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New Hampshire Utilities

Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL

June 11, 2020

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1. Executive Summary

This report presents the results of Opinion Dynamics' evaluation of the NHSaves Home Performance with ENERGY STAR® (HPwES) Program for the New Hampshire natural gas and electric utilities (Eversource, Until, New Hampshire Electric Co-op, and Liberty Utilities). In this section, we present the objectives, methods and findings of Opinion Dynamic's impact and process evaluation that covers the program 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 HPwES Program

The NHSaves HPwES Program provides a comprehensive set of energy saving measures to help eligible New Hampshire residents reduce energy costs, improve their homes' energy performance, and enhance the durability and comfort of their homes. The program is "fuel neutral" and prioritizes treatment of homes that exceed a threshold of energy use intensity, regardless of their primary heating fuel type. Participating HPwES contractors take a whole house approach from energy audit through installation and inspection. To qualify, homes must meet a threshold Home Heating Index (HHI) score, which the utilities calculate using location (zip code), conditioned square footage, and annual heating fuel usage. Prospective participants pay $100 to receive a comprehensive home energy assessment, after which their home performance contractor provides a list of recommendations to improve their household's energy efficiency. Program rebates cover approximately 50% of the cost of recommended weatherization services (insulation, air sealing, and programmable/Wi-Fi enabled thermostats) and free Instant Savings Measures (ISMs), which include LED lighting and domestic hot water saving measures. The HPwES Program also offers rebates for several appliance measures, including refrigerators, furnaces, and boiler replacements, in cases where appliances are nearing the end of their useful life. Rebates are capped at $4,000 per home, but eligible participants may also take advantage of on-bill financing, or interest-rate buy-down financing for the remainder of the project costs.

1.2 Evaluation Objectives

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

Impact Evaluation Objectives

- 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 the reasonableness of savings calculations for 2018-2020, including baseline efficiency assumptions, algorithms, and inputs, and recommend changes for prospective application as necessary.

Process Evaluation Objectives

- Review and assess the effectiveness of HPwES Program design and implementation processes in 2016 and 2017, including the customer participation process and coordination with contractors.
- Collect feedback from participating contractors, customers, and financial institution partners regarding the program and identify opportunities for improvement.
- Review and assess the effectiveness of the program's marketing, education and outreach (ME&O) strategy and coordination with community partners.
- Identify opportunities to attract additional customer and contractor participation and integrate emerging technologies into the program.

1.2.1 Summary of Findings and Recommendations

Below we outline key results and findings of this evaluation.

Energy Savings

The New Hampshire utilities together treated 1,958 unique households in 2016 and 2017 through the HPwES Program and claimed 54,206 MMBTU of energy savings from all measures and fuel types. The impact evaluation resulted in 59,081 MMBTU energy savings with an overall realization rate of 109%, as shown in Table 1-1, which include electric savings (i.e., kWh) converted to MMBTUs.[1] This translates to ex post savings of 30 MMBTUs annually per 2016 and 2017 participating household, which include all measures offered through the HPwES Program (e.g., insulation, LEDs, domestic hot water, etc.). Additionally, the table below also shows total savings from all measures separated into three groups according to participants' primary fuel types—that is, homes that primarily heat with delivered fuels (e.g., oil or propane), natural gas, or electricity.[2] These ex post savings results represent the total savings for all measures based on our team's revisions to individual measure deemed savings assumptions (see Appendix C). For prospective planning purposes, the New Hampshire utilities should use updated measure-specific deemed savings estimates based on this evaluation, and also apply the researched measure in-service rate based on our team's site visits (see Section 3.2).

