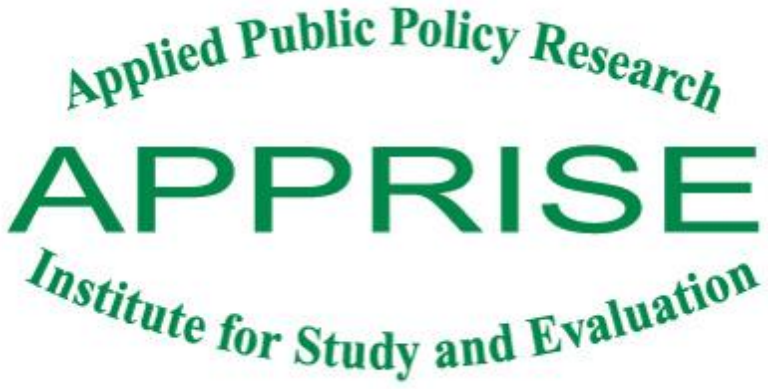


# Low-Income Energy Efficiency Non-Energy Impacts

## Final Report

**September 2021**

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# Executive Summary

A Northeastern electric and gas utility low-income energy efficiency program provides services and energy education to help customers reduce their energy usage and increase the affordability of their energy bills. While the program helps participants reduce their energy usage and their energy costs, energy efficiency programs have also been shown to have additional benefits for participants, including improved comfort, health, and safety. These additional benefits are known as Non-Energy Impacts (NEIs). The purpose of this report is to analyze various methods for estimating and monetizing the program's NEIs, and to recommend values for these benefits.

The goals of the NEI analysis were as follows.

- Apply several methodologies to measure the value of the NEIs, with information derived from participant surveys, program data, and billing data.
- Compare the values that result from the various NEI estimation methods.
- Develop a best estimate of the program's NEI values using all available information.

The NEI literature extends back for a few decades, but there are many challenges with the research. While there are hundreds of reports that cover NEIs from energy efficiency programs, many are dated and most do not calculate benefits that are specific to the program and jurisdiction studied. Many references are only literature reviews, and even those that do quantify the benefits usually utilize estimates that were previously calculated in prior research. Most that reference previous research do not provide an assessment of the accuracy of the estimates or the suitability for the population being studied. Even more challenging, papers point to previous studies (and those point to previous analyses) that do not provide adequate documentation of the research methodology used to estimate the NEIs.

This study aims to overcome several of these issues with the following approach.

- A survey conducted with participants in the program that is being studied.
- Rigorous sample design, implementation, weighting, and analysis.
- High survey response rates.
- Transparency regarding methods, potential issues, and limitations.

This study focused on the NEIs that accrue to the program's participants. It does not assess societal NEIs such as economic, environmental, and infrastructure impacts, and it does not assess utility NEIs such as reductions in arrearage carrying costs and collections expenses.

## *Usage Impacts*

Many NEIs are related to the usage reduction impacts and some NEI valuation methods compare NEI value to energy cost reductions. Therefore, it is important to understand the actual program impacts on energy usage and on energy cost when assessing NEI valuations. This study included an analysis of the impact of the program on electric and natural gas usage for 2019 participants.

Usage data were weather normalized in the pre- and post-usage period to ensure that changes in energy usage were not due to changes in weather. The key findings from this analysis are summarized below.

- Baseload jobs in the full analysis group had average net savings of 817 kWh, or 7.9 percent of pre-treatment usage, after adjusting for a later participant comparison group.
- Electric heating jobs in the full analysis group had average net savings of 1,449 kWh, or 7.7 percent of pre-treatment usage.
- Gas heating jobs in the full analysis group had average net savings of 43 ccf, or 4.2 percent of pre-treatment usage.
- Net savings for the electric baseload group were much higher among survey respondents than among the full analysis group. Among electric heating jobs and gas heating jobs, net savings for survey respondents were comparable to net savings for the full treatment group.

## *Bill Analysis*

Billing data were analyzed for the year prior to the audit visit and for the year after service delivery was completed. The key findings from this analysis are summarized below.

- Among all electric baseload participants, total charges declined by $63, or 6.4 percent of pre-treatment charges, following the program services. Among electric baseload participants who responded to the survey, the decline in charges was higher, at 9.3 percent of pre-treatment charges.
- Among participants with air sealing and/or insulation measures but no HVAC measures, total charges declined by $33, or 2.1 percent of pre-treatment charges. Survey respondents in the air sealing and/or insulation with no HVAC measures group saw a similar decline of 1.7 percent.
- Among participants with HVAC measures, total charges declined by $32, or 2.2 percent of pre-treatment charges, following the program services. However, survey respondents in the HVAC group saw an increase in their energy charges of $61, or 7.1 percent of pre-treatment charges.

## *NEI Analysis*

Non-Energy Impacts were estimated based on responses from a survey of program participants. Three different approaches were used to produce estimates.

- Contingent Valuation (CV): Respondents reported a dollar value of the benefit.
- Direct Scaling (DS): Respondents reported a value for the benefit as a percent of the energy savings they experienced.
- Labeled Magnitude Scaling (LMS): Respondents valued the benefit as more or less valuable than the energy savings they experienced. These responses were then converted to a numeric multiplier.

Participant Survey

APPRISE conducted surveys with 258 2019 program participants. The survey questions addressed participants' perceived energy savings, NEI valuations, and relative valuations of the NEIs compared to energy savings.

The survey utilized a mixed mode phone/web approach. The cooperation rate, the completion rate for participants who were contacted and who were eligible for the survey, was 87 percent. The response rate was 60 percent.

The following specific sequence of questions was asked for each NEI to provide data for the NEI value calculations.

- "Have you noticed a change in your home comfort in the winter since the energy efficiency work? Is your home now much more comfortable, somewhat more comfortable, no change, somewhat less comfortable, or much less comfortable?" (If no change, none of the other questions were asked.)
- "Think about the positive or negative value you experienced from this change in winter comfort — would you say it is more value, less value, or the same value to you as any possible energy savings you may have received from the program?"
- "Could you put a positive or negative dollar value on the change in winter comfort?"
- "What is that dollar value from the change in winter comfort?"
- "How does the dollar value from the change in winter comfort compare to the energy savings — 10% of energy savings, 20%, 30%, etc.?"

There was considerable variation in the percent of respondents who provided data for each question as opposed to answering "Don't Know". Therefore, weights were developed for each individual survey question based on the data available for that question, and the applicable set of weights differed based on the valuation method and the NEI.

NEI Estimates

We estimated NEI values for winter comfort, summer comfort, health, safety, and noise for baseload only, air sealing and insulation, and HVAC measure participants using variations of the CV, DS, and LMS methods. We present a total of seven estimates for each NEI and measure combination, as we included different bill savings estimates and different LMS multipliers.

Our recommended method is the LMS with participant reported bill savings and in-sample multipliers. This method utilizes participant responses for estimated bill savings, NEI values compared to bill savings, and a qualitative comparison of the value of the NEI to the bill savings. The participant's estimate of bill savings is preferred because the respondent is valuing the NEI relative to their perceived bill savings. The in-sample multiplier is preferred because it is derived from the participant's program experience. These estimates were in middle or on the lower end of the methods and provide what we believe is a justifiable value for most of the NEIs.

The total mean annual value of the five estimated NEIs was $196 for baseload only participants, $228 for air sealing and insulation participants, and $386 for HVAC participants.

**Mean Annual NEI Values for Selected NEI Estimation Method**
**LMS with Reported Bill Savings and In-Sample Multipliers**

| Measure Group | Non-Energy Impact | | | | | Total NEI |
|---|---|---|---|---|---|---|
| | Winter Comfort | Summer Comfort | Safety | Health | Noise | |
| Electric Baseload | $72 | $40 | $34 | $11 | $39 | $196 |
| Air Sealing and Insulation | $72 | $58 | $36 | $28 | $34 | $228 |
| HVAC | $74 | $88 | $82 | $97 | $45 | $386 |
| **All Participants** | **$72** | **$48** | **$41** | **$24** | **$39** | **$224** |

## *Recommendations*

The study found that the different NEI estimation methods sometimes resulted in very different NEI values. The differences were based upon asking participants to report a dollar value for the NEI benefit compared to asking them to value it in relation to their bill savings.

Various levels of NEI impacts are expected based on the specific measures installed. The estimated value orderings from this study often did not match expectations for relative valuations. However, for our preferred method, LMS method using reported bill savings and in-sample multipliers, the estimates were moderately in-line with expectation.

Based on these findings, we make the following recommendations for future NEI research.

- Cognitive Interviewing: Conduct in-depth interviews with program participants to assess how they perceive questions, how they think about NEIs, and how researchers can best report their experiences.
- Direct Scaling Responses: Consider allowing responses greater than 100 percent for the value of the NEI relative to bill savings.
- LMS Categories: Include a greater number of categories instead of just more valuable than energy savings, the same value as energy savings, and less value than energy savings.

Additional research is needed with program participants to understand how best to value participant NEIs.

# I. Introduction

A Northeastern electric and gas utility low-income energy efficiency program provides energy efficiency services and energy education to low-income households to help them reduce their energy usage and increase the affordability of their energy bills. While the program helps participants to reduce their energy usage and their energy costs, energy efficiency programs have also been shown to have additional benefits for participants, including improved comfort, health, and safety. These additional benefits are known as Non-Energy Impacts (NEIs). The purpose of this report is to analyze various methods for estimating and monetizing the program's NEIs, and to recommend values for these benefits.

## *A. Research Goals*

There were several goals for this research.

- Apply several methodologies to measure the value of the program's NEIs, through information derived from participant surveys, program data, and billing data.
- Compare the values that result from the various NEI estimation methods.
- Develop a best estimate of the program's NEI values using all available information.

## *B. Information Sources*

This study used several different data sources to develop the NEI estimates.

- Program Data: We analyzed program data to develop a sample frame and select a stratified sample of 2019 program participants for the NEI survey.

- Participant Survey: We conducted a mixed mode web/telephone survey with participants to collect information on perceptions of energy savings and the NEIs.

- Energy Usage: We analyzed energy usage data to estimate the change in electric and natural gas consumption that resulted from participation in the program.

- Energy Bills: We analyzed energy bills to estimate the change in energy costs that resulted from participation in the program.

## *C. NEI Estimation Literature*

The NEI literature extends back for a few decades, but there are many challenges with the research. While there are hundreds of reports that cover NEIs from energy efficiency programs, many are dated and most do not calculate benefits that are specific to the program and jurisdiction studied. Many references are only literature reviews, and even those that do quantify the benefits usually utilize estimates that were previously calculated in prior research. Most that reference previous research do not provide an assessment of the accuracy of the estimates or the suitability for the population studied. Even more challenging, papers point to previous studies (and those point to previous analyses) that do not provide adequate documentation of the research methodology used to estimate the NEIs.

Key weaknesses in the literature include the following.

- No information on how the benefits were calculated.
- Use of energy savings to calculate bill savings with no information on how the energy savings were calculated.
- Input sources that are not clearly documented.
- Input values from 20 or more years ago that are not valid for current conditions.
- Inclusion of benefits that were not found to be statistically significant.
- Exclusion of comparison groups even when specifically designed for the study.
- Estimated bill savings that ranged to unrealistic levels.
- Survey-estimated benefits that were based on sample sizes that could not provide statistically significant results.
- Use of surveys with very low response rates.
- Attribution factors based on "professional judgement".
- Double counting of benefits.
- No discounting of benefits when using a 15-year measure lifetime.

This study aims to overcome several of these issues with the following approach.

- A survey conducted with participants in the program that is being studied.
- Rigorous sample design, implementation, weighting, and analysis.
- High survey response rates.
- Transparency regarding methods, potential issues, and limitations.

This study focused on the NEIs that accrue to program participants. It does not assess societal NEIs such as economic, environmental, and infrastructural impacts, and it does not assess utility NEIs such as reductions in arrearage carrying costs and collections expenses

There are two methods that have typically been used to assess participant NEIs: direct estimation of NEIs through data on the specific impact, and surveys that ask the participants to value the impacts. An example of direct estimation is obtaining data on the reduction in medical costs that results from replacing the heating system in the home. While this approach has the potential to provide the most rigorous estimates, it fails to do so in practice because relevant data from the studied or similar program are not available, data from very different programs are used instead, sample sizes are very small, and results are often not statistically significant. Asking participants to value the health benefit is another method that has clear issues, as it is difficult or impossible for an individual to provide such valuation. However, given the challenges with the direct estimation approach, this study uses the participant survey valuation method to provide valuations for several key participant NEIs.

## *D. NEI Estimation Approach*

The present report takes the survey-based approach to estimate participant NEIs. There are significant challenges with this type of research.

- Respondents sometimes provide a series of survey responses that are internally inconsistent. For example, a respondent may state that the improvement in noise level is

worth the same amount as the energy bill reduction yet report much different dollar values for the bill reduction and the valuation of the change in noise level.

- The value of some NEIs may be difficult for the respondent to accurately assess. For example, health and safety impacts may derive primarily from changes in risk for rare events (such as carbon monoxide poisoning), which are difficult both to evaluate and to value.
- Respondents often have difficulty assigning specific quantitative values to non-market goods.
- Respondents may attempt to please the interviewer or show appreciation for the program, leading to inflated NEI values. Alternatively, dissatisfied respondents may give "protest" responses (extreme negative values).
- Responses may be highly sensitive to the design of the survey; for example, the number of NEIs asked about, the order of questions, the wording of questions, and the timing of the survey (season/weekday/time of day).

Despite these limitations, this report attempts to use the survey method to provide the best possible estimate of NEI value for winter comfort, summer comfort, health, safety, and noise NEIs.

## *E. Organization of the Report*

Four sections follow this introduction.

1) *Section II — Usage Impacts:* This section provides an analysis of the impacts of the program on energy usage by analyzing the pre- and post-treatment energy usage.

2) *Section III — Bill Analysis:* This section provides an analysis of the impacts of the program on energy costs by analyzing the pre- and post-treatment energy bills.

