X1942B Cross-cutting NEI Study – Residential HP & HPWH NEIs

FINALREPORT

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SUBMITTED TO:
Connecticut Energy Efficiency Board

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Abstract

PURPOSE

As part of the X1942 Non-Energy Impacts (NEIs) study, the NMR study team conducted an analysis to quantify NEIs from residential heat pump (HP) and heat pump water heater (HPWH) program participants who did not participate in the Home Energy Solutions (HES) program.[1] This study leveraged the R2027 HP/HPWH Reliability study[2] that collected data from participant end-users to characterize the Connecticut heat pump and heat pump water heater markets, customer costs and reliability, customer satisfaction, and NEIs for mini-split heat pumps (MSHPs), central air source heat pumps (CASHPs), ground source heat pumps (GSHPs), and heat pump water heaters (HPWHs). The survey also stratified by replacement type, early replacement (ER) and replace on failure (ROF), for MSHPs and HPWHs. The analysis applied algorithms used in past studies to establish NEI values for each measure and NEI category. This report, which will become a section in the broader X1942 study report, discusses the results from this analysis and presents the 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.[3] 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 heat pump and HPWH measures.

GOAL

The goal of this part of the X1942 study is to quantify NEIs from residential heat pump and HPWHs and fill gaps and provide measure-specific NEIs not currently included in the Connecticut PSD or not used in cost effectiveness (C/E) testing.[4] This study includes the following high priority NEIs:

- Comfort in the summer and winter
- Equipment reliability

[1] At the time of the study planning, most of the HP/HPWH installations came from the HVAC program and there were few HES participants.

[2] NMR Group, Inc. 2022. *CT R1965 HP/HPWH Baseline and Market Characterization & R2027 HP/HPWH Reliability.* For the Connecticut Energy Efficiency Board. https://energizect.com/sites/default/files/documents/R1965-R2027_HP-HPWH_Market_Reliability_Study_Final_Report_20220511.pdf

[3] 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

[4] The Companies currently quantify and claim several NEIs for HES-IE only in the CTET and TRC Test: costs associated with “arrearages, debt write-off costs, or administrative costs”. See Appendix A of the 2023 PSD.

- Equipment maintenance
- Equipment noise
- Appearance of the home
- Home safety
- Frequency of fuel deliveries
- Household member's health
- Missed work and school
- Other impacts

FINDINGS

Table 0-1 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) 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-Income Eligible program, which uses the TRC test as the primary B/C metric.[5] The NEI values presented in Table 0-1 are per participant perspective annual values, which are expected to last through the life of the heat pump and HPWH measures.

The tables do not provide a comparison of the monetized NEIs in this study to the range of NEI values found in the literature because the team is unaware of any other publicly available studies that have monetized residential heat pump or heat pump water heater NEIs.

Participants who received incentives for heat pumps and/or HPWHs through the program experienced positive net impacts from the program. For most of the NEIs studied, the positive NEIs outweighed negative NEIs for a net average annual value of $446 ($475 including health NEIs) for heat pumps (123% of the value of their expected energy savings; average expected annual savings is 1,723 kWh per participant) and $220 for HPWHs (56% of the value of their expected energy savings; average expected annual savings is 2,348 kWh per participant), as shown in Table 0-1 and Table 0-2. For MSHPs and HPWHs, the analysis also estimated overall NEI values by replacement type.

RECOMMENDATIONS AND IMPLICATIONS

Recommendation 1: These participant NEIs should be used in the appropriate cost-effectiveness tests as allowed now and in the future.[6] For the TRC test, adding the NEIs

[5] See section five of the 2022-2024 Conservation and Load Management Plan and Appendix 6 of the 2022 PSD.
[6] 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.

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-Income Eligible program and includes participant NEIs). Additional NEIs not claimed in this study, presented in Appendix B.4, may also be useful for program planning, design, and marketing.

Recommendation 2: The study recommends using the measure specific NEI values for MSHPs and HPWHs and the average heat pump only NEI values for ASHPs and GSHPs, due to their smaller sample sizes, in cost-effectiveness testing.

Implication 1: Additional research on NEIs may be needed before these NEI values can be applied for cost effectiveness testing. These NEI values identified in this study are not fully comprehensive of all NEIs that may be associated with heat pumps and HPWHs. More specifically, this study did not explore all NEIs to provide a full picture of NEIs associated with heat pumps and HPWHs. Examples of potential NEIs with net negative impacts not included in this study are impacts of potential need for backup in extreme cold or during electric system outages, and environmental impacts from refrigerant leaks.

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

Table 0-1: Summary of Monetized NEIs – Measure Based[1,2]

(Annual NEI per Average Participant that Installed the Measure)

NEIs	CASHP (n=12)	GSHP (n=6)	MSHP (n=170)			Heat Pumps Average (n=188)	HPWH (n=70)		
			ROF (n=69)	ER (n=101)	Average		ROF (n=48)	ER (n=22)	Average
Appearance of the home	$67.94	$132.21	$41.95	$69.89	$58.54	**$61.49**	$36.95	$23.47	**$32.71**
Comfort during summer	$132.76	$45.85	$51.83	$75.33	$65.79	**$69.43**	$131.68	$66.66	**$111.24**
Comfort during winter	$124.05	$37.43	$86.13	$88.09	$87.29	**$88.05**	NA	NA	**NA**
Equipment maintenance	$12.78	$36.95	NA	$44.84	$26.64	**$26.08**	NA	$56.97	**$17.90**
Equipment noise	$51.46	$148.53	$47.69	$88.83	$72.13	**$73.25**	$-89.93	$-24.14	**$-69.25**
Equipment reliability	$13.53	$7.87	NA	$68.86	$40.91	**$38.11**	NA	$52.34	**$16.45**
Frequency of fuel deliveries	$2.15	$105.03	$29.14	$20.39	$23.94	**$25.14**	$34.40	$67.08	**$44.67**
Home safety	$50.09	$132.68	$62.98	$43.72	$51.53	**$54.03**	$23.14	$35.24	**$26.94**
Other impacts	$5.57		$7.71	$13.11	$10.92	**$10.23**	$47.03	$21.92	**$39.14**
Sub Total	**$460.31**	**$646.56**	**$327.42**	**$513.05**	**$437.70**	**$445.82**	**$183.25**	**$299.55**	**$219.80**
Asthma						**$2.29**			
Allergies						**$7.01**			
Colds/viruses						**$0.33**			
Sinusitis						**$1.98**			
Missed work						**$15.18**			
Missed school						**$2.71**			
Sub Total						**$29.50**			
Total	**$460.31**	**$646.56**	**$327.42**	**$513.05**	**$437.70**	**$475.32**	**$183.25**	**$299.55**	**$219.80**

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experience net impacts from the program. NEI values are in 2020 dollars.

[2] Table B-10 and Table B-12 report the main monetized NEI results of this study with 90% confidence intervals. and show the corresponding measure savings values with 90% confidence intervals. See Appendix B.4 for additional results including unadjusted values (Table B-14, Table B-16) and NEIS not claimed in this study (Table B-18, Table B-20).

Table 0-2: Summary of Non-health NEI Percent of Measure Savings [1,2]

(Savings per Average Participant)

NEIs	ASHP (n=12)	GSHP (n=6)	MSHP (n=170)			Heat Pumps Average (n=188)	HPWH (n=70)		
			ROF (n=69)	ER (n=101)	Average		ROF (n=48)	ER (n=22)	Average
Appearance of the home	13%	24%	8%	17%	13%	14%	9%	8%	9%
Comfort during summer	26%	6%	23%	22%	22%	22%	29%	17%	26%
Comfort during winter	25%	6%	21%	22%	21%	21%	NA	NA	NA
Equipment maintenance	6%	7%	NA	9%	5%	5%	NA	13%	4%
Equipment noise	8%	27%	13%	28%	22%	22%	-14%	-6%	-12%
Equipment reliability	6%	2%	NA	22%	13%	13%	NA	18%	6%
Frequency of fuel deliveries	0%	19%	10%	8%	8%	8%	7%	11%	8%
Home safety	10%	25%	25%	12%	17%	17%	6%	8%	6%
Other impacts	1%	NA	2%	4%	3%	3%	10%	6%	9%
Total Value	**95%**	**116%**	**101%**	**142%**	**126%**	**123%**	**47%**	**75%**	**56%**

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program.

[2] See Appendix B.4 for additional results including confidence intervals (Table B-11, Table B-13), unadjusted values (Table B-15, Table B-17), NEIS not claimed in this study (Table B-19, Table B-21).

Section 1 Methodology

1.1 Participant End-user Surveys

This study leveraged the R2027 HP/HPWH Reliability study[7] that collected data from participant end-users to characterize the Connecticut heat pump and heat pump water heater markets, customer costs and reliability, customer satisfaction, and NEIs for mini-split heat pumps (MSHPs), central air source heat pumps (CASHPs), ground source heat pumps (GSHPs), and heat pump water heaters (HPWHs). The survey also stratified by replacement type, early replacement (ER) and replace on failure (ROF), for MSHPs and HPWHs. The study conducted primary data collection via web surveys to quantify NEIs associated with heat pumps and HPWHs in Connecticut. 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 heat pump and HPWH installation scenarios. The following list breaks down the rationale for the NEIs identified in this study:

- **Comfort in the summer –** End users often use heat pumps to cool previously uncooled spaces. Adding air conditioning can provide cooling-related comfort. HPWHs are also associated with dehumidifying spaces, which also contribute to improved comfort.
- **Comfort in the winter –** Replacing old electric resistance or fossil fuel systems with heat pumps can provide additional heating-related comfort by producing a more evenly distributed source of heat for a warmer home.

  This study does not estimate the value of comfort in the winter for HPWHs due to the weaker link between comfort in the winter and water heating.
- **Equipment reliability –** Replacing an old or failing system can provide end users with a more reliable source of space heating and cooling. To note, this NEI can be applied to any space heating and cooling or water heating system and is not specific to heat pumps and HPWHs as replacing an old system improves the reliability of any system.
- **Equipment maintenance –** Retiring a heating system before it fails can allow the end user to avoid some maintenances costs. To note, this NEI can be applied to any space heating and cooling or water heating system and is not specific to heat pumps and HPWHs as replacing an old system reduces the need for maintenance of any system.

[7] NMR Group, Inc. 2022. *CT R1965 HP/HPWH Baseline and Market Characterization & R2027 HP/HPWH Reliability.* For the Connecticut Energy Efficiency Board. https://energizect.com/sites/default/files/documents/R1965-R2027_HP-HPWH_Market_Reliability_Study_Final_Report_20220511.pdf

- **Equipment noise –** Window units are often replaced with MSHPs.[8] MSHPs can have a positive impact on noise as they are generally quieter than window units. HPWHs on the other hand have been associated with increased noise.
- **Appearance of the home –** Replacing window units can improve the appearance of the home but some end users say MSHPs worsen the appearance of their homes.
- **Home safety –** Switching to electricity for heating via heat pumps and HPWHs reduces the risk of gas leaks or carbon monoxide poisoning from fossil fuels systems, improving the safety of the home.
- **Frequency of fuel deliveries –** Heat pumps reduce end user reliance on fuel deliveries and storage tanks
- **Household member's health –** Improved air quality and comfort from heat pumps can reduce incidences of illnesses such as asthma, colds/viruses, allergies.
- **Missed work and school –** Reduced incidence of illnesses from heat pumps 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 maintenance, and self-reported direct measurement of health impacts, such as impacts on asthma triggers and other ailments. Figure 1-1 shows the NEIs by their measurement approach.

Labeled magnitude scale. 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.

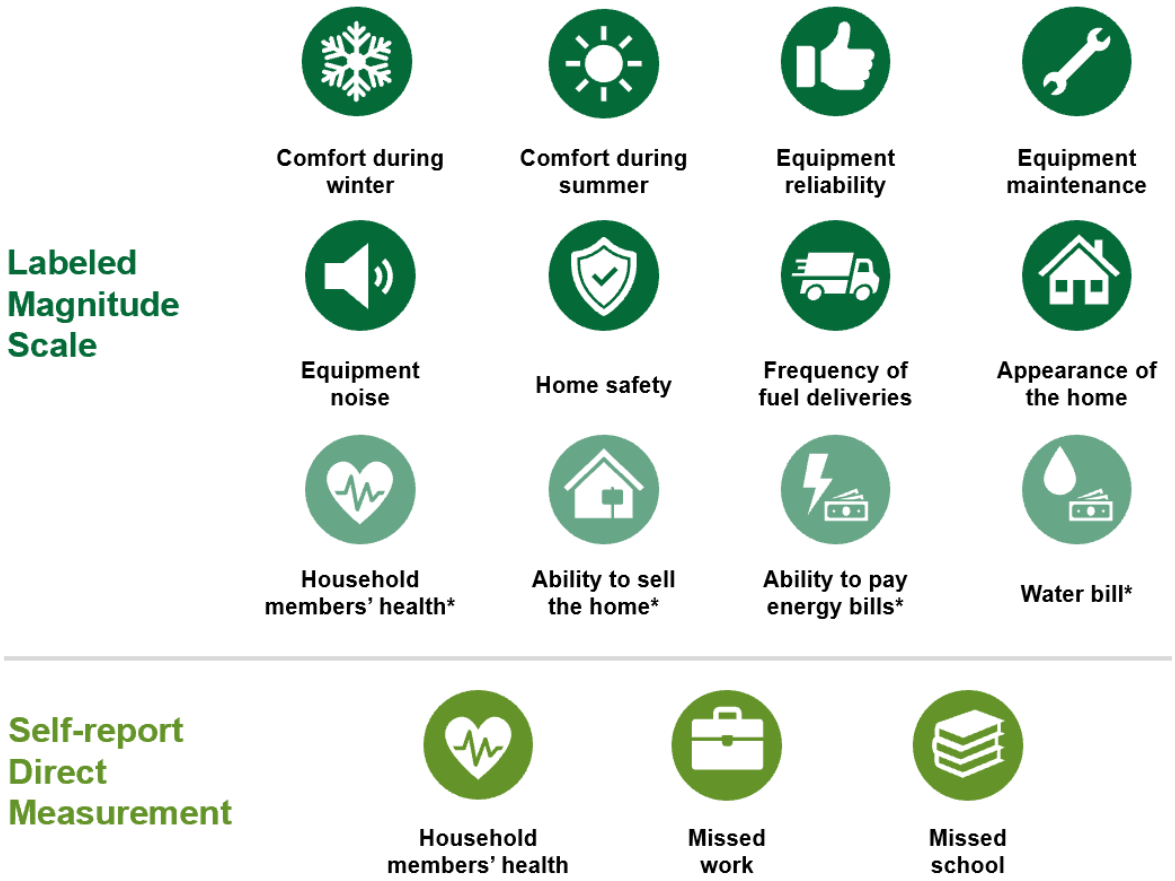
For any elements where respondents observed positive or negative impacts as a result of the program, the survey asked them to compare the value of that NEI to the energy savings associated with their participation in the retail HVAC program. The survey also asked respondents to identify overlapping NEIs 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 a detailed description of the methodology used to calculate NEI values, see Appendix A.2.1.

