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New Hampshire Utilities

Home Energy Assistance Program Evaluation Report 2016-2017 - FINAL

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Opinion Dynamics

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1. Executive Summary

This report presents the results of Opinion Dynamics' evaluation of the NHSaves Home Energy Assistance (HEA) Program for the New Hampshire gas and electric utilities (Eversource, Until, New Hampshire Electric Cooperative, and Liberty Utilities). This report presents the objectives, methods, and findings of Opinion Dynamics' impact and process evaluation and covers the period from January 2016 through December 2017. As is typical with evaluations looking back several years, utilities and program teams have already made changes to the program which, in part, take steps towards several findings and recommendations identified in this report.

1.1 Overview of the HEA Program

The NHSaves Home Energy Assistance (HEA) Program provides a comprehensive set of energy-saving measures to help income-eligible New Hampshire residents reduce energy costs and realize other non-energy impacts (NEIs), such as improved comfort, safety, and health. The program is "fuel neutral" and is coordinated by the New Hampshire Utilities. New Hampshire's five Community Action Agencies (CAAs) implement the HEA Program alongside the federal Weatherization Assistance Program (WAP) and other income-qualified assistance services (e.g., fuel assistance). To facilitate the use of collaborative funding, the eligibility criteria for the HEA Program mirrors the eligibility guidelines of other assistance programs. New Hampshire residents are eligible to receive HEA benefits if they qualify for the state fuel assistance program (currently household income is equal to or less than 60% of the state's median income), the electric assistance program (currently household income is equal to or less than 200% of the federal poverty guideline) or live in subsidized housing. In addition to the comprehensive home energy assessment, eligible households can receive weatherization measures and electric savings measures at no-cost (up to $8,000), which may include insulation, air sealing, LED light bulbs, domestic hot water equipment, programmable thermostats, refrigerators, freezers, space heating equipment, and water heating equipment.[1] Additionally, the HEA Program provides health and safety measures to participants, such as carbon monoxide detectors, smoke detectors, and bath fans. Larger health and safety barriers are also covered if they can be accommodated within the $8,000 rebate cap and the package is still cost effective.

1.2 Evaluation Objectives

Below we list the key research objectives for the impact and process evaluations for the HEA Program during the 2016 and 2017 calendar years.

Impact Evaluation Objectives

- Verify total gross energy (kWH and MMBTU) savings from the 2016-2017 program participants.
- Compare evaluated (ex post) versus utility-reported (ex ante) savings and describe the key contributors to differences.
- Review Targeted Retrofit Energy Analysis Tool (TREAT) models and recommend updates to models based on data gathered during site visits.

[1] Note that space heating and water heating are counted outside of the program's $8,000 cap.

- Identify and empirically quantify participant and utility NEIs associated with the HEA Program, including impacts on comfort, noise, health and safety, and utility arrearages.

Process Evaluation Objectives

- Review and assess the effectiveness of HEA Program design, including the performance of and coordination with CAAs, and program satisfaction levels among participants and partners.
- Identify opportunities to expand the reach of the program given higher levels of program funding and goals, by further engaging partner agencies and reducing waiting lists for weatherization services, and by effectively integrating emerging technologies, including those with potential to achieve cost-effective summer and winter peak coincident demand savings.

1.2.1 Summary of Findings and Recommendations

The 1,548 HEA Program participants[2] from 2016 and 2107 saved approximately 40,507 MMBTUs total and 26 MMBTUs per household. Opinion Dynamics conducted on-site inspections of 50 participating sites to verify household characteristics, equipment specifications, and confirm receipt of energy-saving measures tracked in the HEA Program tracking database (i.e., OTTER) and TREAT models. We then developed ex post savings estimates for the 50 sites by updating TREAT models with primary data collected from each household during site visits. We developed an average ex post realization rate of 91% from the 50 selected sites by dividing ex post savings from updated TREAT models by ex ante TREAT models (i.e., modeled outputs prior to making updates to baseline or retrofit cases based on site visits). We then multiplied the overall realization rate for the 50 sites by all ex ante savings tracked in OTTER to reach program-wide ex post savings presented in Table 1-1 (see Appendix A for a summary of all 50 models used in this analysis). The ex post savings shown in the table below include those from measures that save electricity (kWh) and all other fuels converted to MMBTUs.[3] Also, note that these results underrepresent multifamily households as we lacked contact information for participants that live in master metered buildings (see Section 2.4). While 31% of 2016 and 2017 participants live in multifamily buildings, we only completed site visits with one participant that lived in a multifamily building. For prospective planning purposes, the New Hampshire utilities should apply the total realization rate (91%) to savings claimed by the HEA Program (i.e., those paid for by the program) as the realization rate presented below includes all measures (e.g., insulation, LEDs, domestic hot water, etc.) based on our team's revisions to TREAT models for sample of households.

Table 1-1. Energy Savings Results

Ex Ante Energy Savings (MMBTU) Claimed by the HEA Program	44,514
Ex post Realization Rate*	91%
2016-2017 HEA Program Participants	1,548
Ex Post Gross Energy Savings (MMBTU)	40,507
Ex Post Gross Energy Savings per Household (MMBTU)	26

Site visit results are valid at the 90% confident level with 7.8% relative precision.

[2] The 1,548 unique households represented 1,954 projects as some households received multiple treatments characterized as separate projects in the program tracking database.
[3] To convert kWh savings to MMBTUs, we used a conversion factor of 0.003412. Source: https://www.extension.iastate.edu/agdm/wholefarm/pdf/c6-86.pdf

Energy Modeling

Opinion Dynamics' engineering team made updates to TREAT models for 33 sites (see Appendix A for a complete list of modeling adjustments). For 19 of those 33 models, we made adjustments to the retrofit building conditions. Most commonly, we (1) adjusted heating and cooling system specifications (seven sites); (2) removed savings from air sealing measures for sites where we were unable to confirm blower door tests and CFM reduction (four sites); or removed savings from heating system tune-ups where these measures were incorrectly modeled (four sites).

- **Where possible, the utilities should require CAAs to verify the completion of blower door tests (BDT) for all households that receive air sealing measures.** While BDTs are currently required by the utilities to demonstrate CFM reduction from air sealing measures, our engineering team found at least four out of 50 instances where implementation crews were unable to complete BDTs due to health and safety issues in participating households (e.g., where there is evidence of asbestos insulation that should not be disturbed). In these cases, implementation crews receive guidance to estimate CFM reductions and, as such, we found several instances where pre- or post-retrofit BDT values tracked in project-specific TREAT models appear to have been rounded to the nearest 100 CFM. Utilities should continue to require BDTs be completed by implementation crews wherever possible and, should also require BDT readouts to be submitted along with other project documentation. Where implementation crews cannot perform BDTs for health and safety reasons, utilities should provide guidance to implementation crews on proper documentation (e.g., the use of infrared cameras to document the need for air sealing measures) and clearly note in the program tracking data why a BDT could not be performed. Additionally, in instances where BDTs cannot be performed but air sealing is still necessary, utilities should provide a more systematic method for estimating CFM reduction—e.g., using the average per and post-CFM values from this or future evaluations (see Section 3.1.1) or converting CFM reduction to time and material costs.
- **Utilities should use pre- and post-combustion testing as TREAT model inputs for heating system tune-up measures.** Opinion Dynamics found four instances where implementation crews modeled heating system tune-ups by increasing annual fuel utilized efficiency (AFUE) to exceed or meet 100% of the systems' nameplate AFUE. Program staff indicated that, in households that receive heating system tune-ups, implementation crews are instructed to perform pre- and post-retrofit combustion testing. We recommend that implementers use the results of the combustion tests as model inputs to more accurately estimate savings from furnace and boiler cleaning and tune-up measures. Where combustion testing cannot be completed safely (e.g., where carbon monoxide levels are higher than would be safe for participants and implementation crews), utilities should work to establish a systematic method for estimating pre and post AFUE. As part of a future evaluation, utilities may elect to perform additional primary research (e.g., a metering study or pre/post combustion testing) for a sample of households that receive furnace or boiler tune-ups to establish the actual baseline AFUE pre-treatment and how systems perform post-treatment. Alternatively, utilities could default to a prescriptive approach—e.g., the 2019 Connecticut Program Savings Document (CT PSD) stipulates an existing AFUE for furnaces and boilers of 80% and recommends a 2% increase in efficiency due to cleaning and tune-up measures.[4] Finally, utilities may elect to use time and material costs as a proxy for AFUE reduction. However, we feel that many of the systems treated through the HEA Program are likely older and have nameplate AFUEs lower than the 80% recommended by the CT PSD. As such, additional primary research is the best way to accurately document the existing efficiency of these older systems and the impact of treatment in terms of performance improvement. Specifically, we

[4] CT PSD. Pg. 201

estimate that actual operational efficiency is lower than nameplate and a 2% increase should be based on existing performance, capped at nameplate efficiency.

- **As the New Hampshire utilities move towards upgrading program data tracking systems, decision makers should consider systems' reporting capabilities and their ability to track supplemental information.** Based on interviews with program staff (i.e., both at utilities and CAAs) and our review of TREAT models, it is evident that on-site implementation teams collect large amounts of data related to the HEA Program both during the initial energy assessment and the installation of HEA measures that were not present in the reports used for this evaluation. For example, implementation teams collect detailed information related to households' primary and secondary heating fuel types, baseline heating system capacities, among other specifications. However, these data are often inaccessible without opening individual TREAT models. While it is unrealistic to expect any type of software to be able to report at the same level of granularity allowed for in the TREAT models, when upgrading data tracking software, utilities should consider systems' ability to create customized reports that contain different levels of detail. Additionally, based on previous III, any upgraded program tracking system should enable CAAs to upload supplemental information (e.g., BDT documentation, infrared images, etc.). Further, upgraded software should enable utilities to add fields and make other changes to data tracking and reporting structures as the HEA Program evolves. Considering program tracking software with these capabilities and this type of flexibility will support evaluation and other ad hoc research that will help the HEA Program continue to improve and adapt to participants' needs.

Non-Energy Impacts

As part of this evaluation, Opinion Dynamics quantified select participant and utility non-energy impacts (NEIs) (see Table 1-2). Our analysis focused on NEIs that may be experienced by HEA participants and could be quantified through the tasks of this evaluation, while other research completed in New Hampshire has aimed to quantify a broader list of NEIs for the entire state. For participant NEIs, we used a combination of participant survey data and secondary research to quantify the net impacts to participants of the HEA Program. To quantify increased comfort and decreased noise, we estimated both the share of participants that experienced these NEIs and their perceived value relative to the energy savings they experienced through the program through the participant survey (i.e., a labeled magnitude scaling multiplier[5]). For health-related NEIs, we asked participants about incidences of seeking medical attention or visiting a hospital both before and after participation in the HEA Program and then quantified the impact of any change in the need for medical attention based on secondary research. We also estimated the impact of the HEA Program on customer arrearages, using a difference in difference approach to compare unpaid balances of participants before HEA treatment to unpaid balances after treatment.

[5] Skumatz, Lisa, and Gardner, John (2006), "Differences in the Valuation of NEBs According to Measurement Methodology: Causes and Consequences," Proceedings of the 2006 AESP Conference, Clearwater Beach FL. Skumatz, Lisa and Khawaja, Sami (2009), "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior." For the California Institute for Energy and Environment Behavior and Energy Program. https://uc-ciee.org/downloads/EEM_A.pdf

Table 1-2. Researched Utility and Participant NEIs

NEI Category	Non-Energy Impacts
Utility	Reduced arrearages
Participant	Reduced asthma symptoms
	Reduced thermal stress (both hot and cold)
	Improved comfort
	Decreased internal/external noise

The results of our participant NEI analysis are shown in Table 1-3 below. By far, the largest NEI of the HEA Program was for participants that experienced an increase in the comfort of their home since participating in the HEA Program. Over half of respondents to the participant survey (53%) reported that they had experienced an increase in the comfort of their home since participating in the HEA Program. Additionally, 13% of participants surveyed reported decreased noise inside their home coming from the outside, and 10% reported decreased noise levels from inside their homes. In total, our research suggests that, from the participant NEIs included in the table below, 2016 and 2017 HEA participants realized $531,078 in total, which translated to $343 per participant for all 2016 and 2017 participants. These represent the monetary value of the participant NEIs included in this study. The New Hampshire utilities may elect to use proxy values from secondary research specific to New Hampshire for participant, or other NEIs, not included in this study and may also target those NEIs to quantify through future primary research. For details about our approach and how to apply these results for future program planning purposes, see Section 4.

Table 1-3. Participant NEI Results Summary

Non-Energy Impact	Per Participant (experienced the effect)	Per Participant (all 2016-2017 participants)	Total for the 2016-2017 HEA Program
Increased comfort	$304	$267	$413,431
Decreased noise inside the home	$66	$56	$86,678
Decreased noise coming from outside the home	$30	$15	$22,953
Avoided overnight hospital stays due to reduced asthma symptoms	$6	$5	$8,064
Reduced doctor visits for colds/illnesses related to thermal stress	$0.03	$0.03	$42
Total All NEIs	**$406**	**$343**	**$531,078**

Opinion Dynamics also completed a limited analysis of reduction in utility electric arrearages based on participation in the HEA Program for NHEC and Eversource customers.[6] While we did find evidence that electric utilities did experience reductions in arrearages as a result of HEA participation, we do not have sufficient information to suggest that these results be applied statewide. However, as we were able detect statistically significant NEIs on arrearages for NHEC customers (Table 1-4), we recommend applying these results to HEA participants that are also NHEC customers. Though we did find some evidence of a reduction of arrearages for Eversource customers with at least one month of an unpaid balance, we were unable to detect a statistically significant result. As such, we recommend that the New Hampshire utilities conduct research in the future to quantify these, and other utility NEIs. See 4.2 for a complete discussion of both NHEC and Eversource arrearage analyses.

[6] We did not receive sufficient data to conduct an analysis of gas arrearages, or other utility NEIs.

Table 1-4. Summary of Electric Arrearage Analysis

Utility	Average per Month		
	Unpaid Amount in the Pre-Period	Un-paid Amount in the Post Period	Percent Change
NHEC Electric Arrearage Reduction*	$23.30	$5.93	-25%
Eversource Electric Arrearage Reduction+	$85.63	$58.45	-32%

*Statistically significant at the 98% confidence level

+ Results only apply to 393 Eversource HEA participants with an unpaid balance in at least one month, and not all participants.

Expanding Program Reach

CAAs indicated that most program processes work well and that they have no issues finding qualified participants interested in receiving benefits from the HEA Program (88% of respondents to the participant survey were satisfied with the HEA Program overall). Rather, CAAs face capacity constraints when attempting to reach all those New Hampshire residents interested in participating. As such, the main barriers to reaching additional HEA participants are program funding and limited staff resources (both at CAAs and the contractor workforce). Additionally, CAAs reported that project-level cost-effectiveness requirements may present challenges in future years if WAP funding does not keep pace with the HEA Program.[7] Presently, many participants receive benefits from both programs and CAAs use WAP funding to cover the cost of necessary health and safety improvements.

- **Utilities should leverage HEA Program funds to help CAAs build additional staff capacity.** Lack of administrative staff at CAAs is a substantial barrier to treating more households through the HEA Program. Most CAAs subcontract some or all of the HEA Program's implementation, though, after this evaluation was completed, some CAAs have begun to manage more HEA activities "in house." Utilities should continue to work with CAAs to find ways to leverage program funds to allow agencies to hire additional administrative, or technical staff (e.g., energy auditors), to aid in the delivery of the HEA Program.
- **Utilities should consider funding whole building performance modeling training for CAAs and implementation crews.** CAAs noted that staff training and retention are key barriers to being able to serve more prospective HEA participants**.** Further, according to public comments made before the Energy Efficiency and Resource Standard (EERS) Committee hearing on January 6th 2020, we understand that there is a broader need to recruit and retain more qualified individuals that are able to provide comprehensive, whole building retrofit services (i.e., energy assessments, building performance modeling, measure installation, etc.). As such, utilities should consider sponsoring trainings for CAA staff and implementation teams on best practices for modeling energy savings using TREAT software. Sponsoring these trainings will help relieve the burden of training new staff, provide an incentive for attracting new staff, and help mitigate any quality issues CAAs and utilities currently face regarding TREAT models.
- **The utilities should consider adjusting program requirements to allow more funding for health and safety upgrades on a per-project basis**. CAAs reported that the majority of HEA projects require health and safety upgrades prior to implementing some energy-saving measures (e.g., repairing a leaky roof prior to insulating a home). Program implementers can currently address many of these

[7] Note that in 2016 and 2017, program guidance allowed projects that achieved a benefit-cost ratio less than 1.0. However, this would negatively affect overall cost-effectiveness and, as such, CAAs were reticent to allow projects that did not achieve a benefit-cost ratio of 1.0. New Hampshire utilities and decision makers have made changes to program requirements in subsequent years to address this barrier.

health and safety upgrades by leveraging funding from other programs that they administer (i.e., the WAP).If the utilities choose to increase HEA funding to serve more households without also using some of that funding to cover health and safety upgrades, CAAs may not be able to fund health and safety upgrades through other funding sources for the same share of the HEA participant population.

2. Overview of Evaluation Activities

Table 2-1 below provides a matrix of the research activities conducted for this evaluation and illustrates how each activity served to address the evaluation objectives. We provide descriptions of each activity in the sections that follow.

Table 2-1. Research Methods by Corresponding Objectives

Research Objective	Review of Program Tracking Data	In-Depth Interviews	Literature Review	Participant Survey	Engineering Analysis	Non-Participant Survey	Utility Non-Energy Impact Analysis
Impact Evaluation							
Verify total gross energy (kWH and MMBTU) savings from 2016-2017 program participants	☑				☑		
Compare evaluated (ex post) versus utility-reported (ex ante) savings and describe the key contributors to differences	☑			☑	☑		
Review TREAT models and update models based on data gathered during site visits	☑				☑		
Identify and quantify select participant and utility NEIs associated with the HEA Program			☑	☑		☑	☑
Process Evaluation							
Review and assess effectiveness of HEA design and delivery for 2016 and 2017		☑		☑		☑	
Identify opportunities to expand the reach of the program		☑	☑	☑			

2.1 Impact Evaluation Activities

Opinion Dynamics conducted an engineering analysis to develop ex post savings estimates, and to support applicable updates to savings assumptions. The engineering analysis provides estimated breakdowns of energy savings by end-use claimed by the HEA Program ex ante and subsequent updates to TREAT models to more accurately reflect energy savings realized by the program ex post. In the remainder of this section, we describe each impact method in detail.