3) *Section IV — NEI Analysis:* This section discusses the survey methodology and provides estimates of the monetary value of NEIs achieved through the program.

4) *Section V — Findings and Recommendations*: This section provides a summary of key findings and recommendations with respect to NEIs.

Any errors or omissions in this report are the responsibility of APPRISE. Further, the statements, findings, conclusions, and recommendations are solely those of analysts from APPRISE.

# II. Usage Impacts

This section of the report provides an analysis of the impact of the program on participants' annual electric and gas usage. The section describes the methodology for the analysis and the results for all participants by job type.

## *A. Methodology*

Customers who received program services in 2019 were treated as the analysis group. We focused on the electric impacts for electric baseload and electric heating jobs, and the gas impacts for gas heating jobs.

Energy usage was analyzed for the year prior to the audit visit and the year after service delivery was completed. The analysis included as close to a full year of pre- and post-treatment data as possible. Table II-1 displays the attrition statistics for the treatment group, as well as for the comparison group of 2020 participants. Customers were included in the analysis if their pre- and post-usage data each spanned between 270 and 390 days. Customers were removed from the analysis if their usage was below 1,200 kWh or 300 ccf, or if their change in usage was greater than 65 percent. After these eliminations, we included 52 to 82 percent of the treatment group and 74 to 92 percent of the comparison group.

**Table II-1**
**Usage Impact Data Attrition**

| | Treatment Group | | | Comparison Group | | |
|---|---|---|---|---|---|---|
| | **Electric Baseload** | **Electric Heating** | **Gas Heating** | **Electric Baseload** | **Electric Heating** | **Gas Heating** |
| Original Population* | 5,820 | 627 | 1,347 | 2,283 | 227 | 71 |
| Not Enough Pre-Treatment Days | 789 | 207 | 536 | 285 | 40 | 2 |
| Not Enough Post-Treatment Days | 140 | 28 | 49 | 46 | 3 | 3 |
| All Estimated Reads in Pre or Post | 1 | 0 | 2 | 0 | 0 | 0 |
| Pre-Usage Below 1200 kWh or 300 ccf | 1 | 0 | 21 | 0 | 0 | 0 |
| Post-Usage Below 1200 kWh or 300 ccf | 0 | 0 | 14 | 0 | 0 | 0 |
| Change in Total Usage>65% | 110 | 9 | 25 | 48 | 7 | 1 |
| Additional Outliers | 6 | 5 | 2 | 47 | 10 | 0 |
| Final Sample | 4,773 | 378 | 698 | 1,857 | 167 | 65 |
| **% Included in Analysis** | **82%** | **60%** | **52%** | **81%** | **74%** | **92%** |

Energy usage data were weather normalized in the pre- and the post-treatment period to ensure that changes in energy usage were due to changes in usage patterns, rather than due to changes in weather. We used a Degree Day normalization process to conduct this analysis. This process involved the following steps.

1. Calculate the heating and cooling degree-days that are included in each usage period.

2. Determine whether periods should be classified as baseload periods, heating periods, or cooling periods, based on the number of usage and heating and cooling degree-days in the period.
3. Calculate the total baseload period usage, heating period usage, and cooling period usage.
4. Calculate the relationship between heating usage minus baseload usage and degree- days. Use that slope and the average long-term heating degree-days to calculate normalized heating period usage.
5. Follow the same method to calculate normalized cooling period usage.
6. Add up the baseload usage, heating period usage, and cooling period usage to obtain the normalized annual usage.

## *B. Energy Savings Impacts*

This section provides the average weather-normalized usage for the pre- and post-treatment periods and the average energy savings.

Table II-2 uses the comparison group of later program participants to control for the impact of COVID-19 and other factors exogenous to the program that may have impacted usage. The gross savings for the treatment group were highest for electric baseload customers, 6.2 percent of pre-treatment usage, and for gas heating customers' electric usage, 5.9 percent of pre-treatment usage. After adjusting for the comparison group, the electric baseload and electric heating net savings were greater than the gross savings because customers who were not treated by the program had an increase in their electric usage. The net savings were 7.9 percent of pre-treatment usage for electric baseload participants, 7.7 percent of pre-treatment usage for electric heating participants, and 4.2 percent of pre-treatment usage for gas heating participants.

**Table II-2**
**Average Annual Usage and Savings**
**With Comparison Group**

| | Treatment Group Savings | | | | | Comparison Group Savings | | | | | Net Savings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | Usage | | Annual Savings | | # | Usage | | Annual Savings | | | |
| | | Pre | Post | kWh/ccf | % | | Pre | Post | kWh/ccf | % | kWh/ccf | % |
| Elec BL (kWh) | 4,773 | 10,399 | 9,760 | 640*** | 6.2% | 1,857 | 11,148 | 11,325 | -177*** | -1.6% | 817*** | 7.9% |
| Elec Heat (kWh) | 378 | 18,909 | 17,928 | 981*** | 5.2% | 167 | 19,452 | 19,920 | -468* | -2.4% | 1,449*** | 7.7% |
| Gas Heat (ccf) | 698 | 1,025 | 975 | 51*** | 4.9% | 65 | 1,368 | 1,361 | 7 | 0.5% | 43** | 4.2% |
| Gas Heat (kWh) | 666 | 8,630 | 8,124 | 506*** | 5.9% | 62 | 9,162 | 9,031 | 131 | 1.4% | 375 | 4.3% |

***Denotes significance at the 99 percent level. **Denotes significance at the 95 percent level. *Denotes significance at the 90 percent level.

Table II-3 displays Degree Day normalized savings for program participants who responded to the survey. Each group had only a small number of observations. The electric baseload group with refrigerator installation had net savings of 15.4 percent of pre-treatment usage, the electric heating participants with HVAC measures had mean savings of 11.8 percent, and the electric baseload group with no major measures had mean savings of 11.5 percent.

**Table II-3**
**Average Annual Usage and Savings**
**Survey Respondents**

| | # | Treatment Group Savings | | | | # | Comparison Group Savings | | | | Net Savings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Usage | | Annual Savings | | | Usage | | Annual Savings | | | |
| | | Pre | Post | kWh/ccf | % | | Pre | Post | kWh/ccf | % | kWh/ccf | % |
| **Electric Baseload (kWh)** | | | | | | | | | | | | |
| No Major Measures | 36 | 10,407 | 9,392 | 1,015** | 9.7% | 1,857 | 11,148 | 11,325 | -177 | -1.6% | 1,192*** | 11.5% |
| With Refrigerator | 25 | 10,909 | 9,405 | 1,504*** | 13.8% | | | | | | 1,681*** | 15.4% |
| **Electric Heating (kWh)** | | | | | | | | | | | | |
| w/ Air Sealing/Insulation, no HVAC | 13 | 17,517 | 16,955 | 562 | 3.2% | 167 | 19,452 | 19,920 | -468 | -2.4% | 1,030 | 5.9% |
| With HVAC Measures | 13 | 16,981 | 15,444 | 1,537 | 9.1% | | | | | | 2,006** | 11.8% |
| **Gas Heating (ccf)** | | | | | | | | | | | | |
| w/ Air Sealing/Insulation, no HVAC | 29 | 904 | 841 | 63** | 7.0% | 65 | 1,368 | 1,361 | 7 | 0.5% | 56* | 6.2% |
| With HVAC Measures | 19 | 942 | 898 | 45 | 4.7% | | | | | | 37 | 3.9% |

***Denotes significance at the 99 percent level. **Denotes significance at the 95 percent level. *Denotes significance at the 90 percent level.

## C. Summary

We conducted an analysis of the impact of energy efficiency services on participants' annual electric and natural gas usage. The key findings from this analysis are summarized below.

- Baseload jobs had average net savings of 817 kWh, or 7.9 percent of pre-treatment usage, after adjusting for a later participant comparison group.
- Electric heating jobs had average net savings of 1,449 kWh, or 7.7 percent of pre-treatment usage.
- Gas heating jobs had average net savings of 43 ccf, or 4.2 percent of pre-treatment usage.
- Net savings for the electric baseload group were much higher among survey respondents than among the full treatment group. Among electric heating jobs and gas heating jobs, net savings for survey respondents were comparable to net savings for the full treatment group.

# III. Bill Analysis

This section examines the bill and payment impacts for the 2019 program participants. We review the methodology used in the analysis, and then analyze the billing and payment impacts.

## *A. Methodology*

Billing data in the pre- and post-treatment periods were analyzed. Accounts were required to have between 300 and 390 days of transactions data in both the pre and post periods to be included in the analysis.

Table III-1 displays the attrition statistics. Sufficient data were available for between 42 and 78 percent of program participants. The percentage was lower for the heating participants as many of these customers did not have sufficient data prior to the program treatments. Comparison group data were not available for the billing analysis.

**Table III-1**
**Billing Impact Data Attrition**

| | Electric Baseload | Electric Heating | Gas Heating |
|---|---|---|---|
| Original Population | 5,819 | 626 | 1,347 |
| Not Enough Pre-Treatment Days | 1,048 | 302 | 729 |
| Not Enough Post-Treatment Days | 157 | 23 | 44 |
| Data Outliers | 83 | 12 | 7 |
| Final Sample | 4,531 | 289 | 567 |
| % Included in Analysis | 78% | 46% | 42% |

## *B. Billing Impacts*

Table III-2 displays the change in total charges based on analysis of the billing data. Total charges declined by $63, or 6.4 percent, for electric baseload jobs overall, and by 9.3 percent for electric baseload survey respondents. Program participants with air sealing and/or insulation but no HVAC measures had a 2.1 percent reduction, and the survey respondents in that category had a 1.7 percent reduction. Program participants with HVAC measures had a 2.2 percent reduction in their energy bill, though survey respondents, a small subsample of the group, had a seven percent increase in their charges.

**Table III-2**
**Total Charges By Job Type**

| | Analysis Group | | | | | Survey Respondents | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | # | Pre | Post | Change | Percent Change | # | Pre | Post | Change | Percent Change |
| Electric Baseload | 4,903 | $981 | $918 | -$63*** | -6.4% | 54 | $787 | $714 | -$73 | -9.3% |
| Air Sealing and/or Insulation, no HVAC | 135 | $1,550 | $1,516 | -$33 | -2.1% | 31 | $1,611 | $1,585 | -$27 | -1.7% |
| With HVAC Measures | 350 | $1,444 | $1,412 | -$32 | -2.2% | 23 | $1,627 | $1,741 | $114 | 7.0% |
| **All Job Types** | **5,388** | **$1,025** | **$965** | **-$60*** ** | **-5.9%** | **108** | **$862** | **$800** | **-$61** | **-7.1%** |

***Denotes significance at the 99 percent level. **Denotes significance at the 95 percent level. *Denotes significance at the 90 percent level.

## C. Summary

We conducted an analysis of the impact of program services on participants' energy charges. The key findings from this analysis are summarized below.

- Among all electric baseload participants, total charges declined by $63, or 6.4 percent of pre-treatment charges, following the program services. Among electric baseload participants who responded to the survey, the decline in charges was higher, at 9.3 percent of pre-treatment charges.
- Among participants with air sealing and/or insulation measures but no HVAC measures, total charges declined by $33, or 2.1 percent of pre-treatment charges. Survey respondents in the air sealing and/or insulation with no HVAC group saw a similar decline of 1.7 percent.
- Among participants with HVAC measures, total charges declined by $32, or 2.2 percent of pre-treatment charges, following the program services. However, survey respondents in the HVAC group saw an increase in their energy charges of $61, or 7.1 percent of pre-treatment charges.

# IV. NEI Analysis

This section discusses the NEI survey conducted as part of this study, several approaches for valuing Non-Energy Impacts (NEIs) from the program, and the estimates derived from these approaches.

## *A. Survey Methodology*

APPRISE conducted surveys with 258 2019 program participants. The survey questions addressed participants' perceived energy savings, NEI valuations, and relative valuations of the NEIs compared to energy savings. The ten-minute web/telephone surveys were conducted between January 20, 2021 and March 8, 2021.

The survey utilized a mixed mode phone/web approach, though 95 percent of surveys were completed by phone. We mailed advance letters to all potential respondents, and these letters included a toll-free number and the website for the online survey.

A sample of 568 participants was selected from the 6,743 program participants with data. A valid telephone number was required to be included in the sample. Participants were separated into groups based on job type and installed measures. Table IV-1 displays the distribution of participants in the sample frame, selected sample, and those who completed a survey.

**Table IV-1**
**Distribution of Selected Sample and Completed Surveys**

| | Sample Frame | | Selected Sample | | Completed Surveys | |
|---|---|---|---|---|---|---|
| **Job Type** | **#** | **%** | **#** | **%** | **#** | **%** |
| Electric Baseload, No Major Measures | 3,684 | 70.1% | 100 | 17.6% | 41 | 15.9% |
| Electric Baseload with Refrigerator | 539 | 10.3% | 100 | 17.6% | 44 | 17.1% |
| Electric Heating with Air Sealing or Insulation, No HVAC Measures | 68 | 1.3% | 68 | 12.0% | 31 | 12.0% |
| Electric Heating with HVAC Measures | 260 | 4.9% | 100 | 17.6% | 46 | 17.8% |
| Gas Heating with Air Sealing or Insulation, No HVAC Measures | 236 | 4.5% | 100 | 17.6% | 52 | 20.2% |
| Gas Heating with HVAC Measures | 471 | 9.0% | 100 | 17.6% | 44 | 17.1% |
| **Total** | **5,258** | **100%** | **568** | **100%** | **258** | **100%** |

Table IV-2 furnishes information on the survey response. The most common non-interview reasons were that there was no response from the participant, or the phone number on file for the customer was not a working number. The cooperation rate, the completion rate for participants who were contacted and who were eligible for the survey, was 87 percent. The response rate was 60 percent.