Self-report direct measurement. 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.[9] The analysis used these inputs

[8] 59% of 170 MSHP respondent installations replaced window air conditioning.
[9] While the survey included residential program participants who received heat pump equipment incentives from the HVAC program 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 working and learning may influence responses that may not be reflective of times of regular in office work and in-person learning.

to calculate the avoided cost per occurrence of specific illnesses and loss of earnings from missed work and school. Appendix A.2.2 provides a more detailed description of the methodology used to quantify health NEI values.

Figure 1-1: NEIs by Approach



* Measures excluded from main findings. Additional results are included in Appendix B.4.

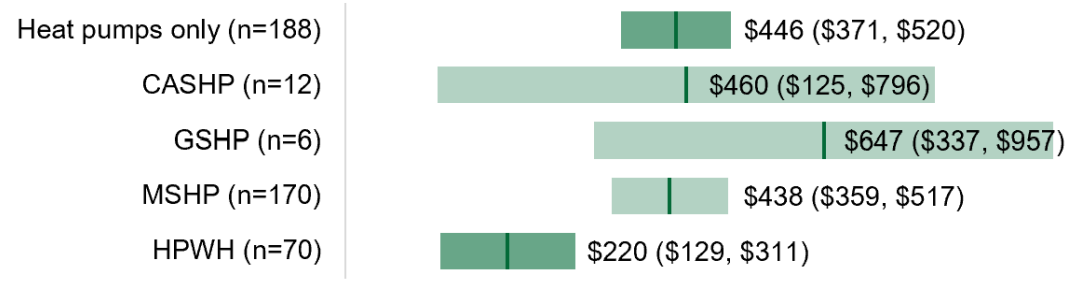
Section 2 Findings

2.1 Non-Health NEIs

The total dollar value of all non-health related NEIs is $446 and $220 for the average heat pump and HPWH program average participant, respectively. Figure 2-1 shows the total dollar value of all NEIs per year by heat pump type for program participants who received incentives for heat pumps and/or HPWHs. While GSHPs have the highest overall NEI values of all the measures ($647), the value is based on responses from only six participants (note the wide range of the 90% confidence interval in Figure 2-1). CASHPs, with 12 respondents, have similarly wide confidence intervals. HPWHs, have the lowest overall NEI value at $220. The differences in the total dollar value of the NEIs by heat pump type are not statistically significant.

Figure 2-2 shows the corresponding percent of savings by measure. On average, respondents value NEIs by 104% for heat pumps and 84% for HPWHs when compared to the value of their expected energy savings. Average energy savings are shown in Table B-1 in Appendix B.

Figure 2-1: Annual NEI Dollar Value per Participant by Measure[1]



[1] Bars show 90% confidence intervals.

Figure 2-2: Percent of Savings by Measure[1]

[1] Bars show 90% confidence intervals.

Heat pumps only. Figure 2-3 shows the average annual NEI dollar values per participant for the heat pump only measure. On average, the NEIs with the highest values are comfort during winter ($88.05), equipment noise ($73.25), comfort during the summer ($69.43), appearance of the home ($61.50), and safety of the home ($54.03). Equipment maintenance, reliability, frequency

of fuel deliveries had the lowest values. For full results with confidence intervals, see Table B-10 thru Table B-13.

CASHPs. For individual NEI values reported for CASHPs (Figure 2-4), comfort during summer and winter have the highest NEI values at $132.75 and $124.05, respectively. CASHP end-users value equipment reliability and maintenance as well as frequency of fuel deliveries the lowest.

GSHPs. The NEIs with the highest values are equipment noise, home safety, and the appearance of the home (Figure 2-5). Comfort during summer and comfort during winter have lower NEI values compared to the heat pump only NEI values. This is likely due to the adjustments, described in Section A.2.1, made to comfort during summer and winter based on whether installation conditions had pre-existing cooling, full or partial displacement, and/or added new load. A larger share of respondents who installed GSHPs did not have preexisting cooling and/or displaced an old heating or cooling system while adding new load compared to other heat pump types, which contributed to lower values for comfort during summer and winter.[10]

End-users primarily had either central air conditioner or no cooling system prior to installing their CASHPs and GSHP (Table B-5). These respondents also indicated high values for equipment noise and appearance of the home. While it is unlikely that installing a CASHP or GSHP resulted in improvements in noise and appearance over central air conditioning or no cooling system, the study did not ask respondents to explain how the noise or appearance improved. Due to the smaller sample size of this group, the study recommends using the heat pump only values for CASHPs and GSHPs.

MSHPs. Respondents who installed MSHPs gave the highest values to comfort during winter, equipment noise, comfort during summer, and appearance of the home (Figure 2-7). The higher value for equipment noise for MSHP respondents ($72.13) may be because most respondents (59% of 170 respondents) reported the MSHP replaced a room that was previously cooled with a window air conditioner (AC) which are typically noisier than MSHPs. Respondents who replaced window, wall, or portable ACs value the reduced equipment noise from MSHPs at $95.45 [n=112; 90% confidence intervals = ($70.38, $120.53)] compared to $27.10 for respondents who had other sources of air conditioning or did not have any previous air conditioning [n=58; 90% confidence intervals = ($3.52, $50.68)]. The differences in these estimates are statistically significant at the 90% confidence level. Similarly for appearance of the home, respondents who replaced a window AC and similar units value appearance higher ($73.90 versus $28.91) that those who did not although the values are not statistically different.

When asked if there were other NEIs experienced with their MSHP installation, 8% of respondents reported reduced humidity and 4% reported not having to install or remove and store the air conditioning unit as NEIs (Table 2-1). These NEIs were valued at $10.91.

[10] Of the six respondents who installed GSHPs, three did not have pre-existing cooling and one displaced their old cooling system while adding new load. Additionally, two displaced their old heating system while adding new load.

Figure 2-3: Average NEI Dollar Values per Year for Heat Pumps Only (n=188)

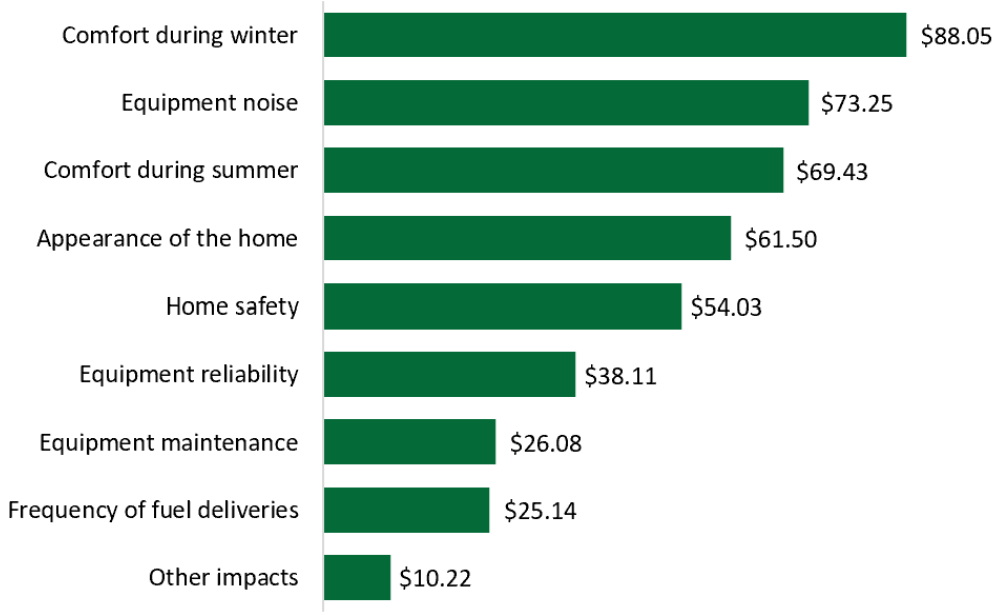


Figure 2-4: Average NEI Dollar Values for CASHPs (n=12)

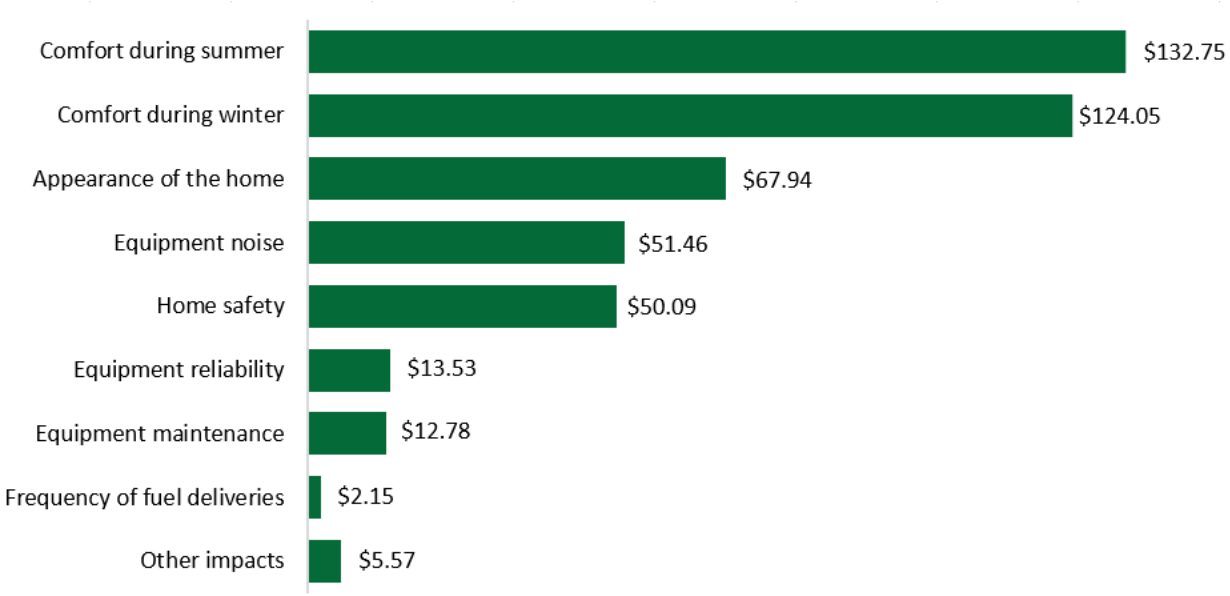


Figure 2-5: Average NEI Dollar Values for GSHPs (n=6)

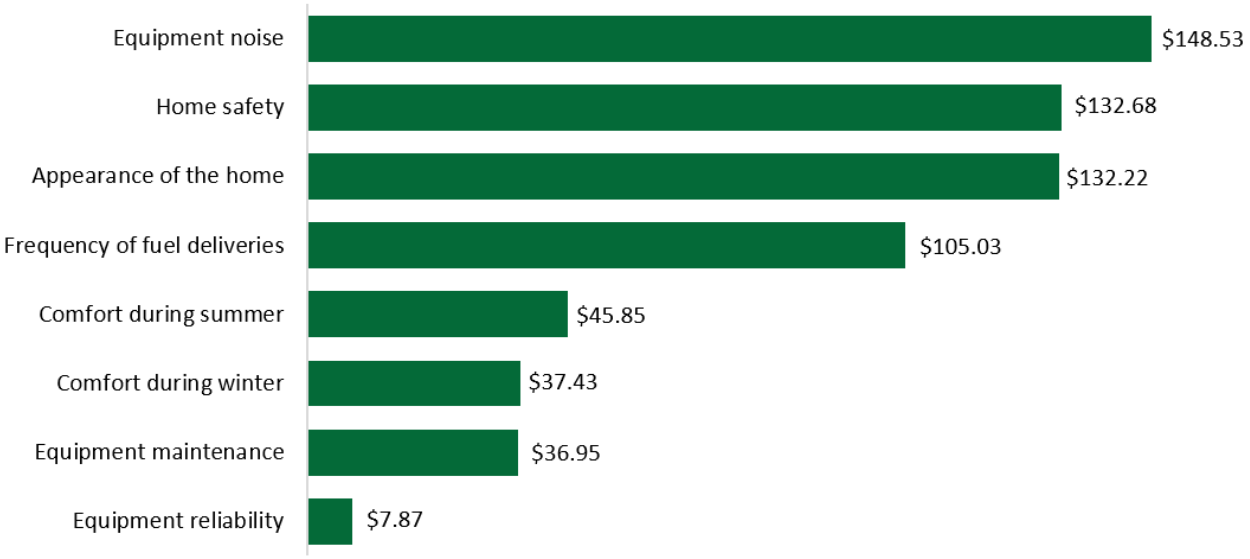
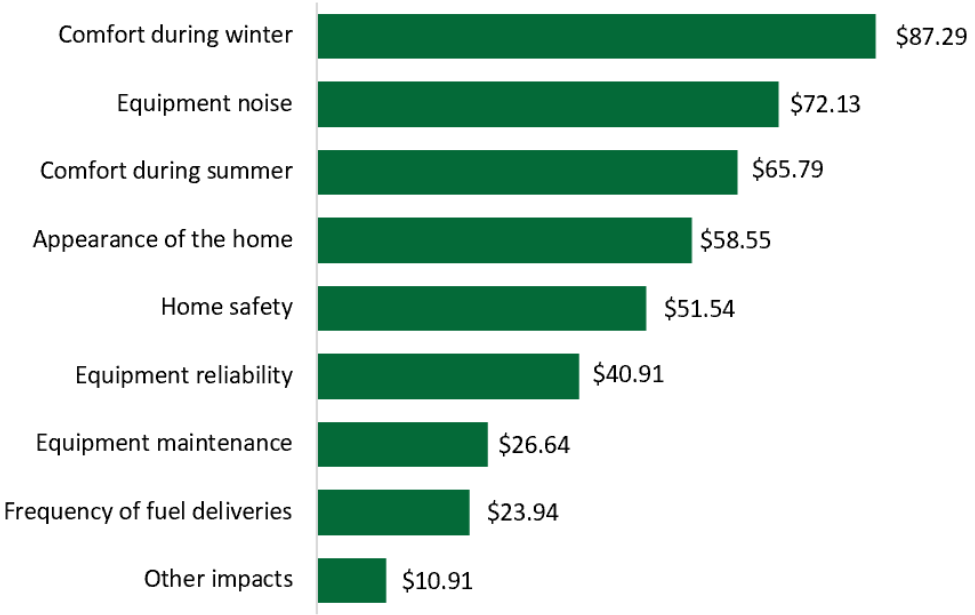


Figure 2-6: Average NEI Dollar Values for MSHPs (n=170)



HPWHs. Respondents valued comfort during summer the most, as shown in Figure 2-7. While the end-user survey did not ask respondents to clarify the source of the comfort, over one-fourth (25%) of respondents reported reduced humidity (Table 2-1) which may contribute to increased comfort. These additional NEIs were valued at $39.14.