2.1.1 Engineering Analysis

The following section explains Opinion Dynamics' approach to three impact evaluation activities used to estimate ex post energy savings for the 2016 and 2017 HEA Program—engineering desk reviews, site visits of participating HEA households, and building energy modeling using TREAT software.

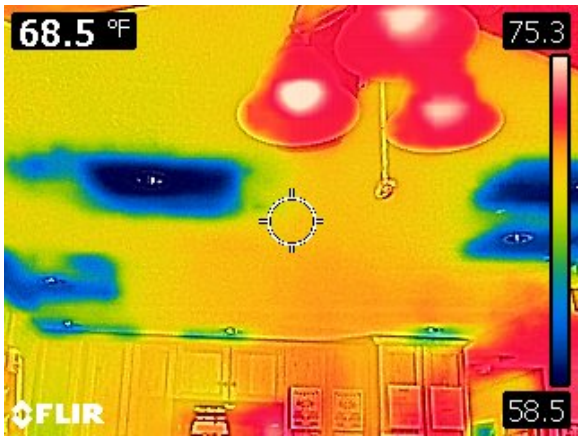
Engineering Desk Reviews

In preparation for site visits, Opinion Dynamics conducted desk reviews to ensure that our field engineers collected the appropriate information to verify measure installation, update TREAT energy models as needed, and calculate ex post savings. For each participating site, we reviewed all available project information prior to the site visit, including utility program tracking data, OTTER extracts, and ex ante TREAT energy models. Our team reviewed these data to ensure that our field engineers collected the appropriate data, and to understand any discrepancies between existing model outputs and claimed savings in OTTER or utility program tracking databases. Finally, based on the preceding desk review, we created custom on-site data collection tools for each site that included fields for measure verification and updates to the TREAT energy models' baseline and efficient building cases.

Site Visits

Opinion Dynamics conducted 50 site visits with 2016 and 2017 participants. The primary objective of the site visits was to verify the installation and continued operation of incentivized measures, as reported in the program tracking data and TREAT energy models. Our field engineers collected key building information including installed measure quantities and parameters, post-retrofit building and measure conditions, major mechanical equipment nameplate data, and other information used in adjusting energy models as needed. We also collected qualitative information related to additional energy improvements completed since participation in the HEA Program. Establishing a timeline of changes in building systems characteristics, both inside and outside the scope of the HEA Program, enabled us to make adjustments to the base building case and retrofit building case TREAT energy models for each site as necessary. We documented measure conditions using photos and infrared thermography and documented homeowner discussions as supporting information to savings calculations. Opinion Dynamics used onsite infrared (IR) imagery to aid in the verification of insulation and weatherization measures. Where IR images showed inefficiencies, such as inconsistent wall insulation (see Figure 2-1), our field engineers investigated and made adjustments to ex post measure quantities as necessary.

Figure 2-1. Infrared (IR) imagery depicting insufficient air sealing and insulation surrounding recessed lights between the first floor and attic.



Outreach and Scheduling

Opinion Dynamics first developed a target of 70 completed site visits with the goal of reporting ex post savings estimates at the 90% confidence level at 10% relative precision. To ensure that results represented the range of primary heating fuel types in New Hampshire, we also developed quotas for the number of sites to be completed at households heated primarily by natural gas, electricity, and delivered fuels.

Opinion Dynamics contacted all 2016 and 2017 HEA participants with valid telephone and email addresses in the program tracking data and offered a $100 incentive to allow our field engineers into their homes to complete site visits, and an additional $50 incentive to provide at least one year of delivered fuel billing data.[8] Our team then scheduled site visits with a random sample of those participants that responded to our initial outreach prior to requesting supporting data from the utilities.

Table 2-2 below shows the number of completed site visits by the primary heating fuel type, along with the share of the population that heats with each of the fuel types. Based on our review of the program tracking data, 5% of 2016 and 2017 HEA participants heat their homes primarily with electricity or wood; however, we were unable to complete any site visits with these participants. Participants who primarily heat their homes with natural gas are also slightly underrepresented in the site visit results. We experienced challenges contacting many natural gas participants for site visits due to limited contact information for participants residing in master-metered gas sites.

[8] We obtained complete billing data (i.e., electric, gas, and/or delivered fuel bills) that covered the entire pre- and post-installation period for 13 of the 50 participants.

Table 2-2. Completed Site Visits by Primary Heating Fuel Type

Heating Fuel Type	Completed Site Visits		HEA Participant Population*	
	Count	Share	Count	Share
Natural Gas	15	30%	539	35%
Fuel Oil	19	38%	346	22%
Propane	13	26%	225	15%
Kerosene	3	6%	205	13%
Wood	0	0%	49	3%
Electricity	0	0%	30	2%
Unknown+	0	0%	154	10%
Total	**50**		**1,548**	

* Estimated based on fuel-specific savings information contained within OTTER.

+ These projects lacked information in the program tracking data about the household's primary heating fuel type.

Engineering Energy Modeling

Prior to the site visits, Opinion Dynamics used the TREAT energy models provided by utilities to compare the ex ante modeled savings to the claimed savings reported in the program tracking database. After completing the site visits, we updated the inputs and re-ran the models to estimate ex post gross MMBTU savings. When site visit observations conflicted with the pre-retrofit building model, we updated both the base and post-retrofit models to reflect these discrepancies. For example, in two instances, base models indicated the usage of one fuel type for space heating, but site visit observations showed a different fuel type for space heating.

As with any building simulation modeling software, savings estimates from TREAT rely on a number of underlying assumptions. As such, though perhaps more precise for individual households that a deemed approach that relies on program-wide averages, savings estimates coming from TREAT software are still estimates and do not represent an actual change in energy consumption. That said, we found the software to be comparable to others used in similar programs that rely on building simulation models. For this evaluation, we did not specifically compare TREAT outputs to other software as that was not included in the scope of this study. Additionally, at the time of this evaluation, TREAT was the only software approved for the New Hampshire WAP and both the WAP and HEA Programs work in close concert. Based on the need to coordinate the WAP and HEA Programs and our experience with similar building simulation modeling software, we have no reason to recommend any different modeling software for the HEA Program.

2.2 Non-Energy Impact Activities

Opinion Dynamics researched the non-energy impacts (NEIs) associated with the HEA Program. The New Hampshire EM&V Working Group is also conducting state-wide NEI research to estimate NEIs more broadly. Opinion Dynamics' goal was to research select participant and utility NEIs as they related to the HEA population specifically. We first conducted a literature review of secondary sources to identify NEIs commonly associated with income-qualified weatherization programs similar to the HEA. Additionally, we reviewed sources to determine best practices for quantifying participant and utility NEIs. Based on that review, we recommended the following utility and participant NEIs for analysis (see Table 2-3).Table 2-3. While participants may have experienced other NEIs related to their participation in the HEA Program, our researched focused on quantifying these based on primary and secondary research. For example, HEA participants may experience other NEIs such as reduced operations and maintenance costs or reduced carbon monoxide poisoning.

Further, the HEA Program may lead to other societal benefits, such as health benefits due to localized emissions reductions or reduced reliance on welfare or economic development benefits. As our research did find evidence to support that both participants and utilities experienced positive NEIs as a result of the program, the New Hampshire EM&V Working Group may consider leveraging statewide NEI research to supplement these NEIs with other quantified benefits as necessary.

Table 2-3. Non-Energy Impacts Recommended for Analysis

NEI Category	Non-Energy Impacts
Utility	Reduced arrearages
	Reduced debt write-offs
	Reduced safety calls
Participant	Reduced asthma symptoms
	Reduced thermal stress (both hot and cold)
	Fewer missed days at work
	Improved comfort
	Decreased internal/external noise

2.2.1 Participant Non-Energy Impacts

Opinion Dynamics estimated the participant NEIs listed in Table 2-4 with primary data collected through the participant and non-participant surveys and secondary data collected through the literature review (see Section 2.3). Our team first linked each of the participants NEIs with specific measures or packages of measures offered through the HEA Program. We then asked each participant survey respondent questions about NEIs specific to the measures they received (see Table 2-4).

Table 2-4. Measures Related to Participant Non-Energy Impacts

NEI	Measures
Reduced asthma symptoms	Insulation, air sealing, furnace replacement/tune-up, boiler replacement/tune-up, programmable thermostat, window/door replacement, or health and safety measures
Reduced thermal stress	
Fewer missed days at work	Insulation, air sealing, furnace replacement/tune-up, boiler replacement/tune-up, domestic hot water, thermostat, window/door replacement, or health and safety measures
Increased comfort	Insulation, air sealing, furnace replacement/tune-up, boiler replacement/tune-up, domestic hot water, thermostat, duct sealing/insulation, or window/door replacement
Reduced internal noise	Furnace replacement/tune-up, boiler replacement/tune-up, duct sealing/insulation, or refrigerator replacement
Reduced external noise	Insulation, air sealing, or window/door replacement

Opinion Dynamics then used secondary sources to determine the estimated per participant monetary value of participant health NEIs (i.e., hospital treatments for asthma symptoms, doctor's visits for cold/flue-like symptoms, and labeled magnitude scaling multipliers for valuing NEIs relative to energy savings). We then used survey data, in conjunction with secondary sources to estimate final participant-level and program-wide NEIs (see Section 4).

2.2.2 Utility Non-Energy Impacts

Opinion Dynamics attempted to quantify utility NEIs based on billing data tracked by each of the four utilities. However, utilities were unable to provide data on debt write-offs[9] or safety calls, and only two electric utilities were able to provide data on arrearages (see Section 4.2). We analyzed changes in arrearages after program participation using a difference-in-difference approach. We calculated the difference in the average monthly pre- and post-weatherization arrearages for a treatment group of 2016 program participants and the difference in the average monthly change in these values for the pre- and post-periods for a comparison group of 2017 participants (see Equation 2-1). The difference in these differences yields the arrearage NEI (see Section 4.2).

Equation 2-1. Utility Arrearage Difference in Difference Equation

$$Arrearage\ NEI = [A1T - A2T] - [A1C - A2C]$$

Where:

$A1T = Average\ monthly\ arrearage\ for\ treatment\ customers\ pre\text{-}participation$

$A2T = Average\ monthly\ arrearage\ for\ treatment\ customers\ post\text{-}participation$

$A1C = Average\ monthly\ arrearage\ for\ comparison\ group\ customers\ pre\text{-}participation$

$A2C = Average\ monthly\ arrearage\ for\ comparison\ group\ customers\ post\text{-}participation$

2.3 Process Evaluation Activities

Opinion Dynamics conducted both primary and secondary research activities to contribute to the process evaluation. Below, we discuss each of these activities in detail.

2.3.1 Program Staff interviews

Opinion Dynamics conducted in-depth interviews with HEA Program managers with each of the four New Hampshire utilities (i.e., Eversource, Until, New Hampshire Electric Cooperative, and Liberty Utilities). Interview topics included program design, delivery, marketing and outreach strategies, opportunities to expand the reach of the program, and NEIs. These interviews provided the evaluation team with a more in-depth understanding of the program design and allowed us to refine our evaluation work plan. These interviews also informed subsequent research tasks, including in-depth interviews with CAA staff and the development of participant and non-participant survey instruments.

2.3.2 In-Depth Interviews with Community Action Agencies

Opinion Dynamics conducted in-depth interviews with staff from each of the five CAAs that implement the HEA Program. The goals of these interviews were to build a better understanding of their experience with the program, identify opportunities to improve and expand the program, and gather feedback on NEIs associated with the HEA Program.

[9] Note Eversource did provide data on bad debt write-offs. However, only eight participants had write-off indicators, which were too few to conduct an analysis of these NEIs.

2.3.3 Literature Review

Opinion Dynamics conducted a literature review of secondary sources to support NEI research (see Section 2.2) and to compare the NHSaves HEA Program to others with similar designs. Specifically, the goals of the literature review were to:

- Explore how similar income-qualified programs account for delivered fuels (e.g., oil, propane, wood, etc.).
- Identify appropriate NEIs for study, industry-agreed upon methods for quantifying those NEis, and proxy values for participant NEIs as necessary; and
- Review the design of similar programs that incorporate residents of mobile and manufactured homes into the program eligible populations.

The evaluation team reviewed the following sources:

- Amann, Jennifer Thorne. (2006). *Valuation of Non-Energy Benefits to Determine Cost-Effectiveness of Whole-House Retrofit Programs: A Literature Review.* American Council for an Energy-Efficient Economy.
- American Council for an Energy-Efficient Economy (ACEEE). (2018). *Supporting Low-Income Energy Efficiency: A Guide for Utility Regulators.* American Council for an Energy-Efficient Economy.
- APPRISE (Applied Public Policy Research Institute for Study and Evaluation). (2018). *R1709 Connecticut Non-Energy Impacts Literature Review.* Applied Public Policy Research Institute for Study and Evaluation.
- Campbell, M. (2018). *South Caroline Electric and Gas Company EnergyWise Program Year 7 EM&V Report*. Opinion Dynamics.
- Cluett et al. (2016). *Building Better EE Programs for L.I. Households*. American Council for an Energy-Efficient Economy.
- Drehobl, A., and F. Castro-Alvarez. (2017). *Low-Income Energy Efficiency Programs: A Baseline Assessment of Programs Serving the 51 Largest Cities.* American Council for an Energy-Efficient Economy.
- Fuchs, L., Skumatz L., and J. Ellefsen. (2004). *Non-Energy Benefits (NEBs) from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs*. American Council for an Energy-Efficient Economy.
- Lusson, K. (2020). *SMART THERMOSTATS: Assessing Their Value in Low-Income Weatherization Programs.* National Consumer Law Center.
- Miller, E., Sumi, D., and J. Iaccarino. (2017). *Indianapolis Power and Light Company Evaluation, Measurement and Verification Revised Report*. The Cadmus Group.
- Nadal, S. (2018). *Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps.* American Council for an Energy-Efficient Economy.
- Shoemaker, M. (2016). *Best Practices in Developing EE Programs for LI Communities.* American Council for an Energy-Efficient Economy.

- Shoemaker, M., Gilleo, A., and J. Ferguson. (2018). *Reaching Rural Communities with Energy Efficiency Programs.* American Council for an Energy-Efficient Economy.
- Skumatz, L. (2014). *Non-Energy Benefits/Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Tests: State of Maryland*. Skumatz Economic Research Associates.
- Skumatz, D'Souza, and Santulli, "Study of the Value of Advanced LED Lighting Features: Monetizing Human Physiological and Environmental Effects of Lighting", for Pacific Northwest National Laboratory, Portland, OR. September 10, 2019.
- Talbot, J. (2012). *Mobilizing Energy Efficiency in the Manufactured Housing Sector*. American Council for an Energy-Efficient Economy.

2.3.4 Participant Survey

Opinion Dynamics conducted a quantitative mail-push-to-web survey of 2016 and 2017 participants to inform the process evaluation and NEI analysis. One of the key process objectives was to assess the effectiveness of the program's design and delivery from the participant's perspective. This included understanding how participants learned about the program, their motivations for participating, their experience with program staff, and general satisfaction. Additionally, through the survey, we identified the share of participants that experienced a change in the participant NEIs included in Table 2-4 if that change was positive or negative, and how participants valued those NEIs relative to energy savings.

Opinion Dynamics fielded the participant survey between July 12th and July 28th of 2019. We attempted a census of 2016 and 2017 program participants with valid mailing addresses, to reach 188 completed surveys. We mailed a $10 VISA gift card to respondents who completed the survey as an incentive. The evaluation team mailed invitation letters and follow-up postcards to participants with information about the survey and a URL to take the survey online. To accommodate participants without access to the internet, we also included a call-in option to allow participants to complete the survey over the phone. In total, 188 participants completed the survey resulting in a 20% response rate (note that 72 of the 188 respondents completed the survey over the phone and 116 completed the survey online).

2.3.5 Non-Participant Survey

Opinion Dynamics also conducted a survey with HEA eligible non-participants. The goals of this survey were to explore the size of the eligible non-participating population, assess customer awareness and interest in the HEA Program, understand drivers and barriers to participation, and collect baseline information for the NEI analysis. We fielded the survey in coordination with the non-participant survey for the 2016 and 2017 evaluation of the Home Performance with Energy Star® (HPwES) Program. As customers must meet income criteria to be eligible for the HEA Program (see Section1.1), we developed a series of screening questions to assess whether respondents fell into the eligible population.

Opinion Dynamics fielded the non-participant survey between October 25th and November 11th, 2019. As an incentive, we offered $10 VISA gift cards and a chance to receive one of five $50 VISA gift cards for those that completed the survey. Similar to our approach for the participant survey, we mailed invitation letters and follow-up postcards to introduce customers to the survey and provided them with the survey URL. For non-participants identified as income-eligible based on income qualified rate codes, we also provided a phone number to allow respondents to take the survey over the phone. Opinion Dynamics received customer databases from utilities, and, prior to developing a simple random sample of 4,865 unique customers with valid mailing addresses, we removed customers that participated in the 2016 and 2017 HEA Program. We also pre-screened all customers currently receiving rate assistance through the Electric Assistance Program

(EAP) as HEA income eligibility closely mirrors the criteria for EAP. Of the 4,865 customers in the survey sample, 1,234 of them were EAP customers. These EAP customers were pre-qualified for the HEA survey and their invitations included a call-in option to accommodate households lacking an internet connection.

Opinion Dynamics set a target of 68 completed surveys to report results with 90% confidence and 10% relative precision. In total, we received 165 completes for HEA eligible non-participants. The overall response rate for the survey (including HPwES respondents) was 7%.