**Table IV-2**
**Survey Response**

| Survey Response Status | All Participants | |
|---|---|---|
| | # | % |
| **Total Selected** | **568** | **100%** |
| Voicemail / No Answer | 130 | 23% |
| Wrong/Non-Working Number | 96 | 17% |
| Refusal | 36 | 6% |
| Language Barrier | 21 | 4% |
| Not Eligible | 13 | 2% |
| Deceased / Physically Unable | 12 | 2% |
| Partial Complete | 1 | <1% |
| Not Available for Duration of Survey | 1 | <1% |
| **Complete** | **258** | **45%** |
| Cooperation Rate | - | 87% |
| Response Rate | - | 60% |

Because the distribution of participants who completed the survey differed from the sample frame, we developed weights to represent the program participants.

Generally, weights are used at the survey respondent level. However, there was considerable variation in the percent of respondents who provided data for each question as opposed to answering "Don't Know". Therefore, weights were developed for each individual valuation method and the NEI. For example, the mean summer comfort valuation using the CV method used a different set of weights than the mean winter comfort valuation using the CV method.

For the sake of comparison, we also computed the weighted means using a simpler weighting scheme with the same set of weights for all survey questions. Those figures are not reported in the tables below, but the overall means were similar between the two weighting schemes.

## *B. Non-Energy Impact Valuation Methodologies*

Surveys are often used to value the participant NEIs that are difficult to measure directly. While participant response may be the best possible method to value the NEIs, it has inherent limitations due to the difficulty of precisely valuing these benefits.[1]

We used three different methods to value the NEIs.

- Contingent Valuation: We asked respondents to estimate the dollar value of each benefit.

[1] Pigg, Scott, Maddie Koolbeck, Leith Nye, Shannon Stendel, Melanie Lord, and Hayley McLeod. 2021. "Addressing Non-Energy Impacts of Weatherization", ORNL/SPR-2020/1840, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

- Direct Scaling: We asked respondents to value each benefit as a percent of the energy savings they experienced from the program.
- Labeled Magnitude Scaling: We asked respondents to value each benefit as more or less valuable than the energy savings from the program.

**Contingent Valuation**

The Contingent Valuation (CV) method asks participants to estimate the value of each impact they experienced in dollar terms. In the NEI survey, respondents were asked to provide a positive or negative dollar value that represented how valuable the NEI was to them. To obtain the respondent's estimated value for the safety NEI, for example, we asked the following questions.

- "Could you put a positive or negative dollar value on the change in safety?"
- (If yes) "What is that dollar value from the change in safety?"

This method is useful because it provides a specific dollar value for each benefit and the values can be easily compared between NEIs.[2] However, there is evidence in the literature that this approach leads to inflated values compared to the values obtained by scaling methods where the respondent is asked to compare the impact to a known dollar value.[3] The CV method also suffers from known inconsistencies wherein valuations differ significantly based on the context and what questions are asked.[4] The most important of these is referred to as the "scope" problem, where contingent valuations fail to scale reasonably with the quantity of a good. An illustrative example is as follows: a respondent is asked about their willingness to pay to clean up one lake, and then asked about their willingness to pay to clean up five lakes, including the one asked about individually, and the respondent offers nearly identical dollar values to the two questions.[5]

The maximum and minimum values for the NEI survey responses were extreme outliers, so for each NEI we removed the top and bottom two percent of responses, similar to methods used in the literature.[6] High end values that were excluded from the analysis ranged from $10,000 to three million dollars. Low end values that were excluded ranged from negative $2,500 to zero dollars. After excluding these values for each NEI, we computed the weighted average dollar value.

A key limitation of CV is that it is difficult for respondents to assign a dollar value to these impacts. Asking respondents to put a dollar value on NEIs may seem too hypothetical or

[2] Skumatz, Lisa. 2014. "Non-Energy Benefits/Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Tests: State of Maryland", prepared for Natural Resources Defense Council (NRDC), Superior, CO.
[3] Horowitz, J. and K. McConnell. 2003. "Willingness to Accept, Willingness to Pay and the Income Effect." *Journal of Economic Behavior and Organization* 51: 537-545.
[4] Hausman, J. 2012. "Contingent Valuation: From Dubious to Hopeless." *Journal of Economic Perspectives* 26 (4): 43-56.
[5] Diamond, P. A., & Hausman, J. A. (1994). Contingent valuation: is some number better than no number?. *Journal of economic perspectives*, 8(4), 45-64.
[6] Skumatz, Lisa. 2002. "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEI) Computations of Participant Value." Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, Washington, DC.

arbitrary, and respondents might not consider the true value of the impact.[7] In this survey, an average of 17 percent of participants provided non-zero values for the various NEIs. Many respondents said they experienced no change in the NEI's studied, so the value was assigned to be $0.

**Direct Scaling**

The Direct Scaling (DS) method asks respondents to report the value of the NEI as a percentage of energy savings. A review of the literature shows that this approach often yields more consistent responses than the CV method, where consistency is assessed by comparing DS results against other valuation methods and other studies.[8] In some instances, researchers preferred the DS method to Labeled Magnitude Scaling because DS does not require the translation of qualitative data to quantitative data.[9]

However, participants are sometimes confused by the questions used in the DS method. For example, the survey asked, "How does the dollar value from the change in winter comfort compare to the energy savings — ten percent of energy savings, 20 percent, 30 percent, etc.?", with response options ranging from zero to 100 percent.

In the literature, surveys using this method typically allowed respondents to provide a percent over 100 where the NEI was of greater value than the energy savings,[10] but this survey confined responses to 100 percent or less. While our approach differs from the literature, we felt that restricting the valuation to a maximum value equal to that of the energy savings may result in more reasonable NEI estimates.

Because this method only collects a valuation in comparison to energy savings, it is necessary to also develop an estimate of energy savings. Two different bill savings values were used in this analysis. The first value was derived from the following survey question.

- "What would you estimate the change in your annual utility bill was compared to the year before you received the program services?"

The second value was developed from an analysis of the change in actual energy bills from the year prior to the treatment to the year following the treatment, as shown in the previous section of this report. While 67 percent of respondents reported a dollar value for the change in their annual utility bill, 42 percent of survey respondents had an estimate from the billing analysis (the others did not have sufficient data to be included in the analysis).

[7] Skumatz, Lisa and John Gardner. 2006. "Differences in the Valuation of Non-Energy Benefits According to Measurement Methodology: Causes and Consequences." Proceedings of the Association for Energy Service Professionals NESP Conference San Diego, CA, AESP, Clearwater FL.

[8] Amann, Jennifer. 2006. "Valuation of Non-Energy Benefits to Determine Cost-Effectiveness of Whole-House Retrofits Programs: Literature Review." Report Number A061. American Council for an Energy-Efficient Economy.

[9] Barkett, Brent, Nicole Wobus, Scott Dimetrosky, Rachel Freeman, and Daniel Violette. 2006. "Non-Energy Impacts Evaluation." New York State Energy Research and Development Authority.

[10] Fuchs, Leah., Lisa Skumatz, and Jennifer Ellefsen. 2004. "Non-Energy Benefits (NEBs) from ENERGY STAR: Comprehensive Analysis of Appliance, Outreach, and Homes Programs." In Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, D.C.: American Council for an Energy-Efficient Economy.

Table IV-3 compares the distribution of reported and actual bill savings by measure group. In each participant group, the 25th percentile was negative for the actual savings and $0 for the reported bill savings. For HVAC participants, the median reported savings were much higher than actual savings.

For each group, the mean reported savings were significantly higher than the mean actual savings. The difference was largest for HVAC participants.

For electric baseload participants, there were an equal number with reported and actual bill savings (although these were not the same respondents). For the other participant groups, there were fewer participants with actual bill savings.

The overall differences between reported and actual savings were similar whether the comparison was made for all participants, or only for those with data for both reported and actual savings.

**Table IV-3**
**Distribution of Reported and Actual Bill Savings**
**By Measure Group**

| Participant Group | Bill Savings | | # | Distribution of Values | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Min | P25 | Median | P75 | Max |
| Electric Baseload | All participants | Reported | 54 | $154 | -$2,280 | $0 | $40 | $300 | $3,000 |
| | | Actual | 54 | $80 | -$711 | -$91 | $36 | $257 | $1,151 |
| | Participants w/ data for both | Reported | 31 | $84 | -$2,280 | $0 | $0 | $240 | $3,000 |
| | | Actual | 31 | $48 | -$711 | -$91 | $54 | $168 | $772 |
| Air Sealing and Insulation | All participants | Reported | 59 | $255 | -$1,800 | $0 | $120 | $500 | $2,800 |
| | | Actual | 30 | $106 | -$669 | -$126 | $14 | $161 | $2,812 |
| | Participants w/ data for both | Reported | 23 | $230 | -$1,200 | $0 | $10 | $500 | $1,200 |
| | | Actual | 23 | $122 | -$669 | -$153 | $15 | $170 | $2,812 |
| HVAC | All participants | Reported | 59 | $310 | -$2,760 | $0 | $20 | $600 | $3,000 |
| | | Actual | 23 | -$82 | -$1,202 | -$379 | -$72 | $346 | $504 |
| | Participants w/ data for both | Reported | 16 | $488 | -$1,200 | $0 | $240 | $810 | $2,124 |
| | | Actual | 16 | -$32 | -$799 | -$411 | $30 | $359 | $504 |
| Overall | All participants | Reported | 172 | $242 | -$2,760 | $0 | $80 | $420 | $3,000 |
| | | Actual | 107 | $52 | -$1,202 | -$143 | $28 | $211 | $2,812 |
| | Participants w/ data for both | Reported | 70 | $224 | -$2,280 | $0 | $10 | $360 | $3,000 |
| | | Actual | 70 | $54 | -$799 | -$143 | $39 | $187 | $2,812 |

**Labeled Magnitude Scaling**

Labeled Magnitude Scaling (LMS) was originally developed to study perceptual differences, and has typically been used to compare taste, touch, temperature, and other sensations. In this literature, the LMS scale is usually a continuous magnitude scale, with subjective labels used as anchors. Typical labels are "weak", "moderate", "strong", and "very strong". The maximum on the scale is the strongest imaginable sensation.[11]

LMS was adapted to valuation of NEIs, but the approach has important differences from the way LMS was used outside the NEI literature. The NEI studies use relational questions for LMS, where respondents report how they value an NEI relative to their bill savings. NEI studies do not use a continuous response scale, but instead have respondents answer a question categorically, and then use a direct scaling response to associate values with the qualitative answers.[12]

Labeled Magnitude Scaling (LMS) asked respondents to answer the following question.

- "Think about the positive or negative value you experienced from this change in [NEI area] — would you say it is more value, less value, or the same value to you as any possible energy savings you may have received from the program?"

These qualitative answers are assigned corresponding scalar values to calculate the resulting NEI valuation.

This question may be easier for participants to answer than the DS question because it uses word-based comparisons such as "more" or "less" valuable. It is also easier to answer than the open-ended dollar-value questions. Researchers have used the LMS method in conjunction with the DS Method to create an approach for analyzing NEIs that is more straightforward for survey respondents.[13]

To translate the qualitative responses into scaled dollar values, one or both of the following methods is used.

- A "within-sample" labeled magnitude scale is constructed based on the qualitative responses and the percentage values for the DS question.
    - For instance, studies used the average of the percentages values for those respondents who gave the "much more valuable" response.

[11] Green, B. G., Shaffer, G. S., & Gilmore, M. M. (1993). Derivation and evaluation of a semantic scale of oral sensation magnitude with apparent ratio properties. *Chemical senses*, *18*(6), 683-702; Cardello, A. V., Schutz, H. G., Lesher, L. L., & Merrill, E. (2005). Development and testing of a labeled magnitude scale of perceived satiety. *Appetite*, *44*(1), 1-13; Lim, J. (2011). Hedonic scaling: A review of methods and theory. *Food quality and preference*, *22*(8), 733-747.

[12] Pearson, D., & Skumatz, (2002) L. A. Non-Energy Benefits Including Productivity, Liability, Tenant Satisfaction, and Others—What Participant Surveys Tell Us About Designing and Marketing Commercial Programs. In *Proceedings of the 2002 Summer Study on Energy Efficiency in Buildings* (p. 2); Ledbetter, M. R., Skumatz, L. A., Penning, J. P., D'Souza, D. C., Santulli, M. E., Nubbe, V. A., & Elliott, C. T. (2019). *Energy Saving Opportunity from Advanced LED Lighting Research* (No. PNNL-29342). Pacific Northwest National Lab. (PNNL), Richland, WA (United States); NMR Group, (2016). *Project R4 HES/HES-IE Process Evaluation and R31 Real-time Research;* https://energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf

[13] Amann, *op. cit.*

- Researchers use a set of *ex ante* LMS multipliers derived from earlier studies. However, many of the existing studies do not report the multiplier values used and instead simply state that the qualitative value responses were translated to dollar values "[u]sing previous research."[14]

Table IV-4 summarizes studies that used the LMS method. Based on a thorough review of the publicly available literature, the only NEI analysis that provided the LMS multiplier values used was the Pacific Northwest National Laboratory (PNNL) study conducted by Ledbetter et al (2019). Most studies in this area derived the scalar values from their own survey results and did not report the specific values.

**Table IV-4**
**Labeled Magnitude Scaling Literature Review**

| Study | Objective | Scale | Source of Scalar Values |
|---|---|---|---|
| Skumatz (2002)[15] | Assess NEIs associated with a residential weatherization assistance program in CT | 5-point scale | Unreported survey results |
| Fuchs, Skumatz, and Ellefsen (2004)[16] | Assess NEIs associated with ENERGY STAR measures in the New York Energy $mart Program. | 11-point scale | Unreported survey results |
| Lim, Wood, and Green (2009)[17] | Develop a labeled hedonic scale for sensations by quantifying the semantic values of terms used to describe liking and disliking of sensations. | 9-point scale | Sensation ratings from 49 human subjects. Scale values from -100 to 100 assigned to five positive and five negative descriptors. |
| NMR Group (2016)[18] | Assess NEIs associated with a home energy efficiency program in CT | 5-point scale | Unreported survey results. (One multiplier of 1.3 associated with "somewhat more" as an example, but the others are unreported.) |
| Ledbetter et al. (2019)[19] | Assess NEIs associated with advanced lighting technologies. | 5-point scale | Scalar values derived from Lim, Wood, and Green (2009) and "within-sample" multipliers derived from the survey results. Both sets of scalar values were reported. |

The Pacific Northwest National Laboratory (PNNL) analysis conducted by Ledbetter et al (2019) reported multipliers from the literature and in-sample multipliers.[20] The multipliers from the literature used in the PNNL study were extrapolated from the labeled hedonic scale constructed by Lim, Wood, and Green (2009).