More moderately valued NEIs include frequency of fuel deliveries and appearance of the home. Respondents reported the noise from the equipment as a negative NEI (-$69.25), driving down the overall value of the NEIs. Negative NEIs such as equipment noise can hinder adoption of HPWHs. To mitigate the effect of negative NEIs, program administrators may wish to provide additional incentives for follow up maintenance visits to address noise such as installing sound

dampening mats, vibration isolation kits, foam service kits, etc. They may also consider adding decibel rating levels to equipment qualification requirements for incentives. Manufacturers may also want to take this into consideration when designing heat pump water heaters.

See Figure B-10 and Figure B-11 in Appendix B.4 for share of individual NEI values that make up the overall value as well as by heat pump type, respectively.

Figure 2-7: Average NEI Dollar Values for HPWHs (n=70)

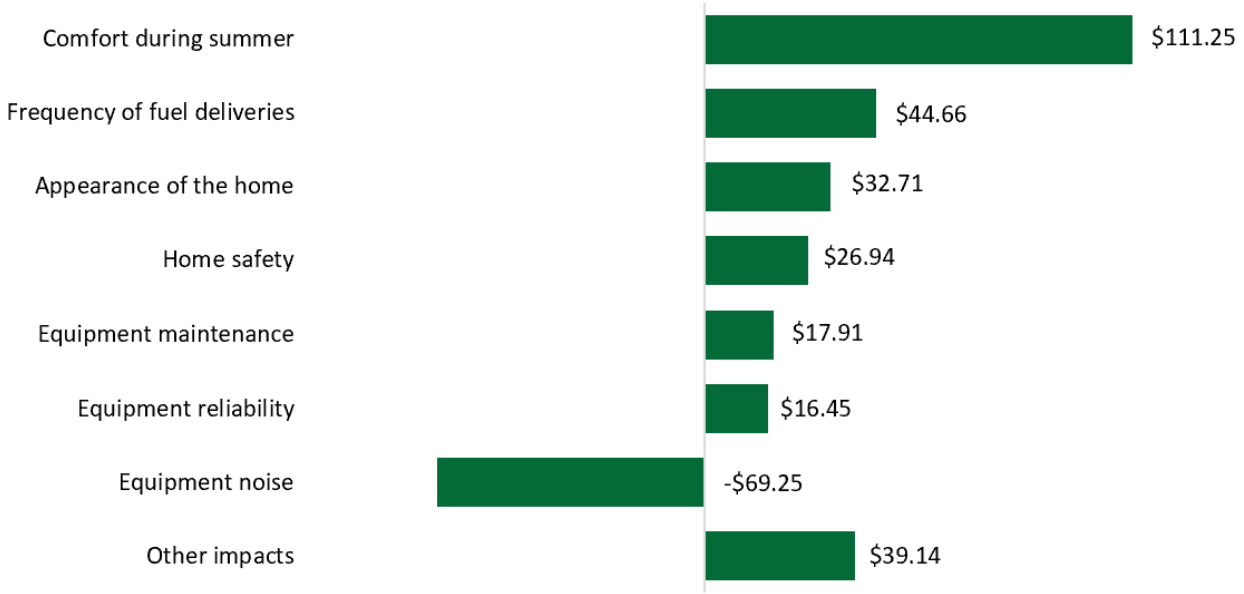


Table 2-1: Other NEIs by Measure

NEI Type	ASHP (n=12)	MSHP (n=170)	HPWH (n=70)
Reduced humidity	1 of 12 respondents	8%	26%
No need to install or remove and store AC unit	0	4%	0%

2.1.1 Early Replacement vs. Replace on Failure

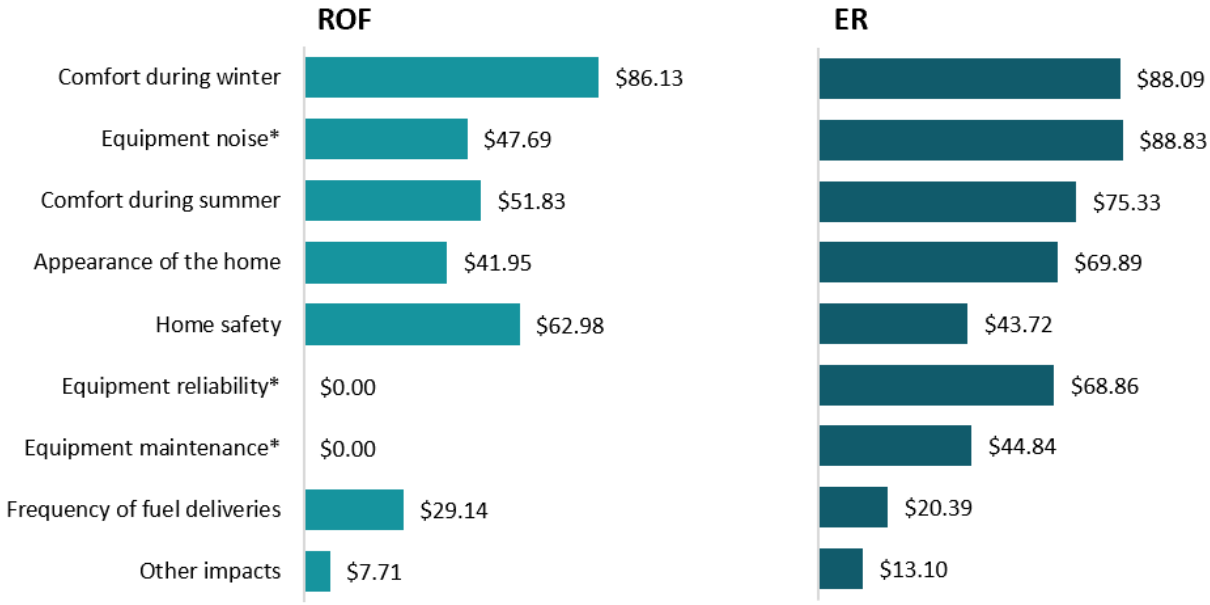
The baseline used to calculate energy dollar savings varies by replacement type. For ER, energy savings are calculated by comparing the new high efficiency heat pump to the existing inefficient system for the remaining useful life of the existing system. ROF compares the new higher efficiency heat pump to the standard efficiency heat pump. The difference in baseline used to calculate savings may result in differences in NEI values. The study compares the NEI values by replacement type for MSHPs and HPWHs.

The total dollar of the NEIs for MSHPs were higher for ER than ROF but the difference in results was not statistically significant. Figure 2-8 shows the dollar value of individual NEIs for MSHPs by replacement type. While ER MSHPs had higher NEI values for equipment noise, comfort during winter and summer, appearance of the home, and equipment reliability compared to ROF MSHPs, the differences were only statistically significant for equipment noise (ROF = $47.69, ER = $88.83) and equipment reliability (ROF = $0, ER = $68.86). MSHPs that replaced failing equipment had higher NEI values for home safety, equipment maintenance, and frequency of fuel deliveries, but their differences were not statistically significant.

Figure 2-8: MSHP NEI Dollar Values by Replacement Type[1]

[1] Shaded bars in the show 90% confidence interval.

Figure 9: MSHP NEI Dollar Values by Replacement Type[1]



[1] Statistically significant difference indicated with (*).

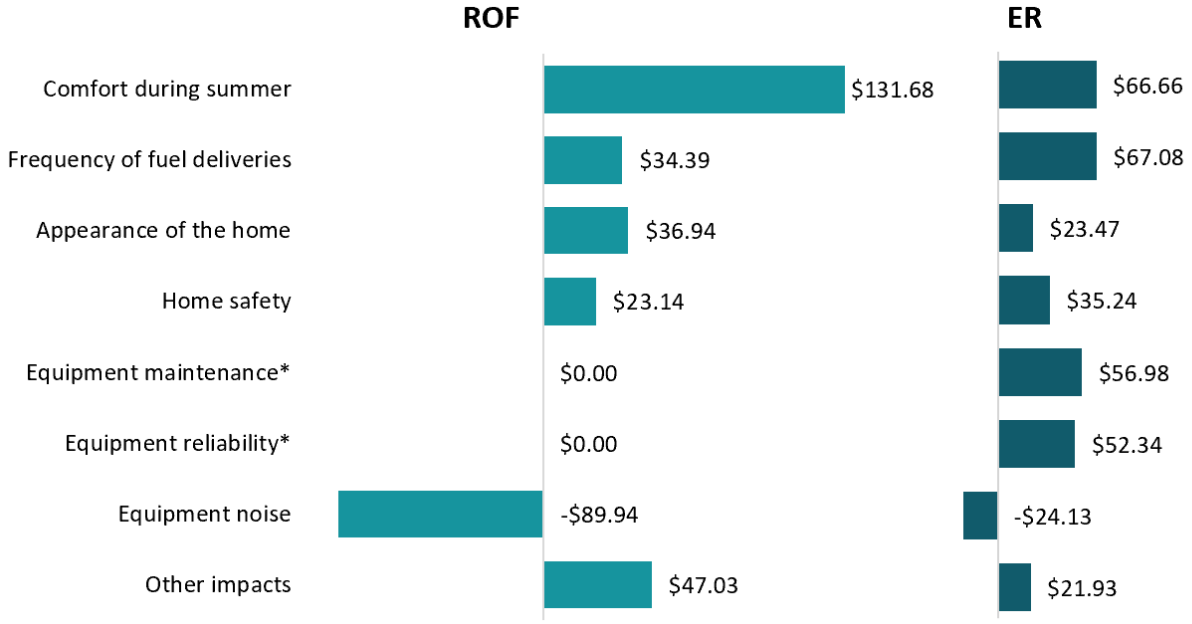
Respondents who installed HPWHs to replace failing equipment valued overall NEIs higher than ER HPWHs but the difference was not statistically significant. Replace on failure HPWHs had higher NEI values for comfort during winter and summer, and appearance of the home, as shown in Figure 2-10. ER HPWHs had higher NEI values for equipment maintenance, frequency of fuel deliveries, home safety, equipment reliability. Although not statistically

significant, ROF respondents valued equipment noise more negatively than ER respondents (ROF = $-89.94, ER = $-24.13). Except for equipment reliability, the difference in ROF and ER values are not statistically significant.

Figure 2-10: HPWH NEI Values by Replacement Type[1]

[1] Shaded bars show 90% confidence interval.

Figure 11: HPWH NEI Values by Replacement Type[1]



[1] Statitically significant difference indicated with (*).

2.2 HEALTH NEIS

Annual NEI values per participant attributable to avoided illnesses range from $0.33 to $7.01 ($3 to $73 lifetime). Table 2-2 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 $7.01 for allergies, $1.98 for sinusitis, and $0.33 for colds and viruses. Asthma is valued at $2.29 but is not statistically significantly different from zero, Appendix A.2.2 provides a more detailed description of the methodology used to estimate these values.

Table 2-2: Annual and Lifetime NEI Values Per Participant for Reduced Illnesses from Heat Pumps

	Asthma	Allergies	Sinusitis	Colds/ Viruses
Avoided cost per incidence, adjusted to 2021 dollars[1] (A)	$284	$684	$249	$34.98
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)	0.021 (-0.004, 0.05)	0.027 (0.01, 0.05)	0.021 (0.004, 0.04)	0.025 (0.01, 0.04)
Annual value per average participant attributable to specific avoided illnesses (B×C)	**$2.29 ($-0.38, $4.96)**	**$7.01 ($2.15, $11.89)**	**$1.98 ($0.40, $3.65)**	**$0.33 ($0.10, $0.56)**
Lifetime NEI attributable to program measures[4, 5]	**$23.78 ($-3.94, $51.50)**	**$72.73 ($22.30, $123.39)**	**$20.60 ($4.16, $37.90)**	**$3.44 ($1.05, $5.78)**

[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, see Table A-3.
[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: $2.29 × weighted average years lifetimes × 15 years × 5% = $23.78*
[5] 90% confidence intervals in parentheses

Annual NEI value per participant attributable to avoided missed work is $15.18. Table 2-3 calculates the annual value per average participant attributable to missed work. Respondents reported an average of 0.27 fewer missed worked days after installing a heat pump through the program which equates to an annual avoided cost of $15.18. Appendix A.2.2 provides additional detail on the approach used to estimate the annual NEI value for missed days worked.

