X1942C Cross-cutting NEI Study – HES & HES-IE NEIs

FINAL REPORT

May 15, 2023

SUBMITTED TO:
Connecticut Energy Efficiency Board

SUBMITTED BY:
Shirley Pon and Greg Clendenning, NMR Group, Inc.

NMR Group, Inc.

EMPLOYEE-OWNED CERTIFIED

Table of Contents

Executive Summary

PURPOSE

As part of the X1942 Non-Energy Impacts (NEIs) study, the NMR study team conducted an analysis to quantify NEIs for program participants who participated in the Home Energy Solutions (HES) and Home Energy Solutions – Income Eligible (HES-IE) programs and installed air sealing and insulation. This study used web surveys to collect data to quantify NEIs associated with air sealing and insulation. The analysis applied algorithms used in past studies to establish NEI values for each measure and NEI category. This report, which is part of the larger X1942 study, uses the same methods described in the *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*[1] and discusses the results from this analysis and presents the air sealing and insulation NEIs the study was able to quantify.

BACKGROUND

The 2016 HES/HES-IE Process Evaluation study (R4) found participants experienced positive net NEIs from participating in the program.[2] They highly valued NEIs such as comfort, safety, and property value improvements. The study recommended the program consider structuring future evaluation efforts to estimate measure specific NEI values that could be added to program BCRs to increase program total resource benefits. This study applies a modified version of the calculation methodology used in the R4 study to quantify NEIs from air sealing and insulation measures associated with the HES and HES-IE programs.

STUDY GOAL

The goal of the X1942C study is to quantify NEIs from insulation and air sealing measures. This study aims to fill gaps and provide measure-specific NEIs not currently included in the Connecticut PSD or not used in cost effectiveness (C/E) testing.[3] This study includes the following high priority NEIs:

- Comfort in the summer
- Comfort in the winter
- Outdoor noise heard inside the home
- Indoor noise heard inside the home
- Air quality in the home
- Change in humidity or dampness
- Change in mold

[11] NMR Group, Inc. 2023. *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*. For the Connecticut Energy Efficiency Board. (In progress)
[2] NMR Group, Inc. 2016. *Project R4 HES/HES-IE Process Evaluation and R31 Real-time Research.* For the Connecticut Energy Efficiency Board, Eversource, and United Illuminating. https://www.energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf
[3] The Companies currently quantify and claim several NEIs for HES-IE only. See Appendix 6 of the 2022 PSD and Appendix A of the 2023 PSD.

FINDINGS

Table 1 presents the NEIs that the study was able to quantify using information from end-user surveys. Currently, none of these NEIs are included in Appendix Six (Non-Energy Impacts) in Connecticut's 2022 Program Savings Document (PSD) or in Appendix B of the 2023 PSD for use in the Total Resource Cost (TRC) Test, which is used as a secondary test to provide a broader perspective of program performance, except for the HES-IE program, which uses the TRC test as the primary B/C metric.[4] Currently, the HES-IE NEIs in the 2022 PSD are at the program-wide level while the 2023 PSD only includes costs associated with "arrearages, debt write-off costs, or administrative costs". The NEI values presented in Table 1 and Table 2 are per participant perspective annual values specific for air sealing and insulation, which are expected to last through the life of the measures.

Participants who received incentives for air sealing and insulation through the program experienced positive net impacts from the program. For most of the NEIs studied, the positive NEIs outweighed negative NEIs. The HES program had a net average annual value of $316 ($346 including health NEIs) or 113% of the value of their expected energy savings (average expected annual savings is 8.5 MMBtu per participant).[5] Although not statistically different from HES, the HES-IE program had a net average annual value of $299 ($329 including health NEIs). This was also 113% of the value of their expected energy savings (average expected annual savings is 8.2 MMBtu per participant), as shown in Table 1 and Table 2.

For benchmarking purposes, this study referenced the Massachusetts Technical Resource Manual[6] which reports total NEI values associated with air sealing and insulation installed in single family and single-family income-eligible households. However, the Massachusetts TRM included NEIs that are different than the NEIs included in this study except for thermal comfort, noise reduction, reduced asthma symptoms, and fewer missed days worked. Table 16 and Table 17 in Appendix B.4 provide the comparison of the NEIs in more detail for single family and single family income-eligible NEIs, respectively.

[4] See section five of the 2022-2024 Conservation and Load Management Plan and Appendix 6 of the 2022 PSD.
[5] Bill savings are based off retail energy prices and not wholesale.
[6] Massachusetts Electric and Gas Energy Efficiency Program Administrators. 2023. *Massachusetts TRM 2023 Plan Version.* https://www.masssavedata.com/TRL/Technical%20Reference%20Manual%202023%20Plan%20-%20010323.pdf *Appendix B.* https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/63b4ada052e03925d3412295/view?authToken=e3b8925034aedea1d18be0cf5b83eb9c3dd6353c4192e6a7a1b60f8c9285aaffc0f60c5bd650cdd4e351f0d720caa31515526737f6abfce8e7a5001cdb00a736e4abb248183d2f

RECOMMENDATIONS

Recommendation 1: NEIs for HES-IE participants who install air sealing and insulation should be used in cost-effectiveness tests as allowed now and in the future.[7] For the TRC test, adding the measure-specific NEIs derived from this study to current estimates of total program benefits relative to costs increases benefit-cost ratios (BCRs) for all fuels and Companies and would inform program planning. It will not impact BCRs for the Modified Utility Cost Test (MUCT), which is the primary test for electric programs that save fossil fuels, because the MUCT does not include participant NEIs (the TRC is the primary test for only the HES-IE program and includes participant NEIs).

Recommendation 2: This study recommends using values in Table 1 for air sealing and insulation for HES-IE participants who installed air sealing and insulation through the program. It is common practice for air sealing to be installed with insulation and this was the case for most respondents in this study. A regression analysis did not find insulation and air sealing total NEI values to be statistically different. For scenarios where only air sealing or insulation are installed, refer to Table 14 and Table 15 in Appendix B.4 for HES and HES-IE measure-specific NEI values, respectively.

Table 1: Summary of Monetized NEIs for Air Sealing and Insulation[1,2]

(Annual NEI Value per Average Participant that Installed Air Sealing and Insulation)

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Air quality in the home	$15.76	$29.06	$21.75
Change in humidity or dampness	$26.61	$49.25	$36.80
Change in mold	$15.76	$26.17	$20.45
Comfort in the summer	$105.20	$53.62	$81.99
Comfort in the winter	$114.31	$63.38	$91.39
Noise heard from inside home	$19.42	$35.95	$26.86
Noise heard from outside home	$19.41	$41.33	$29.28
Sub Total	**$316**	**$299**	**$309**

[7] The approved 2022-2024 C&LM Plan uses three cost-effectiveness tests to compare the net present value of program benefits with the cost to achieve those benefits: (1) the Utility Cost Test, (UCT) (2) the MUCT, and (3) the TRC Test. The UCT includes the value of utility-specific benefits and program costs associated with those benefits but does not include NEIs. The MUCT includes all benefits and costs as the UCT as well as oil and propane-avoided costs, The MUCT is the primary test for electric programs that save fossil fuels. The study team notes that the 2023 Plan Update to the 2022-2024 C&LM Plan has been posted for public comment and includes several changes to cost-effectiveness testing. The 2023 Plan Update incorporates the new Connecticut Efficiency Test (CTET) that applies the principles of the MUCT to all programs and continues the supplemental use of the TRC test for HES-Income Eligible program. The new CTET includes benefits of the avoided costs of electricity, natural gas, oil, propane, and non-embedded gas emissions as well as low-income non energy impact (NEI) costs associated with "arrearages, debt write-off costs, or administrative costs" and all program costs associated with acquiring those benefits. The Companies currently quantify and claim several NEIs for HES-IE only. See Appendix 6 of the 2022 PSD and Appendix A of the 2023 PSD. See also Connecticut Department of Energy and Environmental Protection. April 2022. Updates to Connecticut Conservation and Load Management Cost Effectiveness Testing. https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Attachment-B---Cost-Effectiveness-Testing-Update.pdf

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Asthma		$0.75	
Allergies		$11.40	
Colds/Viruses		$1.86	
Sinusitis		$1.42	
Missed work	$2.99	$3.78	$3.35
Missed school		$10.78	
Health NEIs Sub Total	**$29**	**$30**	**$30**
Total Value[3]	**$346**	**$329**	**$338**

[1] NEIs are for participants who received incentives for air sealing and insulation through the program. NEI values are in 2020 dollars.
[2] Table 12 reports the main monetized NEI results of this study with 90% confidence intervals.
[3] Values may not sum up to total due to errors in rounding.