[14] DeKraii, Laitner, Pursley, Rosenbaum and Thompson. 2012. "The Energy, Economic and Environmental Impacts of Nebraska's Energy Office's Dollar and Energy Savings Loan Program and Weatherization Assistance Program." University of Nebraska.
[15] Skumatz, 2002, *op. cit.*
[16] Fuchs, Skumatz, and Ellefsen, 2004, *op. cit.*
[17] Lim, J., Alison Wood, and Barry G. Green, 2009. "Derivation and Evaluation of a Labeled Hedonic Scale", *Chemical Senses* 34 2009, November.
[18] NMR Group, (2016). *Project R4 HES/HES-IE Process Evaluation and R31 Real-time Research;* https://energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf
[19] Ledbetter M.R., L.A. Skumatz, J.P. Penning, D.C. D'Souza, M.E. Santulli, V.A. Nubbe, and C.T. Elliott. 2019. "Energy Saving Opportunity from Advanced LED Lighting Research." PNNL-29342. Richland, WA: Pacific Northwest National Laboratory.
[20] *Ibid.*

The Lim, Wood, and Green study produced an LMS scale for the magnitude of liking/disliking sensations, called a labeled hedonic scale (LHS). The scale ranged from -100 to 100, with the extremes the most liked/disliked sensations imaginable, and intermediate labels of like/dislike "slightly", "moderately", "very much", and "extremely". The scale used by Lim, Wood, and Green, was not a valuation scale, and scale units were arbitrary. The PNNL study converted the numeric values of the LHS to percentage multipliers. Therefore, a value of zero/neutral on the LHS (equivalent to a response of "same value" in the PNNL study) is one. The value of 18 on the LHS (for "somewhat like") was converted to a multiplier of 1.18. This approach of converting the LHS scale into multipliers was not supported by other uses in the literature, but the values were similar to those derived from in-sample direct scaling in that study.

**Table IV-5**
**LMS Multipliers**

| Response to APPRISE Survey | APPRISE Multiplier | Response to PNNL Survey | PNNL Multiplier |
|---|---|---|---|
| More Value | 1.35 | Much More Valuable | 1.55 |
| | | Somewhat More Valuable | 1.18 |
| Same Value | 1 | Same Value | 1 |
| Less Value | 0.65 | Somewhat Less Valuable | 0.82 |
| | | Much Less Valuable | 0.475 |

Table IV-6 displays the multipliers derived from the participant survey. The mean values displayed are the average percentage values provided for an NEI by a given subset of survey respondents. The order of means was not always consistent with the order of LMS value. For example, for health and safety, electric baseload participants who said that they received "less value" reported higher percentages on average than those who said they received "more value". However, sample sizes within NEI, measure group, and LMS group were typically small and differences were not statistically significant.

**Table IV-6**
**LMS In-Sample Multipliers**

| Non-Energy Impact | Labelled Magnitude Scale | Electric Baseload | | Air Sealing & Insulation | | HVAC | |
|---|---|---|---|---|---|---|---|
| | | Obs. | Mean | Obs. | Mean | Obs. | Mean |
| Winter Comfort | More Value | 22 | .44 | 34 | .40 | 36 | .38 |
| | Same Value | 5 | .34 | 6 | .15 | 6 | .42 |
| | Less Value | 3 | .20 | 2 | .25 | 2 | .10 |
| Summer Comfort | More Value | 24 | .50 | 28 | .39 | 27 | .46 |
| | Same Value | 8 | .34 | 7 | .19 | 7 | .59 |
| | Less Value | 2 | .40 | 0 | - | 2 | .25 |

| Non-Energy Impact | Labelled Magnitude Scale | Electric Baseload | | Air Sealing & Insulation | | HVAC | |
|---|---|---|---|---|---|---|---|
| | | Obs. | Mean | Obs. | Mean | Obs. | Mean |
| Safety | More Value | 19 | .47 | 20 | .46 | 20 | .63 |
| | Same Value | 5 | .40 | 1 | .10 | 4 | .25 |
| | Less Value | 3 | .50 | 0 | - | 1 | .20 |
| Health | More Value | 8 | .49 | 17 | .44 | 17 | .69 |
| | Same Value | 6 | .35 | 1 | .30 | 6 | .43 |
| | Less Value | 1 | .50 | 0 | - | 1 | 1 |
| Noise | More Value | 11 | .41 | 10 | .44 | 15 | .61 |
| | Same Value | 4 | .22 | 4 | .25 | 3 | .47 |
| | Less Value | 3 | .10 | 1 | .20 | 4 | .38 |

Tables IV-7 displays the in-sample multipliers based on the survey responses shown above, collapsed across categories as described below.

- Winter Comfort: Combined air sealing & insulation with HVAC. This was based on small sample size and similar expected impacts.
- Summer Comfort: Combined air sealing & insulation with electric baseload. This was based on small sample size and similar expected impacts.
- Safety, Health and Noise: There was no consolidation across categories for these multipliers.

**Table IV-7**
**LMS In-Sample Multipliers**

| Survey Response | APPRISE In-Sample Multiplier | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter Comfort | | Summer Comfort | | Safety | | | Health | | | Noise | | |
| | Baseload | AS&I HVAC | Baseload HVAC | AS&I | Baseload | AS&I | HVAC | Baseload | AS&I | HVAC | Baseload | AS&I | HVAC |
| More Value | .44 | .39 | .48 | .39 | .47 | .46 | .63 | .49 | .44 | .69 | .41 | .44 | .61 |
| Same Value | .34 | .28 | .45 | .19 | .40 | .10 | .25 | .35 | .30 | .43 | .22 | .25 | .47 |
| Less Value | .20 | .17 | .33 | N/A | .50 | N/A | .20 | .50 | N/A | 1 | .10 | .20 | .38 |

## Survey Data Analysis

The following adjustments were made to the raw survey responses.

- If a respondent said their energy bills had declined since the program services, we considered their reported savings to be positive regardless of the sign they used.
  - For example, someone who said their bill was lower and said the change in their bill was +$40 was treated as having reported savings of $40.
- Respondents who said their energy bill was the same as it had been prior to program services were assigned a value of $0 for their reported bill savings.

  - The exception to this was customers who said their bill was the same, but then reported nonzero savings. These customers retained their reported bill savings value.
- The top and bottom two reported bill change values were excluded from the analysis as extreme outliers. These values were excluded from any calculation that used reported savings.
  - The reported savings values for these customers were -$6,000, -$3,000, $4,200, and $4,800.
- If the respondent's reported savings were negative, then their valuation using any of the methods that utilize reported savings was set to $0.
- If the respondent's actual savings were negative, then their valuation using any of the methods that utilize actual savings was set to $0.
- Respondents who said they experienced no change in a given NEI were assigned a valuation of $0 for that NEI for each of the valuation methods.

## C. NEI Valuation

This section provides findings from the NEI analysis using the NEI valuation approaches discussed above. We focused on five key participant-valued NEIs to keep the survey to a relatively short length and obtain good response rates. The following NEIs were addressed.

- Winter Comfort
- Summer Comfort
- Safety
- Health
- Noise

**Winter Comfort**

The sequence of survey questions used to estimate customers' valuation of the change in winter comfort was as follows. (The same sequence was used for the other NEI's)

- "Have you noticed a change in your home comfort in the winter since the energy efficiency work? Is your home now much more comfortable, somewhat more comfortable, no change, somewhat less comfortable, or much less comfortable?"
- "Think about the positive or negative value you experienced from this change in winter comfort — would you say it is more value, less value, or the same value to you as any possible energy savings you may have received from the program?"
- "Could you put a positive or negative dollar value on the change in winter comfort?"
- "What is that dollar value from the change in winter comfort?"
- "How does the dollar value from the change in winter comfort compare to the energy savings — 10% of energy savings, 20%, 30%, etc.?"

Table IV-8A displays the percent of respondents who had the data needed to compute each type of valuation. The contingent valuation (CV) method was the only method that allowed negative valuations. The scaling methods using actual savings had the highest percentage of customers with missing values, 36 percent of all respondents for direct scaling, and 34 percent for LMS. The LMS using reported bill changes had values from 82 percent of respondents,

more than any other method. For each valuation method, customers with valuations of zero constituted a majority of customers with non-missing values.

**Table IV-8A**
**Status of NEI Value by Method**
**Winter Comfort**

| NEI Value | Valuation Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingent Valuation | | Direct Scaling | | | | Labeled Magnitude Scaling | | | |
| | | | Reported | | Actual | | Reported | | Actual | |
| | # | % | # | % | # | % | # | % | # | % |
| Included Values | | | | | | | | | | |
| • Positive | 61 | 24% | 61 | 24% | 28 | 11% | 65 | 25% | 31 | 12% |
| • Negative | 6 | 2% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| • Zero | 116 | 45% | 145 | 56% | 136 | 53% | 147 | 57% | 139 | 54% |
| All Included Values | 183 | 71% | 206 | 80% | 164 | 64% | 212 | 82% | 170 | 66% |
| Missing | 75 | 29% | 52 | 20% | 94 | 36% | 46 | 18% | 88 | 34% |
| **Total** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** |

Table IV-8B displays the number of respondents with sufficient information for each of the valuation methods for the three measure groups. The LMS method using reported savings values yielded the largest sample size, with 212 respondents. Methods using reported savings yielded larger sample sizes than those using actual savings because respondents were more likely to estimate a savings amount (or report no change in their bill amount) than they were to have the data necessary to calculate an actual estimate of that savings.

**Table IV-8B**
**Number of Respondents per Valuation Method**
**Winter Comfort**

| Participant Group | Number of Respondents | | | | |
|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | Labeled Magnitude Scaling | |
| | | Reported | Actual | Reported | Actual |
| Electric Baseload | 65 | 66 | 66 | 69 | 70 |
| Air Sealing & Insulation | 59 | 67 | 49 | 69 | 51 |
| HVAC | 59 | 73 | 49 | 74 | 49 |
| **All** | **183** | **206** | **164** | **212** | **170** |

Table IV-8C displays the weighted mean valuations of customers' change in winter comfort for each valuation method. The weighted mean was highest for each participant group using the LMS method with reported savings and PNNL multipliers. For electric baseload

participants, this method produced a mean value of $220, compared to values ranging from $17 to $72 for the other methods. As expected, participants who received air sealing and insulation or heating measures generally had higher valuations of the change in winter comfort than electric baseload participants. However, this was not the case for all the valuation methods.

When using actual savings, the air sealing and insulation group had a higher value from the change in winter comfort than the other two groups. However, the CV method and the DS method with reported savings estimated the highest valuations for the HVAC group.

**Table IV-8C**
**Winter Comfort Valuation**

| Participant Group | Weighted Mean NEI Value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | LMS – PNNL Multipliers | | LMS – In-Sample Multipliers | |
| | | Reported | Actual | Reported | Actual | Reported | Actual |
| Electric Baseload | $41 | $62 | $17 | $220 | $55 | $72 | $18 |
| Air Sealing & Insulation | $67 | $94 | $35 | $252 | $110 | $72 | $31 |
| HVAC | $103 | $103 | $16 | $259 | $51 | $74 | $15 |
| **All** | **$51** | **$69** | **$18** | **$227** | **$57** | **$72** | **$18** |

Table IV-8D displays the distribution of each winter comfort valuation for each group to provide more detailed comparison of the results from the various measurement approaches.

- Electric Baseload: The lowest valuation for baseload customers was -$150. The 90$^{th}$ percentile was $486 using the LMS-reported method with PNNL multipliers compared to the next highest value of $227 using LMS-actual with PNNL multipliers.

- Air Sealing & Insulation: While 25 percent of participants reported CV values of at least $100, less than 25 percent had positive values with the LMS method or the DS method using actual savings.

- HVAC: While 25 percent of participants had values of at least $144 for the LMS Method with reported savings and PNNL multipliers, less than 25 percent had positive values using the LMS method or DS method with actual savings.