Table 2-3: Annual NEI Values Per Participant for Missed Work

	Missed Work Values
Wages per day for average residential household[1] (A)	$251.68
Wages lost per day for households with primary earner (corrected for without sick leave)[2] (B)	$55.37
Change in number of average workdays missed due to program effect (C)[3]	0.27 (0.15, 0.40)
Changes in household wages from change in sick days lost from work (B×C)[4]	**$15.18** **($8.16, $22.21)**

[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)*
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)*
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, see Table A-4.
[4] 90% confidence intervals in parentheses.

Annual NEI value per participant attributable to avoided missed school is $2.71. The analysis found a very small (0.03 days) reduction in the average number school days missed, as shown in Table 2-4, after program participation. See Appendix A.2.2 for additional detail on the approach used to estimate the annual NEI value for missed school.

Table 2-4: 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)	0.03 (0.002, 0.06)
Participant value from changes in sick days lost from school (A×B)[3]	**$2.71** **($0.14, $5.27)**

[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, see Table A-5.
[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 heat pump equipment incentives from the HVAC program (excluding HES participants) between 2017 and 2019.[11] Due to the small number of CASHP and GSHP installations, every participant that received incentives for these measures was targeted. For the remaining measures, 2,429 and 1,215 participants were randomly selected for MSHP and HPWH measures, respectively.

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 survey firm made outgoing phone calls to increase the number of completes for CASHP and GSHP participants. The end-user survey for all measures yielded a total of 258 responses, including 12 CASHP, six GSHP, 170 MSHP, and 70 HPWH respondents (Table A-1). The survey also stratified by replacement type, early replacement and replace on failure, for MSHP and HPWH. The number of responses met the study's quotas for MSHPs and HPWHs. The overall response rate was 7% after accounting for two bounced recruitment emails and 305 returned recruitment letters.[12]

Table A-1: End-user Survey Targets and Completes

	Recruitment		Survey results	
Measure Types	**Mailers**	**Email**	**Target**	**Completes**
CASHP (n equipment)	49	40	Census	12
GSHP (n equipment)	7	16	Census	6
MSHP (n equipment)	2,429	0	170	170 (101 ER, 69 ROF)
HPWH (n equipment)	1,215	1	70	70 (22 ER, 48 ROF)
Total (n participants)	**3,700**	**57**	**240+**	**258**

[11] The HVAC program offered modest incentives during this timeframe and did not explicitly promote fuel switching.
[12] Response Rate = Responded ÷ (Mailed – Returned), 258 ÷ (3,757 – 307) = 7%

A.2 NON-ENERGY IMPACTS METHODOLOGY

A.2.1 NEIs Quantified Using Labeled Magnitude Scale

For any elements where participants observed positive or negative impacts as a result of the program, respondents were asked to compare the value of that NEI to the impact of the program on their expected annual energy dollar savings from the heat pump or HPWH equipment they installed (row *B* in Table A-2: *How does the value of the positive/negative effect on [NEI] compare to the value of the expected energy savings from [MEASURE]s?).* After asking about individual NEIs, the questions asked respondents to consider the net impacts of NEIs combined—qualitatively and quantitatively. From these inputs, the study estimated NEI values. Table A-2 presents the inputs into the LMS algorithm and the survey and interview questions associated with them. The analysis involved five primary steps:[13]

1. **Develop magnitude scales.**
    a. First, the survey asks participants to indicate whether they experienced a positive, negative, or no effect from the list of individual NEIs identified in the study (row *A* in Table A-2). From this question, the study determines the direction of each NEI's impact.
    b. Next, the survey asks respondents who indicated they experienced a positive or negative NEI effect to compare the value of that effect to their expected energy bill savings (row *B1* in Table A-2). The survey question response options were associated with the ordinal value, or LMS labels, of positive and negative effects.

Positive LMS Labels	Negative LMS Labels
a. Extremely more valuable	a. Extremely less negative value
b. Strongly more valuable	b. Strongly less negative value
c. Moderately more valuable	c. Moderately less negative value
d. Slightly more valuable	d. Slightly less negative value
e. About the same value	e. About the same value
f. Slightly less valuable	f. Slightly more negative value
g. Moderately less valuable	g. Moderately more negative value
h. Strongly less valuable	h. Strongly more negative value
i. Extremely less valuable	i. Extremely more negative value

[13] The LMS methodology was developed using the following sources:
1. Skumatz, Lisa A. 2020. *2020 Cookbook for NEI Studies*.
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. Skumatz, Lisa A. 2015. *Estimating Participant Non-Energy Benefits For Households and Businesses: SERA Approach.*, and the NEI steps detailed in Vander Vliet and Skumatz, 2022, *"Taking the Bias out of Likert Scales: Four Examples using Better Alternatives", Proceedings of the ECEEE Conference 2022.*

   c. The survey then asks the respondents to estimate a percent value associated with the LMS label (row *B2* in Table A-2). All responses associated with an LMS label are averaged to what can be referred to as a magnitude scale where and *extremely more negative* value is associated with the lowest percentage (a value below zero) and an *extremely more positive* value is associated with the highest percentage (a value above zero). No effect is always associated with a value of zero. Magnitude scales from the survey responses are shown in Figure B-3 and Figure B-4.

2. **Apply magnitude scale values.** The study then applied the averaged magnitude scale back to the respondents so that there is an average magnitude scale value associated with each of their responses for each NEI element.
   For example, if the average magnitude scale determined that a *strongly more negative value* was equivalent to -130% (relative to their expected energy bill savings) and a respondent estimated that noise was negatively impacted and that the negative impact was *strongly more negative value* than their expected energy savings, then the value of -130% would be applied to that respondent for that NEI (see Figure A-1 for a simplified working example of Steps 1-2).
3. **Sum the average magnitude values.** The study summed the positive and negative magnitude values for each NEI to get the *net magnitude scale values* for each NEI.
4. **Correct for overlaps.** For any cases where end-users articulated which, if any, of the individual NEIs overlapped, the analysis identified the highest NEI net magnitude value of those NEIs identified as overlapping and divided the highest NEI net magnitude value by the number of overlapping NEIs (row *C*). The analysis then replaced the NEI net magnitude values of the overlapping NEIs with the *corrected magnitude scale values*. This step accounts for any double counting of overlapping NEIs
5. **Normalize magnitude values.** After applying magnitude values, the study divided each respondent's given numeric value of combined effects (row *E*) with the sum of the values of the individual NEIs that they had reported. The study then proportionally decreased the individual NEI magnitude values so that they did not total to greater than the value of that respondent's reported combined effects. This is to avoid double counting of overlapping effects. Table B-9 in Appendix B provides a comparison of these values.
6. **Estimate NEI dollar values.** The study calculated end-user bill savings by multiplying ex-ante savings from the program tracking data with 2019 residential energy price data, see Table B-1 in Appendix B.1 for additional information. Next, the study multiplied the bill savings with the *normalized magnitude scale values* to obtain NEI dollar values.
7. **Adjust NEI values.** Based on discussions and feedback provided by the EA team, the study made the following adjustments to the NEI dollar values for individual NEIs:
   - Ability to sell the home: 0%

     Rationale: Overlaps with increased home value and should not be considered an NEI because it can only be realized by selling the home, thereby depriving the seller of the stream of future benefits that are causing the increase in value.

   - Ability to pay energy and water bills – 0%

     Rationale: Overlaps with reduced energy costs that are already being counted in the BCR test

- Equipment reliability and maintenance: ROF – 0%, ER – 100%

  Rationale: Under the ROF scenario, the newness of the equipment would be driving the NEI value. Replacing old equipment shifts out the replacement and maintenance cycle where the benefits of reduced maintenance occur earlier in the life of the new system and more frequent maintenance is required later.

- Summer and Winter Comfort: Displacement without new load – 100%, Displacement with new load – 25%,[14] New load/ no pre-existing system – 0%

  Rationale: When a heat pump displaces an existing system without adding new load, all additional comfort can be attributed to the displacement. However, when comfort is associated with added new load, then the baseline is the standard efficiency equipment that would have gone into the home had the heat pump not been installed. Therefore, installing a heat pump in a space that did not have preexisting cooling or heating provides no incremental comfort benefits.

Table A-2: Non-Energy Impacts Inputs and Related Research Instrument Questions for Non-health NEIs

Survey Input	Related Survey Question
A. Impact on individual elements	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.
B. Qualitative value of impact on individual elements	B1. How does the value of the positive/negative effect on [NEI] compare to the value of the expected energy savings from [MEASURE]s? [IF POSITIVE] Is the positive effect extremely more, strongly more, moderately more, slightly more, about the same, slightly less, moderately less, strongly less, or extremely less valuable? [IF NEGATIVE] Does the negative effect have extremely less negative, strongly less, moderately less, slightly less, about the same, slightly more, moderately more, strongly more or extremely more negative value than the expected energy savings?
	B2. [IF POSITIVE] You say that the positive effect on [NEI] was [positive effect level from B2] than the energy savings from that [MEASURE]s. How much more/less value – in percentage terms – would you say you received? [IF NEGATIVE] You say that the negative effect on [NEI] was [negative effect level from B2] than the energy savings from that

[14] A sensitivity analysis showed little difference between using a 25% versus 50% adjustment. The study opted to use the more conservative 25% adjustment.

Survey Input	Related Survey Question
	[MEASURE]s. How much more/less value – in percentage terms – would you say you received?
C. Overlap of impact on individual elements	Did you have trouble separating out the effects we asked about? Did any overlap for you? Which effects overlapped?
D. Net combined effects	Would you say that the combination of these effects is overall positive, negative, or had no effect?
E. Qualitative value of combined effects	E1. Thinking about the combination of all the effects that you mentioned ([LIST NEIs]), how does the overall positive (or negative) value of the combination of these effects compare to the value of the expected energy savings from that [MEASURE]s?
	E2. [IF POSITIVE] Is the combination of the effects extremely more, strongly more, moderately more, slightly more, about the same, slightly less, moderately less, strongly less, or extremely less valuable? [IF NEGATIVE] Does the combination of effects have extremely less negative, strongly less, moderately less, slightly less, about the same, slightly more, moderately more, strongly more or extremely more negative value than the expected energy savings?

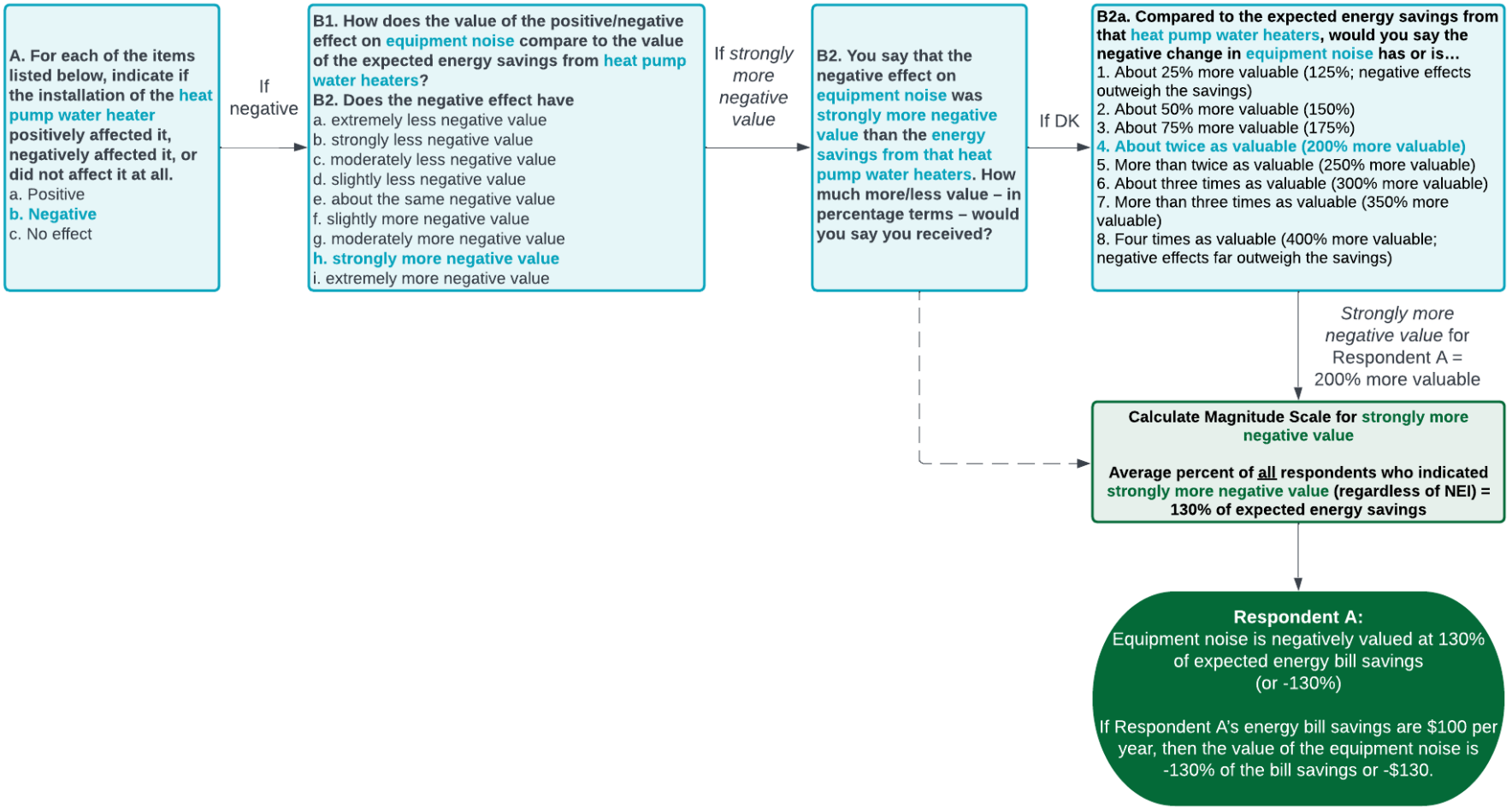
A.2.1.1 Study Limitation

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 heat pump and HPWH installations. The survey asked respondents to provide an estimate of their energy bill savings associated with the heat pump. Approximately one-half of the respondents were unable to or chose not to provide a response suggesting that the majority may not have been aware of their savings from their measure installations.[15]

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 baseline adjustment to the program-reported savings used to estimate bill savings and NEI values, discussed later in Appendix B.1.1.1.