Table 2: Summary of Non-health NEIs as Percent of Annual Measure Savings [1,2]

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Air quality in the home	11%	16%	13%
Change in humidity or dampness	13%	15%	14%
Change in mold	7%	15%	11%
Comfort in the summer	32%	21%	27%
Comfort in the winter	36%	24%	30%
Noise heard from inside home	5%	9%	7%
Noise heard from outside home	10%	14%	11%
Total	**113%**	**113%**	**113%**

[1] NEI multipliers are for participants who received incentives for air sealing and insulation through the program.

Section 1 Methodology

1.1 Participant End-user Surveys

This study conducted primary data collection via web surveys from HES/HES-IE program participant end-users to quantify NEIs associated with air sealing and insulation in Connecticut from 2017 to 2020. See Appendix A.1 for additional details on the methodology and the targets and achieved completes for this research task.

1.2 Identifying NEIs

This study identified specific NEIs to be quantified for particular air sealing and insulation installation scenarios. The following list breaks down the rationale for the NEIs identified in this study:

- **Comfort in the summer –** Adding air sealing and insulation can provide cooling-related comfort by keeping cold air from escaping or hot air and moisture from entering.
- **Comfort in the winter –** Adding air sealing and insulation can provide heating-related comfort by keeping heat from escaping or cold air and moisture from entering.
- **Outdoor noise heard from outside and inside the home –** Adding insulation can reduce the amount of noise traveling through the walls within the home as well as outside noise coming into the home. Air sealing can also reduce the amount of outside noise entering the home.
- **Air quality in the home –** Air sealing and insulation tighten up the home by reducing air flow which can lower the air quality in a home but also reduce the infiltration of outdoor air pollutants into the home.
- **Change in humidity and dampness –** Reduced air flow in a home can lead to an increase in humidity and dampness when moisture gets trapped without adequate ventilation.
- **Change in mold –** Reduced air flow in a home can also lead to an increase in mold when moisture gets trapped without adequate ventilation. Insulation and air sealing also regulate temperature and prevent moisture from entering a home, inhibiting mold growth.
- **Household member's health –** Changes in air quality and increased comfort from air sealing and insulation can increase or decrease incidences of illnesses such as asthma, colds/viruses, allergies.
- **Missed work and school –** Increased or decreased incidence of illnesses from air sealing and insulation can reduce loss of earnings from days of missed work and school.

1.3 QUANTIFYING NEIS

This study uses a combination of a contingent valuation approach where respondents are asked to place a value on the NEIs they experience using a labeled magnitude scale on non-health related impacts, such as reduced noise and improved comfort, and self-reported direct measurement of health impacts, such as impacts on asthma triggers and other ailments. Figure 1 shows the NEIs by their measurement approach.

1.3.1 Labeled magnitude scale (relative valuations)

To develop NEI values, the web survey asked survey respondents if the installation had a positive, negative, or no effect on various non-energy related elements in their households or properties.

For any elements where respondents observed positive or negative impacts as a result of the program, the survey asked them to compare the value of that NEI to the energy savings associated with their participation in the HES or HES-IE program. The survey also asked respondents to identify overlapping NEIs to avoid double counting NEI benefits. Furthermore, the survey asked the respondents to consider the net impacts of the NEIs combined. The analysis used these inputs to estimate NEI dollar values. For more a detailed description of the methodology used to calculate NEI values, see Appendix A.2.1 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*.

1.3.1.1 Study Limitation

Survey respondents were not presented with information about their estimated savings in the survey. The study assumed that program implementor provided respondents with expected savings from their air sealing and insulation installations. The survey asked respondents to provide an estimate of their energy bill savings associated with air sealing and insulation measures. Approximately 28% of the respondents were unable to and another 30% indicated they did not observe any savings, suggesting that the majority may not have been aware of their savings from their measure installations.

Given that the value of the NEI was estimated relative to their expected energy savings, there may be a disconnect between what the respondents were thinking their bill savings were compared to the bill savings calculated from program-reported savings. This disconnect likely introduces uncertainty and bias into the estimates. The study addresses some of this discrepancy by applying a realization rate adjustment to the program-reported savings used to estimate bill savings and NEI values later discussed in Appendix B.1.

1.3.2 Self-report Direct Measurement of Changes in Occurrences

For health impacts, the web survey asked respondents for the number of times they had to seek medical care for specific health ailments in the year before and the year after participating in the program. The survey also asked whether the number of days of work and school missed increase, decrease, or stayed the same.[8] The analysis used these inputs to calculate the avoided cost per

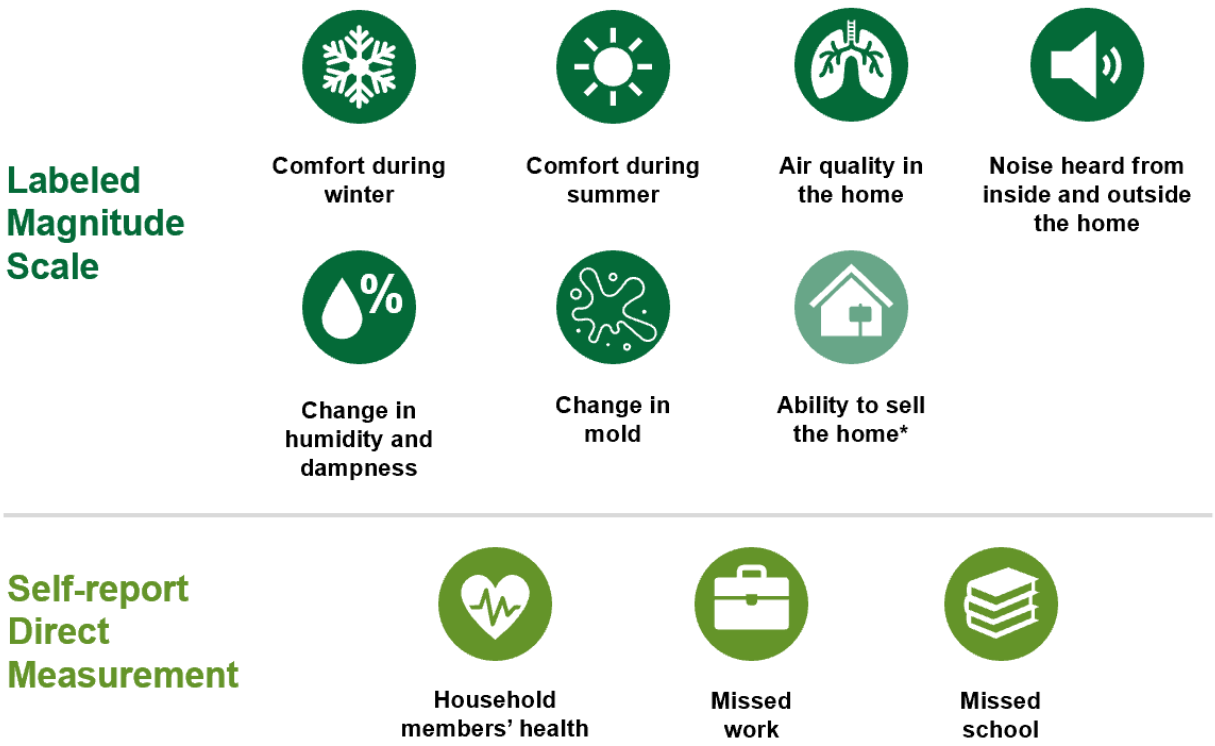
[8] While the survey included residential program participants who received air sealing and insulation equipment incentives from the HES and HES-IE programs between 2017 and 2019, the period of survey fielding coincided with the pandemic that shifted the workforce to remote working and students to remote learning. This period of remote

occurrence of specific illnesses and loss of earnings from missed work and school. Appendix A.2.2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* provides a more detailed description of the methodology used to quantify health NEI values.