## Table IV-8D
## Distribution of Winter Comfort Valuations
## By Measure Group and Valuation Method

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Electric Baseload** | | | | | | | | | |
| Contingent Valuation | 65 | $41 | -$150 | $0 | $0 | $0 | $100 | $200 | $2,000 |
| Direct Scaling - Reported | 66 | $62 | $0 | $0 | $0 | $0 | $180 | $300 | $1,080 |
| Direct Scaling - Actual | 66 | $17 | $0 | $0 | $0 | $0 | $50 | $154 | $267 |
| LMS – Reported (PNNL) | 69 | $220 | $0 | $0 | $0 | $0 | $486 | $1,620 | $4,050 |
| LMS – Actual (PNNL) | 70 | $55 | $0 | $0 | $0 | $0 | $227 | $422 | $747 |
| LMS – Reported (In-Sample) | 69 | $72 | $0 | $0 | $0 | $0 | $159 | $529 | $1,323 |
| LMS – Actual (In-Sample) | 70 | $18 | $0 | $0 | $0 | $0 | $74 | $144 | $244 |
| **Air Sealing & Insulation** | | | | | | | | | |
| Contingent Valuation | 59 | $67 | -$100 | $0 | $0 | $100 | $200 | $500 | $750 |
| Direct Scaling - Reported | 67 | $94 | $0 | $0 | $0 | $30 | $210 | $600 | $2,800 |
| Direct Scaling - Actual | 49 | $35 | $0 | $0 | $0 | $0 | $50 | $81 | $1,406 |
| LMS – Reported (PNNL) | 69 | $252 | $0 | $0 | $0 | $270 | $810 | $1,296 | $3,780 |
| LMS – Actual (PNNL) | 51 | $110 | $0 | $0 | $0 | $0 | $218 | $677 | $2,812 |
| LMS – Reported (In-Sample) | 69 | $72 | $0 | $0 | $0 | $77 | $232 | $372 | $1,084 |
| LMS – Actual (In-Sample) | 51 | $31 | $0 | $0 | $0 | $0 | $62 | $194 | $797 |
| **HVAC** | | | | | | | | | |
| Contingent Valuation | 59 | $103 | -$50 | $0 | $0 | $70 | $200 | $500 | $2,500 |
| Direct Scaling - Reported | 73 | $103 | $0 | $0 | $0 | $48 | $240 | $420 | $2,400 |
| Direct Scaling - Actual | 49 | $16 | $0 | $0 | $0 | $0 | $35 | $203 | $297 |
| LMS – Reported (PNNL) | 74 | $259 | $0 | $0 | $0 | $144 | $810 | $1,134 | $4,050 |
| LMS – Actual (PNNL) | 49 | $51 | $0 | $0 | $0 | $0 | $183 | $502 | $614 |
| LMS – Reported (In-Sample) | 74 | $74 | $0 | $0 | $0 | $41 | $232 | $325 | $1,161 |
| LMS – Actual (In-Sample) | 49 | $15 | $0 | $0 | $0 | $0 | $53 | $144 | $176 |
| **Overall** | | | | | | | | | |
| Contingent Valuation | 183 | $51 | -$150 | $0 | $0 | $0 | $160 | $500 | $2,500 |
| Direct Scaling - Reported | 206 | $69 | $0 | $0 | $0 | $0 | $180 | $300 | $2,800 |
| Direct Scaling - Actual | 164 | $18 | $0 | $0 | $0 | $0 | $50 | $154 | $1,406 |

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| LMS – Reported (PNNL) | 212 | $227 | $0 | $0 | $0 | $0 | $648 | $1,296 | $4,050 |
| LMS – Actual (PNNL) | 170 | $57 | $0 | $0 | $0 | $0 | $227 | $422 | $2,812 |
| LMS – Reported (In-Sample) | 212 | $72 | $0 | $0 | $0 | $0 | $186 | $372 | $1,323 |
| LMS – Actual (In-Sample) | 170 | $18 | $0 | $0 | $0 | $0 | $74 | $144 | $797 |

Table IV-8E compares the distribution of contingent valuations to responses to the question about the change in winter comfort. The ordering of these values was generally as expected. For example, the mean and median for those who said "much more comfortable" were higher than for those who said "somewhat more comfortable".

**Table IV-8E**
**Distribution of Contingent Valuations**
**By Reported Change in Winter Comfort**

| Change in Winter Comfort | # | Distribution of Contingent Valuations | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | Max |
| Much More Comfortable | 31 | $369 | $2 | $100 | $200 | $500 | $2,500 |
| Somewhat More Comfortable | 30 | $195 | $5 | $50 | $100 | $200 | $1,000 |
| No Change[1] | 116 | $0 | $0 | $0 | $0 | $0 | $0 |
| Somewhat Less Comfortable | 5 | -$60 | -$100 | -$80 | -$50 | -$50 | -$20 |
| Much Less Comfortable | 1 | -$150 | -$150 | -$150 | -$150 | -$150 | -$150 |

[1]These participants were not asked to provide a contingent valuation; we assigned a contingent valuation of $0 based on their "no change" response.

## Summer Comfort

Table IV-9A displays the percent of respondents who provided each type of valuation. The scaling methods using actual savings had the highest proportion of customers with missing values; 35 percent of all respondents for direct scaling, and 33 percent for LMS. For each valuation method, customers with valuations of zero constituted a majority of customers with non-missing values.

**Table IV-9A**
**Status of NEI Value by Method**
**Summer Comfort**

| NEI Value | Valuation Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingent Valuation | | Direct Scaling | | | | Labeled Magnitude Scaling | | | |
| | | | Reported | | Actual | | Reported | | Actual | |
| | # | % | # | % | # | % | # | % | # | % |
| Included Values | | | | | | | | | | |
| • Positive | 58 | 22% | 50 | 19% | 25 | 10% | 53 | 21% | 25 | 10% |
| • Negative | 4 | 2% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| • Zero | 128 | 50% | 159 | 62% | 142 | 55% | 161 | 62% | 149 | 58% |
| All Included Values | 190 | 74% | 209 | 81% | 167 | 65% | 214 | 83% | 174 | 67% |
| Missing | 68 | 26% | 49 | 19% | 91 | 35% | 44 | 17% | 84 | 33% |
| **Total** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** |

Table IV-9B displays the number of respondents with sufficient information for each of the valuation methods. The LMS method using reported savings yielded the largest sample size, with 214 respondents using this method. Methods using reported savings yielded larger sample sizes than those using actual savings.

**Table IV-9B**
**Number of Respondents per Valuation Method**
**Summer Comfort**

| Participant Group | Number of Respondents | | | | |
|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | Labeled Magnitude Scaling | |
| | | Reported | Actual | Reported | Actual |
| Electric Baseload | 60 | 68 | 65 | 69 | 68 |
| Air Sealing & Insulation | 60 | 64 | 49 | 66 | 52 |
| HVAC | 70 | 77 | 53 | 79 | 54 |
| **All** | **190** | **209** | **167** | **214** | **174** |

Table IV-9C displays the weighted mean valuations of customers' change in summer comfort. The weighted mean valuations were highest using the LMS method with the PNNL multipliers and reported savings. The mean value was $236 for HVAC participants, compared to only $29 when using LMS with the PNNL multipliers and actual savings.

Air sealing and insulation participants had a summer comfort valuation that ranged from $8 to $211. Methods using actual savings resulted in the lowest values, on average, for air sealing

and insulation participants. The CV method and LMS using reported savings and in-sample multipliers produced values in the middle of the range, $62 and $58 respectively.

The different methods were inconsistent in identifying the relative value of changes in summer comfort between participant groups. Using CV or any of the methods with reported savings resulted in the highest estimated summer comfort value for HVAC participants, but the use of actual savings resulted in the highest value for electric baseload participants.

**Table IV-9C**
**Summer Comfort Valuation**

| Participant Group | Weighted Mean NEI Value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | LMS – PNNL Multipliers | | LMS – In-Sample Multipliers | |
| | | Reported | Actual | Reported | Actual | Reported | Actual |
| Electric Baseload | $37 | $61 | $16 | $107 | $48 | $40 | $19 |
| Air Sealing & Insulation | $62 | $76 | $8 | $211 | $37 | $58 | $10 |
| HVAC | $74 | $98 | $15 | $236 | $29 | $88 | $11 |
| **All** | **$44** | **$67** | **$16** | **$131** | **$45** | **$48** | **$18** |

Table IV-9D displays the distribution of each summer comfort valuation for each group to provide more detailed comparison of the results from the various measurement approaches.

- Electric Baseload: The 90$^{th}$ percentile was highest using the LMS-reported method with PNNL multipliers, at $405, with the next highest equal to $252 using DS with reported savings. Regardless of the method used, less than 25 percent of participants had positive values.

- Air Sealing & Insulation: While the 75$^{th}$ percentile for each of the methods using actual savings was $0, the 75$^{th}$ percentile for methods using reported savings ranged from $10 to $135.

- HVAC: While 25 percent of participants had values of at least $50 for contingent valuation, the 75$^{th}$ percentile for each of the scaling methods was $0.

**Table IV-9D**
**Distribution of Summer Comfort Valuations**
**By Measure Group and Valuation Method**

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Electric Baseload** | | | | | | | | | |
| Contingent Valuation | 60 | $37 | -$10 | $0 | $0 | $0 | $100 | $200 | $1,000 |
| Direct Scaling - Reported | 68 | $61 | $0 | $0 | $0 | $0 | $252 | $300 | $1,080 |

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| Direct Scaling - Actual | 65 | $16 | $0 | $0 | $0 | $0 | $50 | $127 | $267 |
| LMS – Reported (PNNL) | 69 | $107 | $0 | $0 | $0 | $0 | $405 | $600 | $1,620 |
| LMS – Actual (PNNL) | 68 | $48 | $0 | $0 | $0 | $0 | $167 | $534 | $753 |
| LMS – Reported (In-Sample) | 69 | $40 | $0 | $0 | $0 | $0 | $143 | $272 | $572 |
| LMS – Actual (In-Sample) | 68 | $19 | $0 | $0 | $0 | $0 | $80 | $201 | $266 |
| **Air Sealing & Insulation** | | | | | | | | | |
| Contingent Valuation | 60 | $62 | -$100 | $0 | $0 | $40 | $200 | $300 | $1,000 |
| Direct Scaling - Reported | 64 | $76 | $0 | $0 | $0 | $10 | $216 | $288 | $2,800 |
| Direct Scaling - Actual | 49 | $8 | $0 | $0 | $0 | $0 | $47 | $50 | $131 |
| LMS – Reported (PNNL) | 66 | $211 | $0 | $0 | $0 | $135 | $780 | $1,296 | $3,780 |
| LMS – Actual (PNNL) | 52 | $37 | $0 | $0 | $0 | $0 | $66 | $253 | $677 |
| LMS – Reported (In-Sample) | 66 | $58 | $0 | $0 | $0 | $39 | $196 | $377 | $1,100 |
| LMS – Actual (In-Sample) | 52 | $10 | $0 | $0 | $0 | $0 | $19 | $74 | $197 |
| **HVAC** | | | | | | | | | |
| Contingent Valuation | 70 | $74 | -$100 | $0 | $0 | $50 | $150 | $500 | $1,000 |
| Direct Scaling - Reported | 77 | $98 | $0 | $0 | $0 | $0 | $180 | $850 | $2,400 |
| Direct Scaling - Actual | 53 | $15 | $0 | $0 | $0 | $0 | $0 | $203 | $297 |
| LMS – Reported (PNNL) | 79 | $236 | $0 | $0 | $0 | $0 | $972 | $1,800 | $3,240 |
| LMS – Actual (PNNL) | 54 | $29 | $0 | $0 | $0 | $0 | $0 | $290 | $549 |
| LMS – Reported (In-Sample) | 79 | $88 | $0 | $0 | $0 | $0 | $343 | $816 | $1,144 |
| LMS – Actual (In-Sample) | 54 | $11 | $0 | $0 | $0 | $0 | $0 | $118 | $194 |
| **Overall** | | | | | | | | | |
| Contingent Valuation | 190 | $44 | -$100 | $0 | $0 | $0 | $100 | $200 | $1,000 |
| Direct Scaling - Reported | 209 | $67 | $0 | $0 | $0 | $0 | $252 | $300 | $2,800 |
| Direct Scaling - Actual | 167 | $16 | $0 | $0 | $0 | $0 | $50 | $127 | $297 |
| LMS – Reported (PNNL) | 214 | $131 | $0 | $0 | $0 | $0 | $486 | $810 | $3,780 |
| LMS – Actual (PNNL) | 174 | $45 | $0 | $0 | $0 | $0 | $167 | $533 | $753 |
| LMS – Reported (In-Sample) | 214 | $48 | $0 | $0 | $0 | $0 | $145 | $286 | $1,144 |
| LMS – Actual (In-Sample) | 174 | $18 | $0 | $0 | $0 | $0 | $63 | $194 | $266 |

Table IV-9E compares the distribution of contingent valuations to responses about the change in summer comfort. There was little difference between the distribution of values for those who said “much more comfortable” and those who said “somewhat more comfortable”, except at the upper end of the distribution.

**Table IV-9E**
**Distribution of Contingent Valuations**
**By Reported Change in Summer Comfort**

| Change in Summer Comfort | # | Distribution of Contingent Valuations | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | Max |
| Much More Comfortable | 36 | $247 | $8 | $50 | $100 | $300 | $1,000 |
| Somewhat More Comfortable | 22 | $150 | $5 | $50 | $100 | $200 | $600 |
| No Change[1] | 128 | $0 | $0 | $0 | $0 | $0 | $0 |
| Somewhat Less Comfortable | 1 | -$10 | -$10 | -$10 | -$10 | -$10 | -$10 |
| Much Less Comfortable | 3 | -$80 | -$100 | -$100 | -$100 | -$40 | -$40 |

[1]These participants were not asked to provide a contingent valuation; we assigned a contingent valuation of $0 based on their "no change" response.

## Safety

Table IV-10A displays the percent of respondents who provided each type of valuation. The DS method using actual savings had the highest percentage of customers with missing values, 26 percent of all respondents. For each valuation method, customers with valuations of zero constituted the majority of customers with non-missing values for that valuation.

**Table IV-10A**
**Status of NEI Value by Method**
**Safety**

| NEI Value | Valuation Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingent Valuation | | Direct Scaling | | | | Labeled Magnitude Scaling | | | |
| | | | Reported | | Actual | | Reported | | Actual | |
| | # | % | # | % | # | % | # | % | # | % |
| Included Values | | | | | | | | | | |
| • Positive | 33 | 13% | 35 | 14% | 15 | 6% | 39 | 15% | 17 | 7% |
| • Negative | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| • Zero | 162 | 63% | 184 | 71% | 177 | 69% | 187 | 72% | 181 | 70% |
| All Included Values | 195 | 76% | 219 | 85% | 192 | 74% | 226 | 88% | 198 | 77% |
| Missing | 63 | 24% | 39 | 15% | 66 | 26% | 32 | 12% | 60 | 23% |
| **Total** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** |

Table IV-10B displays the number of respondents with sufficient information for each of the valuation methods. The LMS method using reported savings yielded the largest sample size, with 226 respondents. Methods using reported savings yielded larger sample sizes than those using actual savings.