[15] Some respondents stated their energy bill increased in the summer after installing new heat pump in a space without pre-existing cooling.

Figure A-1: Working Example for Equipment Noise NEI (LMS NEI Calculations Steps 1 and 2)[1]



[1] Simplified example excludes Steps 3-7 in LMS NEI calculations which makes various adjustments to the values such as accounting for NEI overlap.

A.2.2 Health NEIs Quantified Using Self Report Direct Measurement

The end-user survey questions asked respondents whether the number of times they experienced illness, missed work or school changed due to program participation. The analysis used these inputs to calculate the avoided cost of specific illnesses and missed work and school. Table A-3, Table A-4, and Table A-5 present the inputs into the NEI calculations for health, missed work, and missed school, respectively, and the survey questions associated with them. The analysis involved four primary steps:

1. **Percent of homes experiencing a change.** The analysis calculated the percent of all respondents who experienced a change in the number of times they had to seek medical care due to illness, miss work, or miss school (row *A* in Table A-3, Table A-4, and Table A-5) since participating in the program.
2. **Average experienced reduction per household.** The study then calculated the average reduction in the number of times they had to seek medical care due to illness, miss work, or miss school for respondents who experienced the change.
3. **Change in number of average reductions.** The study calculated the change in number of average reductions by multiplying the percent of all respondents who experienced a change with the average reduction in the number of times the respondents had to seek medical care due to illness, miss work, or miss school.

4. **Estimate NEI dollar values for avoided illnesses.** The study calculated NEI dollar values for a specific illness by multiplying the *change in the number of average reductions* by the *avoided out of pocket cost per incident*.

Table A-3: Non-Energy Impacts Inputs and Related Research Instrument Questions for Health NEI

Input	Related Survey Question
Percent of homes experiencing a change (A)	Prior to 2020, after installing [MEASURE]s, did anyone in your household need to seek medical care for asthma, allergies, colds/viruses, sinusitis, or hot water scalding? Compared to the year before installing [MEASURE]s, did the need to seek medical care due to asthma decrease, increase, or stay the same?
Average number of times per household having a reduction in seeking medical care (B)	How many fewer/more times did you or a member of your household have to seek medical care?

Table A-4: Non-Energy Impacts Inputs and Related Research Instrument Questions for Missed Work NEI

Input	Related Survey Question
Percent of homes experiencing a change (A)	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?
Average number of days per household having a reduction in days missed work (B)	How many more/fewer times have you or a member of your household missed work?

Table A-5: Non-Energy Impacts Inputs and Related Research Instrument Questions for Missed School NEI

Input	Related Survey Question
Percent of homes experiencing a change (A)	Prior to 2020, after installing [MEASURE]s, did the number of days of school missed because of illness decrease, increase, or stay the same?
Average number of days per household having a reduction in days missed work (B)	How many more/fewer times did your children missed school?
	How many times did you have to pay for or arrange for childcare or miss work because your children missed school?

A.2.2.1 Study Limitation

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.

Appendix B Detailed Results

B.1 Participant Details

B.1.1 Annual Savings

Table B-1 reports the average annual reported gross energy savings of the end-user survey respondents, adjusted gross energy savings, and the corresponding energy bill savings. Adjustments made to gross energy savings are discussed in the next section (Appendix B.1.1.1). GSHPs had the highest bill savings whereas HPWHs had the lowest savings. Measures with higher average savings will translate to higher dollar bill savings.

Table B-1: Average Annual Participant Savings

Measure		Gross Energy Savings (kWh)		Adjusted Gross Energy Savings (kWh)		Dollar Bill Savings[1] (Based on Adjusted Gross Energy Savings)	
	n	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Heat pumps only	188	2,456	2,140	1,723	1,477	$375	$296
CASHP	12	2,384	1,214	2,050	1,044	$448	$228
GSHP	6	2,951	546	2,538	470	$555	$103
MSHP	170	2,441	2,244	1,660	1,526	$363	$303
HPWH	70	2,348	524	2,348	525	$394	$128
Average	**258**	**2,423**	**1,804**	**1,915**	**1,295**	**$380**	**$261**

[1] 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*

B.1.1.1 Adjustments to Annual Savings

The study adjusted participant savings to account for the likelihood of a disconnect when asking respondents about their NEIs relative to their bill savings (Row B in Table A-2); when thinking

about bill savings, respondents are likely to be focusing on comparing pre-installation vs. post-installation energy usage. However, baseline assumptions used to calculate estimated savings in the program tracking data can differ from simple pre- and post- comparisons. Further investigation of the estimated savings in the program tracking data suggest the following assumptions were applied:

- HPWHs use a blended baseline (74% electric resistance, 13% propane, and 13% oil) based on customer survey findings from West Hill's 2018 R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation study[16] for the estimation of program tracked savings. No adjustments needed for NEIs associated with HPWHs.
- ASHPs, MSHPs, and GSHPs assumes the baseline is a working, less efficient electric heating system, including heat pumps and electric resistance heating. This study used an adjustment factor based on the ratio of bill savings from a blended baseline to bill savings from an electric resistance baseline. Adjustments are needed for NEIs associated with heat pumps.

The study made the following heat pump-related adjustment to align tracked savings with savings respondents might be referencing when answering the relative valuation questions:

- The distribution of heating fuel use reported in the survey, shown in Table B-4, is roughly similar to pre-existing conditions based on the population-wide mix of fuels from the Census data (60% oil, 30% electric resistance, and 10% propane).[17] However, the estimated savings in the program tracking data uses a combination of electric resistance and standard heat pump as the baseline, or *program baseline*, from which the savings are calculated. Using dollar savings estimated from program tracked savings, the study calculated the ratios of dollar savings from a blended pre-existing equipment combination to dollar savings from a program baseline (shown Columns C and D of Table B-2) to be 68% for MSHPs and 86% for ASHPs and GSHPs. This ratio is greater than the ratio using dollar savings from a blended pre-existing equipment combination to dollar savings from an *electric resistance baseline* (48% for MSHP and 46% for ASHP and GSHP in Columns A and B).

  Based on these calculations, the study applied an adjustment factor of 68% for MSHPs and 86% for ASHPs and GSHPs to the tracked savings prior to estimating the associated NEI values. These adjustments are reflected in Table B-1. Applying this ratio to the tracked savings provides a better comparison of what the respondents may be thinking to the baseline used to calculate bill savings.

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[16] Source: Eversource Energy and UIL Holdings Corporation. 2019. *Connecticut's 2019 Program Savings Document (PSD).* https://energizect.com/sites/default/files/2019%20PSD%20%283-1-19%29.pdf
Note that the 2018 PSD used similar numbers from a memo from the same study.

[17] This study assumes that homes with natural gas heat were ineligible for heat pump incentives during that time. Excluding natural gas as well as other fuels with very low incidence, the shares of homes eligible for heat pump incentives by fuel would be 66% oil, 27% ER, and 7% propane -- rounded to 60% oil, 30% ER, 10% propane.
Source: U.S. Census Bureau; American Community Survey, 2019 American Community Survey 5-Year Estimates, Table B25040; using data.census.gov; <https://data.census.gov/cedsci/table?q=B25040&g=0400000US09&tid=ACSDT5Y2019.B25040> (9 August 2022).

B.1.1.2 Changes to Savings Baseline

The baseline in this study used to used to estimate savings reflects the PSD assumptions from 2017 to 2019. If the baseline were to change, it is likely the program outreach and estimates of expected savings would also change. For example, if the estimate savings were lower due to a more stringent baseline, the NEIs identified to be associated with heat pump and HPWHs are likely to remain the same but the bill savings that respondents respond to may change and therefore their value of the NEI as a response to those bill savings may also change. For example, if a respondents' estimated savings with a new baseline reduced from $400 to $100 per year, then under the $400 savings scenario, the respondent indicated they valued the NEI the same as their dollar savings. However, under the new baseline's $100 scenario, there is uncertainty as to how the respondent might respond to the lower savings. They can value the NEI at the same as the bill savings or they could value it four times the savings.

Table B-2: Blended Baseline Adjustment Factor for Heat Pumps

Scenario	Type	Capacity (kBTU)	Baseline Heating	Dollar Savings by Baseline Heating	Blended Baseline/ Electric Resistance Baseline		Blended Baseline/ Program Baseline	
					Ratio of dollar savings (A)	Average ratio of dollar savings (B)	Blended Baseline/ Program (C)	Average ratio of dollar savings (D)
1	MSHP	12	Blended	$148	51% ($148/$292)	48%	66% ($148/$224)	68%
2	MSHP	12	Program	$224				
3	MSHP	12	Electric Resistance	$292				
4	MSHP	24	Blended	$285	50% ($285/$577)		66% ($285/$431)	
5	MSHP	24	Program	$431				
6	MSHP	24	Electric Resistance	$577				
7	MSHP	36	Blended	$540	42% ($540/$1,272)		71% ($540/$757)	
8	MSHP	36	Program	$757				
9	MSHP	36	Electric Resistance	$1,272				
10	CASHP	36	Blended	$635	46% ($635/$1,366)	46%	78% ($635/$1,366)	86%
11	CASHP	36	Program	$810				
12	CASHP	36	Electric Resistance	$1,366				
13	CASHP	48	Blended	$840	46% ($840/$8,626)		94% ($840/$897)	
14	CASHP	48	Program	$897				
15	CASHP	48	ER	$8,628				

B.1.2 Pre-existing Heating Equipment and Fuel Use

Program heat pumps most commonly replaced boilers and furnaces for heating and window conditioners for cooling. The survey asked participants for the pre-existing equipment and fuel types prior to their heat pump and heat pump water heater installations. Table B-3 and Table B-5 report the pre-existing heating and cooling equipment that were in place prior to the heat pump installation, respectfully. The most common type of primary heating system in the home prior to heat pump installation were furnaces (37%) and boilers (34%). Heat pumps primarily replaced systems fueled by oil (50%) and electricity (27%). HPWHs commonly replaced systems heated using electricity (57%) and oil (37%), as reported in Table B-4. GSHPs most frequently replaced boilers whereas it was more common for CASHP to replace electric heat pumps.

For cooling, CASHPs and GSHPs most commonly replaced central air conditioning (67% and 33%, respectively). One-half (50%) of GSHP installations went into homes that did not have cooling system. More than one-half (59%) of MSHP installations replaced window air conditioning. Nearly one-third (29%) of MSHP installations were in rooms that did not have a cooling system.

Table B-3: Pre-existing Heating Equipment by Measure

(What was your home's primary heating system before installing the [MEASURE]?)

	CASHP (n=12)	GSHP (n=6)	MSHP (n=170)	Heat Pumps Only (n=188)
Furnace	3 (25%)	2 (33%)	36%	35%
Boiler	1 (8%)	3 (50%)	34%	32%
Electric resistance	1 (8%)	0%	18%	16%
Electric heat pump	7 (58%)	1 (17%)	2%	6%
Wood stove or furnace	0%	0%	2%	2%
None or new construction	0%	0%	4%	4%
Used for cooling only	0%	0%	5%	5%

Table B-4: Pre-existing Fuel Type by Measure

(What type of fuel did/does the old [MEASURE] use?)

	CASHP (n=12)	GSHP (n=6)	MSHP (n=170)	Heat Pumps Only (n=188)	HPWH (n=70)
Oil	33%	83%	50%	50%	37%
Electricity	67%	17%	25%	27%	57%
Natural gas	0%	0%	16%	14%	0%

	CASHP (n=12)	GSHP (n=6)	MSHP (n=170)	Heat Pumps Only (n=188)	HPWH (n=70)
Propane	0%	0%	5%	4%	6%
Wood pellets	0%	0%	4%	4%	0%
Room was not previously heated	0%	0%	1%	1%	0%

Table B-5: Pre-existing Cooling Equipment by Measure[1]

(Before you installed the [MEASURE] system, how were the room(s) served by the new system cooled?)
(Open ended and multiple response)

	CASHP (n=12)	GSHP (n=6)	MSHP (n=170)	Heat Pumps Only (n=188)
Window air conditioner	1 (8%)	1 (17%)	59%	55%
Central air conditioner	8 (67%)	2 (33%)	6%	11%
Portable air conditioner	0%	0%	10%	9%
Geothermal or air source heat pump	3 (25%)	0%	0%	2%
Wall air conditioner	0%	0%	1%	1%
Ductless air conditioner or mini-split	0%	0%	1%	1%
No cooling system	0%	3 (50%)	29%	28%

[1] May not sum to 100% due to multiple response.

B.1.3 Displacement of Pre-existing Equipment

Figure B-1 shows heating displacement by measure. Nearly three-fourths of respondents (71%) said they installed heat pumps that directly replaced an existing heating system without adding new load. Almost one-fourth (23%) of MSHP respondents said they installed MSHP in rooms that did not have pre-existing heating or are used for cooling only.

For cooling displacement, shown in Figure B-2, respondents said heat pumps were most commonly installed in homes that replaced an existing system with (44%) and without (40%) adding new load. The large share of installations that replaced and added new load were primarily driven by MSHP respondents. Three out of the six GSHPs respondents said they did not previously have cooling.