1.3.2.1 Study Limitation

One limitation of this method is that the survey used to calculate the health NEIs in this study asks the respondents to compare the number of times they experienced illness, missed work or school resulting from illnesses before and after their participation in the program. This method did not use a control group to account for weather and other unobserved year over year changes that may impact illness and missed work or school. The survey attempts to control for the pandemic by asking respondents to focus on the period prior to 2020. However, despite this, respondents may have a difficult time separating out the time periods given that it had been several years since they had participated in the program by the time the survey was fielded.

Figure 1: NEIs by Approach



* Measure excluded from main findings

working and learning may influence responses that may not be reflective of times of regular in office work and in-person learning.

Section 2 Findings

2.1 Non-health NEIs

2.1.1 By Program

The total dollar value of all non-health related NEIs is $309 for the average air sealing and insulation end-user. Figure 2 shows the total dollar value of all NEIs per year by program for participants who received incentives for air sealing and insulation. While the HES program has the higher overall NEI value at $316 compared to the HES-IE program at $299, the differences in the total dollar value of the NEIs by program are not statistically significant at the 90% confidence level.

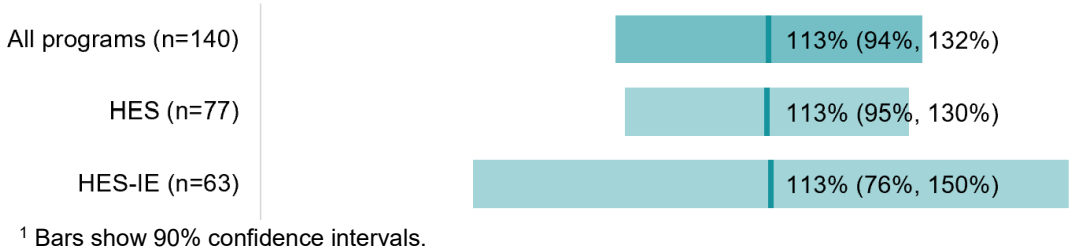
Figure 2: Annual NEI Dollar Value by Program

(Annual NEI Value per Average Participant that Installed Air Sealing and Insulation)

[1] Bars show 90% confidence intervals.

Figure 3 shows the corresponding percent of savings by program. On average, respondents value NEIs the same for HES and HES-IE (113%) when compared to the value of their expected energy savings.

Figure 3: Percent of Savings by Program



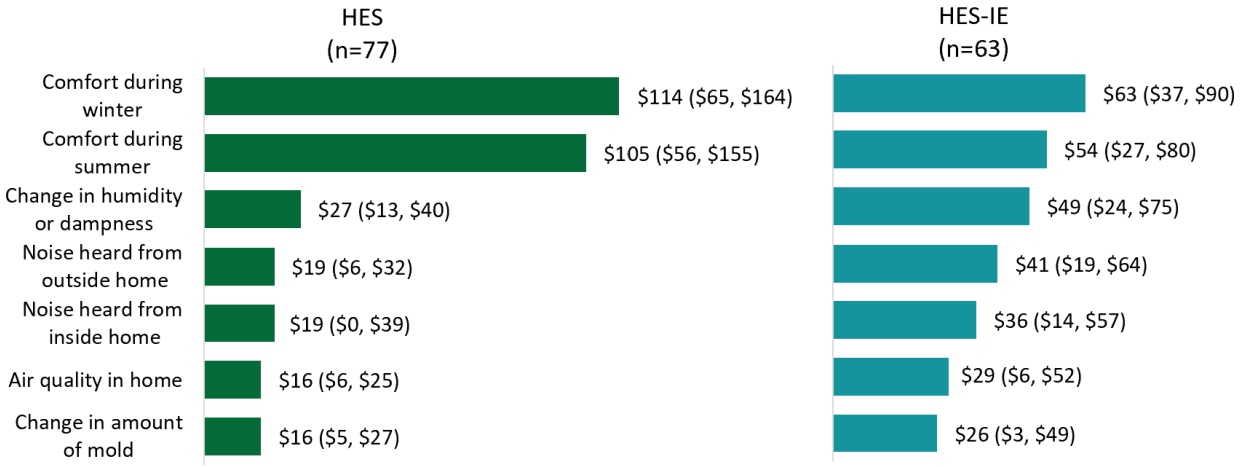
[1] Bars show 90% confidence intervals.

Figure 4 shows the average annual NEI dollar values per participant per year by for air sealing and insulation by program. On average, the NEIs with the highest values are comfort during winter ($114) and summer ($105) for HES. For HES-IE, the NEIs with the highest values included comfort during winter ($63) and summer ($54) and change in humidity or dampness ($49).

Noise heard from inside and outside the home, air quality, and change in the amount of mold had the lowest values for both HES and HES-IE programs. They were also the least experienced NEI. For example, only 12% of HES respondents and 19% of HES-IE respondents indicated they experienced reduced noise heard from inside the home.

Figure 4: Annual NEI Dollar Value by Program [1]

(Annual NEI Value per Average Participant that Installed Air Sealing and Insulation)



[1] 90% confidence intervals shown in parentheses.

2.1.2 By Measure

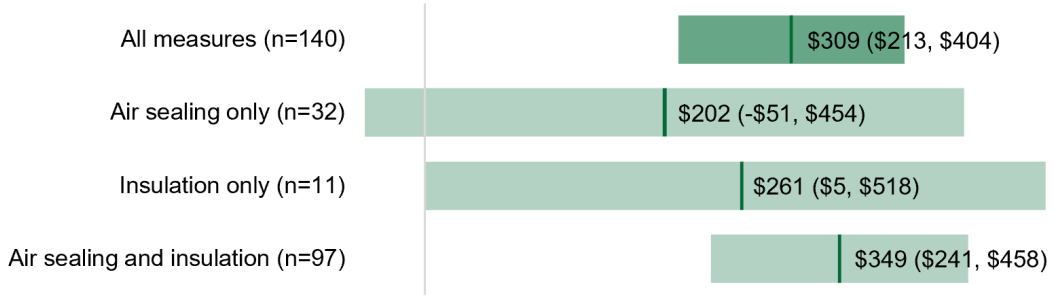
Figure 5 shows the total NEI values by measure installed (air sealing only, insulation only, or air sealing and insulation). The values are not statistically different from each other at the 90% confidence level.[9] The majority of respondents (69%) installed both air sealing and insulation. Since insulation is commonly installed with air sealing, it is likely that participants could have installed either air sealing or insulation at another time that was not documented in the program tracking data. However, while the majority of program participants receive air sealing through the program, historic installation rates for insulation ranged from 11% to 20% from 2014 through 2022.

