensitivity analysis.	5.1.2a	High
Non-Lighting Health and Safety NEIs	Market Rate and Moderate Income Residential—Retrofit and New Construction	Extrapolate (or derive) the values from Low-Income Health and Safety study through empirical studies	\$300k-\$500k	\$2-8 million	The literature review and NEI inventory highlighted several potential health benefits that may	5.1.2b	High

<sup>26</sup> Occupant NEIs for market rate multifamily retrofit projects are now largely based on single family NEI values.





NEIs	Sector or Initiative	NEI Research Description	Cost	Annual Benefit	Reason for Research	Detailed Study Description	NEI Priority from Table 13
		that apply methods used in the low-income health and safety study.			be similar to those developed in the the PAs' low-income health and safety study.		
Refresh and Expansion of Existing C&I NEI Values	C&I	Update C&I NEIs based on current mix of measures in the initiative. Determine whether the more recent C&I NC NEIs could be applied to retrofit initiatives. Apply NEIs to Retrofit, Initial Purchase & End of Useful Life, and Upstream initiatives.	\$150k - \$300k	>\$900k	The NEI inventory found that the Initial Purchase & End of Useful Life, and Upstream offerings did not apply NEIs, or claimed potentially incorrect NEIs, and that the currently claimed C&I Retrofit NEIs may be out of date based on changes in measure mix since the 2012 study.	5.1.2c	High
Health and Safety NEIs	C&I	Integrate health and safety NEIs as well as comfort, sales, and revenue NEIs.	Scoping Study: \$30k - \$60k	Requires scoping study	The literature review identified additional health and safety NEIs, as well as sales and revenue NEIs, that were not quantified in the C&I Retrofit Study. PA interviews identified retro-	5.1.2e	Medium



NEIs	Sector or Initiative	NEI Research Description	Cost	Annual Benefit	Reason for Research	Detailed Study Description	NEI Priority from Table 13
					commissioning measures as potentially having health benefits.		
Health and Safety NEIs - Lighting	Residential	Investigate the potential for and the effects of lighting to result in fewer falls and injuries, as well as reduce crime risk, improve mental health, well-being, and decrease headache frequency.	Scoping Study: \$25k - \$30k	Requires scoping study	Identified by program staff in roundtable interviews, as well as in the literature. Application to multifamily could improve the initiative's cost-effectiveness.	5.1.1a	Medium
Academic Performance - Lighting and Other Efficiency Improvements	C&I	Investigate the potential for energy efficiency measures to reduce fatigue, absenteeism, rates of asthma, impaired cognition and memory.	Scoping Study: \$30k - \$60k	Requires scoping study	Identified by program staff in roundtable interviews, as well as in the literature.	5.1.1b	Medium
Moderate Income Offering NEIs	Moderate Income	Expand NEIs currently claimed under the low-income single family initiative to the new moderate income offering.	\$75k - \$95k	\$50k	Identified through the inventory and PA interviews. This is a new offering. Since this offering is so new, this would remain lower priority until there are a sufficient number of	5.1.1c	Medium



NEIs	Sector or Initiative	NEI Research Description	Cost	Annual Benefit	Reason for Research	Detailed Study Description	NEI Priority from Table 13
					participants on which to conduct the study.		
Residential NEIs Identified in the 2011 Residential and Low-Income NEI Study	Residential—Market Rate and Low-Income	Examine benefits considered but not quantified in the 2011 study: the benefit of establishing payment plans, reducing noise in building, availability of hot water, improved product performance, reduced transaction costs.	Additional scoping required	Additional scoping required	Based on inventory and literature. This is not considered a high priority due to insufficient evidence in the literature to accurately estimate values, potentially low value of each NEI, and difficulty estimating the NEIs through primary data collection.	5.1.2d	Low

In the next three sections, we describe the research studies listed in Table 15 for each NEI. The first set includes those NEIs that were newly identified as part of this study. The second set is those NEIs that were previously identified in the energy efficiency NEI literature. Within each of these two sections, we present the NEIs in order of priority from high to low. The third section contains a description of a study to leverage NEI Research for Selling and Marketing Energy Efficiency Initiatives to C&I Customers. That study is listed separately, since it is not based around specific NEIs, and several of the criteria used in the scoring matrix are not applicable to a marketing study.

### 5.1.1 Studies for Newly-Identified NEIs

#### A. *Lighting—Health and Safety NEIs (Medium Priority)*

Program staff identified health and safety-related NEIs for energy efficient lighting as potential NEIs during the PA roundtable interviews. They were also identified in the 2011 Residential and Low-Income NEI study. As an example, installing longer-lasting, energy-efficient lighting in residential settings, especially in hard-to-reach locations, may result in fewer falls and injuries because the lighting must be replaced less frequently. This NEI is likely to disproportionately affect the elderly population, but applies to the residential sector in general. In addition, exterior energy efficient lighting may result in reduced crime risks. Additional impacts that could be explored are improved school performance (discussed below), improved mental health and well-being, and decreased headache frequency.

Because there has been very little research conducted on the impacts of installing energy efficient and improved lighting on reducing falls and crime, a scoping study might be the best initial step. A scoping study could explore the sample sizes and methods that will likely be needed to detect non-energy effects from lighting measures and produce statistically defensible results. The Low-Income Multi-Family Health & Safety NEI study evaluation team have begun preliminary research into the incidence rates of household trips and falls as well as the impacts of interventions to reduce falls.<sup>27</sup> Further research is needed to estimate incidence rates among the non-senior population in order to develop the sample design. As for reductions in crime attributable to improved lighting, the evaluation team has found only anecdotal evidence for this NEI. Therefore, we propose an initial study to assess the feasibility of measuring reductions in crime from lighting improvements.

To maximize the feasibility of this study, we propose limiting it to PAs' residential initiatives with directly installed lighting, such as low-income initiatives (single family and multifamily), HES audits, and residential multifamily retrofits. If the study finds NEIs, a method could then be developed to extrapolate the findings to upstream lighting.

The evaluation team notes that these NEIs could potentially cover a wide range of applications and sectors, including the entire multifamily sector as well as parking lots, universities, and commercial buildings.

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<sup>27</sup> For example, according to the Center for Disease Control, 28.6% of seniors in Massachusetts experienced a fall, and 10.6% of seniors sustained an injury due to a fall, in 2014. Some research suggests that household interventions that include modifications of the home environment (e.g., installation of guardrails and grab-bars), minimizing medications, and exercise routines can reduce falls by 24%. See: Center for Disease Control. 2016. Falls and Fall Injuries Among Adults Aged >= 65 Years—United States, 2014. Morbidity and Mortality Weekly Report. September 23, 2016.



The estimated budget for the scoping study is \$25,000 to \$30,000.

*B. Academic Performance—Lighting and Other Energy Efficiency Improvements (Medium Priority)*

Academic performance was identified as a potential NEI from energy efficient lighting both by program staff and in the 2011 Residential and Low-Income NEI study. Improved academic performance may be attributable to improved lighting at home as well as to improved lighting and daylighting at school. Literature outside of energy efficiency has examined the links between a school's indoor environment and rates of asthma and other respiratory ailments, absenteeism, fatigue, and impaired cognition and memory. For example, a recent report by the Harvard School of Public Health reviewed the literature examining how school buildings influence student health, thinking, and performance.<sup>28</sup> While quantifying and monetizing an NEI linked to academic performance might prove to be difficult, one possible method would be to link improved academic performance to changes in future earnings. A scoping study would be the best initial step to explore the initiatives that may contribute to this NEI<sup>29</sup> and potential methods of monetizing the NEI.

The estimated budget for the scoping study is \$30,000 to \$60,000.

*C. Moderate Income Offering NEIs (Medium Priority)*

Utilities can realize several NEIs from their low-income energy efficiency initiatives. Some examples include participating low-income customers being better able to pay their utility bills and experiencing fewer gas-related emergencies. Utility NEIs from residential initiatives have traditionally been limited to low-income initiatives, but these benefits may also accrue to utilities from initiatives that target moderate-income households.<sup>30</sup> This study would examine whether similar NEIs accrue to utilities for initiatives offered to moderate-income households, and attempt to quantify these NEIs. In addition to examining the extent to which the utility NEIs currently claimed by the PAs for low-income initiatives may be extended to moderate-income offerings,<sup>31</sup> the study could examine whether the PAs realize additional NEIs because the offerings help prevent participating households from falling below the low-income threshold. Note that potential health and safety NEIs could be examined in a separate study discussed in section 5.1.2

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<sup>28</sup> [http://schools.forhealth.org/Harvard.Schools\\_For\\_Health.Foundations\\_for\\_Student\\_Success.pdf](http://schools.forhealth.org/Harvard.Schools_For_Health.Foundations_for_Student_Success.pdf)

<sup>29</sup> PA program activities that may contribute to this NEI include new construction activities, installation of new equipment in existing buildings as well as retro-commissioning, and tune-ups and repairs to equipment in schools.

<sup>30</sup> The PAs are testing new enhanced incentives within the HES initiative for moderate-income residential customers. These are customers living in 1- to 4-unit dwellings whose incomes are between 61% and 80% of state median income. It offers moderate-income HES customers the opportunity to be "qualified" for increased incentive(s) when income is a barrier to proceeding with identified weatherization opportunities.

<sup>31</sup> Utility NEIs are reviewed in the 2011 residential and low-income NEI study: NMR. 2011. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators.



A potential study could include several tasks:

#### Task 1: Literature review

The goal of the NEI literature review would be to determine if other studies have quantified utility NEIs for moderate-income offerings. The team would focus on the studies reviewed for the 2011 residential and low-income NEI study<sup>32</sup> and new studies completed since 2011.

As part of the review, the evaluation team would assess the income requirements of the offerings included in the literature review to determine if NEI values could be estimated for Massachusetts moderate-income households based on existing studies. We would also assess the extent to which the utility NEIs currently claimed by the PAs for low-income offerings may be extended to moderate-income offerings (i.e., what segment, if any, of the moderate-income population is in the same economic or financial condition or hardship as low-income residents).

#### Task 2: Analysis of Utility NEIs among Offering Participants and Nonparticipants

If NEI values could not be estimated through a review of the literature, the evaluation team would conduct an analysis of participants' and nonparticipants' utility data to estimate values of utility NEIs for the moderate-income offering. The team would attempt to draw a comparison group from lists of households that have received HES audits and were determined to be income-eligible for the offering but did not elect to install the recommended weatherization measures. Alternatively, customers who sought services under, but did not qualify for, the PAs' Low-Income Single Family initiative, and who chose not to participate in the moderate-income program, could also be candidates for the comparison group.

Any analysis would take place approximately one year after the weatherization measures were installed, and would likely include 12 months of utility data pre-weatherization and 12 months of utility data post-weatherization.

The analysis would include a range of account information for the participants and nonparticipants. The types of data the study would analyze, if available from the PAs, include but are not limited to:

- Customer energy bills
- Customer bill payments
- Bad debt write-offs
- Terminations and reconnections (including the PA costs for terminations and reconnections)
- Rate discounts
- Customer calls (including the PA costs)
- Collections activities (including the PA costs)

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<sup>32</sup> NMR. 2011. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for Massachusetts Program Administrators.



- Safety-related emergency calls (including the PA costs)

The analysis would include reviewing and comparing the participants and nonparticipant populations to identify potential differences between participants and nonparticipants. If differences are found, the evaluation team would develop a weighting scheme to attempt to correct for differences and potential bias.

The estimated budget for this study is \$75,000 to \$95,000.

The evaluation team conducted a preliminary analysis to estimate the potential magnitude of utility NEIs attributable to the moderate-income offering. For the purposes of this analysis, the team assumed that utility NEIs for the moderate-income offering would be half the value of the utility low-income NEIs (i.e., \$3.85 per participant). The team further assumed that the moderate-income offering would serve the same percentage of the eligible population of households as the PAs' low-income initiatives. The team estimates that the PAs' initiatives served approximately 7% of eligible households in 2016.<sup>33</sup> Per the American Community Survey 5-year data (2011-2015), there are 195,259 Massachusetts households eligible for the PAs' moderate-income offerings.<sup>34</sup> Assuming that 7% of households participate annually and assuming a utility NEI of \$3.85, we estimate a potential annual benefit of \$50,857.

## 5.1.2 Studies for NEIs Previously Identified in the Literature

### A. Multifamily NEIs (High Priority)

The evaluation team conducted a preliminary analysis to estimate the potential magnitude of multifamily owner NEIs by applying the existing low-income multifamily owner NEIs to market-rate multifamily retrofit projects. For the purposes of this analysis, the team assumed the same value for market rate as for low income NEIs, but only included NEIs for hot water measures (i.e., low-flow showerheads and faucet aerators), thermostats and air sealing. From the BCR models, it appears that refrigerators and freezers, which have low-income multifamily owner NEIs, are not commonly included in market rate projects, so the team excluded them from this analysis. This resulted in a total of \$14.83 in NEIs per retrofitted market-rate multifamily housing unit (assuming all units were to install all measures). The team used the total number of multifamily initiative participants in 2016 (37,851 combined electric and gas participants<sup>35</sup>) to estimate participation counts. Because there is a chance that not all housing units install all the eligible measures, the team estimated a range of NEI values, based on 25% to 100% of participating housing units.

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<sup>33</sup> Per data reported on <http://masssavedata.com/Public/PerformanceDetails>, the PAs low-income programs served 42,865 households and per the American Community Survey 5-year data (2011-2015), there are 633,610 Massachusetts households eligible for the PAs' low-income programs.

<sup>34</sup> The team used the income specifications of the PAs Enhanced Residential Program (<https://www.masssave.com/en/saving/income-based-offers>) and American Community Survey 5-year data (2011-2015) to estimate the number of eligible households.

<sup>35</sup> Per data reported on <http://masssavedata.com/Public/PerformanceDetails>.



Based on these assumptions, we estimate a potential annual benefit ranging from \$140,333 to \$561,330. However, it is important to note that the literature review found that reduced O&M costs may be substantially higher than what the PAs currently claim for low-income multifamily owner NEIs.<sup>36</sup>

If after this study further study is warranted to more precisely quantify the NEIs, the team recommends considering additional IDIs with property managers. The property managers would review financial and management records to provide responses during the interviews. The estimated budget for such an additional study depends largely on the desired sample size and precision of the estimates and would likely range from \$150,000 to \$300,000.

#### *B. Health and Safety NEIs (High Priority)*

The literature review suggests that further research on health and safety NEIs may be warranted for single-family and multifamily market rate and low-income initiatives (as well as the moderate income offering). While the PAs currently claim a health benefit of \$4 per retrofitted home (estimated from the 2011 Residential and Low-income NEI study),<sup>37</sup> the recently completed study estimating health- and safety-related NEIs of weatherization in low-income single family homes indicates that the 2011 study may be underestimating health impacts.<sup>38</sup> Moreover, the 2011 study does not include a health benefit for single-family or multifamily residential new construction.

The team is currently conducting a low-income multifamily health and safety study with the PAs. The PAs may want to consider a similar study for market-rate or moderate income residential initiatives, though perhaps focused on vulnerable populations, such as households with people with asthma or the elderly, among which it may be more likely to detect health and safety impacts.

The team would recommend a similar approach as that proposed for the low-income multifamily study, with data collection pre- and post-implementation of the energy efficiency measures, and with a comparison group of nonparticipating households.

The evaluation team conducted a preliminary analysis to estimate the potential magnitude and value of health and safety NEIs for market-rate single-family retrofits by applying the existing low-income single-family health and safety NEIs to market-rate single-family retrofit projects. For the purposes of this analysis, the team assumed that only the health-related NEIs would apply. The team used the total number of 'HES—measures' initiative participants in 2016

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<sup>36</sup> Two reviewed multifamily studies found reduced maintenance costs ranging from \$171 to \$363 per housing unit.

<sup>37</sup> NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

<sup>38</sup> Three<sup>3</sup> and NMR Group. 2016. Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study. Prepared for: Massachusetts Program Administrators. <http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-NonEnergy-Impacts-Study.pdf>





(42,592 combined electric and gas participants<sup>39</sup>) to estimate participation counts. Because incidence rates of the health NEIs may be lower for market-rate households, the team estimated a range of NEI values, from 10% to 25% of the low-income health NEIs (i.e., from \$19.13 to \$47.82 per household). Based on these assumptions, we estimate a potential annual benefit ranging from \$800,000 to \$2,000,000.

Assuming a similar approach and scope as the current low-income multifamily study, the estimated budget would be similar and likely range from \$300,000 to \$500,000. The budget would largely depend on the desired sample size and precision of the NEI estimates, as well as the expected treatment effect of the weatherization projects.

*C. Refresh/Expansion of Existing C&I NEI Values (High Priority)*

The NEI inventory in Chapter 4 identified several C&I initiatives, including the initial purchase and end of useful life and the upstream initiatives, that either do not currently have NEIs applied to them, or may have incorrect NEIs applied to them. The inventory also identified that some existing NEIs may be outdated based on the change in the measure mix installed by the C&I initiatives from 2011 to 2016. This study would expand NEI values to these initiatives and update out-of-date NEIs.

*D. Residential NEIs Identified in 2011 Residential and Low-Income NEI Study (Low Priority)*

The 2011 Residential and Low-Income NEI study identified several NEIs that were not recommended for quantification. The evaluation team considers these NEIs a lower priority for quantification for one or more of the following reasons:

- There is insufficient evidence in the literature to recommend a value
- The NEI value is potentially low
- It is difficult to estimate an NEI with primary data collection

The following is a list of potential NEIs, with the beneficiary in parentheses:

- Establishing payment plans (utility)
- Reduced noise—dishwashers (participant)
- Availability of hot water—tankless hot water heaters (participant)
- Product performance—high efficiency equipment and appliances (participant)
- Reduced transaction costs—weatherizing a home (participant)<sup>40</sup>

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<sup>39</sup> Per data reported on <http://massavedata.com/Public/PerformanceDetails><http://massavedata.com/Public/PerformanceDetails>

<sup>40</sup> Energy efficiency programs can help individuals avoid the transaction costs of weatherizing their homes on their own. These transaction costs include the time and effort spent learning about the energy efficiency opportunities in the home and locating the appropriate energy efficiency measures in the marketplace.



A potential study for these NEIs could include the following two tasks:

Task 1: Identify the appropriate techniques for estimating NEIs for the portfolio of C&I programs

This study would select the most appropriate and cost-effective techniques for estimating NEIs for initiative and NEI types based on the calculation techniques discussed in the theoretical background of NEI research in 6.2 APPENDIX A. For example, this research could expand the life-cycle cost analysis approach used for the 2016 New Construction study to estimate NEIs resulting from operations and maintenance (O&M) cost changes for all initiatives (i.e., retrofit, new construction, replace-on-failure, and upstream). This would allow focusing any survey efforts on NEIs that are more difficult to quantify, such as health and safety, while leveraging an avoided cost approach to estimate worker safety NEIs.