Figure B-1: Displacement of Pre-existing Heating Equipment by Measure

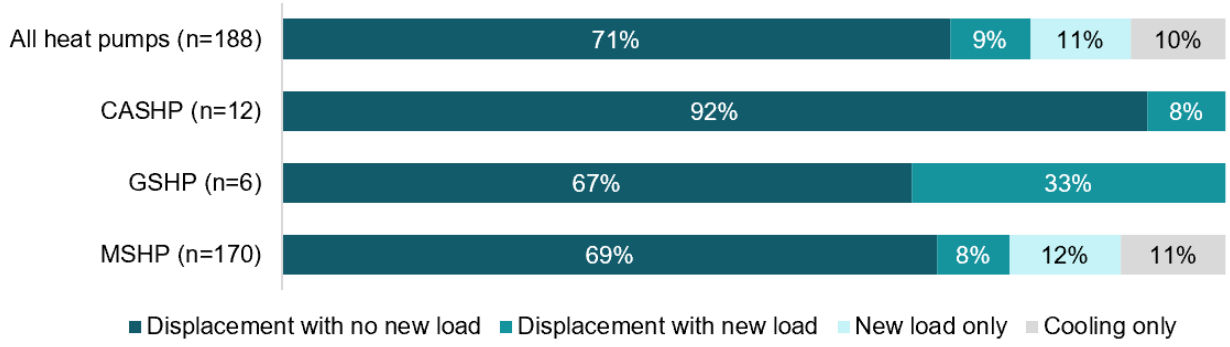
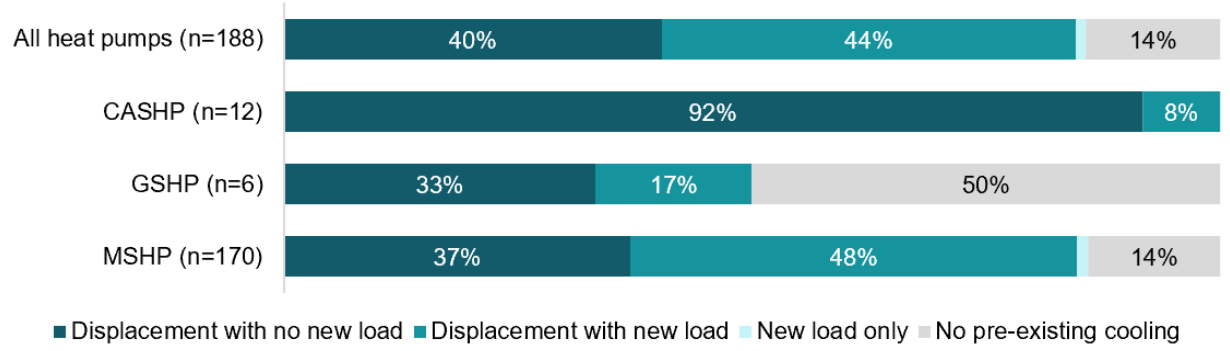


Figure B-2: Displacement of Pre-existing Cooling Equipment by Measure



B.2 Labeled Magnitude Scale Inputs

B.2.1 Labeled 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 Appendix A.2.1, to develop positive and negative magnitude scales shown in Figure B-3 and Figure B-4, respectively.

Figure B-3: Average Positive Labeled 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?)?)

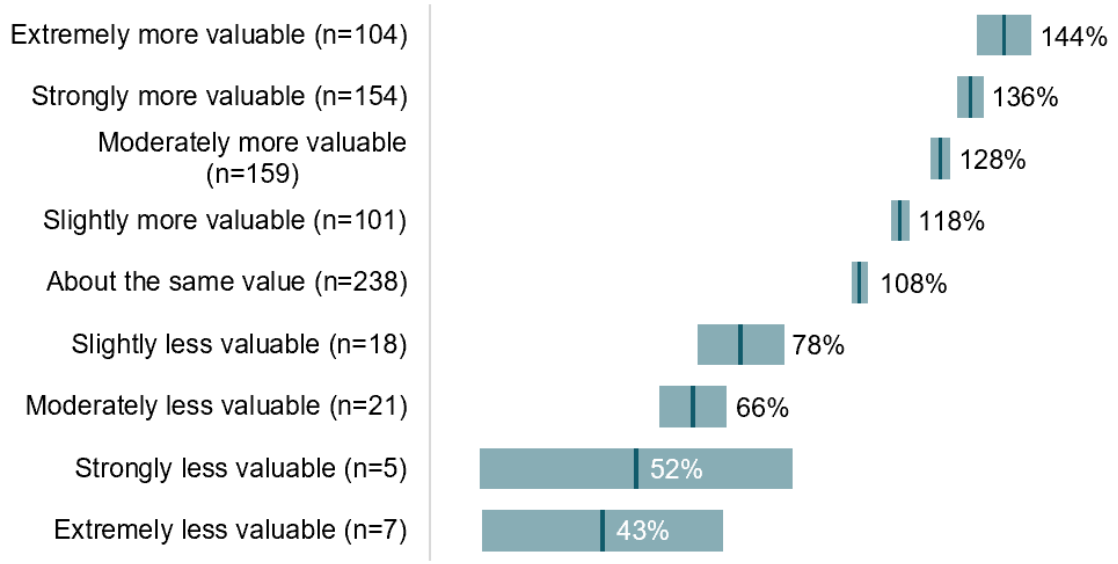


Figure B-4: Average Negative Labeled Magnitude Scales

(You say that the negative 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?)

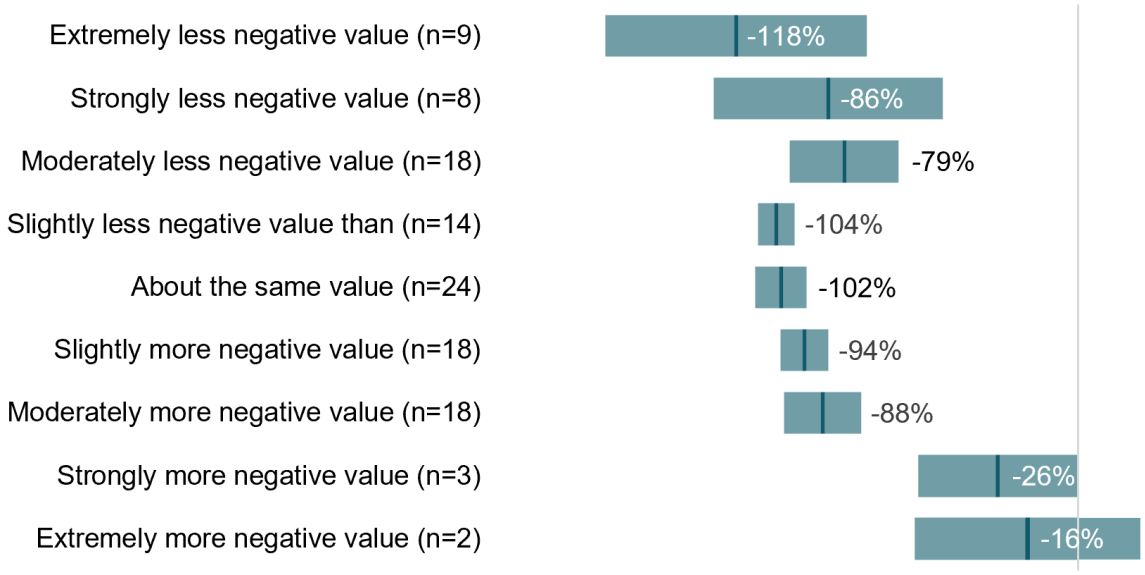


Figure B-5 shows the NEI effects for respondents excluding respondents who said don't know or not applicable. Comfort during summer, equipment reliability, comfort during winter, ability to sell the home, equipment reliability, and comfort during winter were the most frequently reported positive NEIs. Table B-6 presents the average magnitude scale values for the most frequently reported positive and negative NEIs.

Figure B-5: Summary of 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.)

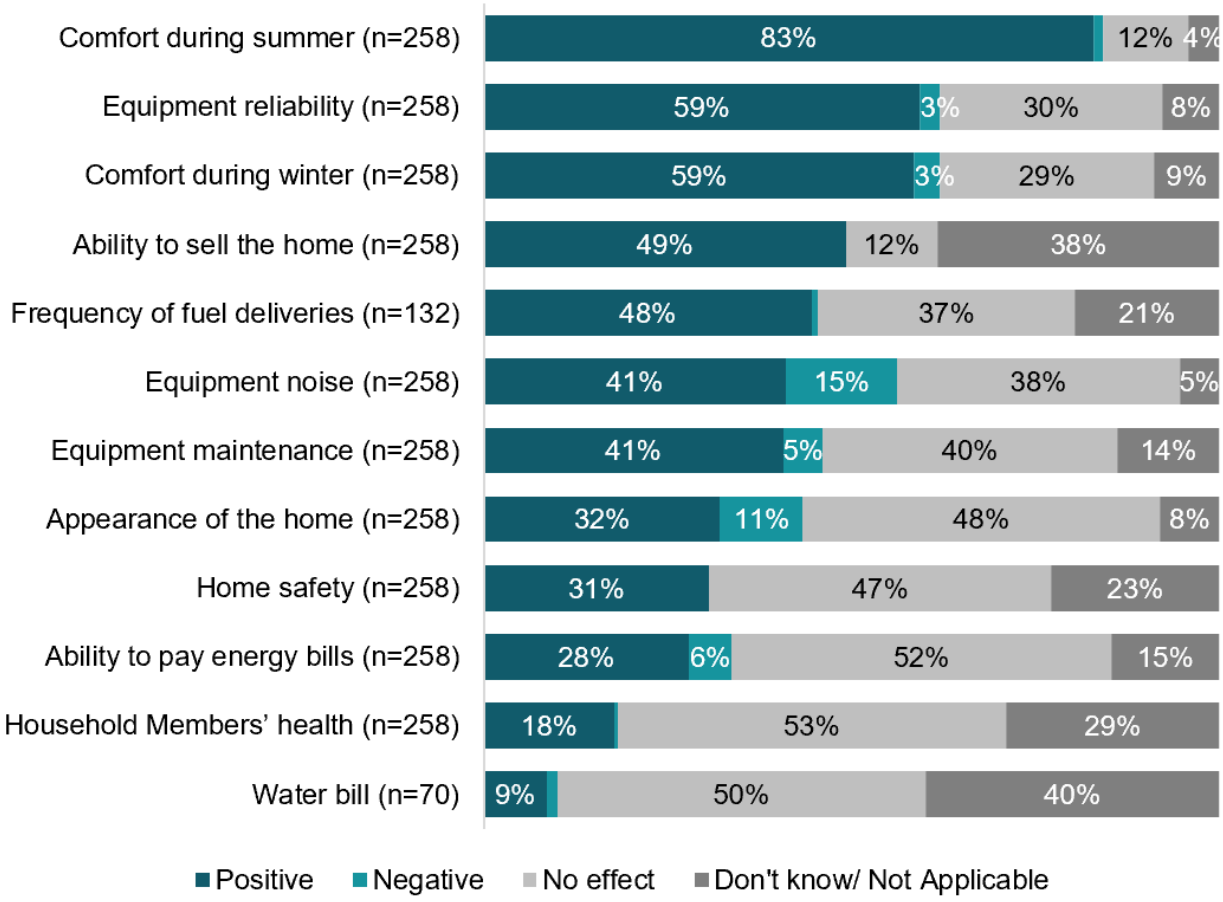


Table B-6: Average Magnitude Value by NEI Effects

Rank	Positive NEIs	Average Magnitude Values	Negative NEIs	Average Magnitude Values
1	Comfort in the summer	128%	Equipment noise	-91%
2	Equipment reliability	124%	Appearance of the home	-88%
3	Comfort in the winter	124%	Pay energy bills	-91%
4	Ability to sell the home	122%	Equipment maintenance	-93%
5	Frequency of fuel deliveries	119%	Equipment noise	-91%

B.2.2 Overlapping NEI Effects

The survey asked respondents whether they experienced overlap of effects and to indicate which effects overlapped. Most GSHP (83%) respondents said they had trouble separating out the effects. A little under one-half of MSHP and HPWH respondents reported overlap at 47% and 41%, respectively. CASHP respondents reported the least overlap (25%) (Table B-7). The NEIs with the most overlap were comfort in the summer, comfort in the winter, equipment reliability, and equipment noise (Table B-8). They most frequently overlapped with each other as well as with equipment maintenance and home sale.

Table B-7: 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
CASHP (n=12)	25%
GSHP (n=6)	83%
MSHP (n=170)	47%
HPWH (n=70)	41%

Table B-8: Common Overlapping NEIs
(Did you have trouble separating out the effects we asked about? Did any overlap for you? Which effects overlapped?)

NEI	n	Percent with Overlapping NEIs	Common Overlapping NEIs
Comfort in the summer	88	34%	Comfort in the winter Equipment reliability Equipment noise Equipment maintenance Home sale
Comfort in the winter	59	23%	Comfort in the summer Equipment reliability Equipment noise Ability to pay energy bills
Equipment reliability	58	22%	Comfort in the summer Comfort in the winter Equipment maintenance Equipment noise Home sale
Equipment noise	40	16%	Comfort in the summer Comfort in the winter Equipment reliability Equipment maintenance

B.2.3 Normalized NEI Effects

Table B-9 compares the total qualitative value of individual NEIs (Row *B* of Table A-2) with the qualitative value of the combined effects of all NEIs (Row *E* of Table A-2) by measure. The sum of the individual effects is, on average, more than twice as large as the combined effects.