2.4 Deviations from Evaluation Plan

During the evaluation, we experienced several impediments related to data quality, completeness, and availability that prevented us from executing the research tasks as originally planned. In these instances, Opinion Dynamics adapted the research activities when possible, as outlined below:

- Programs that serve participants across multiple different utility companies, often have challenges related to matching participants that are gas customers of one utility and electric customers of another. In most cases, we used a combination of customer name and address to match gas and electric projects tracked by different utility companies to reflect that the energy upgrades applied to a single household. However, for multifamily participants that lacked contact information, we were often unable to match individual gas and electric projects.
- Lack of customers' primary heating fuel type prevented our ability to develop a non-participant survey sample based on fuel type. Our initial research plan involved sampling based on customers who heat their homes primarily with natural gas, delivered fuels, and electricity. Because electrically heated homes are relatively rare in New Hampshire, we aimed to oversample these homes in the participant survey. However, lacking information on fuel type, we were unable to develop the non-participant sample as planned.
- We received incomplete or unreliable delivered fuel billing information from participants and fuel suppliers and therefore were unable to use the data to validate savings estimated through the ex post TREAT models. Of the 50 completed site visits, 32 homes (64%) use a delivered fuel for their primary heating source. We were able to obtain some billing information from 23 out the 32 participants, though we had complete delivered fuel consumption data for only 11 sites. As such, we were unable to perform accurate model calibrations for the sample of sites with delivered fuels for the following reasons:
  - Inconsistent and incomplete billing records provided: In some cases, participants were only able to provide individual delivered fuel bills (i.e., not comprehensive billing data). As such, there were many instances where we were unable to accurately determine a full year of annual consumption due to missing individual billing statements (21 of 32 sites).
  - Lack of records predating project implementation: Many participants were able to provide one or two years of delivered fuel records. However, this was still insufficient to establish a full year of pre-treatment fuel consumption for the 2016 and 2017 completed projects.
  - Multiple fuels used onsite: Many sites had multiple fuels used for both space and water heating, as well as cooking. In these instances, we could not always determine the proportion of fuels used for each end-use. While we asked participants what they believed their fuel use breakdown to be, we found this information to be unreliable and imprecise.
- This study does not include an analysis of utility NEIs as they relate to changes in bad debt write-offs or numbers of safety calls as originally planned. We did receive some data from Eversource electric

on bad debt write-offs. However, there were only eight customers with write-off indicators, which did not provide enough observations to be able to complete the analysis for those customers. Additionally, we did not quantify the program's impact on gas arrearages as utilities were unable to provide the necessary data to complete the analysis.

- Multifamily participants are underrepresented in the primary data collection activities of this study (see Table 2-5). As is common in other programs that serve participants in master metered buildings, utilities sometimes lack information from implementation teams on individual participants (e.g., unit numbers, name, contact information, etc.) where property managers or building owners enroll entire buildings in the HEA Program. As such, our efforts to reach these participants during site visit scheduling and surveys were less successful. We completed mailing address information where feasible and addressed survey invitations to "Current Resident" to include the largest number of multifamily participants in survey mailings as possible. However, participants are less likely to respond to surveys and outreach when we lack personal information.

Table 2-5. Housing Type Comparison for Primary Data Collection Activities

Property Type	HEA Participant Population	Site Visits	Participant Survey	Non-Participant Survey
Single Family*	69%	98%	84%	53%
Multifamily	31%	2%	10%	26%
Other+	-	-	7%	21%

* Note that 30% of participant survey and 12% of non-participant survey respondents reported living in manufactured (sometimes referred to as mobile) homes.

+ For participant and non-participant surveys, "Other" includes row houses (1% and 10%, respectively), two to four family homes (4% and 10%, respectively), and other open-ended responses (3% and 1%, respectively). Program tracking data did not contain more granular housing stock information (i.e., beyond single vs. multifamily).

It is important for readers to consider the issues described in this section when interpreting the results of both impact and process evaluations. However, the evaluation team worked with the New Hampshire EM&V Working Group to make reasonable adjustments to the initial evaluation plan to ensure that all evaluation objectives were met.

3. Impact Evaluation Results

Opinion Dynamics completed an impact evaluation of the 2016 and 2017 NHSaves HEA Program. To quantify energy impacts, we applied an engineering analysis, which included onsite inspections, engineering desk reviews of program tracking data, and energy modeling of 50 participating HEA households (see Section 2.1). We also attempted to quantify specific participant and utility NEIs based on information collected through participant and non-participant surveys, and secondary sources (see Section 2.2).

3.1 Engineering Analysis Results

Overall, the program achieved 91% of ex ante savings, resulting in 40,507 MMBTUs of ex post gross savings for 2016 and 2017 HEA participants. The total ex post savings below represent savings claimed and paid for by the HEA Program and do not include savings claimed by other programs (i.e., the WAP). Table 3-1 shows the total savings resulting from our engineering analysis for all measures offered through the HEA Program (i.e., including electric kWh savings converted to MMBTUs[10]) by the primary heating fuel type. To reach ex post savings for each of the 50 households, we made adjustments to either baseline or retrofit building conditions tracked in the ex ante TREAT models, as described in Section 2.1. To develop the realization rate presented in the table below, our engineering team recreated original TREAT models prior to adjusting inputs based on data collected on site (i.e., "original modeled" savings presented in the table below). We provide detailed descriptions of TREAT model updates for each of the 50 sites as Appendix A. The realization rate below reflects changes that our team made to TREAT models for a sample of homes based on our team's observations while on site.

Table 3-1. Site Visit Results by Primary Heating Fuel Type

Primary Heating Fuel Type	Count of Sites	Gross Energy Savings (MMBTU)		Realization Rate+
		Original Modeled	Ex Post Modeled	
Fuel Oil	19	738	1,042	83%
Natural Gas	15	1,075	613	97%
Propane	13	608	537	88%
Kerosene	3	139	140	101%
Total	**50**	**2,559**	**2,332**	**91%**

* Overall realization rate is valid at the 90% confident level with 7.8% relative precision.

As shown in Table 3-2, Opinion Dynamics estimated gross ex post savings for the HEA Program by multiplying the realization rate from the 50 participating sites (91%) by the ex ante savings claimed by the program for the participant population (44,514 MMBTUs). Overall, the HEA Program saved 40,507 MMBTUs during the 2016 and 2017 calendar years, which represents 26 MMBtUs per household. For prospective planning purposes, the New Hampshire utilities should apply the total realization rate (91%) to savings claimed by the HEA Program (i.e., those paid for by the program) as the realization rate presented below includes all measures (e.g., insulation, LEDs, domestic hot water, etc.) based on our team's revisions to TREAT models for sample of households.

[10] To convert kWh savings to MMBTUs, we used a conversion factor of 0.003412. Source: https://www.extension.iastate.edu/agdm/wholefarm/pdf/c6-86.pdf

Table 3-2. Overall Gross Savings Results for the HEA Program

Ex Ante Gross Energy Savings (MMBTU) Claimed by the HEA Program	44,514
Site Visit Realization Rate	91%
2016 and 2017 HEA Participants	1,548
Ex Post Gross Energy Savings (MMBTU)	40,507
Ex Post Gross Energy Savings (MMBTU) per Participant	26

Site visit results are valid at the 90% confident level with 7.8% relative precision.

Site Visit Results

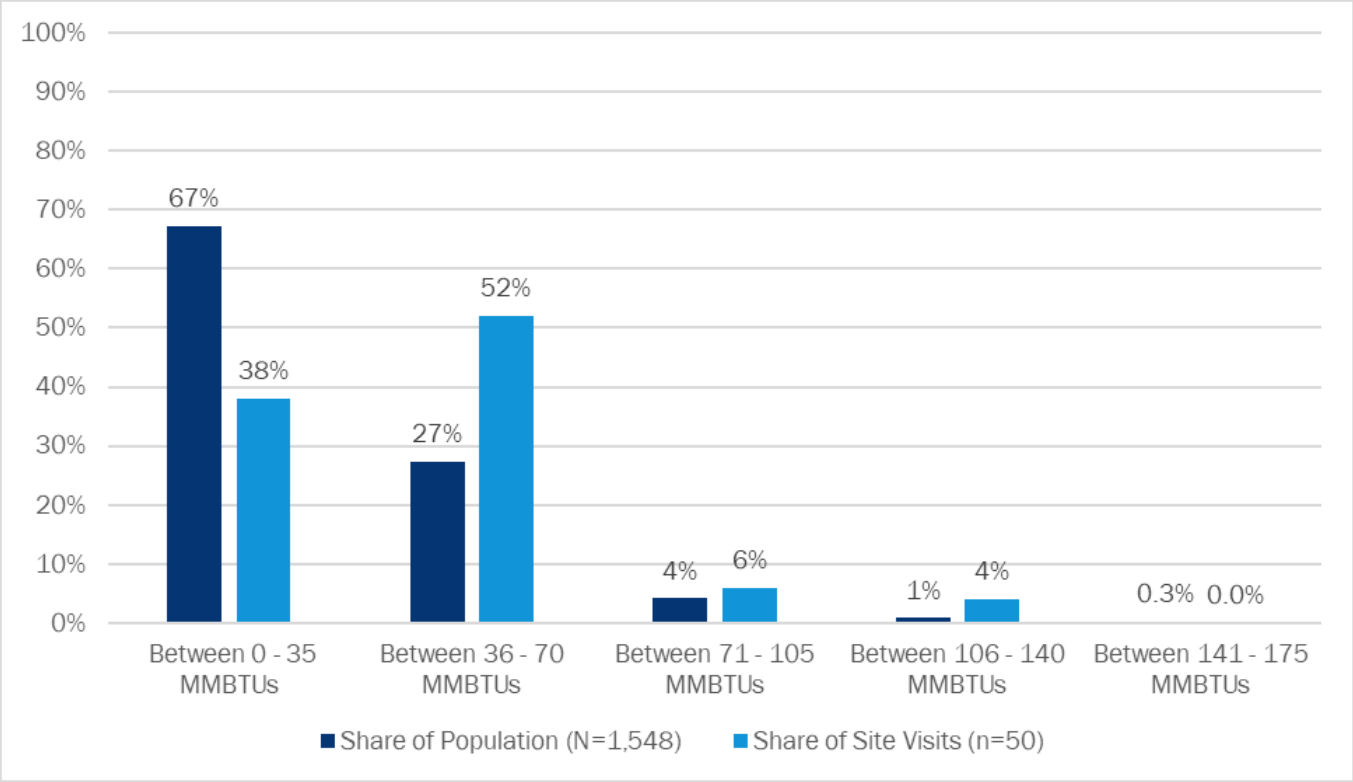
On average, the 50 participants with whom we completed site visits saved 47 MMBTUs per household from all fuels the first year after participating in the HEA and other weatherization programs (e.g. WAP). These represent the total ex post modeled savings per household, which, in cases where measures are jointly funded by the WAP, include savings not claimed by the HEA Program. As shown in Table 3-3, savings per household varied by primary heating fuel type. The 19 participants that heat primarily with fuel oil saved the most per household (55 MMBTUs), while those with propane and natural gas saved less (41 MMBTUs).

Table 3-3. Average Savings per Project by Primary Heating Fuel Type

Primary Heating Fuel Type	Count of Sites	Average Ex Post Modeled Savings Per Household (MMBTU)	Relative Precision at the 90% Confidence Interval
Fuel Oil	19	55	11.3%
Natural Gas	15	41	14.8%
Propane	13	41	19.3%
Kerosene	3	47	35.1%
Total	**50**	**47**	**7.8%**

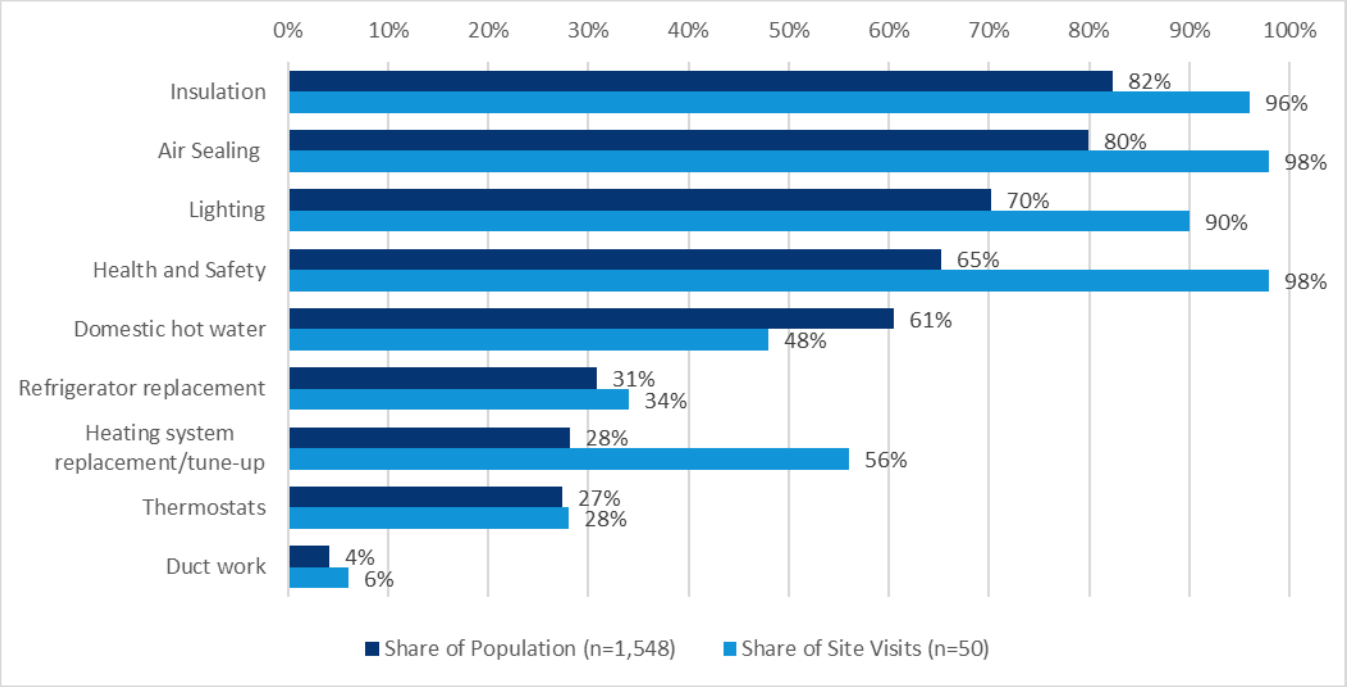
The distribution of the HEA population in terms of per household ex ante MMBTUs is similar to the sample of 50 sites visits. However, a larger share of sampled projects saved more per household when compared to the population (see Figure 3-1). While the majority of HEA sampled projects claimed between 36 and 70 MMBTUs per site (52%), the majority of the HEA participant population claimed less than 35 MMBTUs per site. Though households selected for site visits skewed higher in terms of savings per site when compared to the population, the results of the site visits overall (i.e., regardless of savings per site) are valid at the 90% confidence interval with 7.8% relative precision.

Figure 3-1. Per Household Ex Ante Savings Comparison



The vast majority of households included in the sample of 50 HEA sites received comprehensive energy-saving treatments, including air sealing (98%), insulation (96%), and lighting measures (90%) (see Figure 3-2). Additionally, 56% of sampled households received heating system replacements or tune-ups. In comparison, 82% and 80% of the HEA participant population received insulation and air sealing, respectively, 70% received lighting measures, and 28% received heating system upgrades or replacements (see Figure 3-2).

Figure 3-2. Measure Distribution of Site Visits Compared with the Participant Population



3.1.1 Differences in Baseline and Retrofit Models

Through our engineering analysis, Opinion Dynamics identified a number of differences between ex ante and ex post TREAT models. We made updates to 33 out of 50 sites for which we completed ex post TREAT models. For 21 of the 50 sites, our adjustments resulted in a project-level realization rate of less than 100%, and for four resulted in a realization rate of greater than 100%. In the remainder of this sub-section, we differentiate between updates that we made to the baseline conditions captured in the model (i.e., pre-retrofit building conditions) or the retrofit conditions (i.e., the conditions of the building after receiving treatments from the program). As shown in Table 3-4, we identified more cases that required updates to the baseline building conditions. However, projects requiring updates to the retrofit model resulted in a larger deviation from ex ante savings. Below, we describe differences that our team identified in both baseline and retrofit conditions, and the updates that we made to TREAT models as necessary.

Table 3-4. Summary of Model Discrepancies

Primary Heating Fuel Type	Differences in Baseline Conditions		Differences in Retrofit Conditions	
	Count	Realization Rate	Count	Realization Rate
Fuel Oil	7	96%	7	93%
Natural Gas	7	85%	7	70%
Propane	9	88%	5	84%
Kerosene	2	101%	0	-
Total	**25**	**91%**	**19**	**83%**

Baseline Discrepancies

During onsite inspections of participating households, we identified several discrepancies between the baseline building conditions tracked in TREAT models and what we observed on site. The three most common issues that we observed were the following. We understand that conditions on site may have changed since the initial energy assessment prior to households' participation in the HEA Program. However, we endeavored to capture baseline conditions at each site to the best of our team's ability based on their observations. We also adjusted baseline model conditions based on participants' recollection only in cases where (1) participants recalled being present for the initial energy assessment and (2) when participants, beyond any doubt, could verify the presence/absence of certain equipment.

- **Air conditioning unit quantities**: For 12 sites, we found erroneous quantities of air conditioning units in use. Ten of these sites had room air conditioner (RAC) quantity discrepancies, with the remaining two having erroneous quantities for central air conditioning units.
- **Heating and cooling equipment specifications**: We found ten instances where implementation teams captured baseline building case heating and/or cooling specifications incorrectly. These included: system capacities, efficiencies, and heating fuel type.
- **Presence of supplemental heating sources**: At six sites, we found no supplemental heating source in use as indicated in the baseline building case.

Table 3-5 provides a summary of all updates to baseline building conditions that we made when developing ex post models. We provide complete descriptions of updates made to each model in Appendix A.

Table 3-5. Differences in Baseline Building Conditions

Adjustment Made to Baseline Conditions in Ex Post Model	Count of Sites
Updated air conditioner quantities	12
Adjusted heating and cooling system specifications	10
Removed supplemental heating source(s)	6
Updated thermostat specifications	5
Updated domestic hot water system specifications	2
Adjusted flow rates for showerheads/aerators	2
Added supplemental heating source	1
Updated primary heating fuel type	1
Adjusted basement grade (i.e., tracked as below ground, but was actually above ground)	1
Included basement area as heated (originally tracked as unheated space)	1

Discrepancies in Retrofit Conditions

Opinion Dynamics also documented any differences between retrofit building conditions tracked in the ex ante TREAT models and what our field engineers observed while on site. Most commonly, we observed the following three types of differences.

- **Specifications of heating system improvements**: For seven sites, we found incorrectly listed heating system improvement specifications included in TREAT model retrofit cases. This included both system capacities and efficiencies of heating system improvements as indicated on furnace and/or boiler nameplates.