Table 14 and Table 15 in Appendix B.4 report the HES and HES-IE results, respectively, for air sealing-only and insulation-only installation scenarios. For air sealing-only and insulation-only NEI values, the study split out the combined air sealing and insulation NEI values (shown in Figure 4) by the share of total respondent energy savings associated with the two measures, as reported in Table 8. For HES, the study multiplied the combined NEI values by the shares of the total HES respondent energy savings for air sealing (17%) and insulation (83%) to get air sealing and insulation-only values, respectively. For HES-IE, the study applied 11% for air sealing and 89% for insulation to the total HES-IE respondent energy savings.

[9] Linear regression analyses, discussed in Appendix B.4, showed that air sealing and insulation values were not statistically different from each other for comfort in the winter, comfort in the summer, as well as, total annual NEI value.

Figure 5: Annual NEI Dollar Value by Measure

(Annual NEI Value per Average Participant that Installed Air Sealing and Insulation)



[1] Bars show 90% confidence intervals.

Figure 6: Percent of Savings by Measure

[1] Bars show 90% confidence intervals.

2.2 HEALTH NEIS

Annual NEI values per participant attributable to avoided illnesses range from $0.75 to $11.40 ($7.82 to $118.36 lifetime). Table 3 provides the high-level calculation of the annual value per average participant attributable to asthma, allergies, sinusitis, and cold/viruses. The survey yielded very low levels of change in the number of incidences occurring per year. Survey respondents reported low levels of change for the other ailments. The analysis resulted in annual NEI values (per participant) of $0.75 for asthma, $11.40 for allergies, $1.42 for sinusitis, and $1.86 for colds and viruses. Appendix A.2.2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* provides a more detailed description of the methodology used to estimate these values.

Table 3: Annual and Lifetime NEI Values Per Participant for Reduced Illnesses

	Asthma	Allergies	Sinusitis	Colds/ Viruses
Avoided cost per incidence, adjusted to 2021 dollars[1] (A)	$284	$684	$249	$35
Avoided out of pocket cost per incident adjusted for insurance coverages[2] (B)	$108	$259	$95	$13
Change in number of incidents per year[3] (C)	0.007 (0.0002, 0.01)	0.044 (0.01, 0.24)	0.015 (0.003, 0.03)	0.140 (0.04, 0.20)
Annual value per average participant attributable to specific avoided illnesses (B×C)	**$0.75 ($0.02, $1.52)**	**$11.40 ($3.11, $19.65)**	**$1.42 ($0.25, $2.55)**	**$1.86 ($0.48, $3.22)**
Lifetime NEI attributable to program measures[4, 5]	**$7.82 ($0.21, $15.76)**	**$118.36 ($32.31, $204.00)**	**$14.71 ($2.56, $26.50)**	**$19.26 ($5.02, $33.43)**

[1] *Source:* Agency for Healthcare Research and Quality. Medical Expenditures Panel Survey, 2021. https://www.meps.ahrq.gov/mepsweb/.
[2] Avoided out of pocket cost per one incident adjusted for insurance coverages = avoided cost per incidence, adjusted to 2021 dollars × Percent of CT residents uninsured / not covered by health insurance for Northeast × Average percent out of pocket payment (from MEPs). E*xample Asthma: $284 (A) × 5.9% × 34% = $108 (B)*
[3] Incidence calculated from survey responses.
[4] Lifetime NEI attributable to program measures = Annual value per average participant attributable to avoided illness × weighted average years lifetimes × discount rate. E*xample Asthma: $0.75 × weighted average years lifetimes × 15 years × 5% = $7.82*
[5] 90% confidence intervals in parentheses

Annual NEI value per participant attributable to avoided missed work is $2.99 for average residential households and $3.78 for low-income households. Table 4 calculates the annual value per average participant attributable to missed work. Respondents reported an average of 0.03 fewer missed worked days after installing air sealing and insulation through the program which equates to an annual avoided cost of $2.99 and $3.78 for average residential and low-income households, respectively. Appendix A.2.2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* provides additional detail on the approach used to estimate the annual NEI value for missed days worked.

Annual NEI value per participant attributable to avoided missed school is $10.78. The analysis found a very small (0.13 days) reduction in the average number school days missed, as shown in Table 5, after program participation. See Appendix A.2.2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* for additional detail on the approach used to estimate the annual NEI value for missed school.

Table 4: Annual NEI Values Per Participant for Missed Work

	Average Residential	Low-income
Wages per day for average residential household[1] (A)	$251.68	$145.84
Wages lost per day for households with primary earner (corrected for without sick leave)[2] (B)	$55.37	$70.00
Change in number of average workdays missed due to program effect (C)[3]	0.05 (0.02, 0.09)	
Changes in household wages from change in sick days lost from work (B×C)[4]	**$2.99 ($1.20, $4.78)**	**$3.78 ($1.51, $6.04)**

[1] Wages per day for average residential household = Median hourly wage for Connecticut for all occupations in 2020 is $31.46 × Hours per workday = *$31.46 × 8 = $251.68 (A)*
Wages per day for low-income household = Median hourly wage for Connecticut for all occupations in 2020 is $31.46 × Hours per workday = *$18.23× 8 = $145.84 (A)*
Source: U.S. Bureau of Labor Statistics. "May 2020 State Occupational Employment and Wage Estimates Connecticut," May 2020, www.bls.gov.
[2] Wages lost per day for households with primary earner (corrected for without sick leave) = Percent of homes without sick leave in 2020 is 22% × hourly wage for average residential household. *$251.68 (A) × 22% = $55.37 (B)*
Wages lost per day for households with primary earner (corrected for without sick leave) = Percent of homes without sick leave in 2020 is 22% × hourly wage for low-income residential household. *$145.84 (A) × 48% = $70.00 (B)*
Source: U.S. Bureau of Labor Statistics. *"Employee Benefits in the United States – March 2021."* News Release, September 23, 2021, https://www.bls.gov/news.release/pdf/ebs2.pdf, Table 6 (pg. 17).
[3] Input from survey responses.
[4] 90% confidence intervals in parentheses.

Table 5: Annual NEI Values Per Participant for Missed School

	Missed School Values
Savings from childcare from 1 day of reduced absences[1] (A)	$83.89
Change in number of average school days missed due to program effects[2] (B)	0.13 (-0.02, 0.27)
Participant value from changes in sick days lost from school (A×B)[3]	**$10.78 ($-1.39, $22.96)**

[1] Savings from childcare from 1 day of reduced absences = Family Childcare Cost $15,100/year (June 2021) for one child divided by number of school days in a year- 180 day/year (2018) = *$15,100/180 = $83.89 (A).* Assumption based on an 8-hour day.
Source: American Progress. *"The True Cost of High-quality Child Care Across the United States," June 28, 2021,* https://www.americanprogress.org/issues/early-childhood/reports/2021/06/28/501067/true-cost-high-quality-child-care-across-united-states/.
Source: National Center for Education Statistics. *"Number of instructional days and hours in the school year, by state*," 2018, https://nces.ed.gov/programs/statereform/tab5_14.asp.
[2] Input from survey responses.
[3] 90% confidence intervals in parentheses.

Appendix A Detailed Methodology

A.1 Participant End-User Survey

The sample frame for the end-user survey included residential program participants who received air sealing and insulation incentives from the HES and HES-IE program between 2017 and 2020.

Recruitment letters were mailed to every potential respondent. Participants with email addresses included in the program tracking data were also sent emails. The letters and emails explained the purpose of the survey and provided contact information for participants to verify the legitimacy of the study and to complete the survey by phone. Respondents were sent a $20 digital gift card via email after completing the survey. Two reminder emails and one reminder postcard were sent to participants that did not respond to the survey.