Table B-9: Comparison of Combined Effects[1, 2]

NEI	Sum of Individual Effects[2]	Combination of all Effects[3]	Magnitude
CASHP (n=12)	418% (192%, 645%)	173% (61%, 286%)	2.4
GSHP (n=6)	615% (451%, 779%)	212% (98%, 335%)	2.9
MSHP (n=170)	450% (402%, 499%)	215% (190%, 241%)	2.1
HPWH (n=70)	293% (218%, 369%)	159% (117%, 200%)	1.8
Average HP/HPWH (n=258)	**410% (370%, 450%)**	**198% (177%, 219%)**	**2.1**

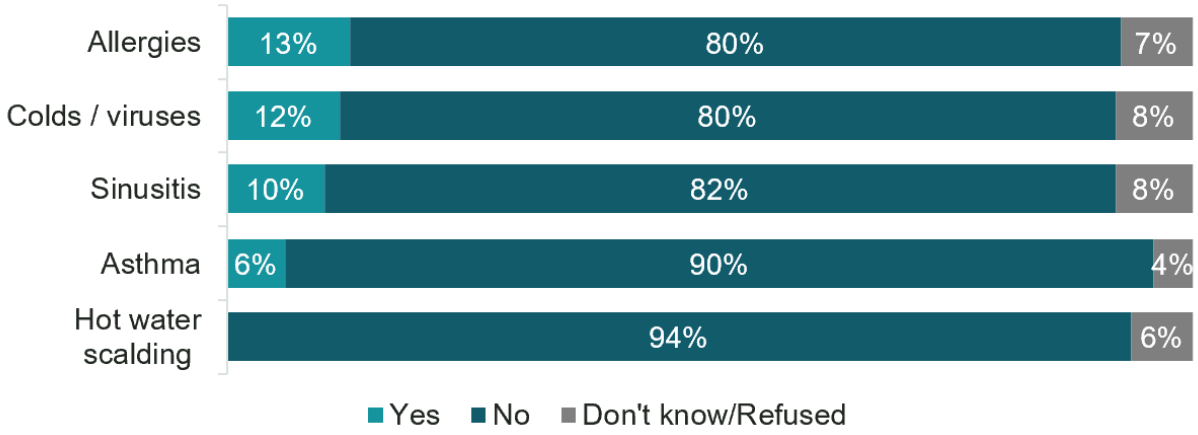
[1] Combined effects in table includes 13 NEIs including 'other' NEIs as reported in the survey. These totals may not equal those reported in Figure 2-2.
[2] 90% confidence intervals provided in parentheses.
[3] Individual effects correspond to the survey question in Row *B* of Table A-2.
[4] Combination of all effects corresponds to the survey question in Row *E* of Table A-2.

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 (87% to 100%) said they did not need to seek medical care for asthma, allergies, colds/viruses, sinusitis, and/or hot water scalding (Figure B-6).

Figure B-6: Medical Care for Specific Illness (n=188)

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



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 the measure had changed. Of the 11 respondents who said they had to seek medical care for asthma, two said the number of times they had to seek medical care for asthma decreased since installing the measure and nine said it stayed the same (not shown).

Nearly one-fifth (18%) of the respondents said they had to seek medical care for allergies, colds/viruses, and/or sinusitis. Of those respondents, more than one-fifth (21%) said the number of times they had to seek medical care decreased since installing the heat pump measure (Figure B-7). Few respondents (3%) said the number of times since they had to seek medical care increased.

Figure B-7: Change in Medical Care for Allergies, Colds/viruses, Sinusitis, and Hot Water Scalding (n=33)

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

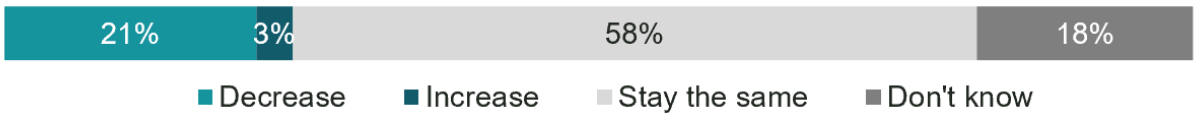


Figure B-8 and Figure B-9 show the share of respondents who said they experienced a change in the number of missed work and school days, respectively, since installing the heat pump measure. Nearly six percent of respondents stated they experienced a decrease and less than

one percent experienced an increase in the number of days worked. Almost four percent of respondents said they experienced a decrease in number of missed school days.

Figure B-8: Change in Number of Missed Days Worked (n=188)

(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?)

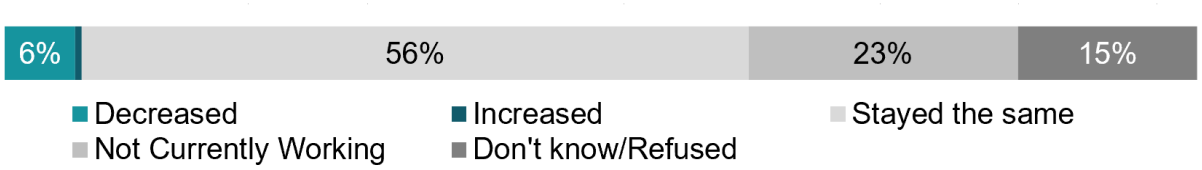
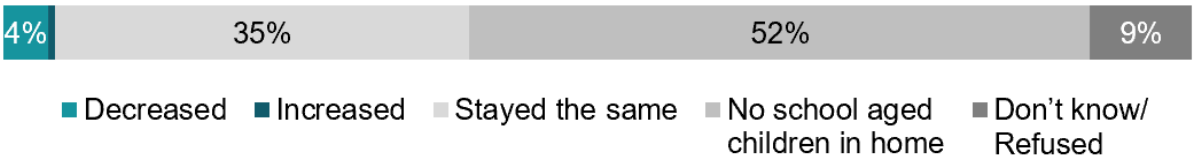


Figure B-9: Change in Number of Missed School Days (n=188)

(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

Figure B-10 shows the share of NEI values that make up the total NEI dollar value for the average heat pump. Figure B-11 further breaks down the share of NEIs values by heat pump type.

Figure B-10: Total Dollar Values per Year by NEI – Heat Pumps Only

Average participant value = $446

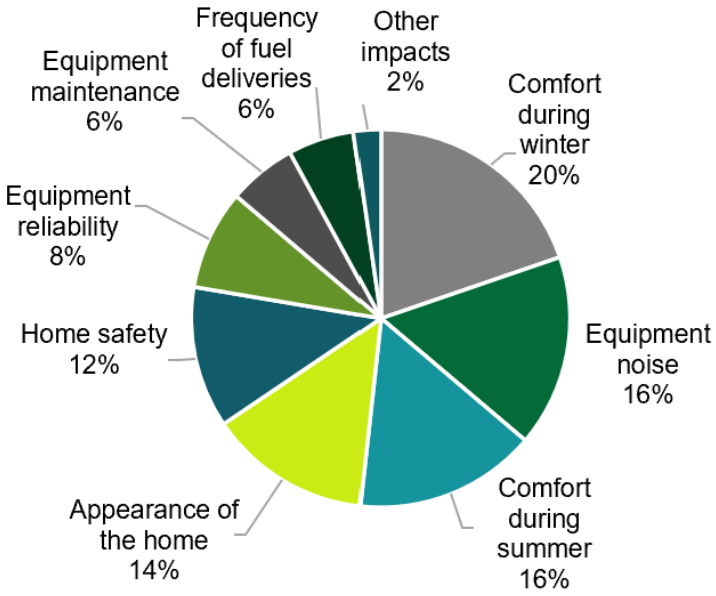


Figure B-11: Total Dollar Values per Year by Heat Pump and NEI Types

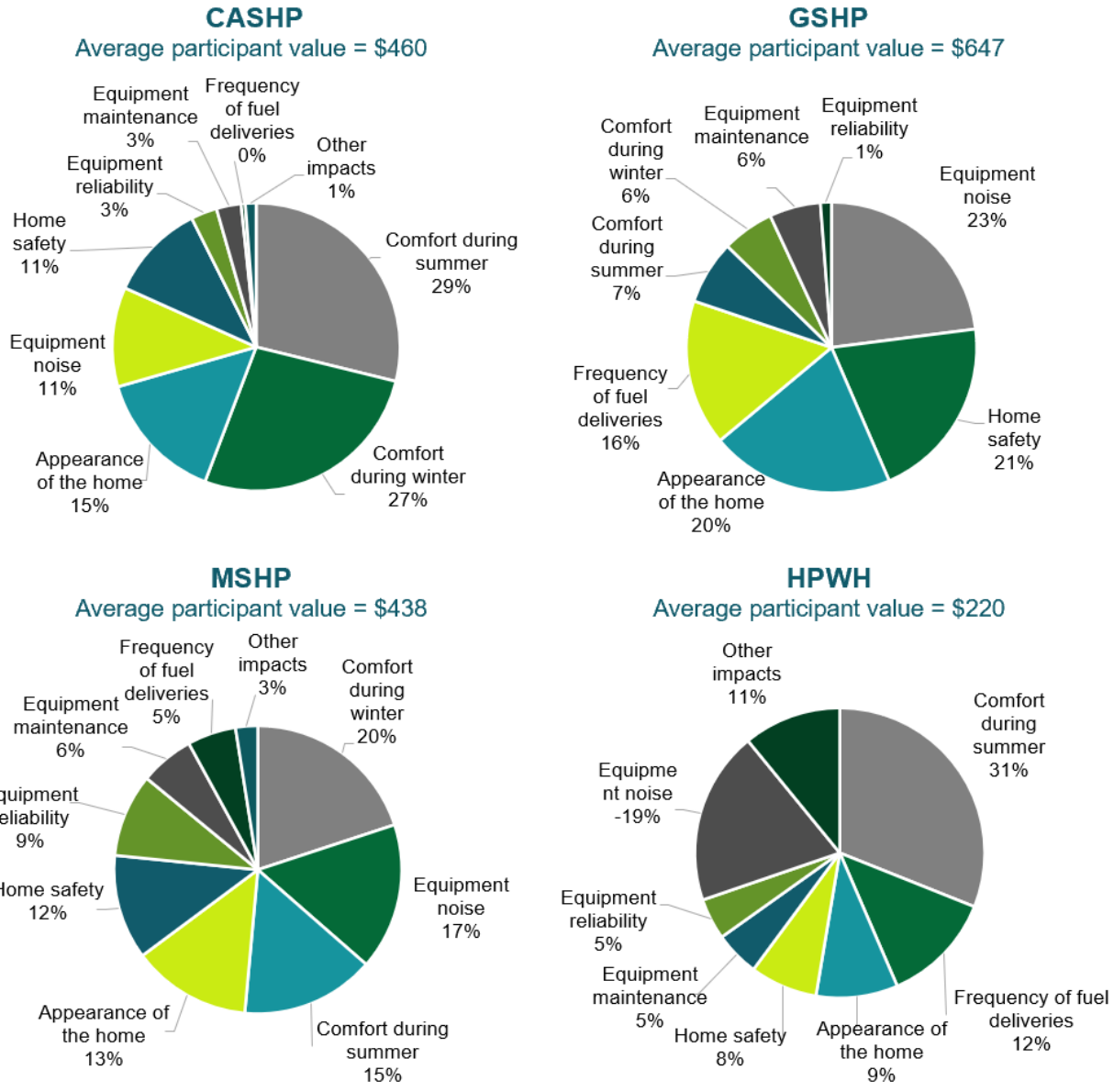


Table B-10 and Table B-12 report the main monetized NEI results of this study with 90% confidence intervals for heat pumps and heat pump water heaters, respectively. Table B-11 and Table B-13 show the corresponding measure savings values with 90% confidence intervals.

Table B-10: Monetized NEIs for Heat Pumps [1,2]

(Annual NEI per average participant that installed a heat pump(s))

NEIs	CASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=170)	Heat Pump Average (n=188)
Appearance of the home	$67.94 (-$3.38, $139.26)	$132.21 (-$24.01, $288.44)	$41.95 ($9.22, $74.67)	$69.89 ($35.40, $104.38)	$58.54 ($34.25, $82.83)	**$61.49 ($38.82, $84.17)**
Comfort during summer	$132.76 ($28.43, $237.07)	$45.85 (-$35.30, $127.00)	$51.83 ($24.40, $79.25)	$75.33 ($53.84, $96.83)	$65.79 ($48.93, $82.65)	**$69.43 ($52.85, $86.00)**
Comfort during winter	$124.05 ($25.86, $222.25)	$37.43 ($5.82, $69.05)	$86.13 ($58.18, $114.08)	$88.09 ($55.94, $120.23)	$87.29 ($65.25, $109.34)	**$88.05 ($67.31, $108.79)**
Equipment maintenance	$12.78 (-$10.18, $35.74)	$36.95 (-$4.95, $78.85)	NA	$44.84 ($14.41, $75.27)	$26.64 ($8.45, $44.83)	**$26.08 ($9.56, $42.61)**
Equipment noise	$51.46 (-$21.07, $123.99)	$148.53 ($25.34, $271.71)	$47.69 ($26.09, $69.29)	$88.83 ($61.08, $116.57)	$72.13 ($53.42, $90.85)	**$73.25 ($55.52, $90.98)**
Equipment reliability	$13.53 (-$10.76, $37.82)	$7.87 (-$2.17, $17.90)	NA	$68.86 ($39.00, $98.73)	$40.91 ($22.75, $59.08)	**$38.11 ($21.62, $54.61)**
Frequency of fuel deliveries	$2.15 (-$1.71, $6.01)	$105.03 (-$37.94, $248.00)	$29.14 ($14.50, $43.77)	$20.39 ($8.04, $32.75)	$23.94 ($14.56, $33.32)	**$25.14 ($15.80, $34.47)**
Home safety	$50.09 (-$10.70, $110.88)	$132.68 (-$1.38, $266.75)	$62.98 ($32.18, $93.77)	$43.72 ($25.83, $61.62)	$51.53 ($35.25, $67.83)	**$54.03 ($38.48, $69.58)**
Other impacts	$5.57 (-$4.43, $15.56)	NA	$7.71 ($1.67, $13.74)	$13.11 ($4.05, $22.16)	$10.92 ($5.03, $16.80)	**$10.23 ($4.88, $15.58)**
Total Value	**$449.13 ($121.62, $776.64)**	**$630.85 ($328.39, $933.31)**	**$319.47 ($234.15, $404.78)**	**$500.59 ($385.10, $616.07)**	**$427.07 ($349.94, $504.21)**	**$434.99 ($362.39, $507.58)**