- **Blower Door Test (BDT) for claimed CFM reduction**: Upon review of ex ante TREAT files, we found several instances where either pre or post-retrofit BDTs appeared to have been rounded to the nearest 100 CFM, prompting a need to verify if those tests occurred. We interviewed participants who were present both during energy assessments and measure installation to verify that implementation crews completed BDTs. For four sites, we confirmed with participants that implementation crews did not complete pre- and post-installation BDTs and assigned 0 CFM reduction savings in those four ex post TREAT models. Additionally, we could not visually verify that air sealing was completed for these sites. We recommend that utilities require BDT readouts wherever possible to document changes in air flow from program treatment. Where BDTs are not possible for health and safety reasons, we recommend that utilities require implementers to track these instances and note the specific reason why they were unable to perform BDTs. Further, we recommend that implementers model air sealing measures in these cases based on the average CFM reductions from this evaluation (i.e., 3,090 CFM50 pretreatment and 2,051 post treatment, resulting in a change in CFM50 of 1,039).
- **Heating system improvements exceeded system baseline operating conditions**: For four sites, we found that heating system improvements where specifications as modeled either met 100% or exceeded efficiencies listed on the systems' nameplate. System tune-ups cannot cause heating systems to overperform their annual fuel utilized efficiency (AFUE), and, as systems degrade over time, achieving 100% of AFUE is not a reasonable assumption. We recommend that utilities conduct additional primary research for these measures to assess the actual baseline AFUE of furnaces and boilers, and the impact on system performance resulting from cleaning and tune-up measures.

Table 3-6 provides a summary of all updates to retrofit building conditions that we made when developing ex post models. We provide complete descriptions of updates made to each model in Appendix A.

Table 3-6. Differences in Retrofit Building Conditions

Adjustment Made to Retrofit Conditions in Ex Post Model	Count of Sites
Updated efficient heating system specifications	7
Removed CFM savings due to unconfirmed BDT	4
Removed heating system improvements (not completed)	4
Removed insulation (not completed)	2
Updated efficient faucet aerator quantity	1
Removed efficiency faucet aerator	1
Updated LED specifications	1
Removed LED upgrades that were not completed	1

4. Non-Energy Impact Results

Opinion Dynamics analyzed select participant and utility NEIs of the 2016 and 2017 HEA Program. Our analysis focused on NEIs that may be experienced by HEA participants and could be quantified through the tasks of this evaluation, while other research completed in New Hampshire has aimed to quantify a broader list of NEIs for the entire state. We based this analysis on information collected during surveys with participants, eligible non-participants, an analysis of utility billing data, and secondary sources, as described in Section 2.2. Based on our research, Opinion Dynamics found evidence that HEA Participants experience the positive NEIs outlined in this section. Further, there is evidence to suggest that New Hampshire electric utilities experience a reduction in arrearages for those that participate in the HEA Program.

4.1 Participant Non-Energy Impacts

Our participant NEI research, focused on several benefits, including changes in home comfort, indoor or outdoor noise, the number of times members of the household sought medical attention due to asthma or thermal stress, and how often primary wage earners missed work. While over half of participants that responded to the survey indicated an increase in their comfort and just over 10% reported hearing less noise inside and outside their homes, a smaller share of participants reported needing medical attention either before or after participation. Additionally, we found no change in the number of days that primary wage earners missed of work when comparing the years before and after their HEA participation.

Table 4-1 below shows the total monetary value of all participant NEIs included in this evaluation, along with the value to each participant—i.e., the total value of participant NEIs divided by 1,548 unique participants that enrolled in the HEA Program during the 2016 and 2017 calendar years. We also included the value of each NEI to those participants that experienced the effect—that is, received the appropriate measures to experience the benefit. When estimating HEA Program benefits, New Hampshire utilities may assume $343.07 in additional non-energy benefits per HEA participant based on this research. Note that HEA participants may experience NEIs beyond those included in this study. As such, the New Hampshire utilities may elect to use proxy values for other participant NEIs based on secondary research specific to New Hampshire and should also target additional NEIs for future primary research.

Table 4-1. Participant NEI Summary

Non-Energy Impact	Per Participant (experienced the effect)	Per Participant (All 2016-2017 Participants)	Total for the 2016-2017 HEA Program
Increased comfort	$304.15	$267.02	$413,431.20
Decreased noise inside the home	$65.72	$55.99	$86,678.15
Decreased noise coming from outside the home	$29.85	$14.83	$22,952.56
Avoided overnight hospital stays due to reduced asthma symptoms	$5.97	$5.21	$8,063.94
Reduced doctor visits for colds/illnesses related to thermal stress	$0.03	$0.03	$41.84
Total All NEIs	$405.71	$343.07	$531,077.69

Opinion Dynamics quantified several NEIs associated with the HEA Program treatment. Below we outline the value of increased comfort, decreased noise inside the home, and decreased noise coming from outside the home based on participant survey responses. Through the survey, we estimated both the share of participants that experienced the positive NEIs and their perceived value relative to the energy savings they experienced

through the program (i.e., a labeled magnitude scaling multiplier [11]). Further, we quantified the value of NEIs of reduced overnight hospital stays due to asthma-related symptoms and reduced need to seek medical treatment due to a decrease in thermal stress based on participant survey responses and secondary research.

Opinion Dynamics estimated different NEIs based on measures that participants received during their HEA Program treatment. We used program tracking data to identify participants that received the appropriate packages of measure and therefore may have experienced specific NEIs (see Table 4-2). For this study, we estimated NEIs for participants that received groups of measures as participants could not reasonably be expected to isolate the share of each NEI associated with individual measures.

Table 4-2. HEA Measures Targeted for Participant NEI Survey Responses

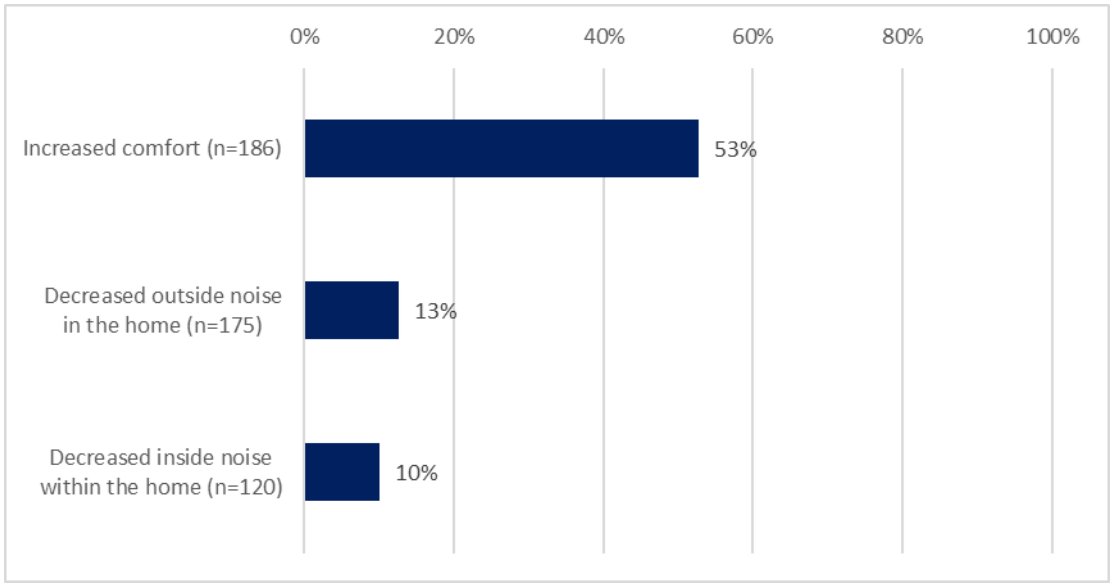
Comfort	Internal Noise Reduction	External Noise Reduction	Health and Productivity (i.e., reduced asthma, thermal stress, and fewer missed days of work)
▪ Insulation ▪ Air sealing ▪ Heating system replacement ▪ Heating system tune-up ▪ Domestic hot water measures ▪ Programmable thermostats ▪ Duct sealing/insulation ▪ Window and/or door replacement	▪ Heating system replacement ▪ Heating system tune-up ▪ Refrigerator replacement ▪ Duct sealing/insulation	▪ Insulation ▪ Air sealing ▪ Window and/or door replacement	▪ Insulation ▪ Air sealing ▪ Heating system replacement ▪ Heating system tune-up ▪ Programmable thermostat ▪ Window and/or door replacement ▪ Health and safety measures

4.1.1 Comfort and Noise

Opinion Dynamics estimated the value of increased comfort and decreased internal/external noised based on participant survey responses. Comfort and noise are both perceptions by residents and are not well-reflected from engineering or metered effects. As such, we asked if participants had experienced an effect after their homes were treated through the HEA Program (i.e., change in comfort, change in internal noise, or change in external noise). Participants that received the appropriate combination of measures (see Table 4-2) most frequently reported an increase in their home comfort and a decrease in internal and external noise as a result of participating in the HEA Program. As shown in Figure 4-1, 53% of HEA participants with the appropriate measures reported experiencing increased comfort. Additionally, 13% of participants that received the appropriate measures reported that they heard less outside noise from within their home and 10% reported hearing less noise originating from inside their home since participating in the HEA Program.

[11] Skumatz, Lisa, and Gardner, John (2006), "Differences in the Valuation of NEBs According to Measurement Methodology: Causes and Consequences," Proceedings of the 2006 AESP Conference, Clearwater Beach FL. Skumatz, Lisa and Khawaja, Sami (2009), "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior." For the California Institute for Energy and Environment Behavior and Energy Program. https://uc-ciee.org/downloads/EEM_A.pdf

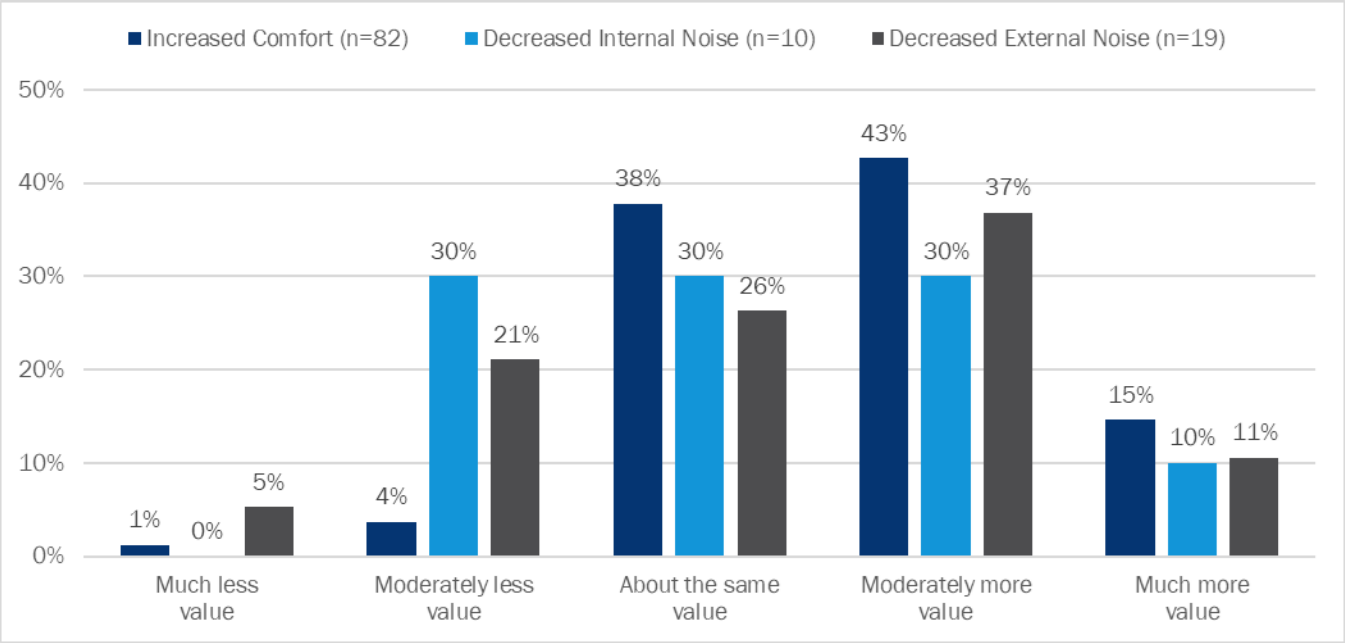
Figure 4-1. Incidence of Comfort and Noise NEIs Among Program Participants



In addition to experiencing a change in comfort and internal/external noise, we also asked participants the value of that effect relative to the energy savings they experienced post-treatment. This valuation method, developed based on a specialized set of survey questions (see Appendix B), is referred to as "labeled magnitude scaling" (LMS).[12] Participants self-reported the value of each of these NEIs (see Figure 4-2 below). Fifty-eight percent of participants reported their increased comfort is more valuable than the energy savings delivered through the program, 40% of participants value reductions in indoor noise more than their energy savings, and 48% value reductions in outdoor noise more than their energy savings.

[12] Skumatz, Lisa, and Gardner, John (2006), "Differences in the Valuation of NEBs According to Measurement Methodology: Causes and Consequences," Proceedings of the 2006 AESP Conference, Clearwater Beach FL. Skumatz, Lisa and Khawaja, Sami (2009), "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior." For the California Institute for Energy and Environment Behavior and Energy Program. https://uc-ciee.org/downloads/EEM_A.pdf

Figure 4-2. Participant value of program NEIs compared to Energy Savings



Based on participants' self-reported valuation, we assigned each respondent an LMS multiplier[13] based on secondary research. We then developed an average LMS multiplier for those that indicated a positive change for each NEI, weighted by survey responses. To develop population level NEIs for increased comfort and reduced internal/external noise, we developed an average LMS multiplier for the population to reflect how participants value each NEI and estimate the average energy cost savings to participants. We developed the population-level LMS multiplier by assigning the weighted average LMS multiplier from the survey to the share of the population that, according to survey responses, experienced the positive NEI, and dividing by the total number of participants that received the appropriate measures (see Table 4-2). Based on the impact evaluation (see Section 3.1), we estimate that the program saved 25.6 MMBTUs per household.[14] We developed a blended cost of $19.93 per MMBTU based on a weighted average of different fuel savings claimed by the HEA Program ex ante (see Table 4-3). This translated to approximately $510.21 in cost savings per participant.

Table 4-3. Fuel Price per MMBTU

Fuel Source	Share of Ex Ante Savings	Price per MMBTU
Natural Gas	32%	$12.50
Fuel Oil	28%	$25.57
Electricity	13%	$49.82
Kerosene	12%	$31.37
Propane	10%	$37.13
Wood (average of pellets and air dried)	6%	$21.58

[13] SERA memo to Opinion Dynamics on March 20th, 2020, with values shown in Skumatz "NEB Values for Next Generation LEDs: Residential, Commercial, and Street Lighting", Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, August 2020, forthcoming.

[14] Note that these savings only included measures funded through the HEA Program. Participants may save additional energy through measures funded by the WAP, or other energy saving programs.

Source: New Hampshire Office of Strategic Initiatives (https://www.nh.gov/osi/energy/energy-nh/fuel-prices/index.htm)

The annual per participant NEI value can be calculated as:

$$Per\ Participant\ value\ of\ NEI = Per\ participant\ energy\ cost\ savings\ (\$) \times Population - level\ LMS\ Multiplier$$

To calculate the total NEIs for increased comfort and decreased internal/external noise, we multiplied the per participant value by the number of participants that received the appropriate package of measures (Table 4-4).

Table 4-4. Monetary Values for Increased Home Comfort and Decreased Noise

Variable	Participant Non-Energy Impact		
	Comfort	External noise reductions	Internal noise reductions
Survey sample that received appropriate measures	186	175	120
Average NEI labeled magnitude scaling (LMS) factor for survey respondents with the measure that reported an effect	1.12	0.98	0.39
Average LMS multiplier for the HEA population that received appropriate measures	0.60	0.13	0.06
Share of program participants receiving the measure group.	88%	85%	50%
Annual per participant value of NEI /year per participant receiving the measures	$304.15	$65.72	$29.85
Number of participants receiving each measure group	1,359	1,319	769
Total annual NEI Value across all 2016-2017 program participants	**$416,302**	**$84,154**	**$22,284**

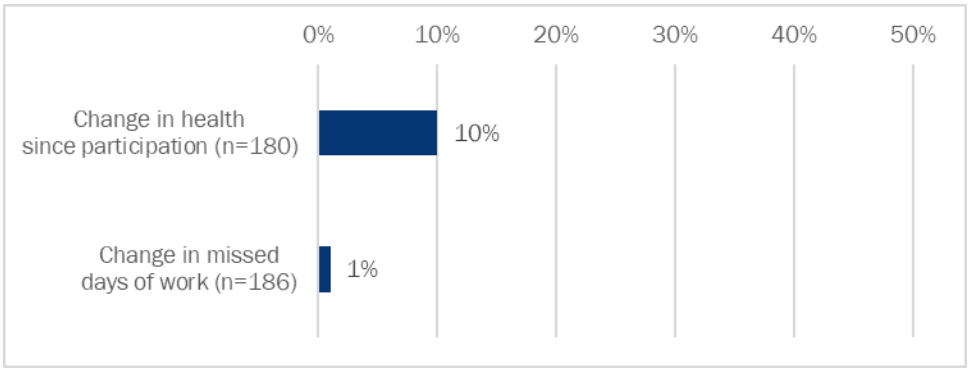
4.1.2 Health and Productivity

Opinion Dynamics also quantified NEIs from participants that experienced a change in their health and productivity. A large portion of HEA participants (65%) received some form of health and safety measures. While these measures do not produce energy savings, in some cases, then enable the safe installation of other energy saving measures (e.g., insulation or air sealing measures). Further, they may contribute to positive health related NEIs. There may be other health benefits to participating in the HEA Program, however, this study focused on a discrete list of NEIs related to improve participant health and productivity. Specifically, we attempted to quantify the following NEIs through both primary and secondary research:

- A change in the number of overnight hospitals stays to treat asthma-related symptoms;
- A change in the need for medical attention due to thermal stress (i.e., doctor's visits to treat cold or flu-like symptoms); and
- A change in the number of missed days of work for households' primary wage earners.

Very few participants reported a change in the health of members of their household as a result of participating in the HEA program. Additionally, while 1% of respondents reported a change in the number missed work days for the primary wage earner, the net change in days missed after participation was zero (see Figure 4-3).