The end-user survey for all measures yielded a total of 140 responses, including 77 HES and 63 HES-IE respondents (Table 6). The number of responses did not meet the original study quota of 420 responses. The overall response rate was 3% after accounting 418 returned recruitment letters.[10]

Table 6: End-user Survey Targets and Completes

Measure Types	Recruitment		Survey results		
	Mailers	Email	Target	HES Completes	HES-IE Completes
Air sealing	346	53	70 HES 70 HES-IE	2	30
Insulation	1,179	45	70 HES 70 HES-IE	10	1
Air sealing and insulation	2,368	494	70 HES 70 HES-IE	65	32
Total (n participants)	**3,893**	**592**	**210 HES 210 HES-IE**	**77**	**63**

A.2 Non-Energy Impacts Methodology

For a detailed description of the study methodology, see *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* Appendix A.2.1.

[10] Response Rate = Responded ÷ (Mailed – Returned), 140 ÷ (4,485 – 418) = 3%

Appendix B Detailed Results

B.1 Participant Annual Savings

Table 7 reports the average annual reported gross energy savings of the end-user survey respondents, the adjusted gross energy savings after applying a realization rate, and the corresponding energy bill savings resulting from the adjusted gross energy savings. The study applied realization rates obtained from the R1983 HES / HES&IE Impact and Process Evaluation Study to adjust the gross energy savings. HES participants had similar savings to HES-IE participants with an overall average of 23.3 MMBtu in savings or $184.94 in bill savings.

Table 8 calculates the share of total respondent adjusted gross savings for by measure and program. For HES, air sealing consisted of 17% of overall savings compared to 83% for insulation. Insulation also made up most of the savings for HES-IE respondents at 89% compared to 11% of savings from air sealing. The study used these percentages to break out NEI values for air sealing-only and insulation-only installations for each program.

Table 7: Average Annual Participant Savings for Air Sealing and Insulation

Program	*n*	Gross Energy Savings (MMBtu)		Adjusted Gross Energy Savings (MMBtu)[1]		Dollar Bill Savings[2]	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
HES	*77*	22.1	16.6	8.5	7.4	$193.21	$195.00
HES-IE	*63*	24.7	23.2	8.2	9.6	$174.83	$198.79
Average	***140***	**23.3**	**19.8**	**8.4**	**8.4**	**$184.94**	**$196.22**

[1] The study applied the following realization rates from the CT R1983 study to the gross energy savings:
HES: 17% for air sealing and 51% for insulation; HES-IE: 10% for air sealing and 46% for insulation
Source: Cadeo, NMR Group, and DNV. 2023. *CT R1983 HES & IE Impact and Process Evaluation*. For the Connecticut Energy Efficiency Board.

[2] Bill savings were calculated by multiplying ex-ante savings with 2019 residential energy price data at $0.2187/kWh for electricity, $3.09/gal for heating oil, and $2.95/gal for propane. To update the dollar bill savings to 2020 dollars, the study applied the BLS CPI Inflation Calculator.
Sources: U.S. Energy Information Agency. "Weekly Heating Oil and Propane Prices"
https://www.eia.gov/dnav/pet/PET_PRI_WFR_DCUS_SCT_W.htm
U.S. Energy Information Administration. "Natural Gas Prices".
https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_sct_m.htm
U.S. Energy Information Administration. "Average retail price of electricity, annual."
https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=008&endsec=o&freq=A&start=2001&end=2019&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=
BLS CPI Inflation Calculator. https://www.bls.gov/data/inflation_calculator.htm

Table 8: Total Annual Respondent Savings for Air Sealing and Insulation

Program	Air Sealing			Insulation			Total	
	n	Savings (MMBtu)	% of total savings	*n*	Savings (MMBtu)	% of total savings	*n*	Savings (MMBtu)
HES	*70*	108	17%	*75*	543	83%	*77*	651
HES-IE	*62*	55	11%	*33*	464	89%	*63*	518

B.2 LMS Inputs

This section describes the inputs from the end-user survey used to estimate LMS magnitude scales. For a detailed description of the study methodology, see *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* Appendix A.2.1.

B.2.1 LMS Magnitude Scales

For each respondent who reported a positive or negative effect, the survey asked how the effect compared to their energy savings. The study used the responses to those questions, as described in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs* Appendix A.2.1, to develop positive magnitude scales shown in Figure 7. Negative magnitude scales not shown as the survey only collected 12 responses in total for the nine magnitudes (max zero to three responses for each).

Figure 7: Average Positive LMS Magnitude Scales

(You say that the positive effect on [NEI] was [NP1] than the energy savings from that [MEASURE]s. How much more or less value – in percentage terms – would you say you received?)

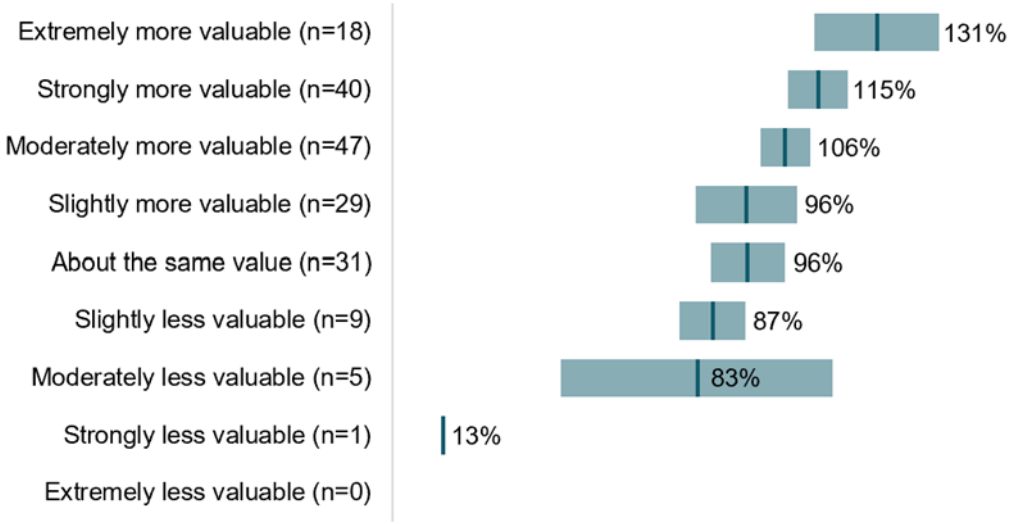
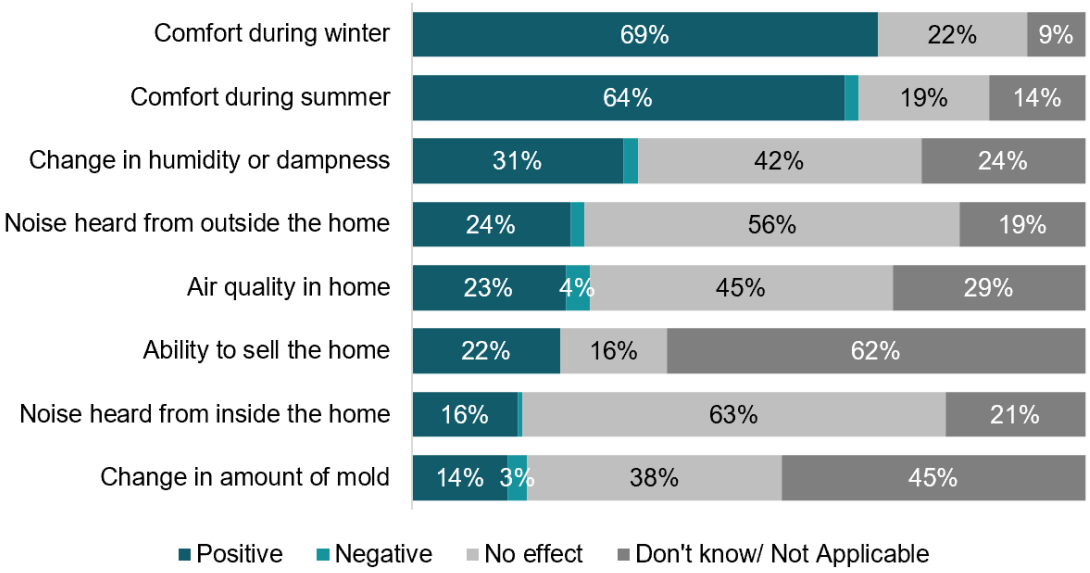


Figure 8 shows the NEI effects for respondents excluding respondents who said don't know or not applicable. Comfort during summer, equipment reliability, comfort during winter, ability to sell the home, equipment reliability, and comfort during winter were the most frequently reported positive NEIs.