Task 2: Expand and update the life-cycle cost analysis estimates of O&M NEIs

The evaluation team's knowledge of the sources of C&I NEIs has expanded considerably since the 2012 retrofit study. Thus, it is now possible to estimate many of the NEIs captured through the 2012 interview process by expanding the life-cycle cost analysis performed in the 2016 new construction study. This would require increasing the measure list as well as offering more alternatives to the baseline conditions, as baselines in the 2016 new construction study were restricted to code. As in the 2016 new construction study, we would conduct interviews with equipment manufacturers and select engineering firms to obtain metrics for key parameters. Finally, we would estimate the life cycle cost differences between the efficient and alternative technologies as a measure of O&M cost savings.

This study would primarily look at the O&M savings for the current mix of measures in the Retrofit, Initial Purchase & End of Useful Life, and Upstream initiatives, similar to the method used in the Non-Residential New Construction Study discussed earlier in this report. A baseline expectation for benefits could be developed off of the potential value of upstream lighting NEIs identified in the NEI inventory that are not currently claimed, since they differ from the measures installed during the 2012 C&I Retrofit NEI Study. Based on the Non-Residential New Construction NEI Study, which examined linear LED lighting measures, applying the lighting NEI value to upstream linear LEDs and upstream fluorescents should result in non-energy benefits of \$949,885.

The estimated budget for this research ranges from \$150,000–\$300,000, depending on the number of measures and initiatives requiring O&M calculations.

*E. C&I Health, Safety, and Other Non-O&M NEIs (Medium Priority)*

Our review of the C&I literature provides evidence that there are several additional NEIs that may be quantified for C&I retrofit and new construction projects, values for which have not been established by the 2012 C&I Retrofit NEI study or 2016 C&I New Construction NEI study. These include NEIs such as increased comfort, worker efficiency, and health and safety impacts.



A potential study for these NEIs could include the following two tasks:

Task 1: Perform an avoided cost study of occupant health and safety NEIs

The evaluation team would estimate health impacts of C&I initiatives using an approach like the one used in the recent evaluation of low-income health and safety NEIs (i.e. a pre-post research design linked to detailed medical cost and other secondary data). For example, reduction of asthma symptoms is a very plausible NEI of initiatives that aim to improve the energy efficiency of elementary and middle schools. Initiatives that increase daylight and improve ventilation in commercial office buildings could also reduce headaches, fatigue, and missed days of work. Retro-commissioning initiatives that return HVAC systems to working order and optimize ventilation, identified by PA staff as an area of interest for NEI research (6.2APPENDIX C:) may improve both occupant health and increase worker efficiency. Initiatives that seek to improve the energy efficiency of small- and medium-sized manufacturing plants could also improve worker safety (e.g., insulating hot pipes could reduce burns). With respect to estimating health impacts, it is important to build research plans that collect pre- and post-implementation data on energy efficiency measures, preferably with a control or comparison group.

Task 2: Conduct survey research of non-O&M NEIs

The evaluation team would conduct IDIs with program participants to identify and quantify NEIs that cannot be measured through the techniques described in Tasks 2 and 3. These may include NEIs associated with comfort, sales revenue, administrative costs, waste disposal, and product loss. The interviews would also be used to help capture missing or uncertain information required for the life-cycle cost analysis or avoided cost studies.

The potential value of NEIs would be highly variable for this research, depending on the scope and types of NEIs quantified. We would suggest a scoping study prior to undertaking more complete research to determine the range of values that might be expected.

The estimated budget for this research ranges from \$300,000 - \$450,000, based on the amount of primary research required to establish values for occupant health and safety, as well as other non-O&M NEIs. As noted above, we suggest a scoping study prior to undertaking this research. A scoping study would have a budget of \$30,000 - \$60,000.

### **5.1.1 Study to leverage NEI Research for Selling and Marketing Energy Efficiency Initiatives to C&I Customers**

This study does not appear in the framework table, since it is not based around specific NEIs or initiatives. It is included here because the ability to use the body of existing Massachusetts C&I NEI research to provide program implementation staff and trade allies with relevant and usable information for selling and marketing NEI initiatives to C&I customers was highlighted as a potential area for future NEI research by PA staff during the roundtable interviews.

A study could include the following research objectives, grouped into three tasks:

Task 1: Identify and summarize relevant and salient NEI information for sales and marketing



The team would enlist the help of the PA's implementation staff to identify the NEI information that is the most relevant for sales and marketing. We would then mine the existing NEI study data to summarize this information for presentation in marketing materials. We would review this information with the PAs' implementation staff and implementation contractors through a series of interviews to ensure that we have stakeholder buy-in for the information we would use to develop marketing materials.

Task 2: Investigate strategies for communicating NEIs to PA staff, customers, and stakeholders

The team would investigate strategies and methods for communicating the full scope and magnitude of initiative benefits to PA staff and customers. Key elements of this task that vary by budget level include: developing graphical summaries of the most relevant NEI information, focus group research, and social network analysis.

Task 3: Develop tools for presenting NEIs to stakeholders

The team would provide a range of tools for communicating NEI information to initiative participants, trade allies, PA staff, and other stakeholders. Under the low-budget scenario, communication tools would be limited to a white paper along with a PowerPoint presentation; we would hold a series of three webinars for PA staff and stakeholders. In the medium-budget scenario, the team proposes adding workshops with PA staff and stakeholders to present and discuss the findings. In the high-budget scenario, we would provide the PAs with a web-based tool that DNV GL is currently designing. This tool would offer program implementation, marketing staff, and trade allies key selling points for energy efficiency measures.

The estimated budget for this research is from \$160,000 to \$550,000, depending greatly on the level of primary research completed, and the types of tools developed for use by program implementation staff.

The goal of this study would not be to quantify new NEI values. The value of the study would be in the potential lift provided to the PAs' energy efficiency initiatives based on the additional information implementation staff and trade allies can provide to customers.



## 6. RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

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### 6.1 RECOMMENDATIONS

Based on the findings presented in this report, we offer the following recommendations:

1. 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. Rather, in the BCR calculations, the PAs should count the NEI values associated with the individual amenities 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.
2. We recommend that the PAs review the BCR-model-related differences highlighted in this report and determine whether there is a reason for each. If so, the PAs should cite their reason for using those values. If not, the PAs should update their claimed NEI values to match the relevant Massachusetts NEI studies. For the NEIs that apply to measures for some PAs but not others (i.e., price hedging and rate discounts), the PAs should determine if these apply to their measures.
3. In cases where the PAs decide to apply an NEI for one initiative or measure to a different initiative or measure, we suggest providing clear public documentation of how the decision was made, such as via citation of the source of each NEI in the technical reference manual (TRM).

### 6.2 SUGGESTIONS FOR FUTURE RESEARCH

In addition to the recommendations based on the findings presented in this report, we also offer the following suggestions for future research:


1. NEIs are critical to promoting and sustaining the cost-effectiveness of low-income and market rate multifamily programs, particularly for PAs installing electric measures. PAs should prioritize studies that focus on multifamily measures to support the continuation and expansion of their multifamily program offerings
2. Additional NEI research highlighted in the framework should seek to go beyond O&M and other previously quantified savings, and attempt to measure effects such as increases in worker productivity from retro-commissioning or HVAC retrofit projects, improved occupant health and safety resulting from lighting measures, and improved academic performance from energy efficiency upgrades at schools.
3. We recommend that the PAs make their existing NEI research readily available to program implementation staff in a useful and relevant manner. We also recommend that the PAs consider research specific to the sales and marketing of energy efficiency measures based on NEIs. For example, focus group research is one approach for testing the effectiveness of marketing messages. Another possibility is use of



controlled experiment to test response to differing marketing channels and social media.

## APPENDIX A: THEORETICAL NEI BACKGROUND

This section provides important theoretical background associated with NEI research. It is organized as follows:

Theoretical Background Overview	<b>1</b>	<b>We first discuss Hedonic price theory, which provides the underlying foundation for the existence of NEIs and the corresponding valuation techniques.</b>
	<b>2</b>	<b>Next, we review the range of methods used to estimate NEIs from survey data and/or modeling approaches.</b>
	<b>3</b>	<b>We discuss the double counting and transfer payments as they apply to the portfolio of NEI estimates the PAs currently claim or may seek to claim in the future.</b>
	<b>4</b>	<b>Finally, we provide recommendations for which NEIs the PAs should not claim to avoid double counting.</b>

### A.1 HEDONIC PRICE THEORY—THEORETICAL BASIS FOR NEIS

The concept of NEIs stems largely from the hedonic price theory of property values and wages developed by Rosen.<sup>41</sup> This theory states that “housing prices reflect differences in the quantities of various characteristics of housing and that these differences have significance in applied welfare analysis.”<sup>42,43</sup> This implies that the demand for housing is correlated with the demand for attributes of the residences. Rosen shows that wellbeing, or utility, from housing is a function of individual attributes of each housing unit, household characteristics, and other goods the household can purchase.

One set of the individual attributes of each housing unit includes the improved amenities, health, and well-being resulting from energy efficiency measures. Assuming perfect information, and no rent or price constraints, occupants’ willingness to pay for the sum of a group of attributes is often not realized until the point of sale or rent negotiation. Prior to the point of sale, however, these benefits still exist.

### A.2 APPROACHES TO ESTIMATING NEIS

While the increased economic benefits associated with these amenities are not immediately monetized due to the absence of market transactions (i.e., sale or rent negotiation) evaluators have developed survey techniques and other research methods to quantify consumers’

<sup>41</sup> Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy* 82, no. 1 (Jan. - Feb., 1974): 34-55.

<sup>42</sup> Freeman III, Merick A. "The Measurement of Environment and Resource Values: Theory and Methods." *Resources for the Future*. Washington D.C. 1993.

<sup>43</sup> Rosen makes a similar case for the value of wages.



willingness to pay for well-being improvements as individual NEIs. Applying this to commercial and industrial buildings, demand for and the price of non-residential building space is also the result of demand for attributes such as amenities and health.

### **A.2.1 Self-Report (Survey-Based) Techniques**

NEI studies using self-reported NEI values rely on surveys or interviews with initiative participants to obtain NEI estimates. They generally use one of two approaches to obtain NEI estimates from respondents:

- **Direct query method (also called contingent valuation or relative valuation)**—With this method evaluators ask respondents to directly state their willingness to pay for NEIs. Willingness to pay asks respondents how much they would pay to obtain a particular NEI, or set of NEIs. For example, “How much would you pay for an increase in thermal comfort?” This approach allows for a broader range of NEIs, as respondents are asked to evaluate each NEI independently of other NEIs. This method does have several drawbacks, including high non-response due to the difficulty in assigning a value to a particular NEI, and a wide range of diverging responses from different respondents regarding the same NEI.
- **Relative valuation method**—With this method, respondents are asked the value of an NEI relative to the bill savings from the initiative. For example, a respondent might be asked whether they experienced increased comfort from an insulation measure in their home, whether the changes were positive or negative, and whether the value of these changes is higher than, lower than, or about the same as the bill savings from installing the energy efficiency measure.
- **Conjoint analysis method**—Using this method, researchers provide respondents with a set of choices regarding technologies whose attributes differ from one another and ask the respondent to rate or rank their preference for each option. Respondents are asked to rate or rank alternative options with differing levels of these attributes. The researchers then use choice modeling to estimate the marginal utility of the various attributes. The conjoint analysis technique is intended to mirror the actual decision-making process of an initiative participant; however, the approach limits the number of attributes (NEIs) that can be evaluated at one time. Further, NEI estimates cannot be taken directly from conjoint analysis survey responses, as they must be calculated using a modeling technique discussed in the next section.

### **A.2.2 NEI Modeling Approaches**

In this section, we summarize several modeling approaches for estimating NEIs that do not rely on self-reported responses.





### *Hedonic Pricing Model*

Hedonic pricing modeling is a regression-based technique that uses sales data to estimate the relative contribution of a product's various attributes to its overall price. These models are estimated by setting the price of a good equal to a set of variables that define the individual attributes of the good. For example, the price of a home is a function of the home's structural, aesthetic, and technological attributes (including energy efficiency equipment).

The estimated coefficients on the product attributes can then be used to obtain estimates of the benefits associated with increased levels of the respective attributes. In the case of a home, attributes can include number of bedrooms, number of bathrooms, home size, lot size, and energy efficiency, as well as characteristics of the surrounding neighborhood, such as proximity to a city, town center, schools, or parks. Some hedonic price models have also been used to determine whether energy efficient homes influence the prices of surrounding homes (i.e., a neighborhood effect). These models treat the attributes (or bundles of attributes) separately, and estimate prices for each of them.

One limitation of hedonic pricing models is that they rarely differentiate the portion of the property value increase that represents the current value of the stream of expected energy savings (i.e., the value that is attributable to bill savings, and thus not an NEI)<sup>44</sup> and the portion of the property value increase attributable to initiative participation due to NEIs which are independent of the energy savings (i.e., aesthetics).

### *Discrete Choice Analysis*

Discrete choice analysis is a regression-based technique used to estimate NEI values from a conjoint analysis-based survey design. The model inputs include survey responses to ratings (e.g., on a scale of 1–5) or discrete choices (e.g., yes/no) regarding alternative energy efficiency technologies to estimate the likelihood of respondents selecting each technology. The model uses these inputs to estimate the impact that each technology's various attributes have on the decision to purchase the technology.

The model estimates the relative contribution that a unit increase in each attribute has on the odds of selecting the given technology. For example, if model is estimating the probability of adopting a specific lighting measure, the model can measure the impact of pricing and non-pricing (e.g., aesthetics) characteristics on adoption...

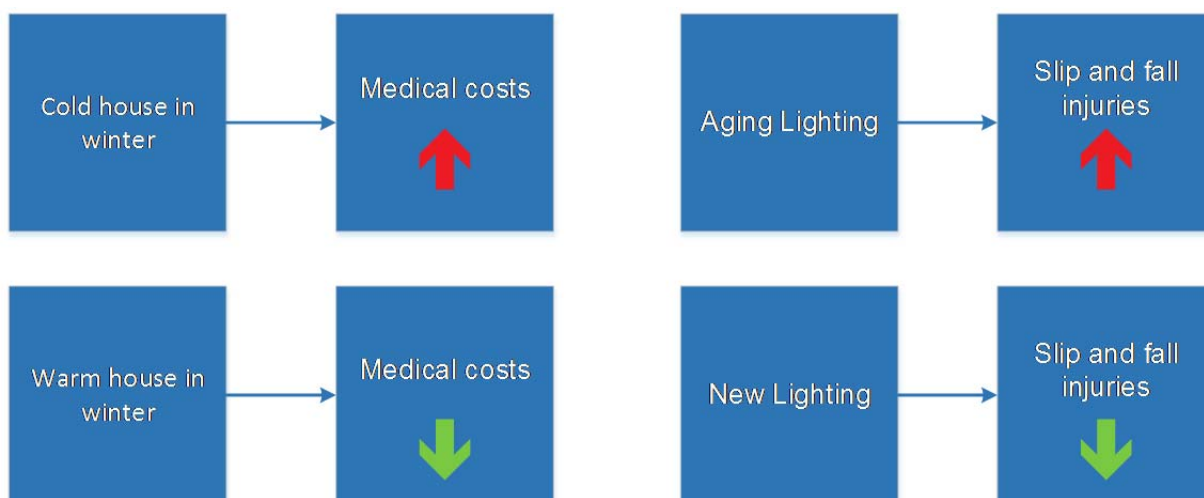
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<sup>44</sup> Bill savings partially overlap with avoided costs accounted for in the Avoided Energy Supply Costs (AESC) in New England (Hornby et al., 2011) and included in the TRC calculations used by the PAs. Therefore, to count NEIs that are derived from customer bill savings would amount to double counting of benefits. Hornby, Rick, Alex Rudkevich, Ben Schlesinger, Scott Englander, John Neri, John Goldis, Kofi Amoako-Gyan, Hua He, Adan Rivas, Richard Tabors. (2015) Avoided Energy Supply Costs in New England: 2015 Report. Cambridge: Synapse Energy.

### Avoided Cost Approach

Another approach to estimating NEIs is to measure the avoided costs associated with health-related impacts resulting from installed measures. This approach was used for the 2016 Residential Health Impact Study, which measured the avoided costs associated with a reduced incidence of health and safety concerns resulting from the low-income weatherization assistance program in Massachusetts. These concerns include things such as asthma, cold- and heat-related thermal stress, missed days of work, deaths, and fire damage.<sup>45</sup> Figure 3 provides a simplified diagram of such real-life avoided costs.

**Figure 3. Examples of Avoided Costs**







### Engineering-Based Modeling

The engineering-based modeling approach uses a life-cycle cost analysis to estimate differences in the repair, maintenance, and replacement costs between energy-efficient and standard-efficiency equipment. This approach is summarized in Figure 4. DNV GL employed a similar approach for the 2015 C&I New Construction NEI study.<sup>46</sup>

<sup>45</sup> Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study. Prepared for the Massachusetts Program Administrators and EEAC Consultants. Three3 and NMR. August 5, 2016.

<sup>46</sup> DNV KEMA and Tetra Tech. February 12, 2016. C&I New Construction NEI Stage 2 Final Report. Submitted to the Massachusetts Electric and Gas Program Administrators.

**Figure 4: Engineering-Based Modeling Approach**

			
Select Sample	Define Baseline	Estimate Cost Difference for High Efficiency and Baseline Technology	Extrapolate to Population
<ul style="list-style-type: none"> <li>• Identify and categorize measures relevant to study</li> <li>• Select random sample for analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Review MA TRM</li> <li>• Look up third-party facility cost estimates</li> <li>• Perform secondary research to inform engineering analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Review project documentation</li> <li>• Review manufacturer O&amp;M manuals</li> <li>• Conduct in-depth interviews</li> <li>• Synthesize sources</li> <li>• Estimate lifetime costs</li> <li>• Convert to net present value</li> </ul>	<ul style="list-style-type: none"> <li>• Aggregate engineering NEI estimates and expand values to the relevant population</li> </ul>

*Blended Engineering—Survey-Based Approach*

The 2012 C&I retrofit NEI study used self-reported information from initiative participants to construct NEI estimates like those developed through an engineering-based approach. The interviews collected data regarding the specific cost and revenue categories impacted, as well as data necessary to estimate NEIs. These data were then used to construct engineering formulas to estimate NEIs.

**A.3 POTENTIAL ISSUES ESTIMATING NEIS**

This section discusses some of the known complications that can arise when estimating NEIs or deciding whether certain NEIs should be estimated.

**A.3.1 Double Counting**

While the studies in the literature review (6.2APPENDIX C:) do not discuss the potential overlap and double counting of NEIs, we submit that there is overlap and likely double counting among NEIs of property value or increased rent and the individual NEIs that contribute to property value or rental income. The potential increase in property values or rental income due to improvements to housing attributes should reflect the cumulative benefits of energy efficiency improvements. These should include any amenities or health impacts and the net present value of energy bill savings. However, the increased amenities that would lead to increased prices are reflected in NEI estimates of health and well-being that are, for the most part, already counted by the PAs. Individual NEIs reflecting increases to residential occupants' well-being can be recognized either by a price change at the point of sale or rent



negotiation, or through the sum of monetized non-property value benefits calculated in NEI studies. Since counting both the rent/price change and the individual NEIs is double counting, the PAs should count *either* the individual NEIs *or* the rent/price increase.