Figure 4-3. Incidence of health and productivity changes sine HEA participation



For these NEIs, we quantified any change in incidences through self-reported survey responses that compared the frequency of incidences both before and after participants received treatment through the HEA Program. We then used secondary sources to estimate the remaining inputs to quantify each NEI—that is, the cost per avoided medical treatment, and the percent of the population that is uninsured. We also made the following assumptions when estimating the monetary benefits for both health related NEIs:

- We are using the state-wide percentage of uninsured residents in our analysis. We could not find a percentage specific to low-income populations (a conservative assumption).
- We assumed that uninsured participants would have paid for the medical costs "out-of-pocket."[15]

Reduction in Asthma-Related Symptoms

We gathered data on the percent of households covered (and not covered) by employer-provided health insurance, Medicare, Medicare, and other private insurance plans for the State of New Hampshire. For the purposed of this analysis, we assumed that uninsured participants would be required to pay for medical expenses out-of- pocket. Additionally, we were unable to find reliable figures for the average co-payment for insured participants so assume those to be zero. Finally, the estimates presented below are conservative and, as such, we did not attempt to quantify the "quality of life" improvements for those covered by insurance but would likely benefit from fewer illnesses.

Based on the participant survey, 1.1% of respondents that received the appropriate measures and indicated a change in their health since participating in the program reported fewer overnight hospital stays due to asthma symptoms post-HEA treatment (see Table 4-5). Additionally, based on United State census data, we estimated that 5.8% of the New Hampshire population was uninsured in 2017. Note that we were unable to find reliable data on the share of the low-income population not covered by medical insurance, so we used data for the entire state in developing our estimate. We estimated the total value of this NEI using the following formula:

[15] This is a less conservative assumption, and would be improved if data on percent of total bills ultimately paid by the uninsured was available for this study. However, the question then becomes whether the NEI health value should represent dollar savings in medical costs paid, or the benefits in terms of the medical benefit received from not getting sick as often, or in terms of the reduced bills due that are potentially hanging over the household (paid or not).

$$\text{Asthma NEI} = (\text{Population} \times \Delta\text{NEI}_{\text{asthma}} \times \text{Uninsured} \times \text{Cost}) + (\text{Population} \times \Delta\text{NEI}_{\text{asthma}} \times (1 - \text{Uninsured}) \times \text{Copay})$$

Where:

Asthma NEI is the total value of avoided overnight hospital stays due to asthma-related symptoms

Population is the population of HEA participants that received the appropriate measures

ΔNEI_{asthma} is the share of respondents that reported a change in overnight hospital stays due to asthma symptoms

Uninsured is the share of the New Hampshire population that does not have medical insurance

Cost is the total cost of overnight hospital stays to treat asthma-related symptoms

Copay is the average co-pay for New Hampshire residents with medical insurance

Table 4-5. Net NEI for Avoided Asthma Hospitalizations due to Asthma related Symptoms

Variable	
Number of survey respondents / sample size	180
Share of survey respondents who experienced fewer overnight hospital stays due to asthma	1.1%
Percent of NH population not covered by medical insurance*	5.8%
Average co-pay for households covered by insurance – no data available	$0
Cost per NH hospital treatment for asthma+	$9,355.59
Number of participants who received NEI-related measures	1,351
Calculated annual NEI for asthma savings across all program households receiving measures	$8,063.94

* US Census Bureau. 2008 to 2018: https://www.census.gov/library/visualizations/interactive/uninsured-rate-2008-2018.html

+ SERA provided these values, which represent average Medicare billing cost for the state for Asthma-related hospital stay. Source: https://www.governing.com/gov-data/health/average-medical-hospital-costs-by-state-map.html

To support our understanding of the potential value of this NEI in future years, we also assessed how often HEA eligible customers sought overnight medical care for asthma related symptoms over the course of a typical year. Out of 165 HEA eligible customers that responded to the non-participant survey (see 2.3.5), 4% reported that they had stayed in a hospital overnight due to asthma related symptoms in the year prior to taking the survey. Additionally, 7% of HEA eligible non-respondents noted that they had visited the emergency room due to asthma related symptoms in the year prior to taking the survey. If future HEA participants seek medical attention for these issues at similar rates, the New Hampshire utilities should expect low asthma related NEIs in future years, similar to the results presented in the table above.

Reduction in Medical Attention for Thermal Stress

We also quantified the total value to HEA participants of reduced doctor's visits due to thermal stress. For the purposes of this analysis, we defined illness due to thermal stress as colds and other sicknesses that manifest in flu-like symptoms. We also assumed the medical attention required for these types of illnesses to be a visit to a primary care physician. Similar to quantifying the value of avoided hospital stays to treat asthma symptoms, we provide a conservative estimate and, as such, quantified the benefits for participants that did not have medical insurance and do not factor in a "quality of life" impact or avoided co-pays for those with insurance.

One respondent (0.6%) indicated that they experienced a change in the need to seek medical attention due to thermal stress after they participated in the HEA Program (see Table 4-6). Similar to avoided costs for reduced asthma symptoms, we based our estimate below on the share of the New Hampshire population that was uninsured in 2017. Additionally, we conducted secondary research to obtain an estimate for the average cost of a doctor's visit in New Hampshire to treat a cold or flu-like symptoms. We developed the final estimate for avoided medical treatment due to fewer participants that experienced thermal stress based on the following formula:

$$\text{Thermal NEI} = (\text{Population} \times \Delta\text{NEI}_{\text{Thermal}} \times \text{Uninsured} \times \text{Cost}) + (\text{Population} \times \Delta\text{NEI}_{\text{Thermal}} \times (1 - \text{Uninsured}) \times \text{Copay})$$

Where:

Thermal NEI is the total value of avoided medical attention due to thermal stress

Population is the population of HEA participants the received the appropriate measures

$\Delta NEI_{Thermal}$ is the share of respondents that reported a reduction in medical visits to treat colds or flu-like symptoms

Uninsured is the share of the New Hampshire population that does not have medical insurance

Cost is the average cost for a doctor's visit in New Hampshire

Copay is the average co-pay for New Hampshire residents with medical insurance

Table 4-6. Net NEI for Reduced Doctor visits for colds / Illnesses from Thermal Stress

Variable	
Number of survey respondents	180
Share of survey respondents who experienced reduction in need for medical attention due to thermal stress	0.6%
Share of NH households not covered by insurance	5.8%
Average co-pay for households covered by insurance – no data available	$0
Average cost of NH doctor visit	$ 89
Number of participants who received NEI-related measures	1,351
Calculated annual NEI for cold incidences across all program households receiving measures	$41.84

* US Census Bureau. 2008 to 2018: https://www.census.gov/library/visualizations/interactive/uninsured-rate-2008-2018.html

+ Value provided by SERA: https://www.guroo.com/#!care-bundles/OV008-office-visit-primary-doctor-established-patient-moderate-complexity/NH-new-hampshire

Similar to asthma related NEIs, we also assessed the baseline need for HEA eligible non-participants to seek medical attention due to thermal stress. Out of 165 eligible non-respondents, 4% indicated that they had sought medical attention for illnesses related to thermal stress (e.g., colds or flus), over the year prior to taking the non-participant survey. If future HEA participants seek medical attention for these issues at similar rates, the New Hampshire utilities should expect low NEIs related to thermal stress in future years, similar to the results presented in the table above.

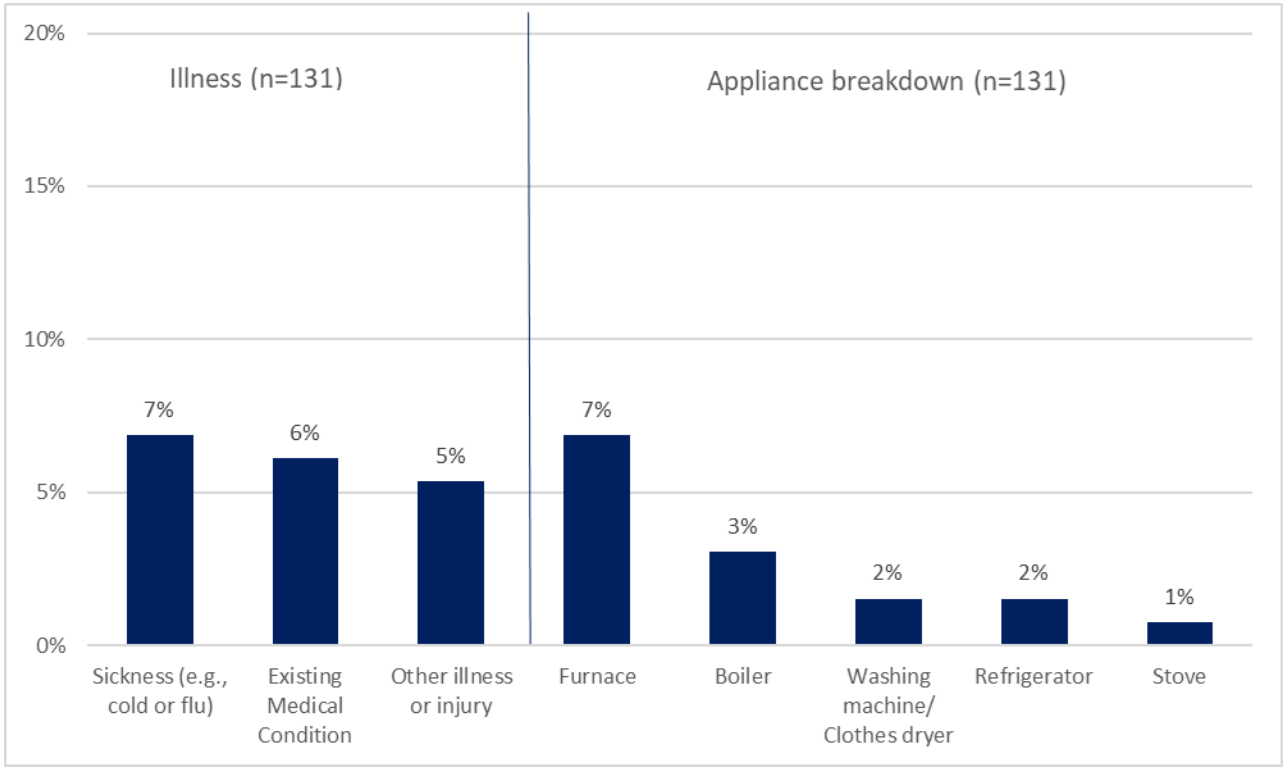
Missed Days of Work

Only 1% (n=19) of HEA participants that responded to the participant survey reported that a primary wage earner experienced a change is missed days of work after participating in the HEA program (see Figure 4-3). However, when these respondents were asked detailed follow up questions about the number of days missed

in the years prior to and following participation, most respondents (n=17) indicated there was not actually a change in days missed[16]. Two respondents reported true changes in the number of days missed – one indicated missing fewer days following participation and the other missed more days. This resulted in a net of no change in the number of days of work missed.

Notably, 34% of the HEA eligible non-participants that we surveyed reported the primary wage earner of their home missed work over the last year due to illness (26%), injury (6%), or major appliance breakdown (7%). Figure 4-4 provides more detail on reasons that non-participants reported missing work if they cited illness or a major appliance breakdown.

Figure 4-4. Reasons for Primary Wage Earner Missing Work (HEA-eligible Non-participants)



4.2 Utility Non-Energy Impacts

Opinion Dynamics focused the utility NEI analysis on avoided arrearages and other changes to monthly discounts required by HEA participants. We obtained sufficient data to perform analyses for NHEC and Eversource customers. While we did find evidence that electric utilities did experience reductions in arrearages as a result of HEA participation, we do not have sufficient information to suggest that these results be applied statewide. However, as we were able detect statistically significant NEIs on arrearages for NHEC customers (see Table 4-7), we recommend applying these results to HEA participants that are also NHEC customers. In the remainder of this section, we present results from both analyses.

New Hampshire Electric Co-op

[16] These respondents reported the primary wage earner missed the same number of days of work in the years before and after their participation in the HEA Program.

Members of the NHEC saw a reduction in the average monthly Energy Assistance Program (EAP) discount and a reduction in the average unpaid amounts for HEA participants. As shown in Table 4-7 below, the arrearage analysis showed that both NEIs were substantial and statistically significant. We leveraged two pieces of billing information to analyze the impact of participation: (1) the applied EAP discount each month, and (2) the cumulative unpaid balance each month. The models indicated the average monthly dollar amount of the EAP discount dropped by 45% after participation, and the size of any new unpaid bills dropped by 28% after customers participated in the HEA Program. This translates into similar levels of reduction across all participants (i.e., not just those with an unpaid balance) for the total amount of new unpaid bills each month (-25%) and the cumulative arrearages each month (-24%).

Table 4-7. Results of NHEC Arrearage Analysis

Impacts for NHEC Electric HEA Participants (n=66)	Value in Pre-Period	Impact of Participation	Percent Change
Monthly EAP Discount per program participant	$30.38	-$13.54*	-45%
Average new monthly unpaid amounts (participants with unpaid amounts)	$110.00	-$31.32*	-28%
Average monthly unpaid amounts (all participants)	**$23.30**	**-$5.93****	**-25%**
Average cumulative unpaid amounts (all participants)	**$92.85**	**-$22.22***	**-24%**

*Statistically significant at the 99% confidence level

**Statistically significant at the 98% confidence level

Eversource

Opinion Dynamics used unpaid monthly balances to analyze the impact that HEA participation had on Eversource arrearages. Although we tested several different model specifications comparing unpaid amounts before HEA participation (pre-period) and after HEA participants (post-period), none showed statistically significant results. Through this analysis, we found a total of 761 unpaid bills (representing 393 Eversource customers), and the vast majority of those (714 bills) occurred in the post period. This preponderance of unpaid bills in the post-period explains why the models could not find any reduction in the overall incidence of unpaid bills in the post period. As such, we completed an arithmetic analysis to further examine any affect that HEA participation may have on unpaid electric bills. To complete this analysis, we developed a simple mean of unpaid bills in the pre- and post-periods and compared the average size of unpaid amounts across the two periods of time. While there were far more unpaid electric bills in the period after HEA participation, on average, the size of those unpaid bills was 32% smaller than those before HEA participation (see Table 4-8). This is not to say that a reduction in unpaid bill amounts would be less valuable to a utility than a reduction in the incidences of unpaid bills. While we did find some evidence that the HEA Program has a positive impact on participants' unpaid balances, we were unable to detect statistically valid results. We therefore do not recommend applying these results to HEA participants that are also Eversource electric customers, but rather suggest additional research in future evaluations to quantify the impacts of the HEA Program on arrearages, among other utility NEIs.

Table 4-8. Results of Eversource Arrearage Analysis

Metric	Value
Average new monthly unpaid amount in the pre-period	$85.63
Average new monthly unpaid amount in the post-period	$58.45
Change in new monthly unpaid amounts	-$27.19
Percent change	-32%

Note: Values in the table apply only to 393 HEA participants with an unpaid balance for at least one month and not to all HEA participants.

5. Process Evaluation Results

Opinion Dynamics conducted a process evaluation of the 2016 and 2017 NHSaves HEA Program based on in-depth interviews with CAA staff, a literature review, a participant survey, and a non-participants survey (see Section 2.3 for a description of each of these activities). Below, we present the key findings from the process evaluation.

5.1 Program Implementation and Service Delivery

The four New Hampshire gas and electric utilities—Liberty Utilities, Eversource, Until, and the New Hampshire Electric Co-op (NHEC)—administer the HEA Program, though much of its implementation is carried out by the five CAAs in the state and their subcontractors. While all five CAAs manage marketing, enrollment, and many of the program coordination duties, a seasoned network of home performance contractors and BPI-certified building inspectors manages much of the service delivery (e.g., home energy assessments, measure installation, and quality control inspection). One CAA manages all implementation activities with internal staff, two rely on subcontractors for a portion of the service delivery, and two delivered the HEA exclusively through subcontractors at the time of this evaluation. Implementation staff (i.e., CAA and subcontractor staff) work to maximize HEA funding to deliver a high level of service to as many qualified residents as their budgets allow. Table 5-1 provides an overview of the HEA implementation process, the roles of the various implementation team members, and data collected at each stage. In the sub-sections that follow, we describe each stage in detail.

Table 5-1. HEA Implementation Process

Implementation Stage	Description	Data Collected
Qualification and Enrollment	▪ Resident contacts the CAA requesting fuel assistance or other services, or utilities refer customers that may be interested in CAA energy programming. ▪ Resident submits fuel assistance application and indicates that they are interested in weatherization services. ▪ CAAs create and prioritize a list of interested residents and schedule home energy assessments.[17]	▪ Fuel type ▪ Demographics ▪ Household characteristics ▪ Income documentation ▪ Energy usage ▪ Fuel history
Home Energy Assessment	▪ Auditor verifies application information, performs diagnostics, documents pre-conditions of insulation, and identifies all energy-savings and health and safety upgrade opportunities. ▪ Auditor updates building simulation model with baseline and retrofit information to evaluate which upgrades are cost-effective. ▪ Auditor uploads final recommended scope of work to utilities for review and approval.	▪ Baseline building conditions (e.g., blower door test, combustion safety test, etc.) ▪ Thermal scan ▪ Additional household characteristics required for building simulation modeling
Measure Installation and QA/QC	▪ CAAs coordinate follow-up appointments and measure installation either with internal CAA implementation teams or subcontractors. ▪ Crews perform installations. ▪ CAAs work with utilities and subcontractors to perform on-site QA/QC inspections in accordance with WAP guidelines as work is completed or shortly after. ▪ When the work is complete, implementation crews upload a final scope of work to utilities via OTTER.	▪ Retrofit building conditions (e.g., post-retrofit blower door test, combustion safety test, etc.) ▪ Post-installation QA/QC inspection notes

5.1.1 Qualification and Enrollment

The CAAs implement the HEA Program in coordination with several other federal assistance programs, including the Low-Income Home Energy Assistance Program (referred to as the Fuel Assistance Program or "FAP" in New Hampshire) and Weatherization Assistance Program (WAP). The CAAs manage all marketing, outreach, and intake activities; however, the utilities sometimes refer customers flagged as high energy users who may benefit from the HEA Program. To streamline enrollment and braided funding, the utilities set the HEA eligibility criteria to mirror the FAP eligible customers must have a household income at or below 60% of the state median income to qualify), the Electric Assistance Program (household income at or below 200% federal poverty guideline), or live in subsidized housing.