Figure 8: Summary of Air Sealing and Insulation NEI Effects

(For each of the items listed below, indicate if the installation of the [MEASURE] positively affected it, negatively affected it, or did not affect it at all.; n = 140)



B.2.2 Overlapping NEI Effects

The survey asked respondents whether they experienced overlap of effects and to indicate which effects overlapped. Nearly one-fifth (19%) of HES respondents indicated they had trouble separating out the effects compared to only 6% of HES-IE respondents (Table 9). The most common overlapping NEIs were comfort in the summer overlapping with comfort in the winter. Other NEIS with overlap include change in humidity or dampness and noise heard from outside the home (Table 10). These NEIs most frequently overlapped with each other as well as noise heard from inside the home and change in mold.

Table 9: Percent of Respondents Who Reported Overlapping NEIs

(Did you have trouble separating out the effects we asked about? Did any overlap for you? Which effects overlapped?)

Measure	Percent with Overlapping NEIs
HES (n=77)	19%
HES-IE (n=63)	6%
Average (n=140)	**14%**

Table 10: Common Overlapping NEIs (n=140)
(Did you have trouble separating out the effects we asked about? Did any overlap for you? Which effects overlapped?)

NEI	Percent with Overlapping NEIs	Common Overlapping NEIs
Comfort in the winter	11%	• Comfort in the summer • Noise heard from outside home • Air quality in your home • Change in humidity or dampness
Comfort in the summer	11%	• Comfort in the winter • Noise heard from outside home • Noise heard from inside home • Change in humidity or dampness • Change in mold
Change in humidity or dampness	3%	• Comfort in the summer • Comfort in the winter • Noise heard from outside home • Noise heard from inside home • Air quality in your home • Change in mold
Noise heard from outside the home	1%	• Comfort in the summer • Comfort in the winter • Noise heard from inside home

B.2.3 Normalized NEI Effects

Table 11 the total qualitative value of individual NEIs with the qualitative value of the combined effects of all NEIs by program. The sum of the individual effects is, on average, more than twice as large as the combined effects. For detailed methodology on normalizing NEI effects, see Appendix A.2.1 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*.

Table 11: Comparison of Combined Effects[1, 2]

Program	Sum of Individual Effects[2]	Combination of all Effects[3]	Magnitude
HES (n=77)	337% (279%, 395%)	134% (111%, 156%)	2.5
HES-IE (n=63)	271% (192%, 350%)	136% (96%, 177%)	2.0
Average (n=140)	**307%** **(260%, 355%)**	**135%** **(113%, 156%)**	**2.3**

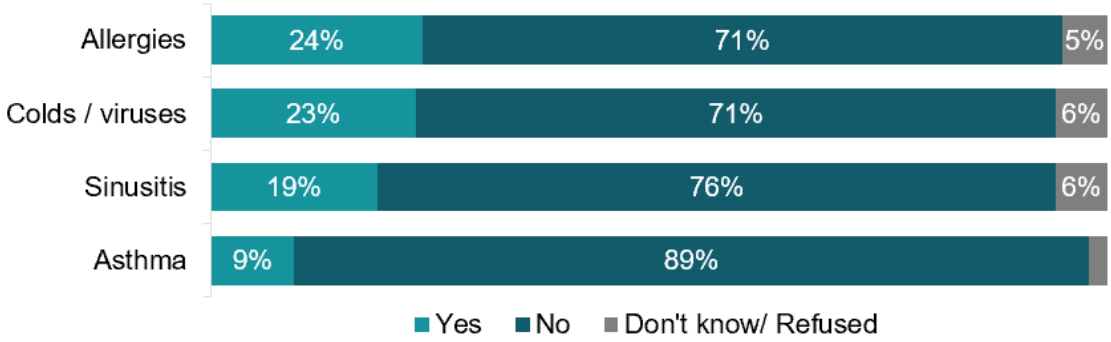
[1] Combined effects in table includes eight NEIs including 'other' NEIs as reported in the survey. These totals may not equal those reported in Table 2.
[2] 90% confidence intervals provided in parentheses.
[3] Individual effects correspond to the survey question in Row *B* of Table A-2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*.
[4] Combination of all effects corresponds to the survey question in Row *E* of Table A-2 in *X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs*

B.3 HEALTH NEI INPUTS

The end user survey asked respondents if anyone had to seek medical care for specific illnesses *prior to 2020*. Most respondents (77% to 91%) said they did not need to seek medical care for asthma, allergies, colds/viruses, sinusitis, and/or hot water scalding (Figure 9).

Figure 9: Medical Care for Specific Illness (n=140)

(Prior to 2020, after installing [MEASURE]s, did anyone in your household need to seek medical care for asthma, allergies, colds/viruses, or sinusitis?)



The survey asked respondents who reported they had to seek medical care for specific illnesses whether the number of times they had to seek medical care the year prior to installing air sealing and/or insulation had changed. Of the 13 respondents who said someone in their household needed to seek medical care for asthma, two said the number of times they had to seek medical care for asthma decreased and two said the number of times increased since installing the measure(s). The remaining nine said it stayed the same, don't know, or refused (not shown).

Over one-third (34%) of the respondents said they had to seek medical care for allergies, colds/viruses, and/or sinusitis. Of those respondents, nearly one-fifth (17%) said the number of times they had to seek medical care decreased since installing air sealing and/or insulation (Figure 10). Few respondents (4%) said the number of times they had to seek medical care increased.

Figure 10: Change in Medical Care for Allergies, Colds/viruses, and Sinusitis (n=47)

(Compared to the year before installing [MEASURE]s, did the need to seek medical care decrease, increase, or stay the same?)

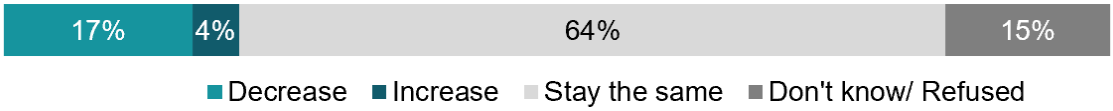


Figure 11 shows the share of respondents who said they experienced a change in the number of missed workdays since installing air sealing and/or insulation. Five percent of respondents stated they experienced a decrease and two percent experienced an increase in the number of days worked. Similar for respondents who said they experienced a change in the number of missed school days, four percent of respondents said they experienced a decrease and three percent of respondents said they experienced an increase in missed school days (Figure 12).

Figure 11: Change in Number of Missed Days Worked (n=140)
(Prior to 2020, did the number of days of work missed because of illness decrease, increase, or stay the same for you or a member of your household?)