### **A.3.2 Transfer Payments**

For those measures where a PA uses an increased property or rental value NEI as a proxy for the individual non-property value NEIs, it is important to consider whether these constitute a transfer payment from buyers to sellers or from tenant-occupants to owner/landlords. If so, they should not be counted as net benefits. As discussed above, a change in rent or price is not often recognized until a sale or rent negotiation. In this case, because such a transaction reflects the remaining value of the individual non-property value NEIs that the new buyers or tenant-occupants will continue to benefit from, it does not constitute a transfer (or “cash-out”) payment.

### **A.3.3 Increased Occupancy Rates**

Apart from price changes, several NEI studies the evaluation team reviewed cite increased occupancy rates as an additional benefit of energy efficiency initiatives. Given that prices are sticky (i.e., based on agreements such as leases, or set by regulations), residents demonstrate the value of more appealing residences by remaining there longer than they otherwise would. The question then becomes whether increased occupancy rates reflect actual benefits, are double counting benefits, or are a transfer payment.

The evaluation team supposes that since an occupancy rate NEI deals with the number of units occupied at existing prices and does not reflect the increased willingness to pay for those units through a price change, it does not constitute double counting.

In cases in which the market is saturated, as in metropolitan areas of Massachusetts, it is unlikely that the installed measure would impact the occupancy rate, and therefore the impact should not be counted. In less metropolitan areas, the increased occupancy could represent a benefit, but only if the occupant would otherwise have moved to a property outside of the geographic location. If the occupant would have moved to some other nearby vacant property, then the change in occupancy for the space in question simply reflects a transfer payment between the two locations.

### **A.3.4 Implications for Past and Ongoing NEI Research**

These theoretical constraints have the following implications for past and ongoing NEI research:

- **Property value NEIs and double counting**—If the PAs include NEIs associated with individual amenities, such as comfort, health, reduced noise, etc. in their benefit models, then the PAs should not also include their existing property value NEIs. This is because the property value NEI would double count some of these non-property value NEIs.
- **Increased occupancy NEIs**—NEIs associated with increased occupancy may reflect true NEIs, provided there is a discernable vacancy rate and the occupant would not simply move to another location within the state. If the occupant relocates within the state, then the change in occupancy is simply a transfer from one location to another.




In metropolitan areas, the vacancy rate has historically been close to zero, making it difficult to justify benefits associated with increased occupancy. In other areas of Massachusetts that have higher vacancy rates, increased occupancy can be counted if it can be shown that the occupant would not relocate within the state. Given this complication, the conservative approach would be to not count increased occupancy, since ensuring that increased occupancy is a true benefit would require understanding both the vacancy rates and where the occupant would have relocated.

## APPENDIX B: INVENTORY OF NEIS CLAIMED BY THE PAS

This section describes the results of the evaluation team’s effort to catalogue the residential, low-income, and C&I NEI values already captured by existing Massachusetts research, to identify potential inconsistencies, and describe initiatives and measures with opportunities to capture additional NEIs not currently claimed in the existing Massachusetts NEI research.

The inventory is based on reviewing the BCR models and the Three-Year Plan. Key findings from the inventory are:

**Key Findings of the NEI Inventory**



- 1** In general, PA BCR models are consistent across PAs.
- 2** In most cases, NEI values for similar measures are consistent across PAs.
- 3** The differences in NEI values that do exist across PAs are due to PA-specific inputs.
- 4** The BCR models in the Three-Year Plan do not reflect the recently completed NEI studies for C&I New Construction and Low-Income Health and Safety.

Our NEI inventory cataloged the residential, low-income, and C&I sector NEI values that have been developed from existing Massachusetts research, and appear in the PAs’ respective 2016-2018 BCR models.<sup>47</sup>

Table 17, Table 18, and Table 19 below present matrices where we show the NEIs associated with initiatives in the residential, low-income, and C&I sectors respectively, while Table 16 provides a detailed legend for these tables. We indicate claimed NEIs as a checkmark (✓) in these tables.

<sup>47</sup> All BCR models used in this analysis were the 2016-2018 three-year plan models that we received from the PAs in 2016.



**Table 16. Legend for Table 17, Table 18, and Table 19**

✓ NEIs claimed in the 2016-2018 PABCR plan models.
✓★ NEIs related to increase property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○ NEIs identified through PA interviews, literature review, or existing NEIs currently applied to other initiatives in the 2016-2018 PABCR plan models, that has not yet been quantified or applied to a particular initiative.
○★ Not yet quantified or applied NEIs related to increased property values. Property value NEIs should only be counted when the individual non-property value NEIs for a particular measure cannot be calculated.
○◆ Not yet quantified or applied NEIs. Measures installed for the common areas of a multi-family facility or building (e.g., lighting and thermostats) would receive the appropriate C&I retrofit NEI, instead of the NEI specific to residential multi-family.
○• Not yet quantified or applied NEIs. Assuming most low-income multi-family units are rentals, only the owner/landlord (not the occupant / tenant) NEIs for property value, maintenance, and durability should apply.

**Table 17. Residential Sector NEIs by Initiative Included in the BCR Models**

NEI	Residential New Construction	Residential Multi-Family Retrofit	Residential Home Energy Services	Residential Behavior/ Feedback	Residential Heating & Cooling Equipment	Residential Consumer Products	Residential Lighting	Moderate-Income Single Family Retrofit
<i>Owner/Occupant Perspective</i>								
Equipment Maintenance	○	○◆	○		✓	○	○	○
Health Benefits	○	✓	✓		✓	○	○	○
Home Durability	○	✓	✓		✓	○	○	○
Improved Safety	○	○◆	○		○	○	○	○
Lighting Quality and Lifetime	✓	✓	✓				✓	○
Noise Reduction	✓	✓	✓		✓	○		○
Property Durability	○	○	○		○	○	○	○
Property Value Increase	✓★	✓★	✓★		✓★	○★	○★	○★
Reduced Tenant Complaints		○						
Rental Unit Increased Property Value		○★						
Rental Units Marketability		○						
Thermal Comfort	✓	✓	✓		✓			○

**Table 18. Low Income Sector NEIs by Initiative Included in the BCR Models**

NEI	Low-Income Single Family Retrofit	Low-Income Multi-Family Retrofit
<b><i>PA Perspective</i></b>		
Arrearages	✓	✓
Bad Debt Write-offs	✓	✓
Customer Calls and Collections	✓	✓
Price Hedging	✓	✓
Rate Discounts	✓	✓
Safety Related Emergency Calls	✓	✓
Terminations and Reconnections	✓	✓
<b><i>Owner/Occupant Perspective</i></b>		
Equipment Maintenance	✓	✓
Health Benefits	✓	✓
Home Durability	✓	✓
Improved Safety	✓	✓
Lighting Quality and Lifetime	✓	✓
Noise Reduction	✓	✓
Property Durability	○	✓
Property Value Increase	✓★	✓★
Reduced Tenant Complaints		✓
Rental Unit Increased Property Value		✓★
Rental Units Marketability		✓
Thermal Comfort	✓	✓





**Table 19. C&I Sector NEIs by Initiative Included in the BCR Models**

NEI	C&I New Buildings & Major Renovations	C&I Initial Purchase & End of Useful Life	C&I Existing Building Retrofit	C&I Small Business	C&I Multi-family Retrofit	C&I Upstream Lighting
<b>Owner/Occupant Perspective</b>						
Administrative Costs	○	○	✓	✓		✓
Health Benefits	○	○	○	○	○	○
Home Durability					○	
Improved Academic Performance	○	○	○			○
Improved Aesthetics	○	○	○	○		○
Improved Safety	○	○	○	○	○	○
Lighting Quality and Lifetime					○◆	
Material Handling	○	○	✓	✓		✓
Material Movement	○	○	✓	✓		✓
Noise Reduction	○	○	○	○	○	
O&M	✓	○	✓	✓	○◆	✓
Other Costs	○	○	✓	✓		✓
Other Labor Costs	○	○	✓	✓		✓
Product Spoilage	○	○	✓	✓		✓
Property Durability					○	
Property Value Increase					○★	
Reduced Tenant Complaints						
Rent Revenue	○★	○★	✓★	✓★		✓★
Rental Unit Increased Property Value					○★	
Rental Units Marketability					○	
Rental Unit Quality						
Sales Revenue	○	○	✓	✓		✓
Thermal Comfort	○	○	○	○	○	
Water and Sewer Savings	○	○	✓	○	○◆	
Waste Disposal	○	○	✓	✓	○	✓

## B.1 THREE-YEAR PLAN VERSUS BCR MODEL CONSISTENCY

### B.1.1 NEI-level Consistency Between BCR Models

While the NEIs identified in the individual PAs' BCR models were generally consistent with each other, in this section we discuss two inconsistencies we identified. When possible, we performed the consistency analysis at the measure and NEI level, comparing the NEIs associated with a measure (e.g., home durability, O&M changes) across all documents. Three PAs (Berkshire, Columbia, and Liberty), did not disaggregate NEIs by type under a measure. In these cases, we used a different method to check for consistency, described in the next section.

Examples of NEIs that some, but not all, PAs claim include NEIs for rate discounts, and price hedging of low-income multifamily air source heat pumps, appliance removal, demand circulators, duct insulation, smart strips, and VFDs. Among electric PAs, these NEIs are claimed for the listed measures by National Grid, Eversource, and Unitil, but not by Cape Light Compact. These measures are shown in Table 20. NEIs for these measures also do not appear in the Three-Year Plan, but based on the source documents, rate discounts and price hedging are the same for all measures and are applied per kWh/therm. It appears that several of the PAs have expanded the list of measures versus those listed in the Three-Year Plan, applying rate discounts and price hedging to the additional measures. In contrast to the multifamily measures, all PAs claim listed measures for their low-income single family initiatives, along with air sealing, CFL bulbs, duct sealing, faucet aerators, light fixtures, freezer replacement, heating retrofits, insulation, LED bulbs, and low-flow showerheads, with values that are consistent across the BCR models.

**Table 20. Example of NEIs Not Claimed by All PAs**

Initiative	Measure	PAs Claiming Price Hedging and Rate Discount NEIs			
		Cape Light Compact	Eversource	National Grid	Unitil
Low-Income Multifamily	Low-income Multifamily Air Source Heat Pumps		X	X	X
	Low-income Multifamily Appliance Removal		X	X	X
	Low-income Multifamily Demand Circulators		X	X	X
	Low-income Multifamily Duct Insulation		X	X	X
	Low-income Multifamily Smart Strips		X	X	X
	Low-income Multifamily VFDs		X	X	X

### B.1.2 Measure-level Consistency Between PAs/Three-Year Plan

For those BCR models where measure-level NEI values are not disaggregated by NEI type, we aggregated the measure-level NEI values from other PAs and compared it to the aggregated values to determine if the NEI values were consistent. Table 21 and Table 22 below show examples of this check. Based on these checks, the NEI values appear consistent in the BCR models that do not split NEIs out by NEI category.



**Table 21. Low-Income Multifamily Retrofit Air Sealing—NEI Type vs. Measure-Level NEI Values**

Types of NEIs	Value	Unit	PA NEIs	Value	Unit
Thermal Comfort	\$30.23	per Unit	Annual	\$66.94	per Unit
Noise Reduction	\$16.39	per Unit			
Home Durability	\$10.61	per Unit			
Health Benefits	\$5.69	per Unit			
Property Durability	\$2.58	per Unit			
Reduced Tenant Complaints	\$1.37	per Unit			
Rental Unit Marketability	\$0.07	per Unit			
<b>Total</b>	<b>\$66.94</b>	<b>per Unit</b>	One Time	\$146.12	per Unit
Rental Unit Increased Property Value	\$1.19	per Unit			
Property Value Increase	\$144.93	per Unit			
<b>Total</b>	<b>\$146.12</b>	<b>per Unit</b>			

**Table 22. Residential Heating & Cooling Equipment Furnace w/ECM 97%—NEI Type vs Measure Level NEI Values**

Three-Year Plan NEIs	Value	Unit	PA NEIs	Value	Unit
Thermal Comfort	\$27.18	per Unit	Annual	\$47.15	per Unit
Home Durability	\$7.12	per Unit			
Equipment Maintenance	\$11.98	per Unit			
Health Benefits	\$0.87	per Unit			
<b>Total</b>	<b>\$47.15</b>	<b>per Unit</b>	One Time	\$379.29	per Unit
Property Value Increase	\$379.29	per Unit			
<b>Total</b>	<b>\$379.29</b>	<b>per Unit</b>			

### B.1.3 Consistency Between NEI Source Documents and PAs/Three-Year Plan

#### Citations

In comparing the Three-Year Plan NEI values with those found in the studies cited to support the NEI values in the plan, the team identified more significant differences. Only the “Residential and Low-Income NEIs” and “Commercial and Industrial Existing Retrofit NEI” studies are cited as sources of NEIs in the current plan.

In describing the calculation of impacts for various measures, the Three-Year Plan states:

“...algorithms or calculated results may be provided for other non-energy impacts (such as water savings or operation and maintenance cost savings).



Data assumptions are based on Massachusetts PA data where available. Where Massachusetts-specific data is not available, assumptions may be based on 1) manufacturer and industry data, 2) a combination of the best available data from jurisdictions in the same region, or 3) credible and realistic factors developed using engineering judgment” (p. 5).

However, our analysis found that if an NEI value included in the Three-Year Plan is not based on one of the NEI studies cited in the plan document, a separate citation that would indicate this source difference is not included. In contrast, energy or resource impacts typically have individual citations for each measure.

The three NEI update memos referenced in the introduction of this report, “Additional Non-Energy Impacts of Low-Income Programs,” “Comparison of Early Replacement and Replace on Failure Residential HVAC NEIs,” and “Commercial and Industrial Existing Retrofit NEIs,” appear to be the basis for several of the claimed NEIs, but as noted above, are not cited as sources in the Three-Year Plan.

The first of these memos proposes alternative values for refrigerator recycling, lighting quality, price hedging, and economic development under the PAs’ low-income initiatives. The second of these memos proposes adjustments to certain NEI values to account for HVAC replace-on-failure measures installed through residential initiatives.

#### *Recommended Versus Selected Values*

While the Three-Year Plan and BCR models tend to be consistent, our review uncovered discrepancies between the suggested NEIs provided by the various NEI studies and the values recorded in the BCR models. We discuss several of these discrepancies below.

### **C&I Upstream Lighting**

We found that certain C&I NEIs may be out of date based on changing measure mixes since the original NEI research was conducted. One example that we identified was certain PAs’ application of the C&I retrofit lighting NEI to the C&I upstream lighting initiative, specifically for screw-base LED bulbs. It is the evaluation team’s understanding that NEI values from the 2012 NEI retrofit initiative were not intended to be applied to upstream fluorescent, upstream linear LED, or upstream LED screw-base bulbs. However, the Three-Year Plan and 2016-2018 BCR plan models currently include an NEI value for the upstream LED screw-base measure.

The C&I retrofit lighting NEI is valued at \$.03/kWh saved. The inclusion of this NEI for the upstream screw-based LEDs increases the value of benefits from the upstream lighting initiative by approximately \$19.9 million, or 16% of total upstream lighting benefits, based on aggregate values across all electric PA BCR models.

Based on conversations with the PAs, it appears that the decision to apply this NEI to upstream lighting was discussed during the writing of the Three Year Plan. The decision was made to include the NEI, since the measure mix installed by the upstream initiative was similar to that installed by the retrofit initiative in 2012, although with LEDs displacing fluorescents. In such cases, where the PAs decide to apply an NEI for one measure to a different measure, we suggest providing clear public documentation of how the decision was made. This



documentation could include EMC meeting notes or citing the source of each NEI in the TRM, for example.

Aside from the need to document decisions regarding the application of NEIs, the application of the C&I existing building retrofit NEI to the upstream lighting initiative highlights three issues:

- First, the retrofit lighting NEI likely underestimates the true value of the O&M portion of the NEI for applicable upstream lighting measures. This is because the longer life of LED bulbs would result in greater O&M savings than the fluorescent bulbs that comprise most of the retrofit sample.
- Second, the relevance of the non-O&M portion of the retrofit NEI to the upstream initiative is unknown. The delivery mechanism of the initiative is different, and the type of participants, purpose, and location of the installed bulbs may differ from the retrofit NEI sample. These factors are all important in the calculation of impacts such as increased sales, administrative costs, and product spoilage. Without specifically examining the upstream initiative, the evaluation team can't say whether these non-O&M NEIs would add to or subtract from the O&M savings resulting from the bulbs.
- Third, changing measure mixes may affect NEIs for other initiatives and measures.

To investigate whether certain C&I existing building retrofit NEIs may be out of date based on changing measure mixes, we compared the measure mix for C&I lighting in 2011 to the measure mix for C&I lighting in 2016.



Table 7 below shows the results of this comparison. Note that the values in each column do not add up to 100% of lighting offering savings, since we have restricted the list to those measures that make up the greatest percentage of savings. The shades of green shown in the 2011 and 2016 columns indicate the percent of savings accounted for by each measure type. The darker the shade, the greater the savings accounted for by that measure.

Additionally, while we do not present tables for other measures here, there have been other substantial changes in the measure mix from 2011-2016. For instance, under the C&I Existing Building Retrofit HVAC offering, EMS and custom motors made up roughly 50% of electric savings in 2011. The initiative is now dominated by chillers, retro-commissioning (which was not a measure in 2011), and prescriptive motors. These three measures now account for 63% of electric savings.

**Table 23. C&I Existing Building Retrofit, Lighting Offering Measure Mix, 2011 and 2016**

Project Track	Measure	2011	2016
Custom	Lighting System Retrofit <sup>48</sup>	17%	51%
Prescriptive	CFLs	3%	1%
	Controls	5%	3%
	Other Fluorescent Bulbs	21%	0%
	High Intensity Fluorescent	5%	0%
	LED	12%	31%
	LED-Exit Sign	1%	
	Lighting System Retrofit	16%	1%
	Metal Halides	1%	
	Performance Lighting		0%
	T8 Fluorescent Bulbs	12%	
	T8 LED Bulbs		5%

### C&I Existing Building Retrofit and Multifamily Retrofit

The current C&I Existing Building Retrofit Initiative comprises 13 measures receiving NEIs in the Three-Year Plan and BCR models. Twelve of these measures have values consistent with the source study, the 2012 C&I Retrofit NEI Study. Prescriptive refrigeration does not match the value in the source study, however; the suggested NEI value for custom refrigeration measures, \$.05/kWh, is used instead. In the existing C&I NEI study, the authors suggest that the PAs use an NEI value of \$0 for all measures that were not statistically significant, since the data did not provide sufficient evidence to support a non-zero estimate. These measures included motors and drives, prescriptive refrigeration, and other.

<sup>48</sup> This custom measure includes upgrades to lighting systems including fixtures, bulbs, and controls that do not necessarily qualify for prescriptive incentives based on the prescriptive lighting system retrofit application, or that do not meet Design Lights Consortium technical requirements. Instead, the PAs provide incentives based on the expected savings of the custom lighting system compared to the baseline.