[1] NEIs are for participants who received incentives for heat pumps through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses

Table B-11: NEI Percent of Measure Savings for Heat Pumps[1,2]

(Savings per average participant)

NEIs	CASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=70)	Heat Pump Average (n=188)
Appearance of the home	13% (-1%, 28%)	24% (-3%, 52%)	8% (-9%, 25%)	17% (11%, 23%)	13% (6%, 21%)	**14% (7%, 20%)**
Comfort during summer	26% (8%, 44%)	6% (-4%, 17%)	23% (4%, 41%)	22% (17%, 26%)	22% (14%, 30%)	**22% (14%, 30%)**
Comfort during winter	25% (7%, 42%)	6% (1%, 11%)	21% (15%, 27%)	22% (17%, 27%)	21% (17%, 25%)	**21% (18%, 25%)**

NEIs	CASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=70)	Heat Pump Average (n=188)
Equipment maintenance	6% (-4%, 17%)	7% (-1%, 15%)	NA	9% (0.1%, 18%)	5% (0.05%, 10%)	**5% (0.05%, 10%)**
Equipment noise	8% (-8%, 25%)	27% (5%, 49%)	13% (7%, 20%)	28% (22%, 33%)	22% (18%, 26%)	**22% (18%, 26%)**
Equipment reliability	6% (-5%, 18%)	2% (-0.5%, 4%)	NA	22% (15%, 28%)	13% (9%, 17%)	**13% (9%, 17%)**
Frequency of fuel deliveries	0.2% (-0.2%, 1%)	19% (-6%, 45%)	10% (5%, 14%)	8% (4%, 11%)	8% (3%, 14%)	**8% (6%, 11%)**
Home safety	10% (-2%, 22%)	25% (1%, 49%)	25% (6%, 43%)	12% (8%, 16%)	17% (9%, 25%)	**17% (9%, 25%)**
Other impacts	1% (-1%, 3%)	NA	2% (1%, 3%)	4% (2%, 7%)	3% (2%, 5%)	**3% (2%, 5%)**
Total Value	**95% (25%, 166%)**	**116% (60%, 172%)**	**101% (70%, 132%)**	**142% (119%, 165%)**	**126% (107%, 144%)**	**123% (107%, 141%)**

[1] NEIs are for participants who received incentives for heat pumps through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

Table B-12: Monetized NEIs for HPWHs [1,2]

(Annual NEI per average participant that installed a HPWH)

NEI	ROF (n=48)	ER (n=22)	HPWH Average (n=70)
Appearance of the home	$36.95 ($14.51, $59.37)	$23.47 ($0.31, $46.63)	**$32.71 ($15.93, $49.49)**
Comfort during summer	$131.68 ($85.68, $177.68)	$66.66 ($28.85, $104.48)	**$111.24 ($77.47, $145.02)**
Comfort during winter	NA	NA	**NA**
Equipment maintenance	NA	$56.97 ($15.50, $98.45)	**$17.90 ($4.39, $31.42)**
Equipment noise	-$89.93 (-$227.27, $47.40)	-$24.14 (-$59.45, $11.19)	**-$69.25 (-$163.32, $24.80)**
Equipment reliability	NA	$52.34 (-$16.83, $121.51)	**$16.45 (-$4.85, $37.75)**
Frequency of fuel deliveries	$34.40 ($9.19, $59.59)	$67.08 ($11.74, $122.41)	**$44.67 ($20.64, $68.69)**
Home safety	$23.14 (-$7.11, $53.39)	$35.24 ($0.67, $69.81)	**$26.94 ($3.90, $49.97)**
Other impacts	$47.03 ($8.74, $85.32)	$21.92 ($1.73, $42.11)	**$39.14 ($12.34, $65.94)**
Total Value	**$183.25 ($59.14, $307.37)**	**$299.55 ($188.46, $410.65)**	**$219.80 ($128.53, $311.07)**

[1] NEIs are for participants who received incentives for heat pump water heaters through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

Table B-13: NEI Percent of Measure Savings for HPWHs [1,2]

(Savings per average participant)

NEI	ROF (n=48)	ER (n=22)	HPWH Average (n=70)
Appearance of the home	9% (4%, 15%)	8% (0.2%, 15%)	**9% (5%, 13%)**
Comfort during summer	29% (20%, 39%)	17% (8%, 27%)	**26% (19%, 33%)**
Comfort during winter	NA	NA	**NA**
Equipment maintenance	NA	13% (4%, 21%)	**4% (1%, 7%)**
Equipment noise	-14% (-36%, 8%)	-6% (-15%, 2%)	**-12% (-27%, 3%)**
Equipment reliability	NA	18% (5%, 31%)	**6% (1%, 10%)**
Frequency of fuel deliveries	7% (-0.01%, 14%)	11% (3%, 19%)	**8% (6%, 11%)**
Home safety	6% (-2%, 13%)	8% (1%, 16%)	**6% (1%, 12%)**
Other impacts	10% (4%, 16%)	6% (0.4%, 12%)	**9% (4%, 13%)**
Total Value	**47% (18%, 77%)**	**75% (47%, 102%)**	**56% (34%, 78%)**

[1] NEIs are for participants who received incentives for heat pump water heaters through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

Table B-14 and Table B-16 report the monetized heat pump and heat pump water heater NEI results, respectively, for selected NEIs prior to adjustment. Table B-15 and Table B-17 show the corresponding measure savings values. Confidence intervals at the 90% level are reported in parentheses.

Table B-14: Monetized NEIs for Heat Pumps – Unadjusted [1,2]

(Annual NEI per average participant that installed a measure)

NEIs	ASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=170)	Heat Pump Average (n=188)
Comfort during summer	$140.80 ($37.77, $243.84)	$191.61 ($31.73, $351.48)	$149.02 ($112.59, $185.43)	$126.34 ($84.86, $167.81)	$135.54 ($106.99, $164.09)	$137.66 ($110.91, $164.41)
Comfort during winter	$125.66 ($27.99, $223.33)	$87.87 ($-31.12, $206.87)	$103.13 ($73.49, $132.76)	$101.86 ($67.99, $135.74)	$102.37 ($79.11, $125.65)	$103.40 ($81.47, $125.33)
Equipment maintenance	$112.24 ($38.20, $186.28)	$135.30 ($15.66, $254.96)	$57.81 ($25.46, $90.16)	$44.84 ($14.41, $75.27)	$50.11 ($27.93, $72.27)	$56.79 ($35.96, $77.60)
Equipment reliability	$112.18 ($39.06, $185.31)	$29.17 ($-1.54, $59.88)	$76.05 ($41.43, $110.67)	$68.86 ($39.00, $98.73)	$71.77 ($49.33, $94.23)	$72.99 ($52.23, $93.77)

[1] NEIs are for participants who received incentives for heat pumps through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

Table B-15: NEI Percent of Measure Savings for Heat Pumps – Unadjusted [1,2]

(Savings per average participant)

NEIs	ASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=170)	Heat Pump Average (n=188)
Comfort during summer	27% (9%, 44%)	32% (4%, 60%)	46% (28%, 65%)	37% (31%, 44%)	41% (33%, 49%)	40% (32%, 48%)
Comfort during winter	25% (7%, 42%)	15% (-6%, 36%)	27% (20%, 35%)	28% (22%, 33%)	28% (23%, 32%)	27% (23%, 31%)
Equipment maintenance	27% (9%, 44%)	24% (3%, 46%)	11% (-4%, 25%)	9% (0.08%, 18%)	10% (2%, 17%)	11% (4%, 18%)
Equipment reliability	27% (9%, 45%)	5% (0.03%, 11%)	16% (-0.9%, 32%	22% (15%, 28%)	19% (12%, 27%)	19% (12%, 26%)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

Table B-16: Monetized NEIs for HPWHs – Unadjusted [1,2]

(Annual NEI per average participant that installed a measure)

NEIs	HPWH ROF (n=48)	HPWH ER (n=22)	HPWH Average (n=70)
Comfort during summer	$131.68 ($85.68, $177.67)	$66.66 ($28.85, $104.48)	$111.24 ($77.47, $145.02)
Comfort during winter	$180.67 ($-2.34, $363.70)	$53.62 ($19.13, $88.09)	$140.75 ($15.47, $266.01)
Equipment maintenance	$48.40 ($14.81, $82.00)	$56.97 ($15.50, $98.45)	$51.10 ($25.11, $487.04)
Equipment reliability	$113.46 ($63.16, $163.76)	$52.34 ($-16.83, $121.51)	$94.26 ($53.90, $134.61)

[1] NEIs are for participants who received incentives for heat pumps through the program and experienced net impacts from the program.
[2] 90% confidence intervals in parentheses.

Table B-17: NEI Percent of Measure Savings for HPWHs – Unadjusted [1,2]

(Savings per average participant)

NEIs	HPWH ROF (n=48)	HPWH ER (n=22)	HPWH Average (n=70)
Comfort during summer	29% (20%, 39%)	17% (8%, 27%)	26% (19%, 33%)
Comfort during winter	35% (7%, 62%)	14% (5%, 23%)	28% (9%, 47%)
Equipment maintenance	12% (5%, 19%)	13% (4%, 21%)	12% (6%, 18%)
Equipment reliability	26% (16%, 35%)	18% (5%, 31%)	23% (16%, 31%)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program.
[2] 90% confidence intervals in parentheses.

Table B-18 and Table B-20 report the monetized results for heat pump and heat pump water heater NEIS, respectively, that were included in the end-user survey but were not claimed in this study. Table B-19 and Table B-21 show the corresponding measure savings values. Confidence intervals at the 90% level are shown in parentheses.

Table B-18: Monetized NEIs for Heat Pumps – NEIs Not Claimed in Study [1,2]

(Savings per average participant that installed a measure)

NEIs	ASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=170)	Heat Pump Average (n=188)
Ability to pay energy bills	$58.13 ($4.17, $112.09)	$4.43 ($-4.49, $13.34)	$55.49 ($19.90, $91.08)	$20.04 ($-5.68, $45.75)	$34.43 ($13.48, $55.38)	$34.98 ($15.78, $54.18
Ability to sell the home	$85.99 ($-11.55, $183.52)	$88.69 ($-31.33, $208.71)	$87.09 ($52.45, $121.72)	$56.41 ($23.01, $89.82)	$68.86 ($44.66, $93.07)	$70.59 ($47.85, $93.32)
Household member's health[3]	$42.69 ($-17.15, $102.53)	$132.69 ($-23.13, $288.51)	$32.31 ($11.64, $52.99)	$37.21 ($12.19, $62.24)	$35.22 ($18.27, $52.18)	$38.81 ($22.56, $55.07)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

[3] Alternative results for 'household member's health' estimated using the LMS approach for informational purposes only. The study uses the health NEI results (e.g., change in incidence) from the self-report direct measurement battery.

Table B-19: NEI Percent of Measure Savings for Heat Pumps – NEIs Not Claimed in Study [1,2]

(Savings per average participant)

NEIs	ASHP (n=12)	GSHP (n=6)	MSHP ROF (n=69)	MSHP ER (n=101)	MSHP Average (n=170)	Heat Pumps Average (n=188)
Ability to pay energy bills	14% (1%, 27%)	1% (-0.01%, 2%)	7% (-9%, 23%)	8% (4%, 12%)	8% (1%, 14%)	40% (32%, 48%)
Ability to sell the home	13% (-1%, 28%)	14% (-2%, 30%)	28% (11%, 46%)	22% (15%, 28%)	24% (16%, 32%)	23% (16%, 31%)
Household member's health[3]	9% (-3%, 21%)	24% (-4%, 51%)	8% (4%, 13%)	8% (4%, 11%)	8% (5%, 11%)	8% (6%, 11%)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

[3] Alternative results for 'household member's health' estimated using the LMS approach for informational purposes only. The study uses the health NEI results (e.g., change in incidence) from the self-report direct measurement battery.

Table B-20: Monetized NEIs for HPWHs – NEIs Not Claimed in Study [1,2]

(Savings per average participant that installed a measure)

NEIs	HPWH ROF (n=48)	HPWH ER (n=22)	HPWH Average (n=70)
Ability to pay energy bills	**$91.12** ($47.03, $135.21)	$57.99 ($18.39, $97.57)	$80.71 ($48.35, $113.06)
Ability to pay water bills	$34.42 ($9.09, $59.74)	$9.32 ($-6.71, $25.33)	$26.52 ($8.52, $44.53)
Ability to sell the home	$55.35 ($21.52, $89.19)	$45.26 ($12.72, $77.81)	$52.19 ($27.20, $77.16)
Household member's health[3]	$18.83 ($0.11, $37.54)	NA	$12.91 ($0.08, $25.73)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

[3] Alternative results for 'household member's health' estimated using the LMS approach for informational purposes only. The study uses the health NEI results (e.g., change in incidence) from the self-report direct measurement battery.

Table B-21: NEI Percent of Measure Savings for HPWHs – NEIs Not Claimed in Study [1,2]

(Savings per average participant)

NEIs	HPWH ROF (n=48)	HPWH ER (n=22)	HPWH Average (n=70)
Ability to pay energy bills	29% (20%, 39%)	17% (8%, 27%)	20% (13%, 26%)
Ability to pay water bills	8% (2%, 13%)	3% (-2%, 7%)	6% (2%, 10%)
Ability to sell the home	15% (7%, 22%)	15% (5%, 25%)	15% (9%, 21%)
Household member's health[3]	5% (0.2%, 9%)	NA	3% (0.1%, 6%)

[1] NEIs are for participants who received incentives for heat pumps and/or HPWHs through the program and experienced net impacts from the program

[2] 90% confidence intervals in parentheses.

[3] Alternative results for 'household member's health' estimated using the LMS approach for informational purposes only. The study uses the health NEI results (e.g., change in incidence) from the self-report direct measurement battery.