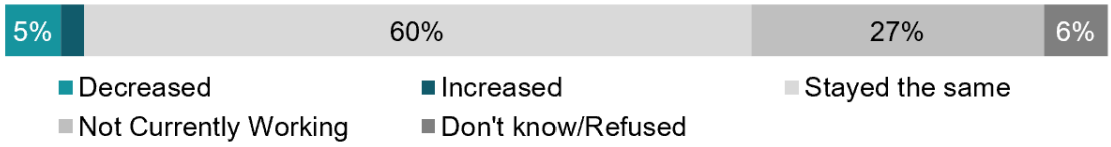
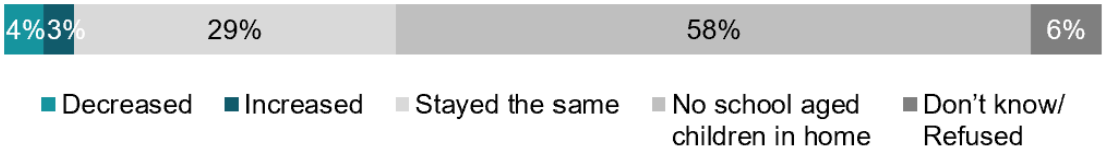


Figure 12: Change in Number of Missed School Days (n=140)
(Prior to 2020, after installing [MEASURE]s, did the number of days of school missed because of illness decrease, increase, or stay the same?)



B.4 ADDITIONAL NEI RESULTS

B.4.1 Results By Program

Table 12 reports the main monetized air sealing and insulation NEI results of this study with 90% confidence intervals. Table 13 shows the corresponding percent measure savings values for non-health NEIs with 90% confidence intervals.

Table 12: Summary of Monetized NEIs for Air Sealing and Insulation[1,2]
(Annual NEI Value per Average Participant that Installed Air Sealing and Insulation)

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Air quality in the home	$15.76 ($6.41, $25.12)	$29.06 ($6.30, $51.81)	$21.75 ($10.38, $33.11)
Change in humidity or dampness	$26.61 ($12.87, $40.36)	$49.25 ($23.55, $74.95)	$36.80 ($23.05, $50.55)
Change in mold	$15.77 ($4.98, $26.56)	$26.17 ($3.19, $49.15)	$20.45 ($8.64, $32.26)
Comfort in the summer	$105.20 ($55.60, $154.80)	$53.62 ($26.88, $80.36)	$81.99 ($52.22, $111.75)
Comfort in the winter	$114.31 ($65.10, $163.52)	$63.38 ($37.13, $89.62)	$91.39 ($61.92, $120.86)
Noise heard from inside home	$19.42 ($0.22, $38.62)	$35.95 ($14.45, $57.46)	$26.86 ($12.64, $41.08)
Noise heard from outside home	$19.41 ($6.48, $32.35)	$41.33 ($18.80, $63.87)	$29.28 ($16.94, $41.62)
Sub Total	**$316.49 ($190.06, $442.91)**	**$298.76 ($150.71, $446.81)**	**$308.51 ($213.21, $403.81)**

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Asthma		$0.75 ($0.02, $1.52)	
Allergies		$11.40 ($3.11, $19.65)	
Colds/Viruses		$1.86 ($0.48, $3.22)	
Sinusitis		$1.42 ($0.25, $2.55)	
Missed work	$2.99 ($1.20, $4.78)	$3.78 ($1.51, $6.04)	$3.35 ($1.34, $5.35)
Missed school		$10.78 ($-1.39, $22.96)	
Sub Total	**$29.20**	**$29.99**	**$29.56**
Total Value	**$345.69**	**$328.75**	**$338.07**

[1] NEIs are for participants who received incentives for air sealing and insulation through the program. NEI values are in 2020 dollars.
[2] 90% confidence intervals in parentheses

Table 13: Summary of Non-health NEIs as a Percent of Annual Measure Savings[1,2]

NEI	HES (n=77)	HES-IE (n=63)	Average (n=140)
Air quality in the home	11% (7%, 15%)	16% (5%, 28%)	13% (7%, 19%)
Change in humidity or dampness	13% (9%, 17%)	15% (10%, 20%)	14% (10%, 17%)
Change in mold	7% (3%, 10%)	15% (3%, 27%)	11% (5%, 16%)
Comfort in the summer	32% (27%, 36%)	21% (14%, 27%)	27% (23%, 31%)
Comfort in the winter	36% (32%, 41%)	24% (18%, 29%)	30% (27%, 34%)
Noise heard from inside home	5% (2%, 8%)	9% (5%, 13%)	7% (4%, 9%)
Noise heard from outside home	10% (6%, 13%)	14% (5%, 23%)	11% (7%, 19%)
Total	**113% (95%, 130%)**	**113% (76%, 150%)**	**113% (94%, 132%)**

[1] NEI multipliers are for participants who received incentives for air sealing and insulation through the program.
[2] 90% confidence intervals in parentheses

B.4.2 Results By Measure

Table 14 and Table 15 present the HES and HES-IE NEI results, respectively, for air sealing and insulation, air sealing-only, and insulation-only installation scenarios of this study. For non-health NEIs, air sealing-only and insulation-only NEI values are estimated from the combined air sealing and insulation NEI values as a percentage of their total energy savings (HES: 17% for air sealing and 83% for insulation; HES-IE: 11% for air sealing and 89% for insulation; as shown in Table 8).

The study applies the same values for the health NEIs to each installation scenario as these values are not dependent on respondents' savings.

Table 14: Summary of Monetized NEIs for HES[1,2]

(Annual NEI Value per Average Participant that Installed Air Sealing and/or Insulation)

NEI	Air Sealing and Insulation (A)	Air Sealing Only (A×17%)	Insulation Only (A×83%)
Air quality in the home	$15.76	$2.62	$13.14
Change in humidity or dampness	$26.61	$4.43	$22.18
Change in mold	$15.76	$2.62	$13.15
Comfort in the summer	$105.20	$17.50	$87.70
Comfort in the winter	$114.31	$19.02	$95.29
Noise heard from inside home	$19.42	$3.23	$16.19
Noise heard from outside home	$19.41	$3.23	$16.18
Sub Total	**$316.49**	**$52.65**	**$263.83**
Asthma		$0.75	
Allergies		$11.40	
Colds/Viruses		$1.86	
Sinusitis		$1.42	
Missed work		$2.99	
Missed school		$10.78	
Health NEIs Sub Total		**$29.20**	
Total Value	**$345.69**	**$81.85**	**$293.03**

[1] NEIs are for participants who received incentives for air sealing and/or insulation through the program. NEI values are in 2020 dollars.

[2] Values may not sum up to total due to errors in rounding.

Table 15: Summary of Monetized NEIs for HES-IE[1,2]

(Annual NEI Value per Average Participant that Installed Air Sealing and/or Insulation)

NEI	Air Sealing and Insulation (A)	Air Sealing Only (A×11%)	Insulation Only (A×89%)
Air quality in the home	$29.06	$3.07	$25.99
Change in humidity or dampness	$49.25	$5.21	$44.04
Change in mold	$26.17	$2.77	$23.40
Comfort in the summer	$53.62	$5.67	$47.95
Comfort in the winter	$63.38	$6.70	$56.68
Noise heard from inside home	$35.95	$3.80	$32.15
Noise heard from outside home	$41.33	$4.37	$36.96
Sub Total	**$298.76**	**$31.58**	**$267.18**

NEI	Air Sealing and Insulation (A)	Air Sealing Only (A×11%)	Insulation Only (A×89%)
Asthma		$0.75	
Allergies		$11.40	
Colds/Viruses		$1.86	
Sinusitis		$1.42	
Missed work		$3.78	
Missed school		$10.78	
Health NEIs Sub Total		**$29.99**	
Total Value	**$328.75**	**$61.57**	**$297.17**

[1] NEIs are for participants who received incentives for air sealing and/or insulation through the program. NEI values are in 2020 dollars.
[2] Values may not sum up to total due to errors in rounding.