In addition, as indicated in the *Market-Rate Multifamily NEI—Task 2 Interim Summary* memo, we found several discrepancies when we compared C&I multifamily measures and the NEI values from the BCR models, the Three-Year Plan, and the C&I NEI Retrofit study. Table 24 highlights several of these discrepancies.<sup>49</sup>

**Table 24. C&I Multifamily NEI Discrepancies**

Fuel	Measure	Assessment
Elec	HVAC - Multifamily	Eversource appears to be claiming the NEI value for “HVAC—custom” (a lower value) rather than “HVAC-prescriptive”
Elec	Hot Water - Multifamily	NEI value should be \$0 as water heater NEIs were not statistically significant in the C&I NEI Retrofit study, rather than claiming the “Custom-Total” value from the NEI report
Elec	Lighting - Multifamily	National Grid is claiming both the residential one-time lighting NEI value and the C&I NEI value while Eversource is claiming the residential NEI value. The programs should differentiate between common area lighting (C&I NEIs) and in-unit lighting (Res NEIs)
Elec	Hot Water Custom-Multifamily	NEI value should be \$0 (water heater NEIs were not statistically significant in the C&I NEI Retrofit study)
Gas	Building Shell - Custom	The BCR models appear 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”
Gas	HVAC - Custom	The BCR models appear to be using “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”
Gas	Heating - Custom	The BCR models appear to be using 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”
Gas	Hot Water - Custom	NEI value should be \$0 (water heater NEIs were not statistically significant in the C&I NEI Retrofit study)
Gas	Duct Insulation	Determine if the measure is prescriptive or custom and claim the appropriate NEI value
Gas	Pipe Wrap (Water Heating)	NEI value should be \$0 (water heater NEIs were not statistically significant in the C&I NEI Retrofit study)
Gas	Pipe Wrap (Heating)	Determine if the measure is prescriptive or custom and claim the appropriate NEI value

<sup>49</sup> NMR and DNV GL. 2017. Market-Rate Multifamily NEI – Task 2 Interim Summary (Draft). Prepared for the Massachusetts Program Administrators.



As indicated in the *Market-Rate Multifamily NEI—Task 2 Interim Summary* memo, there also appear to be several NEIs not attributed to the C&I Multifamily initiative that are attributed to other C&I initiatives.<sup>50</sup>

### **Low-Income Multifamily Retrofit**

Under the Low-Income Multifamily Retrofit initiative, Heating System Retrofit measure, the NEIs for home durability and annual equipment maintenance are reversed in the gas PAs' BCR models' NEI lookup tables (rows 194–195). The Three-Year Plan correctly lists the annual equipment maintenance NEI for a low-income multifamily heating system retrofit at \$9.72, and the annual NEI for home durability at \$27.43. In the gas BCR model NEI lookup tables, the annual equipment maintenance NEI is listed as \$27.43, and the annual home durability NEI is listed as \$9.72. The values are recorded correctly in the electric BCR models.

While this is a discrepancy, it does not appear to affect any calculation in the BCR models, since the final NEI value used in all measure-level calculations is the sum of the NEI-level values. Therefore, the models are consistent at the measure level for the Heating System Retrofit, but not at the NEI level.

Also under the Low-Income Multifamily Retrofit initiative, the low-flow showerhead NEI for “rental unit increase property value” is given as \$.17 per unit in the source literature (Low-income NEI Evaluation p. Three-Year Plan values \$.17 per unit, \$.01 per kWh, or \$.076 per therm. It is not clear where the per-kWh and per-therm values come from. That said, all PAs use the \$.17 per-unit value suggested in the source literature.

### **Low-Income Single-Family Retrofit**

Like the Low-Income Multifamily Retrofit initiative, the heating system retrofit measure under the Low-Income Single Family Retrofit initiative has NEI values switched for home durability and annual equipment maintenance in the BCR models. In the same way, this does not appear to affect any calculation in the BCR models, since the final NEI value used in all measure-level calculations is the sum of the NEI-level values. Again, we found that the models are consistent at the measure level for the Low-Income Single Family Retrofit initiative, but not at the NEI level.

The weatherization measure included in this initiative has NEI values in the Three-Year Plan and BCR models for thermal comfort, noise reduction, home durability, health benefits, and increased property values. The values given in the Three-Year Plan are consistent with the values in each of the BCR models; however, the suggested values (Table 25) do not appear in any of the literature listed at the beginning of this report. Based on discussion with the PAs, it appears that this difference is the result of weatherization measures under the Low-Income Single Family Retrofit initiative being tracked as a combination of insulation and air sealing, versus the combined weatherization measure listed in the literature.

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<sup>50</sup> NMR and DNV GL. 2017. *Market-Rate Multifamily NEI—Task 2 Interim Summary (Draft)*. Prepared for the Massachusetts Program Administrators.





**Table 25. NEI values for Low-Income Single-Family Retrofit Weatherization Measures**

NEI	Value	Unit
Thermal Comfort	\$55.61	per Unit
Noise Reduction	\$29.95	
Home Durability	\$19.37	
Health Benefits	\$10.46	
Property Value Increase	\$368.56	

### **Residential Home Energy Services**

We found a single inconsistency for the Residential Home Energy Services initiative, among the 2013 HVAC ROF update memo by NMR, the BCR models, and the Three-Year Plan. NMR updated the NEI values from their 2011 study by estimating an NEI for each measure assuming it was replaced on failure, and then weighting that NEI value based on the predicted percentage of measures that would be installed as replace-on-failure versus early replacement. For the home durability of early replacement boilers, they found this value to be \$7.30 per unit; however, the Three-Year Plan and BCR models list a different value, \$11.67 per unit, for the home durability NEI of early replacement boilers.

Since early replacement boilers are currently specific to the early retirement offering, it seems plausible that the PAs might use the unadjusted home durability value from the NMR memo, which assumes one-hundred percent replace on failure; however, the 2013 NMR memo provides the unadjusted NEI value at \$17.42, which also does not match the value used by the PAs, but is the correct value for this measure.

### **Residential Heating and Cooling Equipment**

The Residential Heating and Cooling Equipment initiative has the greatest number of inconsistencies among the BCR models, the Three-Year Plan, and the source documents. As with the Residential Home Energy Services initiative, the source document for these NEIs is the 2013 NMR memo.

There are 13 measures comprising 48 separate NEI values that are inconsistent between the source document and the Three-Year Plan/BCR models. We display these inconsistencies in Table 26 below.



**Table 26. Residential Heating and Cooling Equipment NEI Inconsistencies**

Measure	NEI	NEI Value in TRM	NEI Source Document	NEI Value in Source Document	NEI Unit
Boiler 90%	Thermal Comfort	\$ 27.61	HVAC ROF Memo	\$ 24.32	per Unit
Boiler 90%	Equipment Maintenance	\$ 13.88	No Source Found		per Unit
Boiler 90%	Health Benefits	\$ 0.89	HVAC ROF Memo	\$ 0.78	per Unit
Boiler 95%	Thermal Comfort	\$ 27.49	HVAC ROF Memo	\$ 24.32	per Unit
Boiler 95%	Home Durability	\$ 7.28	HVAC ROF Memo	\$ 7.33	per Unit
Boiler 95%	Equipment Maintenance	\$ 13.47	No Source Found		per Unit
Boiler 95%	Health Benefits	\$ 0.88	HVAC ROF Memo	\$ 0.78	per Unit
Central Air SEER 16	Thermal Comfort	\$ 2.24	HVAC ROF Memo	\$ 1.96	per Unit
Central Air SEER 16	Noise Reduction	\$ 2.03	HVAC ROF Memo	\$ 2.50	per Unit
Central Air SEER 16	Home Durability	\$ 0.65	HVAC ROF Memo	\$ 1.17	per Unit
Central Air SEER 16	Equipment Maintenance	\$ 1.07	No Source Found		per Unit
Central Air SEER 16	Property Value Increase	\$ 35.77	HVAC ROF Memo	\$ 51.56	per Unit
Combo Condensing Boiler/Water Heater 90%	Thermal Comfort	\$ 1.21	HVAC ROF Memo	\$ 0.92	per Unit
Combo Condensing Boiler/Water Heater 90%	Equipment Maintenance	\$ 1.10	No Source Found		per Unit
Combo Condensing Boiler/Water Heater 90%	Health Benefits	\$ 0.04	HVAC ROF Memo	\$ 0.03	per Unit
Combo Condensing Boiler/Water Heater 90%	Thermal Comfort	\$ 1.21	HVAC ROF Memo	\$ 0.92	per Unit
Combo Condensing Boiler/Water Heater 90%	Equipment Maintenance	\$ 1.10	No Source Found		per Unit
DHW - Condensing 0.95	Home Durability	\$ 0.70	HVAC ROF Memo	\$ 0.70	per Unit [ROF Only]
DHW - Condensing 0.95	Property Value Increase	\$ 41.28	HVAC ROF Memo	\$ 41.28	per Unit [ROF Only]
DHW - Indirect	Home Durability	\$ 0.70	HVAC ROF Memo	\$ 0.70	per Unit [ROF Only]
DHW - Indirect	Property Value Increase	\$ 41.28	HVAC ROF Memo	\$ 41.28	per Unit [ROF Only]
DHW - Stand Alone 0.67	Property Value Increase	\$ 24.09	HVAC ROF Memo	\$ 58.47	per Unit
Furnace w/ECM 95%	Thermal Comfort	\$ 27.18	HVAC ROF Memo	\$ 24.32	per Unit
Furnace w/ECM 95%	Home Durability	\$ 7.12	HVAC ROF Memo	\$ 7.10	per Unit
Furnace w/ECM 95%	Equipment Maintenance	\$ 11.98	No Source Found		per Unit
Furnace w/ECM 95%	Health Benefits	\$ 0.87	HVAC ROF Memo	\$ 0.78	per Unit
Furnace w/ECM 95%	Property Value Increase	\$ 379.29	HVAC ROF Memo	\$ 378.61	per Unit
Furnace w/ECM 97%	Thermal Comfort	\$ 27.18	HVAC ROF Memo	\$ 24.32	per Unit
Furnace w/ECM 97%	Home Durability	\$ 7.12	HVAC ROF Memo	\$ 7.10	per Unit
Furnace w/ECM 97%	Equipment Maintenance	\$ 11.98	No Source Found		per Unit
Furnace w/ECM 97%	Health Benefits	\$ 0.87	HVAC ROF Memo	\$ 0.78	per Unit
Furnace w/ECM 97%	Property Value Increase	\$ 379.29	HVAC ROF Memo	\$ 378.61	per Unit
Heat Pump SEER 16	Thermal Comfort	\$ 2.88	HVAC ROF Memo	\$ 1.96	per Unit
Heat Pump SEER 16	Home Durability	\$ 0.84	HVAC ROF Memo	\$ 1.17	per Unit
Heat Pump SEER 16	Equipment Maintenance	\$ 1.34	No Source Found		per Unit
Heat Pump SEER 16	Health Benefits	\$ 0.09	HVAC ROF Memo	\$ 0.07	per Unit
Heat Pump SEER 16	Property Value Increase	\$ 46.07	HVAC ROF Memo	\$ 51.56	per Unit
Heat Pump SEER 18	Thermal Comfort	\$ 2.88	HVAC ROF Memo	\$ 1.96	per Unit
Heat Pump SEER 18	Home Durability	\$ 0.84	HVAC ROF Memo	\$ 1.17	per Unit
Heat Pump SEER 18	Equipment Maintenance	\$ 1.34	No Source Found		per Unit
Heat Pump SEER 18	Health Benefits	\$ 0.09	HVAC ROF Memo	\$ 0.07	per Unit
Heat Pump SEER 18	Property Value Increase	\$ 46.07	HVAC ROF Memo	\$ 51.56	per Unit
Mini Split HP (SEER 18)	Equipment Maintenance	\$ -	No Source Found	\$ -	per Unit
Mini Split HP (SEER 18)	Home Durability	\$ 0.65	HVAC ROF Memo	\$ 0.65	per Unit [ROF Only]
Mini Split HP (SEER 18)	Property Value Increase	\$ 40.35	HVAC ROF Memo	\$ 40.35	per Unit [ROF Only]
Mini Split HP (SEER 20)	Equipment Maintenance	\$ -	No Source Found	\$ -	per Unit
Mini Split HP (SEER 20)	Home Durability	\$ 0.65	HVAC ROF Memo	\$ 0.65	per Unit [ROF Only]
Mini Split HP (SEER 20)	Property Value Increase	\$ 40.35	HVAC ROF Memo	\$ 40.35	per Unit [ROF Only]

Of the 48 NEIs displayed in Table 26, 40 have values that are not the same as those provided in the 2013 NEI memo. Many of the values are close, sometimes only differing by a few cents (ex. \$7.10 vs \$7.12 for the furnace home durability NEI). Some inconsistencies appear to be the result of number transposition from the source document to the Three-Year Plan (ex. \$.87



vs. \$.78 for the furnace health benefit NEI). Since these updated NEI values are based on weights derived from assumptions regarding the percentage of replace-on-failure measures versus early replacement measures in the initiative, it is possible that the PAs have changed the assumptions and re-calculated the NEIs for these measures since 2013. However, it is neither obvious nor cited in the Three-Year Plan that this was done.

While most of the Residential Heating and Cooling NEI values displayed above do not match any values in the 2013 NMR source document, there are three measures (mini split heat pump, condensing, and indirect domestic hot water heater) and 88 NEIs that have BCR model and Three-Year Plan values that match, but use the replace-on-failure-only NEI value, instead of the weighted overall NEI value. These values should only be applicable if every installed measure was a replace-on-failure measure. We note, however, that the source document estimated that only 1.3% of ductless mini splits and between 60–70% of hot water heaters were replace-on-failure measures in 2013.

## **B.2 PA INITIATIVES AND MEASURES WITH NO CLAIMED NEIS**

In this section, we describe opportunities to capture additional NEIs that are not currently claimed in the current NEI research for Massachusetts by identifying those initiatives, or certain measures within initiatives, that currently have no NEIs applied to them. For some measures with existing NEIs, ongoing research indicates there may be additional NEIs that could be claimed. For many of the measures listed below, we do expect that an NEI could be calculated, based on our review of the literature, our interviews with the PAs, or the fact that NEIs exist for similar measures being installed under other initiatives. These opportunities are discussed in greater detail in the literature review and roundtable interview sections.

Among the PAs' energy efficiency initiatives, only the Residential Behavior/Feedback Initiative, Residential Consumer Products Initiative, C&I New Buildings & Major Renovations Initiative, and C&I Initial Purchase & End of Useful Life Initiatives do not include NEIs in the BCR models. Other initiatives include both measures with and without NEI values and with measures that were not projected to accrue any energy savings from 2016–2018 (e.g., duct insulation under certain initiatives) were excluded from the analysis. However, the fuel type listed in the tables corresponds to the BCR model. It should be noted that that in some cases, an initiative may provide measures for the alternative fuel. For example, the savings from the direct install lighting measures offered under the gas HES initiative are included in the gas BCR model.

### **B.2.1 Residential Sector**

The following 5 tables identify those measures in the residential sector for which no NEIs are claimed. Table 27 shows the 7 electric and 2 gas measures installed under the Residential New Construction initiative that have no NEIs applied. The initiative has a lighting measure with no NEIs, there may be an opportunity to apply the NEIs that are applied to the other lighting measure in the initiative. Table 28 shows the 7 gas and 9 electric measures that do not have claimed NEIs under the Residential Multifamily Retrofit initiative.

Table 29 shows the 9 electric and five gas measures without claimed NEIs under the Residential Home Energy Service's initiative. Table 30 shows the 6 electric and 2 gas



measures without claimed NEIs under the Residential Heating & Cooling Equipment initiative.  
And

Table 31 shows the 12 electric measures without claimed NEIs under the Residential Consumer Products initiative.

**Table 27. Residential New Construction, Measures Without NEIs**

Fuel	Measure
Electric	Codes and Standards
Electric	Cooling
Electric	Cooling High Rise
Electric	Custom
Electric	Lighting High Rise
Electric	Water Heating
Electric	Water Heating High Rise
Gas	Water Heating
Gas	Water Heating High Rise

**Table 28. Residential Multifamily Retrofit, Measures Without NEIs**

Fuel	Measure
Electric	Common Area Occupancy Sensors
Electric	Boiler Reset Controls
Electric	Duct Insulation
Electric	Demand Circulator
Electric	Faucet Aerators
Electric	Heating System Tune-Ups
Electric	Pipe Wrap
Electric	Smart Strips
Electric	Thermostatic Shut-Off Valves
Gas	Demand Circulator
Gas	Duct Insulation
Gas	Faucet Aerators
Gas	Heating System Replacement
Gas	Pipe Wrap
Gas	Thermostatic Shut-Off Valves
Gas	Water Heating



**Table 29. Residential Home Energy Services, Measures Without NEIs**

Fuel	Measure
Electric	Boiler Reset Controls
Electric	Duct Insulation
Electric	Early Retirement Electric DHW and Dryer
Electric	Early Retirement Gas DHW and Dryer
Electric	Faucet Aerators
Electric	Pipe Wrap
Electric	Refrigerator
Electric	Smart Strip
Electric	Solar Hot Water
Gas	Deep Energy Retrofit
Gas	Early Retirement Clothes Washer, Electric DHW and Dryer
Gas	Early Retirement Clothes Washer, Gas DHW and Dryer
Gas	Faucet Aerators
Gas	Smart Strip

**Table 30. Residential Heating & Cooling Equipment, Measures Without NEIs**

Fuel	Measure
Electric	Circulator Pump
Electric	Duct Sealing
Electric	Early Retirement Central Air
Electric	Early Retirement Heat Pump
Electric	Furnace ECM
Electric	Heat Pump Water Heater
Gas	Boiler Reset Control
Gas	Heat Recovery Ventilator



**Table 31. Residential Consumer Products, Measures Without NEIs**

Fuel	Measure
Electric	Dehumidifier
Electric	Dehumidifier Recycling
Electric	Dryer
Electric	Freezer
Electric	Freezer Recycling
Electric	Low-Flow Showerhead
Electric	Pool Pump
Electric	Refrigerator
Electric	Refrigerator Recycling
Electric	Room Air Cleaner
Electric	Smart Strip
Electric	Thermostatic Shutoff Valve

### **B.2.2 Low-Income Initiatives**

Except for two measures, all the measures under the low-income initiatives have an applicable NEI value. Faucet aerators under the low-income single family initiative and smart strips under the low-income multifamily initiative have no NEI value. There may be an opportunity to apply the same NEI value to each of these measures since the rate discount and price hedging NEIs are the same for single family and multifamily initiatives, and for all measures, based on the Residential and Low-Income NEIs Study and the Additional Non-Energy Impacts of Low-Income Programs Memo. Given this, the BCR models could be updated to include NEI values for single family faucet aerators and multifamily smart strips (i.e., rate discount and price hedging).

### **B.2.3 C&I Initiatives**

The following 5 tables identify those measures in the C&I initiatives for which no NEIs are claimed. A review of all the C&I measures indicates a consistent lack of significant NEIs among gas HVAC and hot water measures, while some initiatives have no NEIs for electric HVAC and hot water, which could be especially significant for the C&I Multifamily Initiative. Much of the C&I NEI research in the past has focused on O&M changes, but integrating new NEIs, such as increased comfort, may result in positive NEIs for these particular measures.