**Table IV-10B**
**Number of Respondents per Valuation Method**
**Safety**

| Participant Group | Number of Respondents | | | | |
|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | Labeled Magnitude Scaling | |
| | | Reported | Actual | Reported | Actual |
| Electric Baseload | 62 | 71 | 70 | 73 | 73 |
| Air Sealing & Insulation | 66 | 73 | 63 | 74 | 65 |
| HVAC | 67 | 75 | 59 | 79 | 60 |
| **All** | **195** | **219** | **192** | **226** | **198** |

Table IV-10C displays the weighted mean valuations of safety for each valuation method. The LMS method with reported savings and PNNL multipliers resulted in the highest values for electric baseload participants and air sealing/insulation participants. For electric baseload participants, this method had a valuation of $72, compared to $22 using the DS method with actual savings. For air sealing and insulation participants, the LMS method with reported savings and PNNL multipliers had a valuation of $108, which was much larger than the lowest estimate of $3 using the DS method and actual savings.

For HVAC participants, the LMS method with reported savings and PNNL multipliers also had a relatively high valuation, $179, compared to other methods. However, the CV method had the highest valuation for HVAC participants, with a value of $212. These top valuations were much higher than the lowest valuations using actual savings and either the DS method, or the LMS method with in-sample multipliers. These methods had values of $4 and $7 respectively.

The different methods were inconsistent in identifying the relative value of changes in safety between participant groups. HVAC participants had the highest valuations with CV or any of the methods that used reported savings, but baseload participants had the highest estimate when actual savings were used.

**Table IV-10C**
**Safety Valuation**

| Participant Group | Weighted Mean NEI Value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | LMS – PNNL Multipliers | | LMS – In-Sample Multipliers | |
| | | Reported | Actual | Reported | Actual | Reported | Actual |
| Electric Baseload | $30 | $37 | $22 | $72 | $61 | $34 | $23 |
| Air Sealing & Insulation | $27 | $56 | $3 | $108 | $20 | $36 | $5 |
| HVAC | $212 | $102 | $4 | $179 | $15 | $82 | $7 |
| **All** | **$55** | **$47** | **$18** | **$89** | **$52** | **$41** | **$20** |

Table IV-10D displays the distribution of each safety valuation for each group to provide more detailed comparison of the results from the various measurement approaches.

- Electric Baseload: No baseload participants reported a negative value for the change in safety. Regardless of the method used, less than 25 percent of participants had positive values.

- Air Sealing & Insulation: The values were generally low for this group, especially when using actual savings. While more than 95 percent of respondents had a value of $0 using the DS-actual method, ten percent of respondents had a value of at least $162 using the LMS-reported method with PNNL multipliers.

- HVAC: The mean was highest using the CV method, at $212, due to a value of $10,000 reported by one participant. The 95$^{th}$ percentile for each of the methods using actual savings was $0.

**Table IV-10D**
**Distribution of Safety Valuations**
**By Measure Group and Valuation Method**

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Electric Baseload** | | | | | | | | | |
| Contingent Valuation | 62 | $30 | $0 | $0 | $0 | $0 | $100 | $100 | $800 |
| Direct Scaling - Reported | 71 | $37 | $0 | $0 | $0 | $0 | $30 | $108 | $1,080 |
| Direct Scaling - Actual | 70 | $22 | $0 | $0 | $0 | $0 | $56 | $169 | $386 |
| LMS – Reported (PNNL) | 73 | $72 | $0 | $0 | $0 | $0 | $270 | $780 | $1,134 |
| LMS – Actual (PNNL) | 73 | $61 | $0 | $0 | $0 | $0 | $308 | $570 | $772 |
| LMS – Reported (In-Sample) | 73 | $34 | $0 | $0 | $0 | $0 | $94 | $384 | $600 |
| LMS – Actual (In-Sample) | 73 | $23 | $0 | $0 | $0 | $0 | $121 | $198 | $309 |

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Air Sealing & Insulation** | | | | | | | | | |
| Contingent Valuation | 66 | $27 | $0 | $0 | $0 | $0 | $50 | $200 | $500 |
| Direct Scaling - Reported | 73 | $56 | $0 | $0 | $0 | $0 | $24 | $300 | $2,800 |
| Direct Scaling - Actual | 63 | $3 | $0 | $0 | $0 | $0 | $0 | $0 | $117 |
| LMS – Reported (PNNL) | 74 | $108 | $0 | $0 | $0 | $0 | $162 | $648 | $3,780 |
| LMS – Actual (PNNL) | 65 | $20 | $0 | $0 | $0 | $0 | $0 | $17 | $789 |
| LMS – Reported (In-Sample) | 74 | $36 | $0 | $0 | $0 | $0 | $46 | $218 | $1,274 |
| LMS – Actual (In-Sample) | 65 | $5 | $0 | $0 | $0 | $0 | $0 | $6 | $266 |
| **HVAC** | | | | | | | | | |
| Contingent Valuation | 67 | $212 | $0 | $0 | $0 | $0 | $150 | $200 | $10,000 |
| Direct Scaling - Reported | 75 | $102 | $0 | $0 | $0 | $0 | $120 | $840 | $2,400 |
| Direct Scaling - Actual | 59 | $4 | $0 | $0 | $0 | $0 | $0 | $0 | $172 |
| LMS – Reported (PNNL) | 79 | $179 | $0 | $0 | $0 | $0 | $810 | $1,215 | $3,240 |
| LMS – Actual (PNNL) | 60 | $15 | $0 | $0 | $0 | $0 | $0 | $0 | $669 |
| LMS – Reported (In-Sample) | 79 | $82 | $0 | $0 | $0 | $0 | $375 | $563 | $1,500 |
| LMS – Actual (In-Sample) | 60 | $7 | $0 | $0 | $0 | $0 | $0 | $0 | $310 |
| **Overall** | | | | | | | | | |
| Contingent Valuation | 195 | $55 | $0 | $0 | $0 | $0 | $100 | $150 | $10,000 |
| Direct Scaling - Reported | 219 | $47 | $0 | $0 | $0 | $0 | $30 | $108 | $2,800 |
| Direct Scaling - Actual | 192 | $18 | $0 | $0 | $0 | $0 | $50 | $154 | $386 |
| LMS – Reported (PNNL) | 226 | $89 | $0 | $0 | $0 | $0 | $270 | $780 | $3,780 |
| LMS – Actual (PNNL) | 198 | $52 | $0 | $0 | $0 | $0 | $227 | $347 | $789 |
| LMS – Reported (In-Sample) | 226 | $41 | $0 | $0 | $0 | $0 | $94 | $384 | $1,500 |
| LMS – Actual (In-Sample) | 198 | $20 | $0 | $0 | $0 | $0 | $79 | $134 | $310 |

Table IV-10E displays the distribution of contingent valuations based on how respondents answered the question asking about their change in safety. The distributions corresponded to the qualitative responses participants provided. At each percentile shown in Table IV-10E, the contingent values were higher for those who said “much safer” than for those who said “somewhat safer”.

**Table IV-10E**
**Distribution of Contingent Valuations**
**By Reported Change in Safety**

| Change in Noise Level | # | Distribution of Contingent Valuations | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | Max |
| Much Safer | 20 | $745 | $20 | $80 | $200 | $500 | $10,000 |
| Somewhat Safer | 13 | $149 | $5 | $50 | $100 | $150 | $500 |
| No Change[1] | 162 | $0 | $0 | $0 | $0 | $0 | $0 |
| Somewhat Less Safe | 0 | - | - | - | - | - | - |
| Much Less Safe | 0 | - | - | - | - | - | - |

[1]These participants were not asked to provide a contingent valuation; we assigned a contingent valuation of $0 based on their "no change" response.

## Health

Table IV-11A displays the percent of respondents who provided each type of valuation. The scaling methods using actual savings had the highest percentage of customers with missing values, 24 percent of all respondents for direct scaling, and 23 percent for LMS. For each valuation method, customers with valuations of zero constituted a majority of customers with non-missing values.

**Table IV-11A**
**Status of NEI Value by Method**
**Health**

| NEI Value | Valuation Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingent Valuation | | Direct Scaling | | | | Labeled Magnitude Scaling | | | |
| | | | Reported | | Actual | | Reported | | Actual | |
| | # | % | # | % | # | % | # | % | # | % |
| Included Values | | | | | | | | | | |
| • Positive | 24 | 9% | 30 | 12% | 13 | 5% | 31 | 12% | 16 | 6% |
| • Negative | 3 | 1% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| • Zero | 176 | 68% | 189 | 73% | 182 | 71% | 193[1] | 75% | 182 | 71% |
| All Included Values | 203 | 79% | 219 | 85% | 195 | 76% | 224 | 87% | 198 | 77% |
| Missing | 55 | 21% | 39 | 15% | 63 | 24% | 34 | 13% | 60 | 23% |
| **Total** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** |

[1]It was not possible to derive an in-sample multiplier for one respondent. When using the in-sample multipliers, the number of zero values was 192 and the number of missing values was 35.

Table IV-11B displays the number of respondents with sufficient information for each of the valuation methods. The LMS method using reported savings yielded the largest sample size,

with 224 respondents. Methods using reported savings yielded larger sample sizes than those using actual savings.

**Table IV-11B**
**Number of Respondents per Valuation Method**
**Health**

| Participant Group | Number of Respondents | | | | |
|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | Labeled Magnitude Scaling | |
| | | Reported | Actual | Reported | Actual |
| Electric Baseload | 68 | 73 | 73 | 75 | 74 |
| Air Sealing & Insulation | 65 | 71 | 63 | 71 | 63 |
| HVAC | 70 | 75 | 59 | 78 | 61 |
| **All** | **203** | **219** | **195** | **224** | **198** |

Table IV-11C displays the weighted mean valuations of customers' change in health. The mean valuations were highest for electric baseload and HVAC participants using the CV method. For HVAC participants, the mean value was $2,157, though this was mostly due to a single large outlier value of $200,000[21]. For electric baseload participants, the value was $1,382, which was again largely due to a single outlier of $50,000. These CV values were extremely high, but other methods had much more moderate values. For HVAC participants, valuations from other methods ranged from $11 to $195. For electric baseload participants, valuations from other methods ranged from $11 to $52.

Air sealing and insulation participants had substantially lower values relative to the other groups when actual savings were used for scaling. This group also did not have any large outlier values for the CV method, resulting in a relatively lower mean CV estimate of $68.

**Table IV-11C**
**Health Valuation**

| Participant Group | Weighted Mean NEI Value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | LMS – PNNL Multipliers | | LMS – In-Sample Multipliers | |
| | | Reported | Actual | Reported | Actual | Reported | Actual |
| Electric Baseload | $1,382 | $39 | $20 | $31 | $52 | $11 | $21 |
| Air Sealing & Insulation | $68 | $56 | $3 | $84 | $12 | $28 | $4 |
| HVAC | $2,157 | $110 | $11 | $195 | $28 | $97 | $14 |
| **All** | **$1,413** | **$50** | **$18** | **$57** | **$47** | **$24** | **$19** |

[21] This extreme value remained after dropping the four highest values, all of which were $1 million. For all other NEIs, the highest CV value in the analysis was $10,000 or less.

Table IV-11D displays the distribution of each health valuation for each group to provide more detailed comparison of the results from the various measurement approaches.

- Electric Baseload: No baseload participants reported a negative value for the change in health. Regardless of the method used, less than 25 percent of participants had positive values.

- Air Sealing & Insulation: The values were generally low for this group, especially when using actual savings. The DS-actual method resulted in a maximum value of only $85, while the LMS method with actual savings and in-sample multipliers resulted in a maximum value of only $75.

- HVAC: The 90$^{th}$ percentiles for each of the methods using actual savings was $0, while the 90$^{th}$ percentiles for each of the scaling methods using reported savings ranged from $120 to $810.

**Table IV-11D**
**Distribution of Health Valuations**
**By Measure Group and Valuation Method**

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Electric Baseload** | | | | | | | | | |
| Contingent Valuation | 68 | $1,382 | $0 | $0 | $0 | $0 | $50 | $500 | $50,000 |
| Direct Scaling - Reported | 73 | $39 | $0 | $0 | $0 | $0 | $48 | $144 | $1,080 |
| Direct Scaling - Actual | 73 | $20 | $0 | $0 | $0 | $0 | $22 | $154 | $386 |
| LMS – Reported (PNNL) | 75 | $31 | $0 | $0 | $0 | $0 | $60 | $373 | $1,134 |
| LMS – Actual (PNNL) | 74 | $52 | $0 | $0 | $0 | $0 | $275 | $389 | $772 |
| LMS – Reported (In-Sample) | 75 | $11 | $0 | $0 | $0 | $0 | $21 | $135 | $410 |
| LMS – Actual (In-Sample) | 74 | $21 | $0 | $0 | $0 | $0 | $108 | $195 | $270 |
| **Air Sealing & Insulation** | | | | | | | | | |
| Contingent Valuation | 65 | $68 | -$15 | $0 | $0 | $0 | $12 | $200 | $5,000 |
| Direct Scaling - Reported | 71 | $56 | $0 | $0 | $0 | $0 | $10 | $198 | $2,800 |
| Direct Scaling - Actual | 63 | $3 | $0 | $0 | $0 | $0 | $0 | $13 | $85 |
| LMS – Reported (PNNL) | 71 | $84 | $0 | $0 | $0 | $0 | $14 | $660 | $3,780 |
| LMS – Actual (PNNL) | 63 | $12 | $0 | $0 | $0 | $0 | $0 | $181 | $230 |
| LMS – Reported (In-Sample) | 70 | $28 | $0 | $0 | $0 | $0 | $4 | $198 | $1,235 |
| LMS – Actual (In-Sample) | 63 | $4 | $0 | $0 | $0 | $0 | $0 | $59 | $75 |
| **HVAC** | | | | | | | | | |
| Contingent Valuation | 70 | $2,157 | -$100 | $0 | $0 | $0 | $70 | $150 | $200,000 |
| Direct Scaling - Reported | 75 | $110 | $0 | $0 | $0 | $0 | $120 | $900 | $2,400 |
| Direct Scaling - Actual | 59 | $11 | $0 | $0 | $0 | $0 | $0 | $0 | $372 |

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| LMS – Reported (PNNL) | 78 | $195 | $0 | $0 | $0 | $0 | $810 | $1,800 | $3,240 |
| LMS – Actual (PNNL) | 61 | $28 | $0 | $0 | $0 | $0 | $0 | $290 | $614 |
| LMS – Reported (In-Sample) | 78 | $97 | $0 | $0 | $0 | $0 | $413 | $780 | $1,652 |
| LMS – Actual (In-Sample) | 61 | $14 | $0 | $0 | $0 | $0 | $0 | $148 | $313 |
| **Overall** | | | | | | | | | |
| Contingent Valuation | 203 | $1,413 | -$100 | $0 | $0 | $0 | $50 | $500 | $200,000 |
| Direct Scaling - Reported | 219 | $50 | $0 | $0 | $0 | $0 | $48 | $144 | $2,800 |
| Direct Scaling - Actual | 195 | $18 | $0 | $0 | $0 | $0 | $10 | $154 | $386 |
| LMS – Reported (PNNL) | 224 | $57 | $0 | $0 | $0 | $0 | $60 | $373 | $3,780 |
| LMS – Actual (PNNL) | 198 | $47 | $0 | $0 | $0 | $0 | $227 | $308 | $772 |
| LMS – Reported (In-Sample) | 223 | $24 | $0 | $0 | $0 | $0 | $21 | $135 | $1,652 |
| LMS – Actual (In-Sample) | 198 | $19 | $0 | $0 | $0 | $0 | $82 | $140 | $313 |

Table IV-11E compares the distribution of contingent valuations to qualitative responses about the change in health. The ordering of these values was generally as expected. The percentile values for those who said "much better" were higher than for those who said "somewhat better", except for the maximum values of the distribution. The person who provided the value of $200,000 said their health was somewhat better, which made the mean significantly higher for that group.