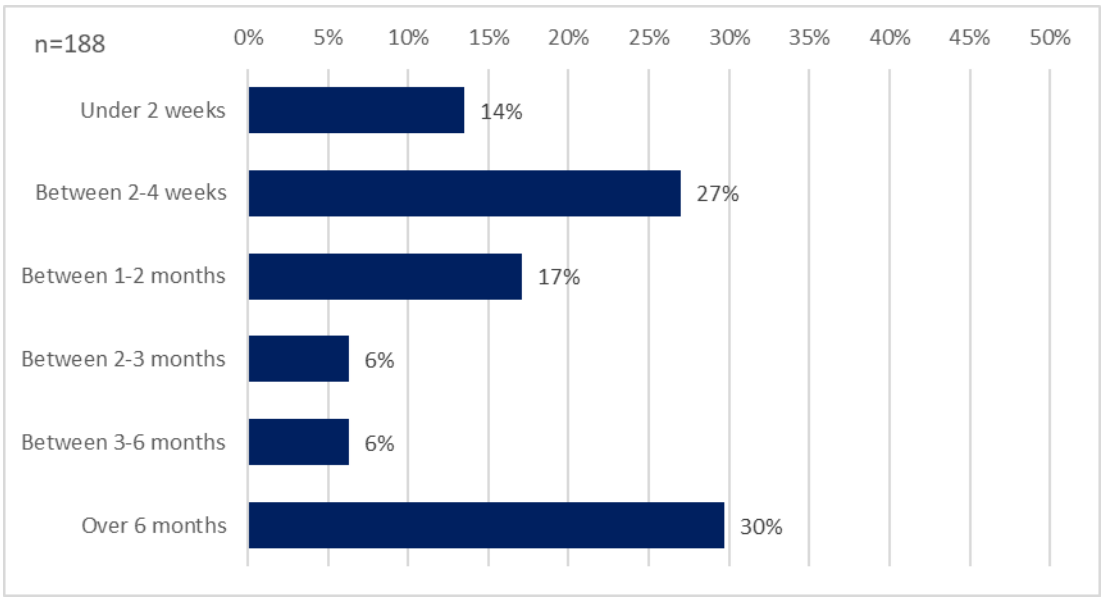
Each year, the CAAs use the FAP as a means of identifying residents that may be interested in receiving weatherization services through either the HEA Program or the WAP. Specifically, participants indicate their interest in weatherization services when they complete the FAP application. The CAAs then compile lists of prospective participants and apply WAP protocols to prioritize residents for treatment—e.g., the number of children, elderly, or disabled residents living in the household; the household's overall energy burden; and application date. These lists are colloquially referred to as "waiting lists", but it is important to note there is no formalized statewide waiting list for these programs and no prescribed protocols for updating the waiting lists year-to-year. Rather, each CAA independently pulls a list of residents in their territory from the sitewide FAP

[17] All five CAAs mentioned maintaining a digital list and three specifically mentioned this list is exported from the statewide fuel assistance database. The agencies then generate a WAP priority score based on other application info (primarily demographic information).

database that indicated interest in weatherization. This data extract contains additional information from the FAP application including demographics and basic information about the home, which allows the CAA to generate a WAP priority score. Notably, FAP applicants who express an interest in weatherization are not guaranteed they will have the opportunity to participate and are not provided information on where they fall on the waiting list. The FAP database is purged at the end of each heating season and residents must re-apply each year (and re-indicate interest in weatherization). Consequently, the CAAs must also pull a new waiting list each year. Processes for when the new list is pulled, tracking how long residents have been on the list, and when it is updated throughout the heating season, is determined on an agency by agency basis.

Most survey respondents (71%) reported experiencing a waiting period between when they first indicated their interest in weatherization services and when they were contacted to schedule a home energy assessment. Notably 27% of participants reported wait times of two to four weeks and 30% of respondents reported waiting over six months. Figure 5-1 shows the distribution of wait times for surveyed participants.

Figure 5-1. Wait time between signing up for the HEA Program and scheduling the home energy assessment



Currently, the waiting lists are tracked exclusively by the CAAs and are not shared with the utilities. There could be opportunities for the utilities to lighten the administrative load on the CAAs by delegating maintenance of the waiting list to the utilities. This could allow program staff to build a statewide list that is updated regularly and preserved year-to-year to track how long some residents have been waiting to be served. However, there may be challenges with the CAAs sharing FAP database extracts with external parties.

5.1.2 Home Energy Assessment

During the home energy assessment, auditors identify possible energy-saving or health and safety measures that fall within the scope of both the WAP and HEA Programs. Auditors specifically look for health and safety issues, such as the presence of asbestos, vermiculite, electrical hazards, or structural issues that may affect their recommendations or prevent the home from being weatherized altogether. Some CAAs choose to install instant savings measures (ISM)—e.g., LEDs, domestic hot water, etc.—directly into participating households

during the initial home energy assessment, while others choose to install all measures, including ISMs, during follow on appointments (i.e., while installing building shell improvements or other deeper savings measures).

Upon completion of the home energy assessment, the auditor will enter all of the data collected into a building simulation model (i.e., TREAT modeling software). Implementation teams will create a recommended scope of work based on projected energy savings and measures costs and will then upload the recommended scope via the HEA program tracking database (OTTER) for utility review and approval. Once the utilities have approved the scope, the CAAs coordinate final service delivery for each participant.

Two of five CAAs used external contractors to perform the home energy assessments at the time of the evaluation. Southwestern Community Services exclusively subcontracted the home energy assessments, though they have since hired staff to complete energy assessments. In years past, Community Action Partnership of Strafford County also subcontracted the home energy assessments but have since moved most of the work in-house. The remaining three agencies (Community Action Program Belknap-Merrimack Counties, Southern New Hampshire Services, and Tri-County Community Action Program) perform all the assessments with in-house staff. The decision to subcontract the assessments does not lead to any major differences in the delivery of the program. The CAAs that reported subcontracting some of the assessments reported they take the audit results and have internal staff develop the proposed measure packages. All the CAAs except for Tri-County Community Action Program subcontract the follow up installations.

5.1.3 Measure Installation

Following the assessment, the auditor creates a household-specific TREAT model by entering building characteristics, baseline information, and recommended upgrades into the building simulation software. CAAs and implementation teams upload modeled outputs into OTTER before reviewing the projected benefit-cost ratio for each recommended measure. The auditor will then use this information to develop their final package of recommended energy upgrades and submit them to the utilities for review and approval. Upon approval, CAAs coordinate final service delivery to participants and work with the utilities to oversee quality assurance/quality control (QA/QC) inspections. Four out of five CAAs exclusively rely on home performance and weatherization contractors to complete all measure installation.

In 2016 and 2017, the majority of households received at least some insulation or air sealing measures (85%), which accounted for 65% of ex ante claimed savings together. Table 5-2 below shows each of the measure groups offered by the HEA program in 2016 and 2017, along with the share of project sites within the evaluation period that installed at least one measure from each group.

Table 5-2. Share of Projects and Ex Ante Savings for Each Measure Group

Measure Group	Count of Unique Households	Share of Households with Measure Group	Share Ex Ante MMBtu Savings
Insulation	1,274	82%	47%
Air Sealing	1,237	80%	21%
Lighting	1,087	70%	2%
Health and Safety	1,009	65%	0%
Domestic hot water	937	61%	3%
Refrigerator replacements	478	31%	3%
Heating system tune-up and replacement	436	28%	7%
Programmable thermostats	424	27%	4%
Duct sealing or duct replacement	64	4%	2%
Custom weatherization/heating*	152	11%	12%
Total Unique Households	**1,548**		

*Program tracking data contained heating fuel savings, but no specific measure descriptions.

5.1.4 Multifamily Measure Installation

According to program tracking data, 69% of HEA participants in 2016 and 2017 lived in single family households compared with 31% that lived in multifamily buildings. While the shares of participants in the two different types housing stock received similar treatments, there were several differences in the measures that each population received (see Table 5-3). Specifically, a larger share of participants in multifamily households received insulation (93%) and air sealing measures (86%), when compared with participants in single family households (77% for both measure groups). Additionally, a much larger share of participants in single family housing received health and safety measures (76%) and heating system tune-ups or replacements (35%), compared with multifamily participants (41% and 12% for both measure groups, respectively).

Table 5-3. Share of Participants in Single Family and Multifamily Households Receiving each Measure Group

Measure Group	Single Family (n=1,063)	Multifamily (n=485)
Insulation	77%	93%
Air Sealing	77%	86%
Health and Safety	76%	41%
Lighting	68%	75%
Domestic hot water	54%	74%
Heating system tune-up or replacement	35%	12%
Refrigerator replacement	33%	27%
Thermostats	30%	22%
Custom weatherization/Heating measures*	16%	0%
Duct work	6%	1%

* Program tracking data contained heating fuel savings, but no specific measure descriptions.

5.2 Implementation Barriers

CAAs reported that the largest barriers to completing more HEA projects relate to the capacity of implementation teams. All five CAAs play the primary role in overseeing all aspects of the HEA Program's delivery. When combined with other social service programs CAAs administer, HEA enrollment, scheduling, and service delivery coordination activities account for a considerable amount of staff capacity. CAAs suggested that, while increasing program funding may help serve some additional residents, meeting higher production goals would be difficult without the ability to hire additional administrative and technical staff.

CAAs and utilities also reported that, in addition to administrative capacity, that there is a shortage of labor with the requisite skills to be able to complete the home energy assessments and measure installation for HEA and other weatherization programs. While one CAA uses internal staff to complete all home energy assessments and measure installations, the other four rely heavily on subcontractors (e.g., BPI certified auditors, weatherization contractors, HVAC technicians, etc.). Many of these subcontractors are also engaged with the market rate Home Performance with ENERGY STAR® Program. As such, to increase the number of residents served by the HEA Program annually, the utilities and CAAs will need to rely on an already constrained labor force.

> *"The HEA Program has been ramping up as far as production, and we can completely understand that. However, there's not a lot set aside for admin costs or things like that. So it's hard to ramp up for the production that they're requesting without having the funding to be able to staff for it as well.*
>
> -- CAA staff member

Another barrier commonly cited by CAA staff was the desire to maintain program-level cost-effectiveness. While the HEA Program does not require each project to achieve a benefit-cost ratio of 1.0 or greater, CAAs know it is important to the utilities that the program remain cost-effective overall. Program teams are aware of this barrier and have taken steps resolve this in future years. This results in the CAAs striving for cost effectiveness on each project. Health and safety upgrades that are often needed prior to completing measure installations can often make a project fail to meet the cost-effectiveness requirement. CAA staff often mitigate this issue by funding some health and safety measures through the WAP and using HEA funding to cover the energy-saving measures. As most HEA projects rely on a combination of funding sources, under current project-level cost-effectiveness requirements, an increase solely in funding for the HEA Program may not result in a proportional increase in the number of HEA projects completed. That is, without WAP funding to cover some of the necessary health and safety upgrades, many prospective HEA projects may not pass the HEA's project-level cost-effectiveness requirements. Notably, the NHSaves programs are transitioning to a portfolio-level benefit-cost threshold, which will limit the impact of low cost effectiveness numbers in the HEA Program and provide the utilities with more flexibility to accept HEA projects with cost effectiveness values below one.

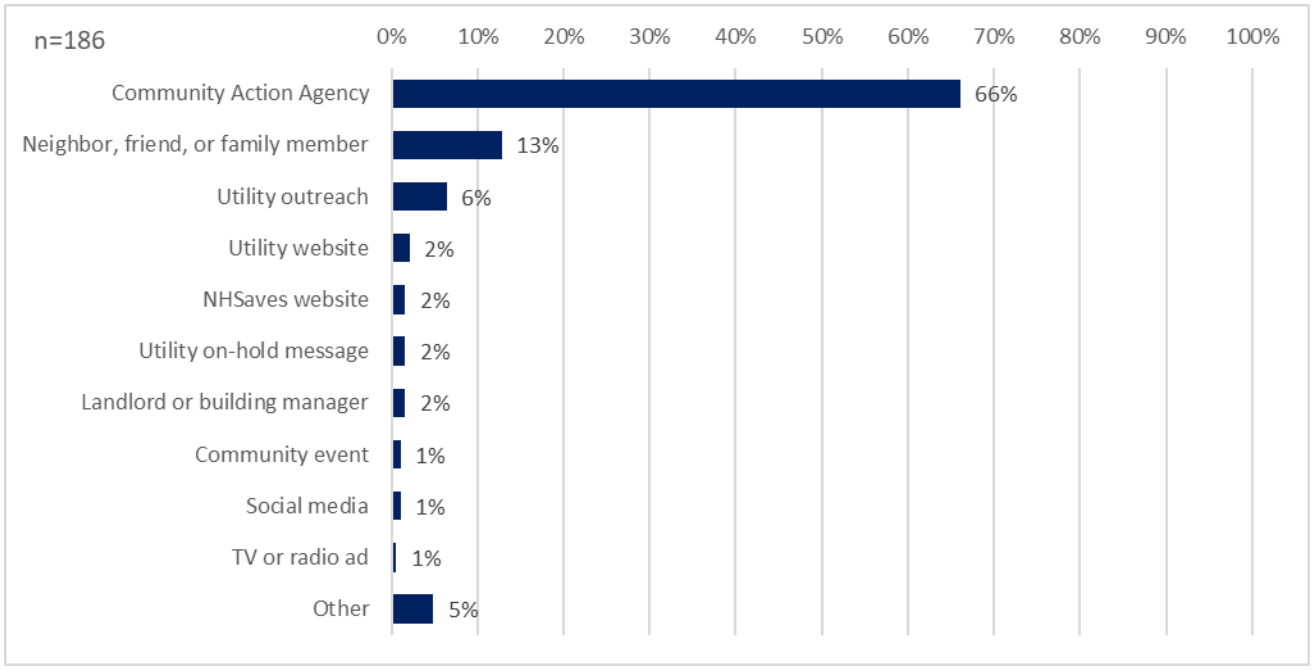
5.3 Program Participation

Each year, CAAs develop and maintain waiting lists of residents interested in receiving assistance with weatherizing their homes. While CAAs are sometimes unable to serve all those on their waiting list due to funding constraints, implementation staff capacity is the larger limiting factor (see Section 5.1.4).

Active marketing and outreach activities are not a central component of the HEA Program design. CAAs rely largely on passive marketing efforts to recruit HEA participants. While CAAs provide information to residents about the upgrades available through the HEA Program, they mostly recruit through other energy assistance programs, largely the FAP. As such, most participants reported first learning of the HEA Program was through their CAA (66%), while some also reported first learning of the program through a friend or neighbor (13%).

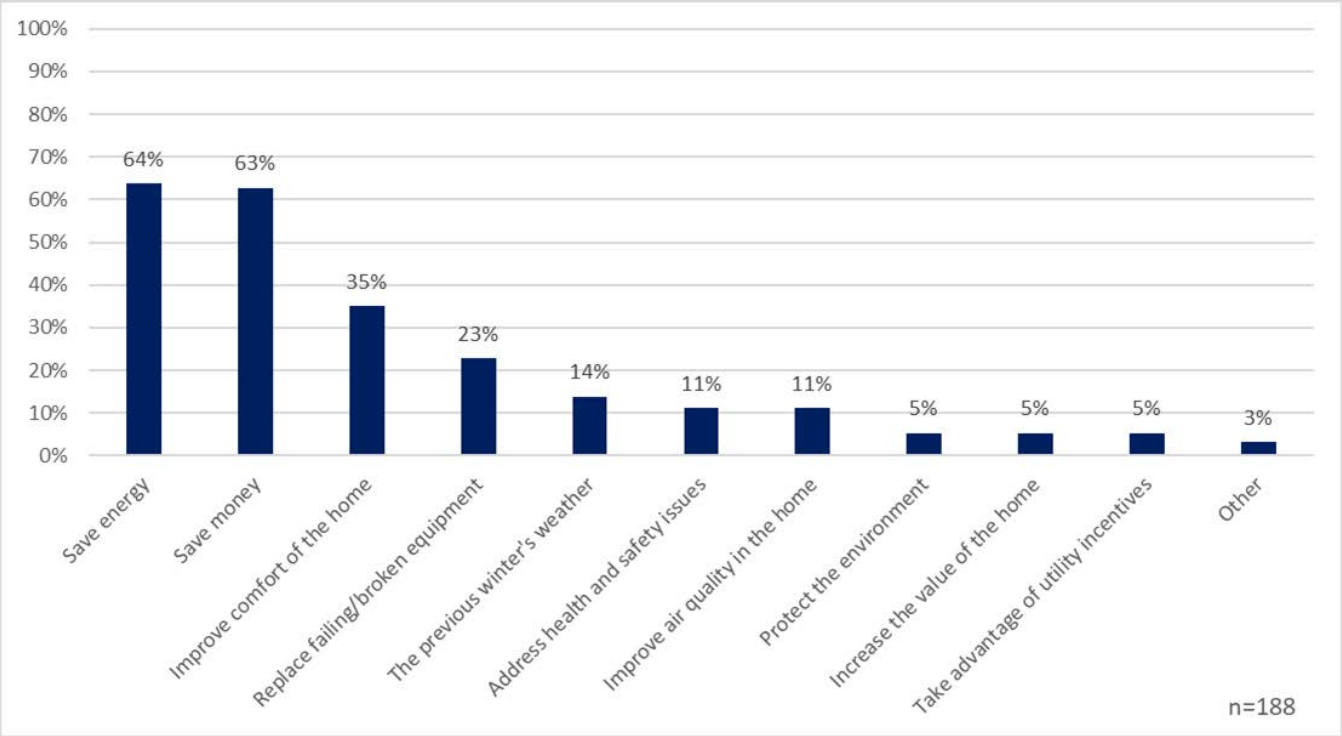
> *"I can't see spending dollars trying to get more people into the program, because there's already more people in the program than we can get to. And advertising that this program's available isn't going to help, because we still can't get to all the people."*
>
> -- CAA staff member

Figure 5-2. How Participants First Learned about the HEA Program



Participants that responded to the survey were largely motivated to enroll in the program to save energy (64%) and/or money (63%). Figure 5-3 lists other factors that drove customers to participate in the 2016 and 2017 HEA Program. Additionally, as discussed in Section 4.1, participants are also motivated by other non-energy benefits, such as improving their homes' comfort.