Table 32 shows the 10 electric and 20 gas measures without claimed NEIs that are installed under the C&I New Buildings & Major Renovations initiative. Many these measures should have NEIs applied in the future based upon the results from the 2016 Commercial and Industrial New Construction Non-Energy Impact Study; however, while the 2016-2018 BCR plan models list NEI values for these measures, the PAs are not currently claiming them in their benefit-cost calculations. In contrast to this, Table 33 contains a very similar set of



measures for the C&I Initial Purchase & End of Useful Life initiative; however, current research does not indicate opportunities to claim NEIs for these measures.

A potential opportunity to apply NEIs to Initial Purchase & End of Useful Life measures would be to adjust the NEI values from the 2016 Commercial and Industrial New Construction Non-Energy Impact Study following a methodology similar to that of the 2013 NMR update memo. The 2013 memo recommended splitting the NEI values based on what part of each NEI might be attributed to the newness of the equipment versus the greater energy efficiency of the equipment. Only the portion of the NEI that is associated with a measure's energy efficiency should be attributable to a PA's initiative for replace on failure measures, since the participant would have incurred the benefit or cost associated with the measure's newness without the initiative; however, even using this methodology, there is a difference in the measure lists that would require additional research: the 2016 Commercial and Industrial New Construction Non-Energy Impact Study did not address upstream hot water measures, which are present in the other initiative.

Table 34 shows the four electric and eight gas measures installed under the C&I Existing Building Retrofit initiative that do not have any NEIs. This is a very similar list to the measures in



Table 35, for the C&I Small Business Retrofit initiative. Table 36 shows the two electric and four gas measures under the C&I Multifamily Retrofit initiative that have no claimed NEIs.

**Table 32. C&I New Buildings & Major Renovations, Measures Without NEIs**

Fuel	Measure
Electric	CHP—Custom
Electric	Comprehensive Design
Electric	Compressed Air
Electric	Food Services
Electric	HVAC
Electric	Lighting
Electric	Motors & VFD
Electric	Other
Electric	Process
Electric	Refrigeration
Gas	Building Shell
Gas	Combination Oven
Gas	Combo Condensing Boiler
Gas	Condensing Boiler
Gas	Condensing Unit Heater
Gas	Convection Oven
Gas	Conveyer Oven
Gas	Food Services
Gas	Fryer
Gas	Furnace w/ECM
Gas	Griddle
Gas	Heat Recovery
Gas	Heating
Gas	Hot Water
Gas	HVAC
Gas	Infrared Heaters
Gas	Other
Gas	Process
Gas	Rack Oven
Gas	Steamer





**Table 33. C&I Initial Purchase and End of Useful Life, Measures Without NEIs**

Fuel	Measure
Electric	CHP—Custom
Electric	Comprehensive Design
Electric	Compressed Air
Electric	Food Services
Electric	HVAC
Electric	Motors & VFD
Electric	Other
Electric	Process
Electric	Refrigeration
Gas	Combination Oven
Gas	Combo Condensing Boiler
Gas	Condensing Boiler
Gas	Condensing Unit Heater
Gas	Convection Oven
Gas	Conveyer Oven
Gas	Food Services
Gas	Fryer
Gas	Furnace w/ECM
Gas	Griddle
Gas	Heat Recovery
Gas	Heating
Gas	Hot Water
Gas	HVAC
Gas	Infrared Heaters
Gas	Other
Gas	Process
Gas	Rack Oven
Gas	Steamer
Gas	Upstream Water Heater



**Table 34. C&I Existing Building Retrofit, Measures Without NEIs**

Fuel	Measure
Electric	Comprehensive Design
Electric	Food Services
Electric	Motors & VFD
Electric	Other
Gas	Faucet Aerator
Gas	Food Services
Gas	Heating
Gas	Hot Water
Gas	HVAC
Gas	Ozonated Laundry
Gas	Pre-Rinse Spray Valve
Gas	Process



**Table 35. C&I Small Business, Measures Without NEIs**

Fuel	Measure
Electric	Compressed Air
Electric	Hot Water
Electric	Motors & VFD
Electric	Other
Gas	Building Shell
Gas	Faucet Aerator
Gas	Heating
Gas	Hot Water
Gas	HVAC
Gas	Low-Flow Showerhead
Gas	Pre-Rinse Spray Valve

**Table 36. C&I Multifamily Retrofit, Measures Without NEIs**

Fuel	Measure
Electric	Hot Water
Electric	HVAC
Gas	Demand Circulator
Gas	Faucet Aerator
Gas	Low-Flow Showerhead
Gas	Wi-Fi Thermostat

## APPENDIX C: PA INTERVIEW AND LITERATURE REVIEW RESULTS

### C.1 ROUNDTABLE INTERVIEWS WITH PA STAFF RESULTS

This section presents results from the NEI Framework Study's IDIs with PA staff, including initiative evaluation, initiative implementation, and marketing staff. These interviews explored which NEIs are the most important to the PAs, and why.

Key points

**Cost-effectiveness testing** – Program evaluation staff were generally aware that NEIs played an important role in cost-effectiveness testing. Currently, NEIs had the greatest impact on the cost-effectiveness of low-income and MF programs, but additional NEIs could help raise the BCRs of new construction programs.

**Energy efficiency sales and program marketing** – The PAs distinguish between the use of NEIs for energy efficiency sales and for program marketing. The former refers to customer-level sales of individual projects, while the latter refers to broader marketing efforts for overall program activity.

- **Energy efficiency sales** – Most of the PAs report using NEIs on an individual project level to sell energy efficiency solutions to customers. They report that NEIs can often play an important role in determining whether the BCR on a project exceeds a value greater than one. Implementation staff were generally unaware of the extensive body of NEI research available for them to assist in EE sales. They indicated that to be useful, the research would have to be more readily accessible and relevant to individual sales.
- **Program marketing** – The PAs report there is some NEI information being used for program marketing, but that information is derived from statewide marketing efforts and published literature such as ACEEE research. They are not currently using the body of literature provided by the PAs' evaluation studies to market their programs.

#### C.1.1 Applying NEIs

The evaluation team began the interviews by establishing interviewees' understanding of how the PAs use NEIs, both in terms of estimating cost-effectiveness and in marketing.

##### *BCR Models*

Before the interviews, the evaluation team reviewed the NEIs that the PAs currently claim, and assessed the value those NEIs provide for individual initiatives and individual measures, characterizing the relative importance of NEIs towards an initiative's cost-effectiveness. The evaluation team asked program staff to then reflect on their observations regarding the value NEIs play in their initiatives. While all confirmed that they use the *common assumptions* described in the Three-Year Plan, their responses indicated that the overall value of NEIs varies based on the mix of measures installed by their individual initiatives, and that PAs rely less on NEIs for gas measures than for electric measures.<sup>51</sup>

<sup>51</sup> As we established through the NEI inventory (6.2APPENDIX B:), the notion of common assumptions discussed by the interviewees proved accurate. NEI values are generally very consistent across PAs; however, the common assumptions described in the Three-Year Plan are not always consistent with the source research.



The program evaluation staff interviewed were aware of the contribution that NEIs made to overall initiative cost-effectiveness, while the program implementation staff were generally only aware of BCR analysis at the individual project level. The implementation staff indicated that NEIs were most important for cost-effectiveness of residential low-income initiatives. They believed that they will also be important for the multifamily low-income initiatives. This is because multifamily initiatives are costly for a number of reasons. Program implementation staff also indicated that any additional NEI research for low-income and multifamily initiatives would assist the initiatives that have lower BCRs. For example, having NEIs associated with O&M savings in rental units may better reflect the benefits in the BCR modeling.

On the C&I side, the PA staff (both evaluation and implementation) were aware that the retrofit measures were currently cost-effective without NEIs. Respondents cited the need for additional C&I research in the areas of worker health and safety, absenteeism, impacts on insurance, and student performance in educational settings. One PA staff member inquired as to whether any existing research had quantified the NEIs related to getting inoperable ventilation/HVAC working during a retro-commissioning project. More specifically, what the value is of improved occupant health based on optimized ventilation after completion of the study.

PA staff suggested there is a need for additional NEI research for new construction measures. The PAs indicated that all C&I initiatives may face increasing sensitivity to the inclusion of NEI values as energy savings become constrained by changing baselines, particularly in lighting; however, sensitivity analysis of the BCR shows that any baseline changes would have to be substantial for savings to be constrained to a level where NEIs are necessary to make these initiatives cost-effective (6.2APPENDIX D:).

### *Using NEIs in Marketing*

While program managers are usually not involved with NEIs for overall cost-effectiveness of initiatives, PA staff reported that C&I program managers will draw on NEI values to help individual projects pass BCR testing for customers during the sales process. However, program implementation staff did not seem to use or even be aware of the existing body of NEI research developed for program evaluation. One program staff person said that estimating NEIs for lighting in the C&I sector is particularly nebulous for them. They often rely on NEI estimates provided by ACEEE research or value cited in their statewide marketing materials.

Several program implementation staff discussed using NEIs during the project development stage of the sales process, including estimating their own NEI values for customers. One staff member said, *“We screen each project individually, so NEIs are customer-specific. For CHP, we include O&M as a penalty. We also include production-level changes, which we calculate ourselves. This is common for CHP and lighting measures. If they (the engineer) don’t provide it (estimates), we have default values we use.”* To ensure consistency, the PAs could explore sharing their existing NEI research with program implementation staff.

On that note, the evaluation team sought to understand how PAs leverage NEIs in marketing and outreach efforts. Program staff reported that NEI promotion is limited; usually, marketing materials emphasize energy savings. An exception is thermal comfort (particularly with the Home Energy Services initiative) for residential customers or maintenance for C&I/multifamily customers that are highlighted at times. Program staff emphasized that messaging was



usually provided by the overall state marketing materials, which do not quantify the potential NEIs in any way. As one interviewee put it, *“I never am introducing something like, you’re going to see a 10% change in sales.”* There was a consensus, however, that the initiative implementation staff were not sure how to leverage the NEI information from evaluation studies for initiative marketing, either overall or at the individual project level.

When the team asked if an NEI emphasis in marketing and outreach efforts should be increased, there were mixed results. Some program implementation staff worried that making assertions about impacts beyond energy savings might result in customer dissatisfaction if non-energy savings did not materialize as suggested. This is particularly true in residential/low-income settings. Other implementation staff were interested in anything that could help demonstrate the value proposition to customers. Some of the new construction program managers were very interested in additional materials to help promote initiatives.

Interviewers asked if there are certain NEIs that are more important to customer uptake; however, most of the PA staff interviewed do not typically have direct customer interactions. One program manager said that in the C&I sector, he observed that maintenance savings appear to be the most important NEI to the customer. Another interviewee offered that *“every customer is different; for example, a (residential) customer with an infant would be drawn to health and safety,”* but added that C&I customers are typically focused on the *“bottom line and payback.”*

Program staff agreed that it could be good to have tools on hand that could assist marketing staff calculate NEIs geared towards larger C&I customers, such as big box stores and multifamily customers. Program implementation staff from one PA suggested providing salespeople with an easy multiplier to plug into a calculator that would quickly estimate NEIs based on square footage of a site during sales conversations. One implementation contractor suggested that the customer-facing cost-effectiveness calculations break out NEIs separately so that customers can observe their impact.

### *Opportunities*

Program staff weighed in on potential opportunities for claiming NEIs, offering their opinions on the potential for crossover across sectors, new NEI categories, and the value that NEIs might play in upcoming initiatives.

### *Potential for Crossover*

In some cases, an NEI category may be applied to one initiative for a certain measure, yet that same measure in a different initiative may not have the same NEI applied to it even though the measures are the same. When asked, program staff identified opportunities for crossover NEIs:

- Interviewees pointed out that many NEIs are claimed for the low-income initiatives that are not claimed for the market-rate initiatives. They felt that some of these should be applicable to market-rate initiatives, but could not identify any specifically.
- Interviewees also discussed that some of the O&M NEIs seen in the C&I initiatives might be applicable to residential buildings.
- Program staff suggested that safety and health/absenteeism could be studied for the C&I sector, in the same way it is being studied for the residential sector. They added



that the marketability of a commercial space could also be considered, since it is currently only considered for multifamily programs.

- One program staff member pointed out that they believed maintenance savings are not currently applied to steam traps.
- Another program staff member indicated that NEIs related to lighting and parking lot safety might be applicable to both C&I and multifamily initiatives due to larger parking lot sizes.

### *New NEI Categories*

Program staff expressed reservations about adding new NEI categories, acknowledging the difficulty of substantiating NEIs. With caution, they offered some suggestions for new NEIs:

- Academic performance impacted by lighting in classrooms
- Production efficiency
- Insurance rates
- Additional storage space provided by smaller equipment may replace the need for a company to purchase or rent additional space
- Chilled beams support the opportunity to build additional stories
- Additional NEIs associated with steam traps

While a few program staff recommended water savings, these are already incorporated into BCR modeling, though not as an NEI.

### *New Initiatives*

The evaluation team asked program staff to hypothesize about the role that NEIs might play in new initiatives, existing initiatives, and enhancements included or proposed in the Three-Year Plan:

- **Zero Net Energy Building.** Enhancements to the C&I New Construction initiative may include an offering to encourage zero net energy building.<sup>52</sup> Given program staff's skepticism of the viability of frequent zero net energy building given its cost, they did not place great importance on NEIs for cost-effectiveness testing and marketing this effort—many did not expect to have any zero net energy buildings in their territory. However, one interviewee pointed out that being able to market the NEIs of zero net energy buildings might help to overcome the low incidence of zero net energy buildings. One program manager assumed that any market actors who ultimately decide to build to zero net energy standards are those who are already committed to being green, and that any additional potential NEIs will not be a deciding factor for them.
- **Sustainable Office Design.** The C&I New Construction initiative is also adding a Sustainable Office Design offering, which includes advanced lighting solutions with the

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<sup>52</sup> Through renewable-energy infrastructure, a net-zero energy building annually consumes no more energy than what it produces onsite.



anticipated benefits of improving employee health, comfort, and production efficiency. The interviewees indicated that applying health and lighting NEIs would help with initiative cost-effectiveness since the initiative was designed more around impacted health and production efficiency, versus saving a large amount of energy. At the same time, there is some concern about spending a lot of resources calculating new NEIs for this initiative since it is not particularly large. Instead, this initiative would be a good candidate for modifying and applying NEIs previously calculated for other initiatives. A key factor will be determining how health impacts vary depending on building type.

- **Renter-Specific.** The renter-specific offering will support instant savings measures and disseminate information to encourage additional energy-saving upgrades or behaviors. Program staff agreed that NEIs may play a role in making this offering cost-effective.
- **Moderate-Income.** The PAs are testing a moderate-income initiative. Program staff speculated that NEIs can play a role in making this offering cost-effective, as NEIs have done for the low-income initiative. One interviewee recommended that the low-income NEIs be applied to this group but suggested that their values be scaled to reflect the distinction between low- and moderate-income resources. Another estimated that there is not a significant difference in purchasing-power parity between low-income customers, defined as having 60% or less of the area median income (AMI), and moderate-income customers, defined as having 80% of the AMI—which implies that the NEIs should not be different for these two groups.
- **Street lighting.** The PAs are considering supporting energy-efficient street lighting. We had the opportunity to discuss this with one PA's program staff. One interviewee speculated that color-tuning options may slightly increase cost-effectiveness because they enhance visibility/safety. The program staff held reservations about the technology itself, reporting findings from other studies that showed negative health NEIs.<sup>53</sup>

### *Areas of Concern*

As noted, program implementation staff warned that adding, publicizing, or adjusting NEIs should be approached cautiously and with a strong focus on substantiation, to ensure that impacts advertised to customers are as accurate as possible.

Interviewers also asked staff if there are any NEIs currently claimed by the PAs that should no longer be claimed. Program staff did not identify any such currently claimed NEIs.

## **C.2 LITERATURE REVIEW RESULTS**

This section presents the results of an abbreviated literature review. As noted in the methodology section, the objective of the literature review is to identify NEIs that are not currently claimed in the existing Massachusetts NEI research, rather than to perform a

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<sup>53</sup> Negative health NEIs would be those resulting from the blue light associated with LED technology. The American Medical Association (AMA) recommends using LED lighting that minimizes blue light because of the potential negative health effects of blue light, including increased glare, decreased visual acuity and safety, and melatonin-suppression at night that disrupts circadian rhythms and can cause sleep and health problems. From: <https://www.ama-assn.org/ama-adopts-guidance-reduce-harm-high-intensity-street-lights>.





comprehensive review of the body of NEI literature. The literature review performed for the 2011 Massachusetts Residential and Low-Income NEI study reviewed over 100 other studies.<sup>54</sup> The current literature review supplements that 2011 literature review with recent sources to inform the framework regarding the types of NEIs the PAs are missing or understating, and how the PAs could realistically claim these additional NEIs.

Table 37 summarizes the key findings from the literature review. More detailed findings are provided below.

**Table 37. Summary of Potential NEIs in the Literature Not Claimed by the PAs**

Sector	Potential NEI
<b>Multifamily</b>	Reduced tenant turnover resulting in reduced vacancy rates and tenant turnover costs including maintenance and repair costs and marketing and advertising costs.
<b>Low-income/Residential/Multifamily</b>	Improved health effects
<b>C&amp;I</b>	O&M costs for replace on failure measures
	Improved health effects
	Improved aesthetics
	Increase in production efficiency

### C.2.1 Residential NEIs Overview

- The reviewed residential multifamily NEI literature identifies several NEIs, such as improved rental unit quality, which result in reduced turnover costs, reduced marketing costs, reduced tenant turnover, and reduced vacancy rates that all contribute to a relatively small number of monetized NEIs. These monetized NEIs include increased rental income, reduced O&M costs, and increased property values. Reduced O&M costs (including reduced turnover costs, such as cleaning and reduced marketing cost, represent new NEIs for market rate multifamily retrofit initiatives, whereas increased rental income and property value represent double counting of non-property value NEIs (discussed further below).<sup>55</sup> Two reviewed multifamily studies found substantial reduced maintenance costs, of \$171 to \$363 per housing unit.

<sup>54</sup> NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

<sup>55</sup> Building owners may also be able to delay some costs of upkeep, such as repainting an apartment or conducting minor repairs, due to reduced unit turnover. But it is not clear whether these are avoided costs or delayed costs (and therefore not an NEI). There may be a financial benefit to an owner to delaying these expenses into the future. The team can explore these potential benefits in the planned interviews with owners of market rate multifamily buildings.



- Two recent studies documenting the potential health effects of residential energy efficiency projects suggest that further research on health NEIs may be warranted for single family and multifamily market rate and multifamily low-income initiatives.<sup>56,57</sup>
- Due to the double counting associated with property values or rental income and the individual non-property value NEIs that are the source of property value or rental income changes, we recommend that the PAs do not count their existing property value NEIs for those measures with both property value NEIs and other individual NEIs. Rather, in any BCR calculations, the PAs should count the values associated with improved comfort, health, home durability, reduced O&M costs, reduced tenant complaints, etc. For those measures that only have property values NEIs, such as appliances and low-flow showerheads, we recommend using those as proxies in BCR calculations for the individual NEIs that have not yet been counted.