**Table IV-11E**
**Distribution of Contingent Valuations**
**By Reported Change in Health**

| Change in Health | # | Distribution of Contingent Valuations | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | Max |
| Much Better | 12 | $1,644 | $12 | $80 | $150 | $1,950 | $10,000 |
| Somewhat Better | 12 | $20,978 | $10 | $40 | $100 | $600 | $200,000 |
| No Change[1] | 176 | $0 | $0 | $0 | $0 | $0 | $0 |
| Somewhat Worse | 3 | -$68 | -$100 | -$100 | -$90 | -$15 | -$15 |
| Much Worse | 0 | - | - | - | - | - | - |

[1]These participants were not asked to provide a contingent valuation; we assigned a contingent valuation of $0 based on their "no change" response.

## Noise

Table IV-12A displays the percent of respondents that provided each type of valuation. The percent of respondents with a missing value for this NEI ranged from 11 percent to 20 percent. Most respondents had an estimated valuation of $0, between 71 and 77 percent of respondents for each valuation method.

**Table IV-12A**
**Status of NEI Value by Method**
**Noise**

| NEI Value | Valuation Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Contingent Valuation | | Direct Scaling | | | | Labeled Magnitude Scaling | | | |
| | | | Reported | | Actual | | Reported | | Actual | |
| | # | % | # | % | # | % | # | % | # | % |
| Included Values | | | | | | | | | | |
| • Positive | 27 | 10% | 28 | 11% | 12 | 5% | 32 | 12% | 15 | 6% |
| • Negative | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| • Zero | 182 | 71% | 197 | 76% | 194 | 75% | 198 | 77% | 195 | 76% |
| All Included Values | 209 | 81% | 225 | 87% | 206 | 80% | 230 | 89% | 210 | 81% |
| Missing | 49 | 19% | 33 | 13% | 52 | 20% | 28 | 11% | 48 | 19% |
| **Total** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** | **258** | **100%** |

Table IV-12B displays the number of respondents with sufficient information for each of the valuation methods. The LMS method using reported savings yielded the largest sample size, with 230 respondents. Methods using reported savings yielded larger sample sizes than those using actual savings.

**Table IV-12B**
**Number of Respondents per Valuation Method**
**Noise**

| Participant Group | Number of Respondents | | | | |
|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | Labeled Magnitude Scaling | |
| | | Reported | Actual | Reported | Actual |
| Electric Baseload | 68 | 75 | 73 | 76 | 76 |
| Air Sealing & Insulation | 71 | 74 | 69 | 75 | 70 |
| HVAC | 70 | 76 | 64 | 79 | 64 |
| **All** | **209** | **225** | **206** | **230** | **210** |

Table IV-12C shows the weighted mean valuations of customers' change in noise level. Across measure groups, mean valuations were highest using the LMS method with reported savings and PNNL multipliers. For electric baseload participants, this method had a mean valuation of $147, which was a higher valuation than for air sealing and insulation and HVAC participants. For electric baseload participants, the other methods had values between $2 and $39. Some electric baseload participants may have seen a reduction in noise from new refrigerators or AC wall units, but a high noise value is not expected for this group.

Air sealing and insulation participants had a valuation for $68 from the CV method. This was not as high as the valuation from LMS with the PNNL multipliers and reported savings, but it was high compared to the CV valuations for HVAC and electric baseload, which were $19 and $20 respectively. Air sealing and insulation participants did not have the highest valuation using any other method.

The different methods were inconsistent in identifying the relative value of changes in noise between participant groups.

**Table IV-12C**
**Noise Valuation**

| Participant Group | Weighted Mean NEI Value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Contingent Valuation | Direct Scaling | | LMS – PNNL Multipliers | | LMS – In-Sample Multipliers | |
| | | Reported | Actual | Reported | Actual | Reported | Actual |
| Electric Baseload | $20 | $30 | $2 | $147 | $17 | $39 | $5 |
| Air Sealing & Insulation | $68 | $55 | $1 | $112 | $7 | $34 | $2 |
| HVAC | $19 | $61 | $8 | $99 | $11 | $45 | $5 |
| **All** | **$22** | **$36** | **$3** | **$138** | **$15** | **$39** | **$5** |

Table IV-12D displays the distribution of each noise valuation for each group to provide more detailed comparison of the results from the various measurement approaches.

- Electric Baseload: No baseload participants reported a negative CV value for the change in noise. While ten percent of respondents had values of at least $324 using the LMS method with reported savings and PNNL multipliers, less than ten percent of respondents had positive values using the DS-actual method.

- Air Sealing & Insulation: The values were low for this group when using actual savings. Less than five percent of respondents had nonzero values using the DS-actual method, while ten percent had values of at least $405 using the LMS method with reported savings and PNNL multipliers.

- HVAC: The values were much lower for the methods using actual savings than for the methods using reported savings. The 95$^{th}$ percentiles for each of the methods using actual savings was $0, while the 90$^{th}$ percentiles for each of the methods using reported savings ranged from $14 to $65.

## Table IV-12D
## Distribution of Noise Valuations
## By Measure Group and Valuation Method

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| **Electric Baseload** | | | | | | | | | |
| Contingent Valuation | 68 | $20 | $0 | $0 | $0 | $0 | $0 | $100 | $3,000 |
| Direct Scaling - Reported | 75 | $30 | $0 | $0 | $0 | $0 | $36 | $83 | $840 |
| Direct Scaling - Actual | 73 | $2 | $0 | $0 | $0 | $0 | $0 | $8 | $112 |
| LMS – Reported (PNNL) | 76 | $147 | $0 | $0 | $0 | $0 | $324 | $486 | $3,000 |
| LMS – Actual (PNNL) | 76 | $17 | $0 | $0 | $0 | $0 | $44 | $103 | $558 |
| LMS – Reported (In-Sample) | 76 | $39 | $0 | $0 | $0 | $0 | $98 | $147 | $675 |
| LMS – Actual (In-Sample) | 76 | $5 | $0 | $0 | $0 | $0 | $13 | $31 | $125 |
| **Air Sealing & Insulation** | | | | | | | | | |
| Contingent Valuation | 71 | $68 | $0 | $0 | $0 | $0 | $50 | $200 | $6,000 |
| Direct Scaling - Reported | 74 | $55 | $0 | $0 | $0 | $0 | $2 | $210 | $2,800 |
| Direct Scaling - Actual | 69 | $1 | $0 | $0 | $0 | $0 | $0 | $0 | $47 |
| LMS – Reported (PNNL) | 75 | $112 | $0 | $0 | $0 | $0 | $405 | $660 | $3,780 |
| LMS – Actual (PNNL) | 70 | $7 | $0 | $0 | $0 | $0 | $0 | $0 | $465 |
| LMS – Reported (In-Sample) | 75 | $34 | $0 | $0 | $0 | $0 | $105 | $195 | $1,232 |
| LMS – Actual (In-Sample) | 70 | $2 | $0 | $0 | $0 | $0 | $0 | $0 | $116 |
| **HVAC** | | | | | | | | | |
| Contingent Valuation | 70 | $19 | $0 | $0 | $0 | $0 | $60 | $100 | $600 |
| Direct Scaling - Reported | 76 | $61 | $0 | $0 | $0 | $0 | $14 | $120 | $2,400 |
| Direct Scaling - Actual | 64 | $8 | $0 | $0 | $0 | $0 | $0 | $0 | $372 |
| LMS – Reported (PNNL) | 79 | $99 | $0 | $0 | $0 | $0 | $65 | $810 | $3,240 |
| LMS – Actual (PNNL) | 64 | $11 | $0 | $0 | $0 | $0 | $0 | $0 | $502 |
| LMS – Reported (In-Sample) | 79 | $45 | $0 | $0 | $0 | $0 | $38 | $368 | $1,472 |
| LMS – Actual (In-Sample) | 64 | $5 | $0 | $0 | $0 | $0 | $0 | $0 | $228 |
| **Overall** | | | | | | | | | |
| Contingent Valuation | 209 | $22 | $0 | $0 | $0 | $0 | $0 | $100 | $6,000 |
| Direct Scaling - Reported | 225 | $36 | $0 | $0 | $0 | $0 | $36 | $120 | $2,800 |
| Direct Scaling - Actual | 206 | $3 | $0 | $0 | $0 | $0 | $0 | $8 | $372 |

| Valuation Method | # | Distribution of NEI Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | P90 | P95 | Max |
| LMS – Reported (PNNL) | 230 | $138 | $0 | $0 | $0 | $0 | $324 | $660 | $3,780 |
| LMS – Actual (PNNL) | 210 | $15 | $0 | $0 | $0 | $0 | $44 | $89 | $558 |
| LMS – Reported (In-Sample) | 230 | $39 | $0 | $0 | $0 | $0 | $98 | $195 | $1,472 |
| LMS – Actual (In-Sample) | 210 | $5 | $0 | $0 | $0 | $0 | $8 | $22 | $228 |

Table IV-12E compares the distribution of contingent valuations to qualitative responses about the change in noise level. The values were higher for those who said "much less noisy" than for those who said "somewhat less noisy" at the lower end of the distribution, but the opposite was true at the upper end of the distribution.

**Table IV-12E**
**Distribution of Contingent Valuations**
**By Reported Change in Noise**

| Change in Noise Level | # | Distribution of Contingent Valuations | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Min | P25 | Median | P75 | Max |
| Much Less Noisy | 15 | $691 | $50 | $100 | $100 | $200 | $6,000 |
| Somewhat Less Noisy | 12 | $179 | $5 | $63 | $175 | $225 | $600 |
| No Change[1] | 182 | $0 | $0 | $0 | $0 | $0 | $0 |
| Somewhat Noisier | 0 | - | - | - | - | - | - |
| Much Noisier | 0 | - | - | - | - | - | - |

[1]These participants were not asked to provide a contingent valuation; we assigned a contingent valuation of $0 based on their "no change" response.

## *D. NEI Method Assessment*

This section discusses the advantages and disadvantages of the NEI estimation methods in the context of our analysis.

Comparison of Scaling Methods and Contingent Valuation

For all the NEIs except health, the CV method produced results that were somewhat close to the middle of the range of estimates. The estimated valuation for changes in health using the CV method was a major exception, with an average valuation of $2,157 for HVAC participants and $1,382 for electric baseload participants. This was much higher than the valuations from any of the other methods.

The extremely high values for health can be explained by the presence of extreme values that respondents provided for the CV question. The CV method often results in extreme values, and there were several very high valuations for other NEIs. However, dropping the most extreme outliers typically resulted in maximum values of $10,000 or less for the remaining distributions. In the case of health however, four extreme values were dropped (all $1 million) and the maximum remaining value was $200,000. There were also two other large outliers in

the data, with reported valuations of $50,000 and $10,000. These values were all extreme outliers, with 95 percent of contingent valuations for health below $500.

This demonstrates one of the major disadvantages of CV, which is that it produces extreme values. However, it is reasonable that some participants who had a large improvement in health would place an extremely high value on that benefit.

Survey respondents were highly inconsistent between the dollar values they reported and how they answered the relative valuation questions. If a respondent said the change in winter comfort was more valuable than their bill savings, we would expect them to have a CV dollar value higher than their reported bill savings. In practice, respondents typically answered that they valued the NEI higher than their bill savings even when their CV response was notably lower than their reported bill savings. Among respondents who said that the NEI was of the "same value" to them as their bill savings, they did not usually report equal dollar values, and the differences between their NEI dollar valuation and reported bill savings were often large.

This inconsistency between relative valuation and contingent valuations occurred frequently. Among 54 respondents who had enough information to compare winter comfort, 31 provided inconsistent responses. Among those who said that they valued winter comfort more than their bill savings, on average they provided a contingent valuation that was $148 *lower* than their reported bill savings. This issue was seen across the NEIs.

Compared to scaling methods, CV has fewer restrictions on the possible valuations assigned by a respondent. In addition to allowing negative valuations, this method does not have the ceilings and floors associated with multipliers, nor does it force values to scale with bill savings.

The major disadvantage of the CV method is that its open-ended nature yields volatile and inconsistent valuations, and the prompt is difficult for some respondents to answer. Although most of the average valuations appeared reasonable, the high value for health highlights the extent to which valuations can be leveraged by extreme responses. Therefore, we agree with the common notion in the literature that the disadvantages of CV make it too unstable to be a reliable indicator of NEI value.[22] However, in conjunction with other methods, CV may contribute valuable information.