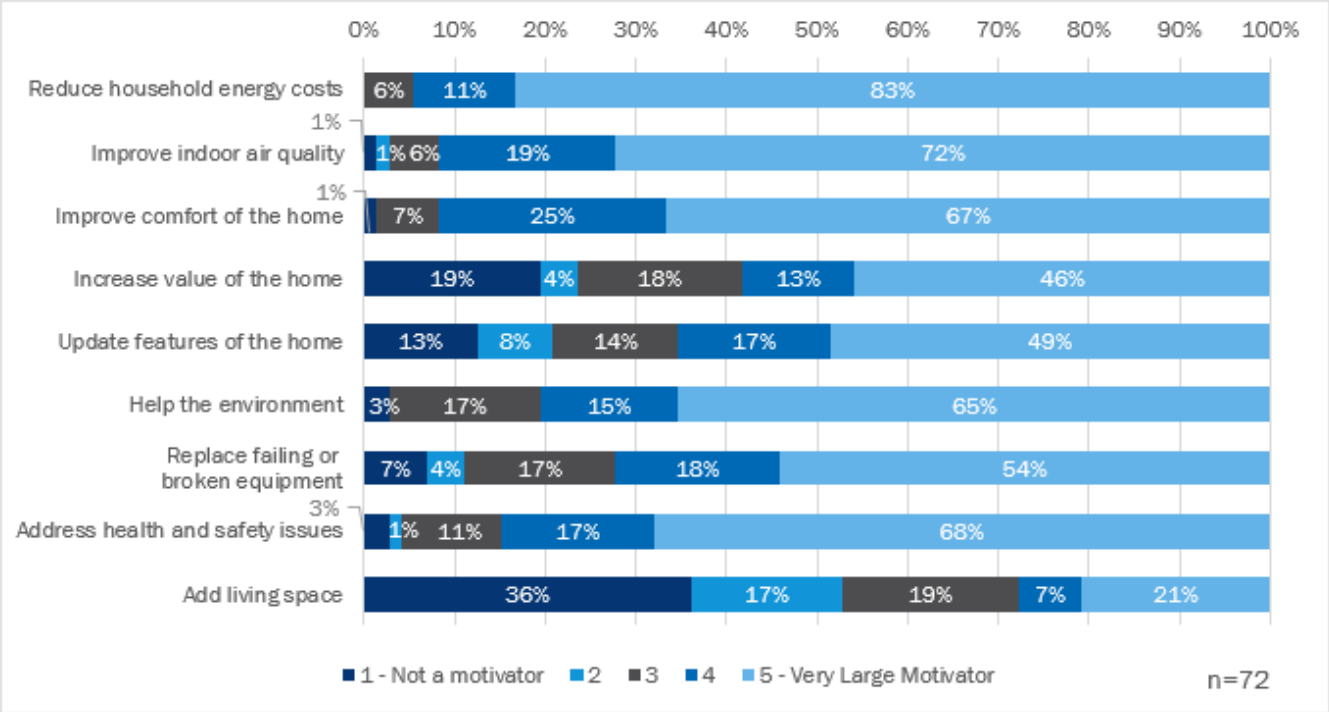
Figure 5-3. HEA Participants' Motivations Factors



Note: Respondents selected up to 3 factors that motivated them to participate in the HEA Program.

Similar factors motivate eligible non-participants that are interested in participating in the HEA Program. Figure 5-4 below shows the share of interested non-participants that reported factors driving their interest in the program. Similar to participants, the largest share indicated that saving money and energy drove their interest in the HEA Program. Other motivating factors included improving indoor air quality and improving the comfort of their home.

Figure 5-4. Share of HEA Eligible Non-Participants that would be Motivated to Participate by Various Factors



Note: The chart indicates the share of non-participants interested in participating in the HEA Program that were motivated by each factor, providing a rating of four or five on a scale from one to five where one was "not a motivator," and five was a "very large motivator."

5.3.1 Service Offerings

Opinion Dynamics also explored interest in the program among eligible non-participants. As shown in Table 5-4, 44% of eligible non-participants reported that they are either somewhat or extremely interested in participating in the HEA Program.

Table 5-4. Non-Participant Interest in the HEA Program

Interest	Share of Eligible Non-Participants (n=165)
1 – Not at all interested	25%
2	10%
3	21%
4	12%
5 – Extremely interested	32%

Further, eligible non-participants were interested in receiving many of the energy-saving measures already offered by the HEA Program. As shown in Table 5-5, 54% of those eligible non-participants that indicated an interest in the program, reported that they would be specifically interested in receiving air sealing measures. These non-participants also expressed an interest in receiving hot water measures (35%), insulation (31%), and LEDs (29%) through the HEA Program. Notably, 26% of non-participants expressing an interest in the HEA

Program would be attracted by smart or Wifi-enabled thermostat offerings. Notably, income-qualified programs operating elsewhere in the United States[18] do not commonly offer smart thermostats because savings from these devices are heavily reliant on access to the internet and remote interaction with the thermostat via smartphones or tablets. Low-income customers tend to have less access to these technologies[19].

Table 5-5. Measures of Interest to Non-Participants Who Expressed Interest in Future Participation

Measure	Overall (n=72)
Air sealing	54%
Hot water measures	35%
Insulation of attic, walls, and basement	31%
LED lights	29%
Smart/Wifi-enabled thermostats	26%
Heating/cooling system tune-up	24%
Refrigerator replacement	21%
Heating/cooling system replacement	15%
Other	4%

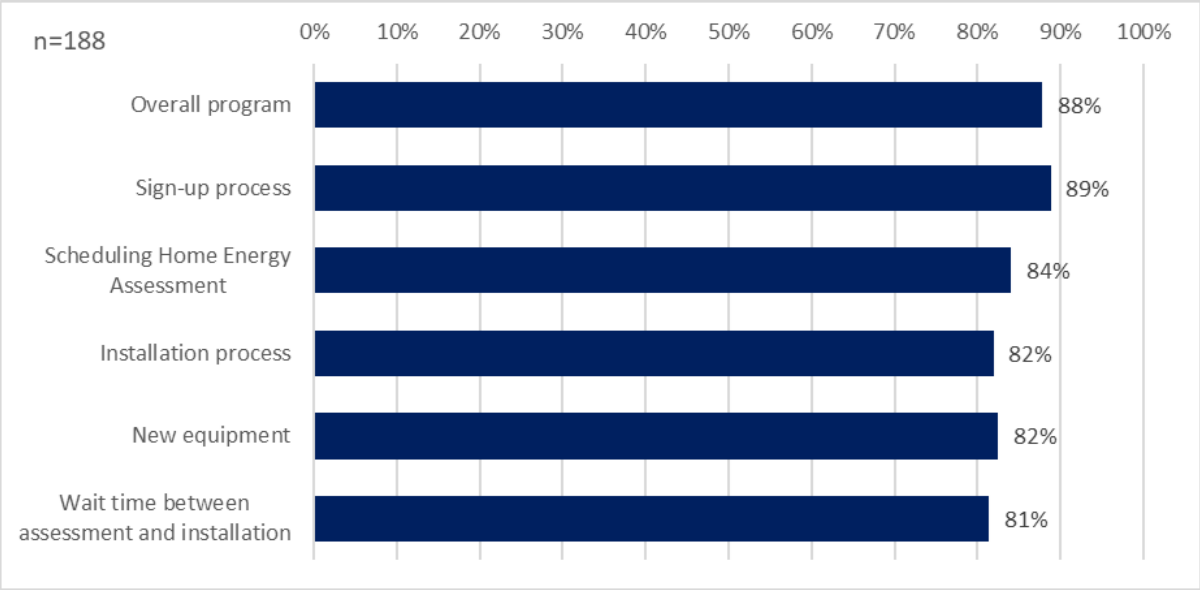
Note: Includes participants who expressed interest in participating in the HEA Program.

5.3.2 Participant Satisfaction

2016 and 2017 HEA participants responding to the participant survey reported high levels of satisfaction with the program overall, and with program processes. As Figure 5-5 shows, 88% of surveyed participants were satisfied with the HEA Program overall, and 89% of participants were satisfied with their sign-up and enrollment process. Eighty-four percent of participants reported that they were satisfied with home energy assessment scheduling, 82% were satisfied with the measure installation and the new equipment they received, and 81% indicated that there were satisfied with the wait time between their home energy assessment and measure installation. Further, respondents that were present during their energy assessment (89%) said that the auditor discussed strategies for saving energy in their home, and 96% said this information motivated them to improve their household's energy efficiency. Nearly all respondents reported the auditor helped them identify which equipment in their home used the most energy (95%).

[18] Drehobl and Castro-Alvarez, 22
[19] Lusson, 8-10

Figure 5-5. Percentage of Participants Satisfied with Each Program Component

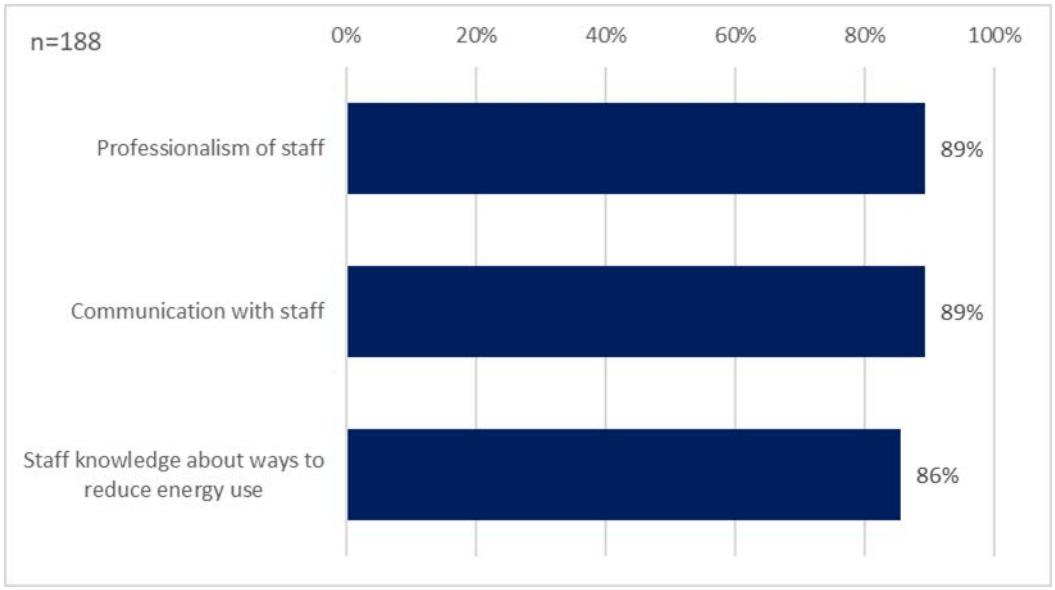


Note: The chart indicates the share of respondents that provided a rating of 7 or higher on a scale from 0-10 where 0 means "extremely dissatisfied" and 10 means "extremely satisfied."

Participants cited several reasons for their satisfaction, including high-quality work, friendly and professional program representatives, satisfaction with savings, and the ability to complete upgrades they otherwise would not have been able to make. The relatively few participants that were less satisfied mostly noted low-quality work and the feeling that the improvements were not effective in reducing their household's energy consumption.

Seventy-six percent of participants also noted they were satisfied with their household's energy savings after participating in the HEA Program. Notably, 67% of participants reported seeing reductions in their energy bills, 26% said there had been no change in their energy bills, and a smaller portion (7%) reported an increase in their bills. Participants were also highly satisfied with both program staff and their contractors. Figure 5-6shows that participants were satisfied with the program staff's professionalism (89%), communication (89%), and knowledge of ways to reduce energy use (86%).

Figure 5-6. Percentage of Participants Satisfied with Program Implementation Staff



Note: The chart indicates the share respondents that provided a rating of seven or higher on a scale from 0-10 where 0 means "extremely dissatisfied" and 10 means "extremely satisfied."

5.3.3 Expanding Participation

As discussed previously, CAAs develop a waiting list of prospective participants each year for the HEA Program based on those indicating interest in weatherization services on their FAP applications. As such, the HEA Program does not require additional outreach to attract more interested participants. As noted in Section 5.1.4, lack of staff resources (both administrative and skilled labor) presents challenges for serving a larger population. Beyond increasing staff capacity, program teams made a number of other recommendations to expand program participation.

- **Develop a moderate-income offering**—Several representatives from CAAs noted that there are a large number of participants that do not meet the income qualifications for the HEA Program, have a need to weatherize their homes, but cannot afford the Home Performance with ENERGY STAR® Program co-pay.
- **Add offerings aimed at manufactured homes**—Program staff also indicated that manufactured homes (sometimes referred to as mobile homes) are a difficult segment to serve through the HEA Program due to limited opportunities to install additional insulation. Specifically, walls cavities in manufactured homes tend to be thin and therefore lack space to add supplemental insulation. While insulation contractors may be able to supplement with basement and attic insulation, contractors sometimes have difficulty accessing certain areas due to low ceiling clearance (i.e., reaching all the way to the exterior walls in the basement. Along with a moderate income offering, including measures aimed at this type of housing stock—e.g., ductless heat pumps, heat pump water heaters, and efficient water heating fixtures—may help HEA Program teams to serve more participants with manufactured homes.
- **Allow more health and safety upgrades through the HEA Program**—Program teams indicated that a substantial portion of HEA participants require health and safety upgrades prior to completing insulation or air sealing works (65% of participating households received health and safety measures). The WAP currently funds many of these upgrades, and representatives from CAAs

suggested adjusting program requirements and funding to allow more health and safety upgrades through the HEA Program may help program teams serve more participants (see Section 5.1.4).

- **Partner with public housing authorities**—Program staff noted that continuing to partner with public housing authorities throughout the state will be an important avenue for completing more projects in multifamily buildings.

6. Findings and Recommendations

The following sections outline our findings and recommendations from the NHSaves HEA Program impact and process evaluation for 2016 and 2017. We outline several of the program's key strengths, areas for improvement, and potential barriers to gaining increased participation and savings. As is typical with evaluations looking back several years, utilities and program teams have already made changes to the program which, in part, take steps towards several findings and recommendations identified in this report.

6.1 Program Energy Impacts

The 1,548 HEA Program participants from 2016 and 2107 saved 40,507 MMBTUs total and 26 MMBTUs on average per household. Note that these savings represent those claimed by the HEA Program and no other programs that jointly funded HEA projects (e.g., the WAP). Opinion Dynamics conducted on-site inspections of 50 participating households to verify household characteristics, equipment specifications, and confirm receipt of energy-saving measures tracked in the HEA Program tracking database (i.e., OTTER). We then developed ex post savings estimates for the 50 sites by updating TREAT models with primary data collected from each household during site visits. We developed an average realization rate from the 50 selected sites (91%) by dividing ex post savings from updated TREAT models to ex ante savings tracked in OTTER. We then multiplied the overall realization rate for 50 sites by all ex ante savings tracked in OTTER to reach program-wide ex post savings presented in Table 6-1. Note that the results below include savings from both measures that save electricity (i.e., kWh converted to MMBTUs[20]) and those that saved other fuels (e.g., natural gas, oil, propane, etc.). Further, note that these results underrepresent multifamily participants as we lacked contact information for participants that live in master metered buildings (see Section 2.4). While 31% of 2016 and 2017 participants live in multifamily buildings, we only completed site visits with one participant that lived in a multifamily building. For prospective planning purposes, the New Hampshire utilities should apply the total realization rate (91%) to savings claimed by the HEA Program (i.e., those paid for by the program) as the realization rate presented below includes all measures (e.g., insulation, LEDs, domestic hot water, etc.) based on our team's revisions to TREAT models for sample of households.

Table 6-1. Energy Savings Results

Ex Ante Energy Savings (MMBTU) Claimed by the HEA Program	44,514
Site Visit Realization Rate	91%
2016-2017 HEA Program Participants	1,548
Ex Post Gross Energy Savings (MMBTU)	40,507
Ex Post Energy Savings per Household (MMBTU)	26

Site visit results are valid at the 90% confident level with 7.8% relative precision.

Table 6-2 below shows the share of ex ante savings claimed by the HEA Program associated with each fuel type, along with total ex post savings allocated to each fuel type proportionally. As shown, the majority of claimed savings fall under natural gas (32%) and fuel oil (28%), while electric savings and other fuel types represent a smaller portion of total claimed savings.

[20] To convert kWh savings to MMBTUs, we used a conversion factor of 0.003412. Source: https://www.extension.iastate.edu/agdm/wholefarm/pdf/c6-86.pdf

Table 6-2. Share of Ex Ante and Ex Post Savings by Fuel

Fuel Type	Ex Ante (MMBTU)	Share of Total Ex Ante	Ex Post (MMBTU)
Natural Gas	14,301	32%	14,298
Fuel Oil	12,463	28%	12,462
Electric	5,600	13%	5,599
Kerosene	5,159	12%	5,158
Propane	4,237	10%	4,237
Wood	2,753	6%	2,753
Total	**44,514**	**100%**	**40,507**

Energy Modeling

Opinion Dynamics' engineering team made updates to TREAT models for 33 sites (see Appendix A for a complete list of modeling adjustments). For 19 of those 34 models, we adjusted the retrofit building conditions. Most commonly, we (1) adjusted heating and cooling system specifications (seven sites); (2) removed savings from air sealing measures for sites where we were unable to confirm blower door tests and CFM reduction (four sites); or removed savings from heating system tune-ups where these measures were incorrectly modeled (four sites).