### C.2.2 Commercial and Industrial NEIs Overview

- The PAs already capture all the O&M cost and revenue NEIs contained in the literature for retrofit measures, although some measures or initiatives (e.g., replace on failure) require additional study.
- We have identified other NEIs that the PAs' existing research does not capture. Some of these NEIs represent opportunities for additional sources of initiative participation benefits. NEIs that the PAs do not currently capture include:
  - *Health-related NEIs*—These NEIs can be captured through interviews or an avoided-cost approach like that employed by Three<sup>3</sup> for residential NEIs.
  - *Aesthetics*—The C&I retrofit NEI study<sup>58</sup> attempted to increased sales and worker production efficiency gain NEIs resulting from aesthetic improvements. However, the New Construction NEI study<sup>59</sup> did not attempt to quantify these changes.
  - *Production efficiency gains*—The C&I retrofit NEI study asked respondents whether they had experienced any efficiency changes resulting from the installed measures, and reflected impacts such as increases to comfort, employee morale, and operational efficiency. While these changes were quantified where possible, they are likely under-reported for process/industrial applications, the very measures on which they are most likely to have the greatest impact. NEIs associated with industrial/process production increases have not been studied in detail in Massachusetts. The C&I retrofit NEI study suggests that these NEIs are not only present but are substantial, and may represent an additional opportunity. Studying these NEIs would require an

<sup>56</sup> Three3 and NMR. Residential Health-Related NEIs. 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

<sup>57</sup> E4The Future, Inc., 2016. Occupant Health Benefits of Residential Energy Efficiency. <http://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf>

<sup>58</sup> DNV KEMA and Tetra Tech. June 29, 2012. *Final Report – Commercial and Industrial Non-Energy Impacts Study.* Submitted to the Massachusetts Program Administrators.

<sup>59</sup> DNV KEMA and Tetra Tech. February 12, 2016. C&I New Construction NEI Stage 2 Final Report. Submitted to the Massachusetts Electric and Gas Program Administrators.



engineering-based approach that could account for the custom nature of industrial process measures. While the NEIs may be substantial, it is important to consider the tradeoff between study costs and the applicability of results to the range of measures.

- *Resource-based NEIs*—The C&I retrofit NEI study was unsuccessful in capturing resource-based NEIs, such as fuel and water savings, through the interview process. The PAs do claim these resource savings in their BCR models based on other studies, but there may be additional opportunities for the PAs to update these benefits through an engineering based study.
- *Green business value*—These benefits are included in any increased sales that the business may experience due to the installed measures. However, any additional impacts associated with the value of “doing a good deed” are closely related to societal impacts, which the PAs are not able to claim; thus, we do not recommend pursuing such additional impacts.
- *Property value/rent/ease of renting*—As with the discussion regarding property values for residential measures, to the extent that changes in rent revenue result from opportunities to reduce O&M costs, increase revenue, or add amenities for multifamily properties, they should not be counted.

The remainder of the literature review section is organized as follows:

- Residential NEI Studies—This section provides a summary of the reviewed residential NEI studies and their findings.
- C&I NEI Studies—This section provides a general overview of C&I NEI studies and their findings. It also identifies areas that have not been addressed by the existing C&I NEI research as an introductory view of the forthcoming NEI research inventory.

### **C.2.3 Residential NEI Studies**

Overall, there have been a limited number of residential and low income studies based on primary research quantifying NEIs that were not already included in the 2011 Massachusetts Residential and Low-Income NEI study. The recently published NEI literature can be divided into four general categories of reports and conference papers:

1. Case studies of NEIs associated with multifamily retrofit initiatives
2. General overview studies of NEI research and NEI values
3. Studies examining the effects of residential energy efficiency initiatives on property values for residential housing
4. Studies examining the health impacts of residential energy efficiency initiatives.

We provide a brief overview of these four segments of the literature, focusing on items 1, 3, and 4 above. The multifamily studies (#1) provide monetized values of NEIs that represent an opportunity to claim NEIs in excess of those currently described in the existing Massachusetts NEI research and claimed by the PAs. The evaluation team does not recommend adopting the multifamily NEI values from the literature for the PAs’ initiatives. Instead, we suggest that the studies provide support for:



- Considering further study of multifamily NEIs in Massachusetts<sup>60</sup>
- Applying the existing low-income multifamily owner NEIs to market rate multifamily retrofit projects.

The literature on health impacts of low-income and non-low-income multifamily residential retrofits and on non-low-income single family residential retrofits represents another potential opportunity for PAs to claim additional NEIs. However, the health-related studies (#4) reviewed here do not estimate monetized NEI values beyond what the PAs currently claim. The property value studies (#3), like the multifamily case studies, provide monetized estimates of NEIs, but do not represent an opportunity for additional NEIs in excess of already claimed NEIs. As discussed in the Background section, property values overlap with individual non-property value NEIs, and should not be claimed if the individual non-property value NEIs are claimed.

In Table 38 we present a summary of the NEIs identified in the residential literature review. Column (a) presents a wide range of individual NEIs identified in the studies that contribute to a smaller set of monetized NEIs (column (b)). For example, increased marketability and ease of finding renters, higher occupancy rates (or reduced vacancy rates), and improved rental-unit quality all contribute to increased rental income. Column (c) reports the housing type associated with the NEI identified in the literature; column (d) includes our evaluation team’s recommendation for treating the NEI.

**Table 38. Residential NEIs Identified in Literature Review**

Individual/Component NEIs (a)	Monetized NEI (b)	Housing Type (c)	Recommendation (d)
Increased unit marketability/ease of finding renters	Increased Rental Income	Multifamily	Do not claim, due to difficulty isolating transfers and low vacancy rate in metro areas
Higher occupancy or reduced vacancy rates <sup>1</sup>			
Improved rental unit quality (increased rental rate)			
Ease of finding renters (reduced marketing costs)	Reduced costs (O&M)	Multifamily	Apply Massachusetts low-income multifamily owner NEIs to market rate multifamily projects; consider market rate multifamily study
Reduced tenant turnover costs (cleaning and upkeep)			
Reduced operation and maintenance costs of equipment			
Fewer tenant complaints			
Avoided catastrophic failure of mechanical systems	Avoided emergency repairs and emergency replacement (not	Multifamily	Consideration to be included in a multifamily study

<sup>60</sup> The evaluation team is currently conducting a study to gain a qualitative understanding of the types and magnitude of the NEIs associated with multifamily retrofits, focusing on those that likely accrue to owners and landlords of market-rate multifamily rental properties and multifamily condominiums.



	monetized in reviewed studies)		
Property value	Property value	Multifamily & Single Family	Do not claim; overlaps with O&M and other NEIs
Improved Health <sup>2</sup>	Reduced medical costs; reduced lost income (missed days from work); fewer deaths	Multifamily & Single Family	Consider market rate (multifamily & single family) and multifamily low-income studies

<sup>1</sup> In the 2011 Residential and Low-income NEI study, the survey of low-income owners asked about reduced tenant turnover but no respondents indicated a change in tenant turnover since the improvements had been made.

<sup>2</sup> The health-related NEIs were not monetized in the reviewed studies but could be monetized through metrics such as reduced medical costs.

### *Summary of Residential NEI Values*

Table 39 presents a summary of the monetized NEIs from the residential literature review. When possible, we have included an analysis of the NEI value in relation to the energy savings value. We also indicate the housing type included in the NEI study. As noted earlier, because the existing literature is largely based on a limited number of case studies, the evaluation team does not recommend adopting the multifamily NEI values from the literature for the PAs' initiatives. Instead, we suggest that the studies provide support for considering further study of multifamily NEIs in Massachusetts, while the property values represent double counting of the individual non-property value NEIs currently claimed by the PAs.

**Table 39. Summary of Residential NEIs Quantified in Recent Studies**

Potential NEI	Housing Type	NEI Value per Housing Unit (\$)	NEI per \$ of Energy Savings	Data Source/Method	Reference
Maintenance costs	Multifamily	\$171	\$0.95	IDI with building owner	Elevate Energy, 2014
Maintenance costs	Multifamily	\$363	\$0.83	Not reported	NYSERDA, 2013
Rental income	Multifamily	\$400	\$3.11	Review of financial records	Scheu and Evens, 2014
Rental Income (reduced vacancy rate)	Multifamily	\$613	\$1.15	IDI with building owner	Marjersik, 2004
Property value	Single Family	6.4% to 10.3% increase per home (\$4,500 to \$7,000)	Not Available	Hedonic pricing model	Drakos et al., 2011
Property value	Single Family & Multifamily	1.5% increase	Not Available	Hedonic pricing model	Lyons et al., 2014
Property value	Single Family & Multifamily	3.46% increase	Not Available	Paired sales analysis	Adomatis, Sandra, 2015

### C.2.4 Multifamily Studies

Several recent studies have examined NEIs accruing to owners and managers of multifamily housing. Examples of quantified NEIs include O&M savings, increased rental income (sometimes due to reduced vacancy rates), and savings due to reduced turnover rates.

#### *Elevate Energy, 2014*

A 2014 case study conducted by Elevate Energy examined the NEIs attributed to an affordable multifamily housing retrofit in Chicago, IL. The project, which included air sealing, insulation, and furnace replacements, retrofitted 33 buildings and 70 housing units, resulting in an average natural gas savings of 19%. This was equal to over \$12,000 in annual natural gas bill savings.

Through an in-depth interview with the building owner, the study found that the retrofit resulted in a 17% reduction in maintenance costs, which we estimate to be equal to \$171 per unit, or \$11,986 for the entire project.<sup>61</sup>

<sup>61</sup> The report estimates that per unit annual maintenance costs are equal to \$836 since the retrofit was completed. Using the reported 17% reduction in maintenance costs, we estimate pre-retrofit annual maintenance costs of \$1,007, or a savings of \$171 per unit.



In addition to building owner NEIs, the study found evidence of several potential tenant NEIs. Results of a survey of tenants found that 67% reported that their unit stays cool during hot weather, and 81% reported that their unit stays warm during cold weather. In addition, about one-third of tenants said that they felt more confident and less stressed paying rent and utility bills, and 89% reported they would ask about energy efficiency if they moved to a new building.

*Scheu And Evens, 2014*<sup>62</sup>

A second study conducted by Elevate Energy examined the financial records of 13 multifamily buildings that received energy efficiency retrofits, and compared these to 21 multifamily buildings that received an energy assessment but did not complete a retrofit.<sup>63</sup> For the retrofitted buildings, annual gas bills decreased by 25% and electric bills decreased by 15%. The study found that buildings that completed an efficiency upgrade experienced a 1.6% increase in net operating income (NOI), equal to \$29.10 per unit per year. Annual rental incomes increased by almost \$400 per unit (\$399.67) in the year after energy efficiency upgrades were completed.<sup>64</sup>

Building owners interviewed for the study identified several benefits, including reduced O&M costs, as well as reduced unit turnover and vacancies that can result in lost rental income. Owners' estimates of the costs of unit turnover ranged from \$900 to \$3,000 per unit, and noted that unit turnover costs often include deferred maintenance and upgrades, such as repainting walls, sanding and re-staining floors, and upgrading bathrooms and kitchens. Estimating an NEI for "reduced turnover" would need to differentiate between costs associated with deferred maintenance and upgrades, which would not be considered an NEI, and costs directly incurred by unit turnover, i.e., costs that would not be incurred if a tenant remained in the unit.

*NYSERDA, 2013*<sup>65</sup>

A NYSERDA case study of a retrofitted 317-unit multifamily co-op building found substantial maintenance savings. The project installed a wide range of energy efficiency measures that resulted in a 15% reduction in total energy use (equal to over \$139,000 in annual energy bill savings). The project included an upgraded ventilation system, pumps, motors, absorption chiller, steam line leak repairs and insulation, and energy-efficient lighting fixtures and motion sensors installed in common areas and a maintenance room. The study estimated annual maintenance savings ranging from \$250 to \$475 per unit. Averaging the low and high maintenance savings value, the project resulted in an approximate annual maintenance

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<sup>62</sup> Philbrick, D., R. Scheu, and A. Evens. 2014. Valuing the Financial Benefits of Energy Efficiency in the Multifamily Sector. Chicago, IL: Elevate Energy. <http://www.elevateenergy.org/prod/httpdocs/wp/wp-content/uploads/Financial-Performance-White-Paper-Elevate-Energy-Submit.pdf>.

<sup>63</sup> The report describes the buildings and housing units as "naturally occurring affordable" defined as buildings that are in neighborhoods where market rate rents are affordable to low and moderate income households.

<sup>64</sup> The report did not specify if the increased rental income was attributable to reduced turnover, unit-vacancies (net of associated costs to rent the unit) or due to increased monthly rental rates.

<sup>65</sup> NYSERDA. 2013. Aging Systems Open the Door for Major Energy Savings: Carnegie House, Manhattan. Albany, NY: NYSERDA. <http://www.en-powergroup.com/wp-content/uploads/2013/04/Carnegie-Case-Study.pdf>.



savings of \$363 per unit, or \$115,000 for the building (i.e., \$363 estimated annual per-unit maintenance savings \* 317 units equals \$114,913).

In addition, the case study identified another potential NEI that was not quantified: avoided catastrophic failure of the mechanical system. Emergency repairs and replacements can be expensive, and short-term solutions may be less efficient or incorrectly sized compared to program-supported retrofits.

*Marjersik, 2004*<sup>66</sup>

A case study of an energy-efficiency upgrade to a 204-unit subsidized apartment complex in Buffalo, New York examined the upgrade's impacts on the property value and vacancy rates. The upgrade replaced electric resistance heaters with direct-vented, natural gas-fired room heaters, and upgraded heating systems for the lobby, maintenance office, and community room, resulting in \$109,000 in annual energy bill savings.

Vacancy rates at the complex dropped from 16% to 2% after the upgrade, and the building superintendent estimated that 90% of the change in vacancy rates was attributable to the upgrades. The study author estimated that the reduced vacancy rate resulted in an increased annual rental income of \$125,000, or \$613 per unit per year.

### **C.2.5 General Overview Studies of NEI Research and NEI Values**

Several recent reports and conference papers have provided an overview of NEIs and their role in cost-effectiveness testing. The studies provide a summary of existing NEI research, most of which was included in the Massachusetts Residential and Low-Income NEI study or summarized in the previous section on multifamily studies. Examples of recent overview studies include the following:

1. Cluett, Rachel and Jennifer Amann. 2015. Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening. Report A1502. American Council for an Energy-Efficient Economy. <http://aceee.org/multiple-benefits-multifamily-energy-efficiency>
2. Malmgren, Ingrid and Lisa A. Skumatz. 2014. Lessons from the Field: Practical Applications for Incorporating Non-Energy Benefits into Cost-Effectiveness Screening. Paper presented at 2016 ACEEE Summer Study on Energy Efficiency in Buildings. <http://aceee.org/files/proceedings/2014/data/papers/8-357.pdf>
3. Russell, Christopher, Brendon Baatz, Rachel Cluett, and Jennifer Amann. 2015. *Recognizing the Value of Energy Efficiency's Multiple Benefits*. Report IE1502, American Council for an Energy-Efficient Economy. <http://aceee.org/research-report/ie1502>
4. Skumatz, Lisa. 2016. Non-Energy Benefits/NEBs—Winning at Cost-Effectiveness Dominos: State Progress and Three-Year Plans. Paper presented at 2016 ACEEE

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<sup>66</sup> Majersik, C. 2004. The Impact of Energy Costs on Multifamily Residential Building Value. Case Study: Pine Harbor Apartments. Prepared for NYSEERDA. Washington, DC: Institute for Market Transformation. <http://www.imt.org/uploads/resources/files/PineHarborCaseStudy2004.pdf>.





Summer Study on Energy Efficiency in Buildings.  
[http://aceee.org/files/proceedings/2016/data/papers/6\\_1147.pdf](http://aceee.org/files/proceedings/2016/data/papers/6_1147.pdf).

### C.2.6 Property Value Studies

The PAs currently use a property value NEI reported in the 2011 Massachusetts Residential and Low-Income NEI study based on surveys of initiative participants. Several recent studies have attempted to estimate the effects of energy efficiency measures on property values using a hedonic price model.

As previously discussed, if the PAs continue to count benefits that drive increased property values separately, such as increased health and comfort, then including property value NEIs will result in double counting all or some of these benefits.

Below we summarize several recent studies that have estimated energy efficiency's effects on property values.

*Drakos Et Al., 2011*<sup>67</sup>

This 2011 study used a hedonic pricing model to estimate a property value NEI for single family homes for a weatherization program administered by People Working Cooperatively (PWC), a nonprofit organization based in Cincinnati, Ohio. PWC's weatherization program includes home repair and mobility modification services to low-income homeowners. Home repairs covered both major and minor repairs, including roof replacements, electrical system upgrades, and plumbing system repairs or replacements. The study found that on average, homes served by PWC had a sales price of 6.4 to 10.6% greater than homes not served by PWC (estimated to be valued at \$4,500 to \$7,000 per home). In addition, each home in a neighborhood that included a home served by PWC had a sales price 1.9 to 3.8% higher (estimated to be valued at \$2,600 to \$4,000 per home). However, it is important to note that the study did not isolate the portion of the increase attributable to the home repairs from the portion attributable to the efficiency improvements. The study also did not isolate the portion of the property value attributable to the present value of energy savings from the portion attributable to the energy efficiency measures.

*Lyons Et Al., 2014*<sup>68</sup>

Using a hedonic pricing model, the authors estimated the effect of a home's energy efficiency on the home's property value. Using data on 2,780 homes in Dublin, Ireland, the team evaluated the relationship between the energy performance rating of residential homes and their market price, controlling for several home characteristics including building type (apartment, detached single family home, etc.), size, age, and location. The authors found that that energy efficiency has a significant, positive correlation with list price, estimating that a 50-

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<sup>67</sup> Drakos, Jamie, M. Sami Khawaja and Jennifer Price. 2011. Increasing Property Values and Decreasing Forced Mobility: Analysis of Nonenergy Benefits for Low-Income Programs. Paper presented at International Energy Program Evaluation Conference, Boston, MA.

<sup>68</sup> Lyons, Ronan C, Sean Lyons and Sarah Stanley. 2014. The Price Effect of Building Energy Ratings in the Dublin Residential Market. Paper presented at the 2014 International Energy Policy & Programme Evaluation Conference, Berlin. <http://www.iepec.org/conf-docs/papers/2014/Sarah%20Stanley.pdf>.



point improvement in one metric of efficiency (the energy performance indicator, measured in kWh/m<sup>2</sup>/yr.) is associated with a list price that is 1.5% higher. However, as with the paper by Drakos et al. (2011), the study did not isolate the portion of the property value attributable to the present value of energy savings from the portion attributable to the energy efficiency measures.

*Adomatis And Sandra, 2015*<sup>69</sup>

This study used a paired analysis of 8 single family and multifamily homes with green features (LEED® certification or other features such as solar panels) and 32 homes without green features. It found that, on average, a home with green features had a price 3.46% higher than a comparable home without green features. As with the other reviewed studies, the study did not isolate the portion of the property value attributable to the energy efficiency measures. Further, the homes included a combination of “green” and energy efficient measures.