B.4.2.1 NEI Benchmarking

Table 16 and Table 17 provide benchmarking comparisons of the HES and HES-IE air sealing and insulation NEI values with those in the Massachusetts TRM, respectively.

Table 16: NEI Benchmarking Comparison – HES

NEI	Massachusetts 2016[1]		CT HES 2023	
	Air Sealing	Insulation	Air Sealing	Insulation
Thermal comfort	$10.13	$25.15	Summer: $17.50 Winter: $19.02	Summer: $87.70 Winter: $95.29
Noise reduction	$4.88	$11.54	From inside: $3.23 From outside: $3.23	From inside: $16.19 From outside: $16.18
Home durability	$3.95	$9.82	n/a	n/a
Air quality in the home	n/a	n/a	$2.62	$13.14
Change in humidity	n/a	n/a	$4.43	$22.18
Change in mold	n/a	n/a	$2.62	$13.15
Health benefits	$0.32	$0.80	See values below for NEIs with (*)	
Allergies*	n/a	n/a	$11.40	
Colds/Viruses*	n/a	n/a	$1.86	
Sinusitis*	n/a	n/a	$1.42	
Days missed work*	n/a	n/a	$2.99	
Days missed school*	n/a	n/a	$10.78	
Total	**$19.28**	**$47.31**	**$81.85**	**$293.03**

[1] Massachusetts Electric and Gas Energy Efficiency Program Administrators. 2023. *Massachusetts TRM 2023 Plan Version.* https://www.masssavedata.com/TRL/Technical%20Reference%20Manual%202023%20Plan%20-%20010323.pdf *Appendix B.* https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/63b4ada052e03925d3412295/view?authToken=e3b8925034aedea1d18be0cf5b83eb9c3dd6353c4192e6a7a1b60f8c9285aaffc0f60c5bd650cdd4e351f0d720caa31515526737f6abfce8e7a5001cdb00a736e4abb248183d2f

Table 17: NEI Benchmarking Comparison – HES-IE

NEI	Massachusetts 2016[1]		CT HES-IE 2023	
	Air Sealing	Insulation	Air Sealing	Insulation
Thermal comfort	$35.89	$30.13	Summer: $5.67 Winter: $6.70	Summer: $47.95 Winter: $56.68
Noise reduction	$16.39	$13.56	From inside: $3.80 From outside: $4.37	From inside: $32.15 From outside: $36.96
Reduced asthma symptoms	$2.99	$2.51	$0.75	
Fewer missed days worked	$44.74	$37.56	$3.35	
Reduced cold-related thermal stress	$138.66	$116.41	n/a	n/a
Reduced heat related thermal stress	$43.69	$36.67	n/a	n/a
Reduced home fires (safety)	$2.24	$17.40	n/a	n/a
Home durability	$10.61	$8.76	n/a	n/a
Air quality in the home	n/a	n/a	$3.07	$25.99
Change in humidity	n/a	n/a	$5.21	$44.04
Change in mold	n/a	n/a	$2.77	$23.40
Allergies	n/a	n/a	$11.40	
Colds/Viruses	n/a	n/a	$1.86	
Sinusitis	n/a	n/a	$1.42	
Days missed school	n/a	n/a	$10.78	
Total	**$295.21**	**$263.00**	**$61.57**	**$297.17**

[1] Massachusetts Electric and Gas Energy Efficiency Program Administrators. 2023. *Massachusetts TRM 2023 Plan Version.* https://www.masssavedata.com/TRL/Technical%20Reference%20Manual%202023%20Plan%20-%20010323.pdf *Appendix B.* https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/63b4ada052e03925d3412295/view?authToken=e3b8925034aedea1d18be0cf5b83eb9c3dd6353c4192e6a7a1b60f8c9285aaffc0f60c5bd650cdd4e351f0d720caa31515526737f6abfce8e7a5001cdb00a736e4abb248183d2f

Three[3] and NMR Group. 2016. Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEI) Study. Prepared for the Massachusetts Program Administrators. https://ma-eeac.org/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-Non-Energy-Impacts-Study.pdf

B.5 Regression Analysis

The study included linear regression analyses to determine whether results for air sealing and insulation were statistically significantly different from one another. The study regressed the NEI dollar value (independent variable) on air sealing and insulation dummy (dependent) variables. The air sealing variable was a one if the respondent had installed air sealing and zero if not. The same applies to insulation.

The linear regression analyses were used to determine whether NEI values were statistically different for air sealing and insulation for comfort in the winter (Table 18a), comfort in the summer

(Table 18b), and the total NEI value (Table 18c). Linear hypothesis testing showed that the differences in the values between air sealing and insulation were not statistically significant.[11]

[11] Hypothesis testing requires Prob >F = 0.10 or below for statistical significance.

Table 18: Regression Analyses for Air Sealing and Insulation

a.

```
. reg d_wintercomfort airsealing insulation
```

Source	SS	df	MS		
Model	156954.573	2	78477.2864	Number of obs	140
Residual	6008342.64	137	43856.5156	F(2, 137)	1.79
				Prob > F	0.1709
Total	6165297.21	139	44354.6562	R-squared	0.0255
				Adj R-squared	0.0112
				Root MSE	209.42

d_winterco~t	Coefficient	Std. err.	t	P>|t|	[90% conf.	interval]
airsealing	47.09537	66.62646	0.71	0.481	-63.24152	157.4323
insulation	78.7592	42.69245	1.84	0.067	8.058282	149.4601
_cons	-12.76213	76.22074	-0.17	0.867	-138.9876	113.4634

```
. test airsealing=insulation      //not statistically significantly different

 ( 1)  airsealing - insulation = 0

       F(  1,   137) =    0.19
            Prob > F =    0.6660
```

b.

```
. reg d_summercomfort airsealing insulation
```

Source	SS	df	MS		
Model	112296.962	2	56148.4811	Number of obs	140
Residual	6174427.82	137	45068.8162	F(2, 137)	1.25
				Prob > F	0.2909
Total	6286724.78	139	45228.2358	R-squared	0.0179
				Adj R-squared	0.0035
				Root MSE	212.29

d_summerco~t	Coefficient	Std. err.	t	P>|t|	[90% conf.	interval]
airsealing	47.46553	67.54104	0.70	0.483	-64.38595	159.317
insulation	65.22806	43.27849	1.51	0.134	-6.443364	136.8995
_cons	-12.06799	77.26702	-0.16	0.876	-140.0262	115.8902

```
. test airsealing = insulation

 ( 1)  airsealing - insulation = 0

       F(  1,   137) =    0.06
            Prob > F =    0.8112
```

c.

```
. reg sumdollarsavings airsealing insulation
```

Source	SS	df	MS		
Model	118528.496	2	59264.2478	Number of obs	140
Residual	35991998.1	137	262715.314	F(2, 137)	0.23
				Prob > F	0.7983
Total	36110526.5	139	259787.961	R-squared	0.0033
				Adj R-squared	-0.0113
				Root MSE	512.56

sumdollars~s	Coefficient	Std. err.	t	P>|t|	[90% conf.	interval]
airsealing	40.5198	163.0694	0.25	0.804	-229.5316	310.5711
insulation	68.50407	104.4905	0.66	0.513	-104.5376	241.5457
_cons	126.938	186.5515	0.68	0.497	-182.001	435.877

```
. test airsealing = insulation

 ( 1)  airsealing - insulation = 0

       F(  1,   137) =    0.02
            Prob > F =    0.8761
```