Comparison of Direct Scaling and Labeled Magnitude Scaling

The DS method and LMS using multipliers derived from the DS question consistently produced lower estimates than LMS using the PNNL multipliers. When respondents said they valued NEIs more than their bill savings, that corresponds to a PNNL multiplier greater than one. However, the DS question limited respondents to provide a value between 0 and 100 percent of their bill savings. If respondents correctly understood the DS method, those who said the NEI was more valuable than their bill savings should provide the maximum response

[22] Clendenning, et al. 2012, *op. cit.* See also: Hausman, J. 2012. "Contingent valuation: from dubious to hopeless." *Journal of Economic Perspectives, 26*(4), 43-56. See also: Kahneman, D., Ritov, I., Jacowitz, K. E., & Grant, P. 1993. "Stated willingness to pay for public goods: A psychological perspective." *Psychological Science, 4*(5), 310-315.

of 100 percent. However, a majority had lower values, and that the mean response for this group was consistently below the lower PNNL multiplier of 0.65. It is possible that these respondents understood the question to mean they were valuing the NEI at, for instance, ten percent *more than* bill savings rather than ten percent *of* bill savings. However, many relative valuations were also inconsistent with contingent valuations in dollars, where this confusion was unlikely to have occurred. More in-depth research with participants should be conducted to further understand these measurement issues.

Respondents who said that the value of NEIs was the same or less than their energy savings tended to provide lower values for the direct scaling question than those who said the NEI was of more value than their energy savings. However, their responses again provided lower multipliers than those from the PNNL study, even though in these cases it was possible for them to provide direct scaling values equal to those multipliers (between zero percent and 100 percent).

When asked to furnish the NEI value as a percentage of energy savings, there was clustering at low values (ten percent to 30 percent), at the middle value of 50 percent, and at the extremes (zero and 100 percent).

The DS multipliers may be underestimated given our restrictions, limiting responses to 100 percent of the energy value. This was an intentional design, to create more reasonable valuations than are sometimes seen. However, we will consider removing this restriction in future research.

Using Reported or Actual Bill Savings

Reported bill savings resulted in higher estimates of NEI values than actual bill savings. This occurred because some respondents reported savings that were much higher than those measured in the data. The distributions of reported and actual bill savings therefore differed greatly, with more extreme values for reported savings. In statistical terms, this resulted in a much more right-skewed distribution of reported savings compared to actual savings, and a significantly higher mean for the reported savings. This was true even after dropping the most extreme outliers.

Many respondents reported that they did not see a change in their energy bills and therefore reported bill savings of $0. In comparison, actual savings provides a non-zero amount for all but one participant, whether or not that change was due to the installed measures. This is important because the NEI scaling estimates were $0 when reported bill savings were zero (or less than zero). Forty-four percent of actual savings were below $0, and therefore produced estimates for NEI value of zero dollars. There were also fewer participants for whom actual savings were available among air sealing/insulation participants and HVAC participants. Sample sizes were consistently smallest when using the methods with actual savings. Therefore, the number of participants with non-zero estimates of NEI value was higher when using reported savings.

The major disadvantage of using actual savings values is that we expect respondents to provide NEI valuations that are consistent with their beliefs about bill savings. These answers might be different if they were told their actual bill savings. For example, we would expect someone who believed that their bill savings were zero to say that they value the NEI more than their bill savings if they received any value. However, if they were aware that their actual bill savings were substantial, they might say that the value of the NEI was lower. Therefore, the accuracy of the assigned multipliers may be lower when using actual savings. This is important because NEI studies often attempt to apply multipliers from previous studies to actual bill savings estimates, because many of these studies do not include a participant survey.

We found that actual savings values produced relative valuations by measure group that were least likely to match our prior expectations and were inconsistent with the ordering of NEI values produced by CV or scaling with reported savings.

## E. Estimated Non-Energy Impacts

Table IV-13 displays the estimated value of the five NEIs by measure group, using the DS method with actual bill savings and the LMS method with PNNL multipliers and reported bill savings. These methods typically provided the lowest and highest NEI valuations. The estimates from these two methods were quite different, demonstrating the sensitivity of NEI estimates to research methodology.

**Table IV-13**
**Estimated Non-Energy Impacts**
**By Measure Group**

| Participant Group | Average Valuation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Direct Scaling – Actual | | | | | Labeled Magnitude Scaling – Reported (PNNL) | | | | |
| | Winter Comfort | Summer Comfort | Safety | Health | Noise | Winter Comfort | Summer Comfort | Safety | Health | Noise |
| Electric Baseload | $17 | $16 | $22 | $20 | $2 | $220 | $107 | $72 | $31 | $147 |
| Air Sealing & Insulation | $35 | $8 | $3 | $3 | $1 | $252 | $211 | $108 | $84 | $112 |
| HVAC | $16 | $15 | $4 | $11 | $8 | $259 | $236 | $179 | $195 | $99 |
| **Total** | **$18** | **$16** | **$18** | **$18** | **$3** | **$227** | **$131** | **$89** | **$57** | **$138** |

Table IV-14 displays the measures installed for each group of participants, to provide an understanding of the level of NEIs expected.

- Electric Baseload: Over half of the participants received a new refrigerator, which may contribute to lower noise from a quieter appliance. A new refrigerator could also contribute to health and safety if the old appliance was not working properly and allowing food to spoil more quickly. The AC replacement could also contribute to improved summer comfort and health.
- Air Sealing and Insulation: All participants in this group received air sealing work, 54 percent also received insulation measures, and 17 percent received a new refrigerator.

These measures could lead to significant impacts on winter and summer comfort as well as health. Moderate impacts are also expected for safety and noise.

- HVAC: Participants received repairs or upgrades to their heating and cooling equipment. We expect these measures to have moderate to substantial impacts on home temperatures during winter, and therefore to have significant impacts on winter comfort and health. For those with gas heating, this could also improve safety. Many of these participants also received air sealing and insulation work, which may improve all measured NEIs to varying degrees. Some participants also had a new air conditioner installed, which is expected to improve summer comfort and noise.

**Table IV-14**
**Measures By Participant Group**

| Participant Group | Total | Percent of Jobs with Each Measure | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Air Sealing | Insulation | Boiler | Furnace | Electric Baseboard | Heat Pump | Heat Sys. Labor/Part | Refrigerator | AC |
| Electric Baseload | **85** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 52% | 16% |
| Air Sealing & Insulation | **83** | 100% | 54% | 0% | 0% | 0% | 0% | 0% | 17% | 0% |
| HVAC | **90** | 39% | 22% | 11% | 8% | 7% | 7% | 51% | 19% | 31% |

Table IV-15 compares the expected NEI values and the estimated NEI values using the LMS method with in-sample multipliers and reported savings. The table shows that the estimated values somewhat match expectations, but there are notable differences.

- Winter Comfort: Baseload measures are not expected to have an impact on winter comfort, while air sealing and insulation, and HVAC measures, are expected to have a large impact. However, our estimate for baseload customers was about the same as the other groups.
- Summer Comfort: Baseload measures are expected to have some impact on summer comfort as they can occasionally include replacement of window AC units, but overall, the impact is expected to be low. Air sealing and insulation, and HVAC measures are expected to have a large impact. Our estimates do show higher NEI summer comfort values for air sealing and insulation and the highest for HVAC.
- Safety: Baseload measures are expected to have a low impact on safety. Air sealing and insulation is expected to have a medium impact on safety, and HVAC measures are expected to have the largest impact on safety. Our estimate for baseload safety was about the same as air sealing and insulation, but the HVAC estimate was higher, as expected.
- Health: Baseload measures are expected to have a low impact on health. Air sealing and insulation, and HVAC measure are expected to have a large impact as they can improve the winter and summer temperature in the home. As expected, the estimates for air sealing and insulation and for HVAC were higher than baseload.
- Noise: The NEI estimates were expected to be lowest for baseload, but they were about the same as air sealing and insulation, and HVAC was only somewhat higher.

Although our estimates using the preferred method did not always match expectations, they aligned better than some of the other methods. The difference between expectations and estimates was not consistent across methods. Methods using actual savings tended to have the lowest match with expectations.

**Table IV-15**
**NEI Comparison to Expectation**
**Using LMS with Reported Bill Savings and In-Sample Multipliers**

| Participant Group | Expected and Estimated NEI Values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Winter Comfort | | Summer Comfort | | Safety | | Health | | Noise | |
| | Expect | Estimate | Expect | Estimate | Expect | Estimate | Expect | Estimate | Expect | Estimate |
| Electric Baseload | None | $72 | Low | $40 | Low | $34 | Low | $11 | Low | $39 |
| Air Sealing & Insulation | High | $72 | High | $58 | Med | $36 | High | $28 | Med | $34 |
| HVAC | High | $74 | High | $88 | High | $82 | High | $97 | Med | $45 |

Table IV-16 displays our preferred and recommended set of NEI values for the study, the LMS method with reported bill savings and in-sample multipliers. Across the five NEIs, the table shows a total NEI value of $196 for baseload only participants, $228 for air sealing and insulation participants, and $386 for HVAC participants.

The LMS method with reported bill savings and in-sample multipliers was selected for the following reasons.

- Participant Response: This method makes use of participant responses on estimated bill savings, NEI value compared to bill savings, and a qualitative comparison of the value of the NEI to the bill savings. It does not make use of the most unreliable data – the CV direct estimate of NEI value.
- Bill Savings: The estimate uses the participant's estimate of bill savings, as they are valuing the NEI compared to that level, as opposed to the actual bill savings. This also provides a larger sample of respondents than using actual savings.
- Multiplier: The estimate uses the in-sample multiplier, which is derived from program participants' experience, as opposed to using the PNNL multiplier, which is arbitrarily developed based on an unrelated previous study.
- NEI Value: Estimates were concentrated towards the middle or low ends of the estimate ranges and provide what we believe are justifiable values for most of the NEIs. The estimates were moderately in line with expectations. Other methods often produced estimates that did not match expectations and were sometimes implausible.

However, important uncertainties remain regarding these results.

- Reported Savings: These values could overestimate NEIs in some cases because of inflated reports by some respondents.

- In-Sample Multipliers: These multipliers may be less accurate if respondents were confused about how to assign a value as a percent of their bill savings.
- LMS Interpretation: The in-sample multipliers were not consistent with the literal interpretation of the LMS question. For example, the multipliers for "more value" were less than one.
- Health and Safety Impacts: Respondents may lack the knowledge to accurately assess how these have changed as a result of the program.
- Negative Valuations: The LMS method does not allow for negative valuations, so it may overestimate the value of NEIs if there were substantial negative impacts for some participants.

**Table IV-16**
**Mean Annual NEI Values for Selected NEI Estimation Method**
**LMS with Reported Bill Savings and In-Sample Multipliers**

| Measure Group | Non-Energy Impact | | | | | Total NEI |
|---|---|---|---|---|---|---|
| | Winter Comfort | Summer Comfort | Safety | Health | Noise | |
| Electric Baseload | $72 | $40 | $34 | $11 | $39 | $196 |
| Air Sealing and Insulation | $72 | $58 | $36 | $28 | $34 | $228 |
| HVAC | $74 | $88 | $82 | $97 | $45 | $386 |
| **All Participants** | **$72** | **$48** | **$41** | **$24** | **$39** | **$224** |

## F. Summary

We asked program participants to value the Non-Energy Impact (NEIs) associated with the work done in their home, which was categorized as baseload measures, air sealing and insulation, or HVAC work. Using multiple calculation methods, we developed estimates of the NEIs for the participants who provided sufficient data.

Our recommended method is the LMS with reported bill savings and in-sample multipliers. This method utilizes participant responses for estimated bill savings, NEI values compared to bill savings, and a qualitative comparison of the value of the NEI to the bill savings. The participant's estimate of bill savings is preferred because the respondent is valuing the NEI relative to their perceived bill savings. The in-sample multiplier is preferred because it is derived from the participant's program experience. These estimates were in the middle or on the lower end of the methods and provide what we believe is a reasonable value for most of the NEIs given our expectations.

The total value of the five estimated NEIs was $196 for baseload only participants, $228 for air sealing and insulation participants, and $386 for HVAC participants. The HVAC participants had the highest value for all five NEIs.

We expected baseload only participants to have relatively low NEI values, as most of the measures for these participants did not have a clear relationship to the NEIs under

consideration. Our preferred method estimated a total NEI value for this group that was higher than expected relative to the other groups. The results for this group should therefore be treated with some caution.

# V. Findings & Recommendations

This section summarizes the findings on the NEIs associated with the program and provides recommendations for future NEI research.

## A. Key Findings

The study found that the different NEI estimation methods sometimes resulted in very different NEI values. The differences were based upon asking participants to report a dollar value for the NEI benefit compared to asking them to value it in relation to their bill savings.

We recommend using the LMS with reported bill savings and in-sample multipliers. This method utilizes participant responses for estimated bill savings, NEI values compared to bill savings, and a qualitative comparison of the value of the NEI to the bill savings. The participant's estimate of bill savings is preferred because the respondent is valuing the NEI relative to their perceived bill savings. The in-sample multiplier is preferred because it is derived from the participant's program experience. These estimates are in the middle or on the lower end of the methods and provide what we believe is a reasonable value for most of the NEIs given our expectations.

Various levels of NEI impacts are expected based on the specific measures installed. The estimated value orderings from this study often did not match expectations for relative valuations. However, for our preferred method, the estimates were moderately aligned with expectation. Participants who received HVAC measures had the greatest NEI values for winter comfort, summer comfort, safety, health, and noise.

The total value of the five estimated NEIs was $196 for baseload only participants, $228 for air sealing and insulation participants, and $386 for HVAC participants.

## B. Recommendations

Based on these findings, we make the following recommendations for future NEI research.

- Cognitive Interviewing: Conduct in-depth interviews with program participants to assess how they perceive questions, how they think about NEIs, and how researchers can best report their experiences.
- Direct Scaling Responses: Consider allowing responses greater than 100 percent for the value of the NEI relative to bill savings.
- LMS Categories: Include a greater number of categories instead of just more valuable than energy savings, the same value as energy savings, and less value than energy savings.

Additional research is needed with program participants to understand how best to value participant NEIs.