### **C.2.7 Health Impacts of Residential Energy Efficiency Initiatives**

In addition to the PAs’ recent study that examined and quantified the health- and safety-related NEIs of weatherization in low-income single family homes,<sup>70</sup> there have been two other recently released reports that examine the potential health impacts of residential energy efficiency initiatives:

1. E4The Future, Inc., 2016. Occupant Health Benefits of Residential Energy Efficiency. <http://e4thefuture.org/wp-content/uploads/2016/11/Occupant-Health-Benefits-Residential-EE.pdf>
2. Wilson, Jonathan, David Jacobs, Amanda Reddy, Ellen Tohn, Jonathan Cohen, and Ely Jacobson. 2016. Home RX: The Health Benefits of Home Performance – A Review of the Current Evidence. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technology Office. Report # DOE/EE 1505. DOE Home RX Report.

The studies focus on documenting the potential health impacts of residential energy efficiency projects, but do not provide monetized NEI values for health-related NEIs beyond what the PAs currently claim. Examples of potential health effects include the following:

- Fewer heat or cold related deaths
- Reduced hypertension and heart disease

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<sup>69</sup> Adomatis, Sandra. 2015. What is Green Worth? Unveiling High-Performance Home Premiums in Washington, D.C. Paper prepared for the Institute for Market Transformation and the District of Columbia’s Department of Energy and Environment. [http://www.imt.org/uploads/resources/files/HighPerformance\\_Home\\_Valuation\\_Report\\_Sept2015.pdf](http://www.imt.org/uploads/resources/files/HighPerformance_Home_Valuation_Report_Sept2015.pdf)

<sup>70</sup> Three3 and NMR. 2016. Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study. Prepared for the Massachusetts PAs. <http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-Non-Energy-Impacts-Study.pdf>



- Reduced risks, such as hospitalizations, due to asthma and chronic obstructive pulmonary disease
- Reduced cancer risks
- Improved mental health

While the studies do not monetize the potential health impacts, they do suggest that further research may be warranted.

While the PAs currently claim a health benefit of \$4 per retrofitted home (estimated from the 2011 Residential and Low-income NEI study),<sup>71</sup> the recently completed study estimating health- and safety-related NEIs of weatherization in low-income single family homes illustrates that the 2011 study may be underestimating health impacts. Moreover, the 2011 study does not include a health benefit for residential new construction (single family or multifamily).

### C.2.8 General Overview C&I Studies

Research into NEIs associated with C&I initiatives is considerably less extensive than research into NEIs associated with residential initiatives. Our review focused on the four studies that constituted the most comprehensive C&I NEI work prior to the 2012 Massachusetts study: Optimal Energy (2008), TecMarket Works (2007), Wobus et al. (2007), and Hall and Ross (2003). Below we compare the NEIs from these four studies to those already reported by the PAs to identify any possible areas for further research. The Optimal Energy study employed an engineering-based approach to estimate NEIs, while each of the remaining studies obtained NEI estimates from self-reports. We review each of these studies in the sections that follow.

The evaluation team did not identify any C&I NEI studies that quantify health impacts, although we believe these impacts could be estimated using techniques like Three<sup>3</sup>'s approach to low-income health impacts of weatherization programs.<sup>72</sup>

#### *Optimal Energy, 2008*<sup>73</sup>

This study provided non-electric benefits associated with prescriptive C&I electric initiatives in Massachusetts. Using an engineering-based approach, this study estimated cost changes resulting from newly installed lighting and energy management system (EMS) equipment. The benefit of this approach was that it clearly defined and documented the specific sources for cost savings resulting from the installed measures. However, due to the complexity in modelling, the study used a more conservative approach to quantifying NEIs, assuming values of zero for all measures except those associated with prescriptive lighting and EMS measures. Furthermore, it did not address custom measures or questions pertaining to initiative

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<sup>71</sup> NMR. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for: Massachusetts Program Administrators. 2011.

<sup>72</sup> Three<sup>3</sup> and NMR. 2016. Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts Study. Prepared for the Massachusetts Program Administrators. August 5, 2016. <http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-Non-Energy-Impacts-Study.pdf>.

<sup>73</sup> Optimal Energy, Inc. *C&I Prescriptive Non-Electric Benefits*. Wyatt, Francis. August 22, 2003.



attribution and NEIs. However, the Optimal Energy study provided the framework for the 2016 Massachusetts New Construction NEI Study.

*TecMarket Works, 2007*<sup>74</sup>

In this study, the authors created the framework for the 2013 Massachusetts C&I retrofit NEI research. They used a survey-based approach to obtain self-reported non-electric benefits for custom measure initiatives. The study made several improvements over much of the prior survey-based NEI research effort. First, it separated NEIs into mutually exclusive business impacts that might result from the installation of energy efficiency measures. The authors first used closed-ended questions to determine whether respondents experienced changes to any of the business areas. This allowed respondents to distinguish cost and revenue impacts derived from separate business areas such as O&M, material handling, administration, and waste management. The study then used open-ended questions to obtain quantified NEI estimates. The study also focused considerable attention on handling extreme values for NEIs. It was limited to only non-electric impacts for custom measures, and excluded gas measures and prescriptive electric measures.<sup>75</sup> While the TecMarket Works study formed the basis for the 2013 Massachusetts NEI C&I retrofit study, the research resulted in many missing (“don’t know”) responses to the open-ended self-reported valuation questions.

*Wobus Et Al., 2007*<sup>76</sup>

This study was conducted for NYSERDA to contrast NEI estimates for C&I lighting and controls based on two approaches that use self-reports: a) the direct query method, and b) a conjoint analysis research design. (The direct query technique was employed by each of the other studies reviewed in this memo.) It asks respondents to directly state their willingness to pay for NEIs. This approach allows for a broader range of NEIs, as respondents are asked to evaluate each NEI independently of other NEIs. In contrast, the conjoint analysis technique provides respondents with a set of choices regarding lighting technologies with various attributes, including project cost, lighting energy cost, color, lighting controls, bulb life, and light distribution. Respondents were asked to choose among options with differing levels of these attributes. The researchers then used choice modeling to estimate the marginal utility of the various lighting attributes. The conjoint analysis technique is intended to mirror the actual decision-making process of a program participant; however, the approach limits the number of attributes (NEIs) that can be evaluated at one time. NEIs contained in this conjoint analysis were limited to even light distribution, lighting quality, and bulb life. Researchers also indicated that the conjoint analysis approach is difficult to implement for measures other than lighting due to challenges associated with defining a set of choices that contain project attributes that respondents are knowledgeable about and able to evaluate in purchase decisions.

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<sup>74</sup> TecMarket Works. “*Non-Electric Benefits from the Custom Projects Program: A look at the effects of custom projects in Massachusetts*” Prepared for: National Grid. Roth, Johna and Nick Hall. September 25, 2007.

<sup>75</sup> The study included estimates of fuel savings, including gas, oil, and propane from electric measures. Therefore, they called these benefits non-electric benefits rather than non-energy.

<sup>76</sup> Wobus, Nicole, Jennifer Meissner, Brent Barkett, Dr. Don Waldman, Dr. Kenneth Train, Dr. Jennifer Thacher, and Dr. Daniel Violette. “Exploring the Application of Conjoint Analysis for Estimating the Value of Non-Energy Impacts.” Prepared for NYSERDA. Energy Program Evaluation Conference, Chicago. 2007.



Hall and Ross, 2003<sup>77</sup>

This study created the groundwork for TecMarket Work's 2007 study discussed above, as it also relied on self-reports to obtain NEI estimates for a range of C&I initiatives. The focus of this study was impacts received by businesses from Wisconsin's Focus on Energy residential and business initiatives. The research identified and quantified participant NEIs, and excluded utility and societal NEIs. The research was also published as part of the 2003 Focus on Energy Public Benefits Evaluation Report.<sup>78</sup> The study focused on: 1) NEIs received by business partners who implement residential initiatives (i.e., not the residential customers), 2) NEIs received directly from business partners from educational and training programs, and 3) NEIs received by participants in Focus's business programs. Like TecMarket Works (2007), the researchers grouped NEIs into categories that were deemed mutually exclusive. Respondents were asked to report whether they experienced each category of NEI and the direction of those impacts (positive or negative), and then respondents were asked to monetize the reported changes. In addition, participant respondents were asked to report on the importance of these NEIs to overall operations.

### C.2.9 Summary of C&I NEI values

Table 40, Table 41, Table 42, and Table 43 present the range of NEI values for each of the C&I studies reviewed. The tables indicate the technique used to estimate NEIs, the specific NEIs identified, and where possible, the measures to which NEI estimates apply. The NEIs shown in red indicate the NEIs that the PAs' existing NEI research does not capture, and that could be potential opportunities for additional NEI benefits.

- *Health-related NEIs*—The study by Hall and Ross (2003) identified NEIs associated with injury and illness, while Wobus (2007) reported NEIs related to increased safety, noise level, and air quality. These NEIs be captured through an interview-based approach or an avoided-cost approach like that employed by Three3 for residential NEIs. Other impacts listed below that may have health implications are decreased noise and improved air quality.
- *Aesthetics* –There are several NEIs related to increased aesthetics that may not be fully captured by the PAs' existing C&I NEI research. The C&I retrofit NEI study attempted to capture these aesthetic improvements through increased sales and worker production efficiency gains that resulted from improved light quality and better working conditions. However, the New Construction NEI study did not attempt to quantify these changes. Consequently, NEIs associated with new construction measures may understate NEIs. Further, there may be additional value resulting from aesthetic improvements not captured by either C&I study, such as improved grades in educational settings.

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<sup>77</sup> Hall, Nick and Johna Ross. "Non-Energy Benefits from Commercial and Industrial Programs: What are the Benefits and Why are They Important?" Energy Program Evaluation Conference" Seattle, WA. 2003.

<sup>78</sup> PA Government Services, Inc. "Focus on Energy Public Benefits Evaluation: Non-energy Benefits to Implementing Partners from the Wisconsin Focus on Energy Program: Final Report." State of Wisconsin Department of Administration, Division of Energy. Prepared by TecMarket Works. October, 2003.



- *Production efficiency gains*—The C&I retrofit study asked respondents whether they experienced any production efficiency changes due to the installed measures, and reflected impacts such as increased comfort, improved employee morale, and increased operational efficiency. Where possible, these changes were quantified, but they are likely under-reported for process/industrial applications, the very measures on which they are likely to have the greatest impact. This is due to the study design that based NEI estimates on samples of different measure categories or end uses for prescriptive and custom electric and gas measures separately. This resulted in a limited sample size for industrial/process measures and large variance in the value of the NEIs depending upon the process that was impacted. However, interviews with PA and internal DNV GL implementation staff indicate that process improvements are common and can be important factors in determining the BCR of industrial projects. The difficulty in capturing them in studies such as the existing C&I NEI studies is that their values tend to be highly process specific and vary widely. Determining NEIs that reflect process improvements would therefore require a detailed engineering-based approach. With such an approach, statistical significance may not be an appropriate criterion for determining whether the values are indicative of the entire population of measures.
- *Resource-based NEIs*—The C&I retrofit NEI study was unsuccessful in capturing resource-based NEIs, such as fuel and water savings, through the interview process. While respondents were asked about these changes, they were not able to provide the information necessary to quantify them. These questions came at the end of an extensive interview process that asked respondents to provide detailed information to monetize cost and revenue changes. Consequently, respondent fatigue was likely a factor in their inability to estimate water and fuel savings. It is also likely that the appropriate respondent to help monetize NEIs was not also knowledgeable about the energy and water savings. The PAs do claim these resource savings in their BCR models based on other studies, but there may be additional opportunities for the PAs to update these benefits through an engineering based study, or an interview based study focusing primarily on resource savings (to avoid respondent fatigue).
- *Green business value*—Wobus (2008) estimated NEIs for the “sense of doing good.” From the C&I participant’s perspective, this value could be associated with the benefit of a business being perceived as a “green business.” Such benefits should be included in any increased sales that the business may experience due to the installed measures. There are additional impacts associated with the value of “doing a good deed;”; however, such impacts are closely related to societal impacts, which the PAs are not able to claim. We thus do not recommend pursuing these additional impacts.
- *Property value/rent/ease of renting*—A few respondents in the C&I retrofit study reported that they “believed” the installed measures resulted in an increase in their property values. At the time of that study, the evaluation team did not accept these values as real, because no actual transaction took place. However, the C&I retrofit NEI study did request that respondents provide measures of NEIs associated with increased rental income. As with the property values for residential measures, these changes in rent revenue should not be counted, due to the extent to which these changes may result from opportunities to reduce operating costs, increase revenue, or add amenities for multifamily properties.



**Table 40. Summary of NEI Values per Project from Hall and Ross 2003**

Approach	NEI	Measure Specific	Low Value	High Value	Average Value
Interview	Maintenance	No	\$(1,000)	\$20,000	\$2,031
	Employee morale*	No	\$-	\$3,000	\$1,356
	Equipment life	No	\$(1,000)	\$8,000	\$1,357
	Waste generation	No	\$-	\$17,500	\$836
	Production efficiency*	No	\$-	\$20,000	\$3,171
	Non-energy costs	No	\$(333)	\$7,500	\$485
	Sales	No	\$-	\$7,500	\$824
	Personnel Needs	No	\$(1,500)	\$10,000	\$715
	Injury/Illness	No	\$-	\$-	\$-
	Defects/Errors	No	\$(67)	\$25,000	\$1,531

\*Indicates that NEIs are included in the PAs existing research, but the values are incomplete



**Table 41. Summary of NEI Values per Project from Wobus 2008**

Approach	NEI	Measure Specific	Low Value	High Value	Average Value
Survey/ Willingness to Pay	O&M costs	Lighting only	\$-	\$23,000	\$4,800
	Light Quality	Lighting only	\$-	\$16,000	\$2,500
	Comfort	Lighting only	\$-	\$10,000	\$2,500
	Production efficiency	Lighting only	\$-	\$13,000	\$2,500
	Safety	Lighting only	\$-	\$5,000	\$1,500
	Control over equipment	Lighting only	\$-	\$4,000	\$1,000
	Sense of doing good	Lighting only	\$-	\$7,500	\$1,000
	Ease of selling/leasing	Lighting only	\$-	\$6,000	\$800
	Aesthetics	Lighting only	\$-	\$3,000	\$700
	Waste Generation	Lighting only	\$-	\$2,000	\$500
	Power quality	Lighting only	\$-	\$400	\$300
	Noise levels	Lighting only	\$-	\$3,000	\$200
	Indoor air quality	Lighting only	\$-	\$-	\$-
Survey/ Conjoint Analysis	Even light distribution	Lighting only	\$-	\$-	\$2,046
	Lighting quality	Lighting only	\$-	\$-	\$1,121
	Bulb life	Lighting only	\$-	\$-	\$586

**Table 42. Summary of NEI Values per Project from TecMarket Works 2007**

Approach	NEI	Measure Specific	Low Value	High Value	Average Value
Interview	Natural gas used— heating facility	Custom electric total	N/A	N/A	\$36,669
	Natural gas used non- heating	Custom electric total	N/A	N/A	\$10,625
	Fuel or heating oil	Custom electric total	N/A	N/A	\$200
	Water used	Custom electric total	N/A	N/A	\$5,319
	Waste water	Custom electric total	N/A	N/A	\$10,916
	Production or sales levels	Custom electric total	N/A	N/A	\$156,923
	O&M costs	Custom electric total	N/A	N/A	\$4,966
	Administrative or other labor	Custom electric total	N/A	N/A	\$6,136





Approach	NEI	Measure Specific	Low Value	High Value	Average Value
	Cost of supplies, materials and materials handling	Custom electric total	N/A	N/A	\$10,591
	Product spoilage or defects	Custom electric total	N/A	N/A	\$211,875
	Rent received or facility-related revenues	Custom electric total	N/A	N/A	\$40,000
	Transportation or materials movement costs	Custom electric total	N/A	N/A	\$37,680
	Solid waste or other pollution and emissions levels and handling costs	Custom electric total	N/A	N/A	\$12,357
	Insurance, licensing and other fees	Custom electric total	N/A	N/A	\$-
	Any other costs or profits	Custom electric total	N/A	N/A	\$45,300

**Table 43. Summary of NEI Values per Project from Optimal Energy 2008**

Approach	NEI	Measure Specific	Low Value	High Value	Average Value
Engineering Analysis	O&M bulb replacement	Prescriptive Lighting Retrofit	\$.06/Bulb	\$57.00/Bulb	NA
	O&M bulb replacement	Prescriptive Lighting—New Construction	\$6.69/fixture	\$58.44/Bulb	NA
	O&M cost savings	Custom Lighting	NA	NA	\$.009/kWh
	Fossil fuel savings	EMS	NA	NA	\$3.73/kWh
	Fossil fuel savings	Demand Control Ventilation	NA	NA	\$3.73/kWh

## APPENDIX D: FULL BCR SENSITIVITY ANALYSIS

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As referenced in the Framework for Future NEI Research (Section 5), the evaluation team performed a sensitivity analysis based on the BCR models. In this analysis, we modified the benefit values accrued by certain end uses to simulate what would happen in various situations that would cause a decrease in these benefit values (e.g., shifting baselines, decreased realization rates, or decreased net savings). In all the analysis tables below, we highlight initiatives with BCRs of <1 in red, and initiatives with BCRs between 1 and 1.2 in yellow. The tables for lighting end-uses, lighting and HVAC end-uses, and all end-uses were presented in the body of the report. All tables are presented below.