- **Where possible, the utilities should require CAAs to verify the completion of blower door tests (BDT) for all households that receive air sealing measures.** While BDTs are currently required by the utilities to demonstrate CFM reduction from air sealing measures, our engineering team found at least four out of 50 instances where implementation crews were unable to complete BDTs due to health and safety issues in participating households (e.g., where there is evidence of asbestos insulation that should not be disturbed). In these cases, implementation crews receive guidance to estimate CFM reductions and, as such, we found several instances where pre- or post-retrofit BDT values tracked in project-specific TREAT models appear to have been rounded to the nearest 100 CFM. Utilities should continue to require BDTs be completed by implementation crews wherever possible and, should also require BDT readouts to be submitted along with other project documentation. Where implementation crews cannot perform BDTs for health and safety reasons, utilities should provide guidance to implementation crews on proper documentation (e.g., the use of infrared cameras to document the need for air sealing measures) and clearly note in the program tracking data why a BDT could not be performed. Additionally, in instances where BDTs cannot be performed but air sealing is still necessary, utilities should provide a more systematic method for estimating CFM reduction—e.g., using the average per and post-CFM values from this or future evaluations (see Section 3.1.1) or converting CFM reduction to time and material costs.
- **Utilities should use pre- and post-combustion testing as TREAT model inputs for heating system tune-up measures.** Opinion Dynamics found four instances where implementation crews modeled heating system tune-ups by increasing annual fuel utilized efficiency (AFUE) to exceed or meet 100% of the systems' nameplate AFUE. Program staff indicated that, in households that receive heating system tune-ups, implementation crews are instructed to perform pre- and post-retrofit combustion testing. We recommend that implementers use the results of the combustion tests as model inputs to more accurately estimate savings from furnace and boiler cleaning and tune-up measures. Where combustion testing cannot be completed safely (e.g., where carbon monoxide levels are higher than would be safe for participants and implementation crews), utilities should work to establish a systematic method for estimating pre and post AFUE. As part of a future evaluation, utilities may elect to perform additional primary research (e.g., a metering study or pre/post combustion testing)

for a sample of households that receive furnace or boiler tune-ups to establish the actual baseline AFUE pre-treatment and how systems perform post-treatment. Alternatively, utilities could default to a prescriptive approach—e.g., the 2019 Connecticut Program Savings Document (CT PSD) stipulates an existing AFUE for furnaces and boilers of 80% and recommends a 2% increase in efficiency due to cleaning and tune-up measures.[21] Finally, utilities may elect to use time and material costs as a proxy for AFUE reduction. However, we feel that many of the systems treated through the HEA Program are likely older and have nameplate AFUEs lower than the 80% recommended by the CT PSD. As such, additional primary research is the best way to accurately document the existing efficiency of these older systems and the impact of treatment in terms of performance improvement. Specifically, we estimate that actual operational efficiency is lower than nameplate and a 2% increase should be based on existing performance, capped at nameplate efficiency.

- **As the New Hampshire utilities move towards upgrading program data tracking systems, decision makers should consider systems' reporting capabilities and their ability to track supplemental information.** Based on interviews with program staff (i.e., both at utilities and CAAs) and our review of TREAT models, it is evident that on-site implementation teams collect large amounts of data related to the HEA Program both during the initial energy assessment and the installation of HEA measures that were not present in the reports used for this evaluation. For example, implementation teams collect detailed information related to households' primary and secondary heating fuel types, baseline heating system capacities, among other specifications. However, these data are often inaccessible without opening individual TREAT models. While it is unrealistic to expect any type of software to be able to report at the same level of granularity allowed for in the TREAT models, when upgrading data tracking software, utilities should consider systems' ability to create customized reports that contain different levels of detail. Additionally, based on previous III, any upgraded program tracking system should enable CAAs to upload supplemental information (e.g., BDT documentation, infrared images, etc.). Further, upgraded software should enable utilities to add fields and make other changes to data tracking and reporting structures as the HEA Program evolves. Considering program tracking software with these capabilities and this type of flexibility will support evaluation and other ad hoc research that will help the HEA Program continue to improve and adapt to participants' needs.

6.2 Non-Energy Impacts

As part of this evaluation, Opinion Dynamics quantified the select participant and utility non-energy impacts (NEIs). For participant NEIs, we used a combination of participant survey data and secondary research to quantify the net impacts to participants of the HEA Program. To quantify increased comfort and decreased noise, we estimated both the share of participants that experienced these positive NEIs and their perceived value relative to the energy savings they experienced through the program through the participant survey (i.e., a labeled magnitude scaling multiplier[22]). For health-related NEIs, we asked participants about incidences of seeking medical attention or visiting a hospital both before and after participation in the HEA Program and then quantified the impact of any change in the need for medical attention based on secondary research. We also estimated the impact of the HEA Program on customer arrearages, using a difference in difference

[21] CT PSD. Pg. 201

[22] Skumatz, Lisa, and Gardner, John (2006), "Differences in the Valuation of NEBs According to Measurement Methodology: Causes and Consequences," Proceedings of the 2006 AESP Conference, Clearwater Beach FL. Skumatz, Lisa and Khawaja, Sami (2009), "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior." For the California Institute for Energy and Environment Behavior and Energy Program. https://uc-ciee.org/downloads/EEM_A.pdf

approach to compare unpaid balances of participants before HEA treatment to unpaid balances after treatment.

Table 6-3. Researched Utility and Participant NEIs

NEI Category	Non-Energy Impacts
Utility	Reduced arrearages
Participant	Reduced asthma symptoms
	Reduced thermal stress (both hot and cold)
	Improved comfort
	Decreased internal/external noise

In Table 6-4 below, we provide monetary benefits of each participant NEI included in this study. We present results per participant, both for those that experienced the effect (i.e., received the appropriate package of measures), per participant for all participants, and the total value for all 2016 and 2017 participants. By far, the largest NEI of the HEA Program was for participants that experienced an increase in the comfort of their home since participating in the HEA Program. Over half of respondents to the participant survey (53%) reported that they had experienced an increase in the comfort of their home since participating in the HEA Program. Additionally, 13% of participants surveyed reported decreased noise from outside their home, and 10% reported decreased noise levels from inside their homes. In total, our research suggests that, from the participant NEIs included in the table above, 2016 and 2017 HEA participants realized $531,078 in total (i.e., across all 2016 and 2017 HEA Program participants). When estimating HEA Program benefits, New Hampshire utilities may assume $343.07 in additional non-energy benefits per HEA participant based on this research—that is, the total value of the participant NEIs divided by the 1,548 unique participants that enrolled in the HEA Program between 2016 and 2017 (see Section 4 for additional details on our approach). Note that HEA participants may experience NEIs beyond those included in this study. As such, the New Hampshire utilities may elect to use proxy values for other participant NEIs based on secondary research specific to New Hampshire and should also target additional NEIs for future primary research.

Table 6-4. Participant NEI Results Summary

Non-Energy Impact	Per Participant (experienced the effect)	Per Participant (all 2016-2017 participants)	Total for the 2016-2017 HEA Program
Increased comfort	$304	$267	$413,431
Decreased noise inside the home	$66	$56	$86,678
Decreased noise coming from outside the home	$30	$15	$22,953
Avoided overnight hospital stays due to reduced asthma symptoms	$6	$5	$8,064
Reduced doctor visits for colds/illnesses related to thermal stress	$0.03	$0.03	$42
Total All NEIs	**$406**	**$343**	**$531,078**
Non-Energy Impact	Per Participant (experienced the effect)	Per Participant (all 2016-2017 participants)	Total for the 2016-2017 HEA Program
Increased comfort	$304	$267	$413,431
Decreased noise inside the home	$66	$56	$86,678
Decreased noise coming from outside the home	$30	$15	$22,953
Avoided overnight hospital stays due to reduced asthma symptoms	$6	$5	$8,064
Reduced doctor visits for colds/illnesses related to thermal stress	$0.03	$0.03	$42
Total All NEIs	**$406**	**$343**	**$531,078**

Opinion Dynamics completed a limited analysis of reduction in utility electric arrearages based on participation in the HEA Program for NHEC and Eversource customers.[23] While we did find evidence that electric utilities did experience reductions in arrearages as a result of HEA participation, we do not have sufficient information to suggest that these results be applied to statewide electrical customers. However, as we were able detect statistically significant NEIs on arrearages for NHEC customers (Table 6-5) we recommend applying these results to HEA participants that are also NHEC customers. Though we did find some evidence of a reduction of arrearages for Eversource customers with at least one month of an unpaid balance, we were unable to detect a statistically significant result. As such, we recommend that the New Hampshire utilities conduct research in the future to quantify these, and other utility NEIs. See 4.2 for a complete discussion of both NHEC and Eversource arrearage analyses.

Table 6-5. Summary of Electric Arrearage Analysis

Utility	Average per Month		
	Unpaid Amount in the Pre-Period	Un-paid Amount in the Post Period	Percent Change
NHEC Electric Arrearage Reduction*	$23.30	$5.93	-25%
Eversource Electric Arrearage Reduction+	$85.63	$58.45	-32%

[23] We did not receive sufficient data to conduct an analysis of gas arrearages, or other utility NEIs.

*Statistically significant at the 98% confidence level

+ Results only apply to 393 Eversource HEA participants with an unpaid balance in at least one month, and not all participants.

6.3 Expanding Program Reach

CAAs indicated that most program processes work well and that they have no issues finding qualified participants interested in receiving benefits from the HEA Program (88%of respondents to the participant survey were satisfied with the HEA Program overall). Rather, CAAs face capacity constraints when attempting to reach all those New Hampshire residents interested in participating. As such, the main barriers to reaching additional HEA participants are program funding and limited staff resources (both at CAAs and the contractor workforce). Additionally, CAAs reported that project-level cost-effectiveness requirements may present challenges in future years if WAP funding does not keep pace with the HEA Program. Note that in 2016 and 2017, program guidance allowed projects that achieved a benefit-cost ratio less than 1.0. However, this would negatively affect overall cost-effectiveness and, as such, CAAs were reticent to allow projects that did not achieve a benefit-cost ratio of 1.0. New Hampshire utilities and decision makers have made changes to program requirements in subsequent years to address this barrier. Presently, many participants receive benefits from both programs and CAAs use WAP funding to cover the cost of necessary health and safety improvements.

- **Utilities should leverage HEA Program funds to help CAAs build additional staff capacity.** Lack of administrative staff at CAAs is a substantial barrier to treating more households through the HEA Program. At the time of this evaluation, most CAAs subcontracted some or all of the HEA Program's implementation, though CAAs have since taken steps to complete more HEA activities (e.g., energy assessments) "in-house. "Utilities should continue to work with CAAs to find ways to leverage program funds to allow agencies to hire additional administrative, or technical staff (e.g., energy auditors), to aid in the delivery of the HEA Program. Additionally, adding more staff would allow CAAs to improve data tracking and collection.
- **Utilities should consider funding whole building performance modeling training for CAAs and implementation crews.** CAAs noted that staff training and retention are key barriers to being able to serve more prospective HEA participants. Further, according to public comments made before the Energy Efficiency and Resource Standard (EERS) Committee hearing on January 6th 2020, we understand that there is a broader need to recruit and retain more qualified individuals that are able to provide comprehensive, whole building retrofit services (i.e., energy assessments, building performance modeling, measure installation, etc.). As such, utilities should consider sponsoring trainings for CAA staff and implementation teams on best practices for modeling energy savings using TREAT software. Sponsoring these trainings will help relieve the burden of training new staff, provide an incentive for attracting new staff, and help mitigate any quality issues CAAs and utilities currently face regarding TREAT models.
- **The utilities should consider adjusting program requirements to allow more funding for health and safety upgrades on a per-project basis.** CAAs reported that the majority of HEA projects require health and safety upgrades prior to implementing some energy-saving measures (e.g., repairing a leaky roof prior to insulating a home). Program implementers can currently address many of these health and safety upgrades by leveraging funding from other programs that they administer (i.e., the WAP).If the utilities choose to increase HEA funding to serve more households without also using some of that funding to cover health and safety upgrades CAAs may not be able to fund health and safety upgrades through other funding sources for the same share of the HEA participant population.

Appendix A. Complete Ex Post Modeling Results

Opinion Dynamics identified and updated ex post models for 50 HEA participants based on engineering desk reviews and data captured through site visits. below shows original modeled savings (i.e., those savings included in the ex ante TREAT models prior to making updates based on site visit data), ex post savings, the site-specific realization rate, and details modeling adjustments that we made for each household.

Table A-6. Comparison of Ex Ante and Ex Post Models

Site Number	Original Modeled Savings (MMBTU)	Total Ex Post Savings (MMBTU)	Site-Specific Realization Rate	Changes to Baseline Model Conditions	Changes to Retrofit Model Conditions
1	38.1	41.7	109%	Removed electric baseboard heating; Updated DHW storage unit (fed off boiler): temperature set to 140F, input capacity is 100 kBtuh (output of boiler)	Boiler improvement efficiency updated from 95% to 85% AFUE
2	61.4	55.5	90%	Updated AC quantities: changed 4 room air conditioners (RAC) to 2 RAC; Updated thermostat (t-stat): manual t-stat to programmable t-stat; Changed heating setback temp from NA to 65F; Updated DHW: changed fuel from electric to oil (feeds off boiler); Updated heating equipment specs: Changed input Btuh from 4,500 to 93,000	None
3	57.0	60.2	106%	Updated AC specs: Changed efficiency of 5 EER to 10.7 EER (12.2 SEER); Changed heating setback temp from 72F to 67F	None
4	81.4	81.4	100%	None	None
5	38.4	42.9	112%	Updated heating setback temp to 65F	None
6	71.7	71.7	100%	None	None
7	61.6	59.4	96%	Updated heating specs: Input capacity from 64,000 to 78,000 Btuh and efficiency of 70% to 77%	None
8	51.5	51.5	100%	None	None
9	101.3	101.0	100%	None	Only one faucet aerator improvement confirmed onsite, two claimed
10	35.0	22.5	64%	Updated AC specs: changed SEER value from 4 to 10; Changed basement to unheated (basement found to be an unfinished space); Change DHW from Tank (76% EF) to On-demand (80% EF)	None

Site Number	Original Modeled Savings (MMBTU)	Total Ex Post Savings (MMBTU)	Site-Specific Realization Rate	Changes to Baseline Model Conditions	Changes to Retrofit Model Conditions
11	51.9	59.6	115%	Added (3) RAC with EER=10.7	Heating improvement efficiency and capacity update based on nameplate specifications observed onsite
12	66.5	48.8	73%	None	Boiler tune-up incorrectly specified as claimed (i.e., AFUE exceeded nameplate AFUE); No LEDs installed as claimed, per homeowner
13	40.3	24.4	61%	Updated heating specs: Changed AFUE of 60% to 95%, changed input capacity of furnace from 86,000 Btuh to 66,000 Btuh; Added central air conditioner (CAC)	CFM reduction savings not verified as homeowner denied a blower door test being performed; Boiler improvement efficiency and capacity update based on nameplate specifications observed onsite
14	20.2	20.2	100%	None	None
15	24.4	24.4	100%	None	None
16	42.4	42.4	100%	None	None
17	38.4	38.4	100%	None	None
18	105.1	96.3	92%	Updated heating specs: Changed AFUE to 86%	No boiler replacement improvement made as claimed
19	83.2	83.2	100%	Changed heating and DHW fuel from propane to natural gas	None
20	73.7	73.7	100%	None	None
21	58.4	55.1	94%	Updated heating specs: changed EER from 5 to 9, changed capacity of 25,000 Btuh to 3,000 Btuh; Changed water heater type from tank to tankless (electric)	CFM reduction savings not verified as homeowner denied a blower door test being performed
22	30.7	29.6	96%	None	Heating improvement efficiency and capacity update based on nameplate specifications observed onsite.
23	42.5	42.5	100%	None	None
24	32.0	18.2	57%	None	CFM reduction savings not verified as homeowner denied a blower door test being performed

Site Number	Original Modeled Savings (MMBTU)	Total Ex Post Savings (MMBTU)	Site-Specific Realization Rate	Changes to Baseline Model Conditions	Changes to Retrofit Model Conditions
25	18.6	18.6	100%	Updated HVAC: No electric baseboard heating present; Changed heating setback temp to 62F	Heating improvement capacity update based on nameplate specifications observed onsite
26	22.5	22.5	100%	None	None
27	33.1	33.1	100%	None	None
28	46.6	46.6	100%	Changed HVAC: (1) CAC to (3) RAC with capacity of 5,000 Btuh and EER of 9.7	None
29	73.3	66.6	91%	Updated HVAC: (3) RACs at 11 EER	CFM reduction savings not verified as homeowner denied a blower door test being performed; Heating improvement capacity update based on nameplate specifications observed onsite.
30	60.9	60.9	100%	Removed wood pellet stove	None
31	33.1	11.9	36%	Updated heating specs: 80% AFUE to 78% AFUE; Updated DHW specs: 3,800 Btuh to 38,000 Btuh	Attic and wall insulation improvements not installed in home, removed from model.
32	38.1	28.1	74%	Updated: 0 to 100% of aerators and showerheads are low flow	No boiler replacement improvement made as claimed, removed from model
33	50.4	50.0	99%	Updated HVAC type; Removed RACs	None
34	81.2	81.2	100%	None	None
35	70.8	34.3	48%	Updated: 0 to 100% of aerators and showerheads are low flow; Basement walls changed from above ground to below ground; Furnace is primary heating not secondary, no wood heating on site	None
36	2.0	2.0	100%	None	None
37	35.7	35.7	100%	None	None
38	74.5	74.5	100%	Removed RAC	None
39	21.7	21.7	100%	None	None
40	45.3	42.4	94%	Removed electric resistance heating; Removed AC	None
41	28.3	27.7	98%	Added (2) RAC at 10.8 EER with capacity of 12,000 Btuh; Added Pellet stove; Updated heating specs; Changed oil furnace from capacity of	Furnace tune-up incorrectly specified (i.e., AFUE exceeded nameplate AFUE), removed from model

Site Number	Original Modeled Savings (MMBTU)	Total Ex Post Savings (MMBTU)	Site-Specific Realization Rate	Changes to Baseline Model Conditions	Changes to Retrofit Model Conditions
				50,000 Btuh with efficiency of 80% AFUE to 75,000 Btuh at 75% AFUE	
42	32.8	32.8	100%	None	None
43	29.4	19.8	67%	None	CFM reduction savings not verified as homeowner denied a blower door test being performed; Installed 9W LED confirmed onsite vs 4W claimed
44	62.3	53.0	85%	None	CFM reduction savings not verified as homeowner denied a blower door test being performed; Faucet aerator failure
45	45.9	45.9	100%	None	None
46	53.1	35.2	66%	Changed cooling equipment from CAC to RAC	CFM reduction savings not verified as homeowner denied a blower door test being performed; Heating improvement capacity update based on nameplate specifications observed onsite.
47	28.4	26.3	93%	None	Attic hatch insulation failure observed onsite
48	119.4	72.5	61%	Updated heating specs: Changed AFUE from 75% to 95%	Furnace cleaning documentation presented by homeowner showed testing result of 21% efficiency gained, updated AFUE in model.
49	94.5	94.5	100%	Added: (2) RAC	None
50	49.9	49.9	100%	Added: (2) RAC	None
Total	**2,182**	**2332**	**91%**		

Appendix B. Participant and Non-Participant Survey Instruments


NH HEA Participant Survey_FINAL Versio


HEA-HPwES Non-Participant Sur

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