Table 44. Lighting End Use Sensitivity Analysis

BCR Fuel	Core Initiative	BCR with NEIs No Reduction in Energy Savings	BCR with NEIs 10% Reduction in Energy Savings	BCR with NEIs 20% Reduction in Energy Savings	BCR with NEIs 50% Reduction in Energy Savings	BCR with NEIs 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.41	2.39	2.31	2.18	2.26	2.23	2.21	2.13	2.01
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.93	0.89	0.78	0.58	0.80	0.76	0.72	0.60	0.40
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.63	2.57	2.41	2.14	2.29	2.23	2.18	2.02	1.75
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.01	1.98	1.88	1.71	1.57	1.54	1.52	1.43	1.29
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.29	1.23	1.05	0.76	0.93	0.88	0.84	0.69	0.46
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.99	2.91	2.65	2.21	3.08	2.99	2.91	2.65	2.21
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Electric	C2a - C&I Existing Building Retrofit	2.41	2.32	2.23	1.94	1.48	1.86	1.80	1.73	1.53	1.20
Electric	C2b - C&I Small Business	2.14	1.97	1.80	1.28	0.42	1.73	1.59	1.45	1.02	0.32
Electric	C2c - C&I Multifamily Retrofit	1.07	1.00	0.94	0.74	0.42	0.81	0.77	0.72	0.58	0.35
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.52	3.51	2.76	2.76	2.75	2.75	2.74
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.44	2.42	2.00	2.00	1.99	1.98	1.97
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
Gas	C2a - C&I Existing Building Retrofit	4.33	4.33	4.33	4.33	4.33	3.62	3.62	3.62	3.62	3.62
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 45. Compressed Air End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.97	0.97	0.80	0.80	0.80	0.80	0.80
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.68	2.68	2.68	2.68	2.29	2.29	2.29	2.29	2.29
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.05	2.05	2.05	2.05	1.57	1.57	1.57	1.57	1.57
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.35	1.35	1.35	1.35	0.93	0.93	0.93	0.93	0.93
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.07	3.07	3.06	3.03	3.08	3.07	3.07	3.06	3.03
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.06	4.02	3.90	3.69	4.10	4.06	4.02	3.90	3.69
Electric	C2a - C&I Existing Building Retrofit	2.41	2.41	2.40	2.38	2.35	1.86	1.86	1.85	1.84	1.82
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.45	2.45	2.00	2.00	2.00	2.00	2.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
Gas	C2a - C&I Existing Building Retrofit	4.33	4.33	4.33	4.33	4.33	3.62	3.62	3.62	3.62	3.62
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 46. Custom End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.97	0.97	0.80	0.80	0.80	0.80	0.80
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.68	2.68	2.68	2.68	2.29	2.29	2.29	2.29	2.29
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.05	2.05	2.05	2.05	1.57	1.57	1.57	1.57	1.57
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.35	1.35	1.35	1.35	0.93	0.93	0.93	0.93	0.93
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.06	3.05	3.00	2.93	3.08	3.06	3.05	3.00	2.93
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Electric	C2a - C&I Existing Building Retrofit	2.41	2.41	2.41	2.41	2.41	1.86	1.86	1.86	1.86	1.86
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.45	2.45	2.00	2.00	2.00	2.00	2.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.32	6.07	5.32	4.07	6.57	6.32	6.07	5.32	4.07
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.11	5.10	5.06	5.01	5.12	5.11	5.10	5.06	5.01
Gas	C2a - C&I Existing Building Retrofit	4.33	4.26	4.20	4.01	3.70	3.62	3.57	3.52	3.35	3.08
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 47. Envelope End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.94	0.92	0.83	0.68	0.80	0.77	0.74	0.65	0.51
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.56	2.45	2.09	1.50	2.29	2.17	2.05	1.70	1.11
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.02	1.99	1.90	1.75	1.57	1.54	1.51	1.43	1.28
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.33	1.32	1.28	1.22	0.93	0.92	0.90	0.87	0.81
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.98	2.87	2.56	2.05	3.08	2.98	2.87	2.56	2.05
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Electric	C2a - C&I Existing Building Retrofit	2.41	2.41	2.41	2.40	2.38	1.86	1.86	1.86	1.85	1.83
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.49	3.44	3.30	3.07	2.76	2.71	2.67	2.53	2.30
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.48	2.31	1.80	0.94	1.93	1.76	1.59	1.07	0.22
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.33	2.20	1.83	1.21	2.00	1.88	1.75	1.38	0.76
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.77	1.65	1.30	0.70	1.45	1.34	1.23	0.89	0.33
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.23	3.11	2.74	2.14	2.11	2.00	1.89	1.54	0.98
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
Gas	C2a - C&I Existing Building Retrofit	4.33	4.33	4.33	4.33	4.33	3.62	3.62	3.62	3.62	3.62
Gas	C2b - C&I Small Business	5.18	5.13	5.07	4.89	4.60	5.08	5.02	4.96	4.78	4.49
Gas	C2c - C&I Multifamily Retrofit	2.37	2.22	2.08	1.64	0.91	2.07	1.95	1.82	1.43	0.79



**Table 48. Food Service End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.97	0.97	0.80	0.80	0.80	0.80	0.80
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.68	2.68	2.68	2.68	2.29	2.29	2.29	2.29	2.29
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.05	2.05	2.05	2.05	1.57	1.57	1.57	1.57	1.57
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.35	1.35	1.35	1.35	0.93	0.93	0.93	0.93	0.93
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.08	3.08	3.07	3.07	3.08	3.08	3.08	3.07	3.07
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.09	4.09	4.07	4.04	4.10	4.09	4.09	4.07	4.04
Electric	C2a - C&I Existing Building Retrofit	2.41	2.41	2.41	2.41	2.41	1.86	1.86	1.86	1.86	1.86
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.45	2.45	2.00	2.00	2.00	2.00	2.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.07	5.03	4.91	4.71	5.12	5.07	5.03	4.91	4.71
Gas	C2a - C&I Existing Building Retrofit	4.33	4.32	4.31	4.30	4.27	3.62	3.62	3.61	3.59	3.56
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 49. HVAC End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.25	2.07	1.53	0.62	2.26	2.08	1.90	1.35	0.45
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.96	0.94	0.91	0.80	0.79	0.79	0.77	0.74
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.64	2.59	2.46	2.24	2.29	2.24	2.20	2.07	1.84
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.92	0.84	0.63	0.28	0.93	0.86	0.79	0.57	0.22
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	1.96	1.88	1.63	1.22	1.57	1.49	1.41	1.16	0.75
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.32	1.29	1.21	1.07	0.93	0.90	0.88	0.80	0.68
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.00	2.91	2.67	2.26	3.08	3.00	2.91	2.67	2.26
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	3.88	3.67	3.03	1.96	4.10	3.88	3.67	3.03	1.96
Electric	C2a - C&I Existing Building Retrofit	2.41	2.38	2.35	2.25	2.08	1.86	1.83	1.80	1.72	1.58
Electric	C2b - C&I Small Business	2.14	2.14	2.13	2.11	2.07	1.73	1.73	1.72	1.71	1.68
Electric	C2c - C&I Multifamily Retrofit	1.07	1.03	1.00	0.89	0.71	0.81	0.78	0.75	0.66	0.51
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.64	2.63	2.60	2.55	1.93	1.92	1.91	1.88	1.83
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.39	2.32	2.12	1.79	2.00	1.93	1.87	1.67	1.34
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.07	1.91	1.42	0.60	1.96	1.80	1.63	1.14	0.32
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.85	1.82	1.72	1.54	1.45	1.42	1.39	1.29	1.12
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.28	3.22	3.03	2.72	2.11	2.05	2.00	1.82	1.53
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.17	5.78	4.59	2.61	6.57	6.17	5.78	4.59	2.61
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	4.75	4.38	3.27	1.43	5.12	4.75	4.38	3.27	1.43
Gas	C2a - C&I Existing Building Retrofit	4.33	4.06	3.79	2.98	1.63	3.62	3.39	3.15	2.44	1.26
Gas	C2b - C&I Small Business	5.18	4.96	4.73	4.04	2.90	5.08	4.86	4.64	3.99	2.90
Gas	C2c - C&I Multifamily Retrofit	2.37	2.31	2.25	2.07	1.77	2.07	2.02	1.98	1.83	1.59





**Table 50. Hot Water End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.43	2.42	2.40	2.35	2.26	2.25	2.24	2.22	2.18
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.96	0.94	0.80	0.80	0.79	0.78	0.76
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.67	2.67	2.64	2.61	2.29	2.28	2.27	2.25	2.21
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.96	0.94	0.88	0.77	0.93	0.91	0.88	0.82	0.71
Electric	A2b - Residential Consumer Products	1.51	1.50	1.50	1.49	1.47	1.51	1.50	1.50	1.49	1.47
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.05	2.05	2.04	2.04	1.57	1.57	1.57	1.57	1.56
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.35	1.34	1.34	1.33	0.93	0.93	0.93	0.92	0.91
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Electric	C2a - C&I Existing Building Retrofit	2.41	2.41	2.41	2.41	2.41	1.86	1.86	1.86	1.86	1.86
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.06	1.06	1.04	1.00	0.81	0.81	0.80	0.79	0.77
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.52	3.51	3.47	3.40	2.76	2.74	2.73	2.69	2.63
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.64	2.62	2.59	2.53	1.93	1.91	1.90	1.87	1.81
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.44	2.42	2.39	2.00	1.99	1.99	1.97	1.93
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.20	2.17	2.07	1.91	1.96	1.93	1.89	1.80	1.63
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.31	3.26	3.14	2.93	2.11	2.07	2.03	1.92	1.72
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.56	6.55	6.52	6.46	6.57	6.56	6.55	6.52	6.46
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.06	5.00	4.82	4.52	5.12	5.06	5.00	4.82	4.52
Gas	C2a - C&I Existing Building Retrofit	4.33	4.25	4.17	3.94	3.55	3.62	3.58	3.53	3.38	3.14
Gas	C2b - C&I Small Business	5.18	4.95	4.72	4.03	2.87	5.08	4.85	4.61	3.92	2.77
Gas	C2c - C&I Multifamily Retrofit	2.37	2.34	2.31	2.21	2.06	2.07	2.04	2.01	1.92	1.77



**Table 51. Process End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.97	0.97	0.80	0.80	0.80	0.79	0.79
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.68	2.67	2.66	2.63	2.29	2.28	2.28	2.26	2.24
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.36	1.21	0.77	0.04	1.51	1.36	1.21	0.77	0.04
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.04	2.03	2.01	1.96	1.57	1.56	1.56	1.54	1.50
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.34	1.34	1.34	1.32	0.93	0.93	0.92	0.92	0.91
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.07	3.07	3.06	3.04	3.08	3.07	3.07	3.06	3.04
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.04	3.97	3.79	3.47	4.10	4.04	3.97	3.79	3.47
Electric	C2a - C&I Existing Building Retrofit	2.41	2.35	2.29	2.12	1.82	1.86	1.82	1.78	1.66	1.46
Electric	C2b - C&I Small Business	2.14	2.14	2.14	2.14	2.14	1.73	1.73	1.73	1.73	1.73
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.45	2.45	2.00	2.00	2.00	2.00	2.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.08	5.05	4.95	4.79	5.12	5.08	5.05	4.95	4.79
Gas	C2a - C&I Existing Building Retrofit	4.33	4.31	4.29	4.24	4.16	3.62	3.61	3.59	3.54	3.45
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 52. Refrigeration End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.44	2.44	2.44	2.44	2.26	2.26	2.26	2.26	2.26
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.97	0.97	0.97	0.97	0.80	0.80	0.80	0.80	0.80
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.68	2.68	2.68	2.68	2.29	2.29	2.29	2.29	2.29
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.99	0.99	0.99	0.99	0.93	0.93	0.93	0.93	0.93
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	3.23	3.23	3.23	3.23	2.99	2.99	2.99	2.99	2.99
Electric	B1a - Low-Income Single Family Retrofit	2.05	2.03	2.02	1.99	1.92	1.57	1.56	1.55	1.52	1.47
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.34	1.34	1.32	1.29	0.93	0.92	0.92	0.91	0.88
Electric	C1a - C&I New Buildings & Major Renovations	3.08	3.07	3.07	3.06	3.03	3.08	3.07	3.07	3.06	3.03
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	4.05	4.00	3.86	3.62	4.10	4.05	4.00	3.86	3.62
Electric	C2a - C&I Existing Building Retrofit	2.41	2.40	2.39	2.37	2.32	1.86	1.86	1.85	1.83	1.80
Electric	C2b - C&I Small Business	2.14	2.12	2.10	2.02	1.90	1.73	1.71	1.70	1.65	1.56
Electric	C2c - C&I Multifamily Retrofit	1.07	1.07	1.07	1.07	1.07	0.81	0.81	0.81	0.81	0.81
Electric	C2d - C&I Upstream Lighting	3.29	3.29	3.29	3.29	3.29	2.82	2.82	2.82	2.82	2.82
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.53	3.53	2.76	2.76	2.76	2.76	2.76
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.65	2.65	2.65	2.65	1.93	1.93	1.93	1.93	1.93
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.45	2.45	2.45	2.45	2.00	2.00	2.00	2.00	2.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.24	2.24	2.24	2.24	1.96	1.96	1.96	1.96	1.96
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.89	1.89	1.89	1.89	1.45	1.45	1.45	1.45	1.45
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.35	3.35	3.35	3.35	2.11	2.11	2.11	2.11	2.11
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
Gas	C2a - C&I Existing Building Retrofit	4.33	4.33	4.33	4.33	4.33	3.62	3.62	3.62	3.62	3.62
Gas	C2b - C&I Small Business	5.18	5.18	5.18	5.18	5.18	5.08	5.08	5.08	5.08	5.08
Gas	C2c - C&I Multifamily Retrofit	2.37	2.37	2.37	2.37	2.37	2.07	2.07	2.07	2.07	2.07



**Table 53. Lighting and HVAC End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.23	2.02	1.40	0.37	2.26	2.05	1.85	1.23	0.19
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.93	0.88	0.75	0.52	0.80	0.75	0.71	0.57	0.34
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.58	2.49	2.19	1.70	2.29	2.19	2.09	1.80	1.31
Electric	A1e - Residential Behavior/Feedback Program	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.92	0.84	0.63	0.28	0.93	0.86	0.79	0.57	0.22
Electric	A2b - Residential Consumer Products	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	1.93	1.81	1.46	0.88	1.57	1.46	1.35	1.02	0.48
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.26	1.17	0.92	0.48	0.93	0.86	0.78	0.57	0.21
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.91	2.74	2.24	1.40	3.08	2.91	2.74	2.24	1.40
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	3.88	3.67	3.03	1.96	4.10	3.88	3.67	3.03	1.96
Electric	C2a - C&I Existing Building Retrofit	2.41	2.29	2.16	1.78	1.14	1.86	1.77	1.67	1.39	0.91
Electric	C2b - C&I Small Business	2.14	1.96	1.78	1.24	0.34	1.73	1.58	1.44	1.00	0.27
Electric	C2c - C&I Multifamily Retrofit	1.07	0.97	0.87	0.57	0.07	0.81	0.74	0.66	0.43	0.04
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.53	3.53	3.52	3.51	2.76	2.76	2.75	2.75	2.74
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.64	2.63	2.60	2.55	1.93	1.92	1.91	1.88	1.83
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.38	2.31	2.11	1.76	2.00	1.93	1.86	1.65	1.31
Gas	A1e - Residential Behavior/Feedback Program	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.07	1.91	1.42	0.60	1.96	1.80	1.63	1.14	0.32
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.85	1.82	1.72	1.54	1.45	1.42	1.39	1.29	1.12
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.28	3.22	3.03	2.72	2.11	2.05	2.00	1.82	1.53
Gas	C1a - C&I New Buildings & Major Renovations	6.57	6.17	5.78	4.59	2.61	6.57	6.17	5.78	4.59	2.61
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	4.75	4.38	3.27	1.43	5.12	4.75	4.38	3.27	1.43
Gas	C2a - C&I Existing Building Retrofit	4.33	4.06	3.79	2.98	1.63	3.62	3.39	3.15	2.44	1.26
Gas	C2b - C&I Small Business	5.18	4.96	4.73	4.04	2.90	5.08	4.86	4.64	3.99	2.90
Gas	C2c - C&I Multifamily Retrofit	2.37	2.31	2.25	2.07	1.77	2.07	2.02	1.98	1.83	1.59



**Table 54. All End Use Sensitivity Analysis**

BCR Fuel	Core Initiative	BCR with NEIs - No Reduction in Energy Savings	BCR with NEIs - 10% Reduction in Energy Savings	BCR with NEIs - 20% Reduction in Energy Savings	BCR with NEIs - 50% Reduction in Energy Savings	BCR with NEIs - 100% Reduction in Energy Savings	BCR no NEIs - No Reduction in Energy Savings	BCR no NEIs - 10% Reduction in Energy Savings	BCR no NEIs - 20% Reduction in Energy Savings	BCR no NEIs - 50% Reduction in Energy Savings	BCR no NEIs - 100% Reduction in Energy Savings
Electric	A1a - Residential New Construction	2.44	2.21	1.98	1.31	0.18	2.26	2.03	1.81	1.13	0.00
Electric	A1b - Residential Multi-Family Retrofit	0.97	0.89	0.81	0.57	0.18	0.80	0.72	0.64	0.40	0.00
Electric	A1c - Residential Home Energy Services - Measures	2.68	2.45	2.22	1.54	0.39	2.29	2.06	1.83	1.14	0.00
Electric	A1e - Residential Behavior/Feedback Program	2.10	1.89	1.68	1.05	0.00	2.10	1.89	1.68	1.05	0.00
Electric	A2a - Residential Heating & Cooling Equipment	0.99	0.89	0.80	0.52	0.06	0.93	0.84	0.74	0.46	0.00
Electric	A2b - Residential Consumer Products	1.51	1.35	1.20	0.75	0.00	1.51	1.35	1.20	0.75	0.00
Electric	A2c - Residential Lighting	3.23	2.93	2.63	1.74	0.24	2.99	2.70	2.40	1.50	0.00
Electric	B1a - Low-Income Single Family Retrofit	2.05	1.88	1.71	1.20	0.36	1.57	1.41	1.26	0.79	0.00
Electric	B1b - Low-Income Multi-Family Retrofit	1.35	1.24	1.13	0.80	0.25	0.93	0.84	0.74	0.46	0.00
Electric	C1a - C&I New Buildings & Major Renovations	3.08	2.77	2.46	1.54	0.00	3.08	2.77	2.46	1.54	0.00
Electric	C1b - C&I Initial Purchase & End of Useful Life	4.10	3.69	3.28	2.05	0.00	4.10	3.69	3.28	2.05	0.00
Electric	C2a - C&I Existing Building Retrofit	2.41	2.17	1.93	1.21	0.00	1.86	1.68	1.49	0.93	0.00
Electric	C2b - C&I Small Business	2.14	1.93	1.72	1.07	0.00	1.73	1.56	1.38	0.87	0.00
Electric	C2c - C&I Multifamily Retrofit	1.07	0.96	0.85	0.53	0.00	0.81	0.73	0.65	0.41	0.00
Electric	C2d - C&I Upstream Lighting	3.29	2.96	2.63	1.64	0.00	2.82	2.53	2.25	1.41	0.00
Gas	A1a - Residential New Construction	3.53	3.26	2.98	2.16	0.78	2.76	2.48	2.21	1.38	0.00
Gas	A1b - Residential Multi-Family Retrofit	2.65	2.46	2.26	1.69	0.72	1.93	1.73	1.54	0.96	0.00
Gas	A1c - Residential Home Energy Services - Measures	2.45	2.25	2.05	1.45	0.45	2.00	1.80	1.60	1.00	0.00
Gas	A1e - Residential Behavior/Feedback Program	4.44	3.99	3.55	2.22	0.00	4.44	3.99	3.55	2.22	0.00
Gas	A2a - Residential Heating & Cooling Equipment	2.24	2.04	1.84	1.26	0.28	1.96	1.76	1.57	0.98	0.00
Gas	B1a - Low-Income Single Family Retrofit	1.89	1.74	1.58	1.12	0.36	1.45	1.31	1.16	0.73	0.00
Gas	B1b - Low-Income Multi-Family Retrofit	3.35	3.12	2.90	2.22	1.10	2.11	1.90	1.69	1.06	0.00
Gas	C1a - C&I New Buildings & Major Renovations	6.57	5.91	5.26	3.29	0.00	6.57	5.91	5.26	3.29	0.00
Gas	C1b - C&I Initial Purchase & End of Useful Life	5.12	4.60	4.09	2.56	0.00	5.12	4.60	4.09	2.56	0.00
Gas	C2a - C&I Existing Building Retrofit	4.33	3.89	3.46	2.16	0.00	3.62	3.26	2.90	1.81	0.00
Gas	C2b - C&I Small Business	5.18	4.67	4.15	2.59	0.00	5.08	4.57	4.06	2.54	0.00
Gas	C2c - C&I Multifamily Retrofit	2.37	2.13	1.89	1.18	0.00	2.07	1.87	1.66	1.04	0.00