Table 1-1. Impact Evaluation Results by Primary Heating Fuel Type

Primary Fuel Source	Ex Ante MMBTU	Ex Post MMBTU*	Realization Rate
Delivered Fuels	30,080	34,363	114%
Natural Gas	19,897	20,666	104%
Electricity	4,228	4,052	96%
Total	**54,206**	**59,081**	**109%**

* Results are valid at the 90% confidence level +- 8% relative precision

While the overall realization rate for the 2016 and 2017 program period was 109%, Opinion Dynamics observed large deviations between ex ante and ex post deemed savings at the individual measure level. Our

[1] 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

[2] Note that, for the purposes of reporting impacts, we referenced program tracking data to estimate primary fuel source. However, we used participant survey data as inputs for primary and secondary heating fuel types when updating deemed savings estimates. The program tracking data report used for this evaluation did not specify heating fuel type, though our team made some assumption when presenting these results by primary fuel source based on the largest source of savings for each household tracked in the database.

impact evaluation included a review of the engineering algorithms and assumptions used to develop the ex ante savings for each program measures and, where possible, we identified the source of deviations between ex ante and ex post savings. When necessary, we recommended changes and updates to deemed savings assumptions that will better align ex ante measure savings with evaluated savings in the future (see Section 0 and Appendix C).

Multifamily Impacts

Due to incomplete contact information for master-metered natural gas sites, Opinion Dynamics had difficulty collecting primary data from participants that live in multifamily (MF) buildings (see Section 2.3). Specifically, to support development of ex post impacts we conducted site visits with 67 participants from 2016 and 2017. While 34% of participating households over the two-year period lived in multifamily buildings, 6% of the participants with whom we completed site visits lived in multifamily buildings. There were some subtle differences in the share of multifamily households that received certain measures when compared to single family (SF) households (see Section 4.2.2). While similar shares of participants received insulation and air sealing in both housing types (85% SF and 80% MF), fewer multifamily participants received lighting measures (54% SF and 19% MF). Additionally, a greater share of multifamily participants received domestic hot water measures (17% SF and 27% MF). Aside from differences in the measure mix between the two household types, there are also inherent differences in single and multifamily buildings as it relates to realizing energy savings from comprehensive weatherization programs. As such, the ex post energy savings results presented in this report underrepresent the HPwES Program's impact on multifamily buildings and the New Hampshire EM&V Working Group should consider conducting multifamily-specific impact research in future evaluations.

Program Funding

Lack of program funding was a common barrier cited by utility program staff and participating contractors to treating a larger number of participants through the HPwES Program. Program staff reported that budgets for the HPwES Program have remained limited and the utilities have been specifically reticent to increase marketing and outreach budgets as NHSaves contractors may not be able to meet additional demand. Further, participating contractors noted that utilities do not currently have a systematic means of sharing remaining program funding levels year over year. As such, contractors are apprehensive to make long term investments in staff and infrastructure that would be required to serve additional HPwES participants. Note that the New Hampshire utilities, and other decision makers, are aware of this issue and have taken steps to address gaps in program funding in future years.

- **Increase program funding and create a unified means of sharing remaining funding levels with participating contractors that are consistent across all New Hampshire utilities.** Contractors and program staff both cited lack of funding as a major barrier to increasing participation in the HPwES Program. Both contractors and program staff agree that there is a large amount of remaining opportunity throughout the state and that customers are still relatively unaware of the HPwES Program. According to the non-participant survey, only 6% of eligible non-participants are aware of the HPwES Program. However, program staff are reticent to expand outreach as contractors, at their current capacity, would be unable to support additional demand. Utilities should work with stakeholders to both increase long term funding for the program and ensure that contractors understand how much funding remains available throughout the year across all four utilities. With additional funding and streamlined communication related to funding levels, contractors will be able to make the investments in staff and infrastructure that will be required to serve additional demand for the HPwES Program.

Consistency of Program Delivery Across All Utilities

Opinion Dynamics found that that there are subtle differences in how some utilities deliver certain aspects of the program. For example, some utilities offered on-bill financing during the 2016 and 2017 program years, while others did not. As such, while utilities instruct contractors to share details related to financing during the home energy assessment, contractors do not always do this as for fear that they may later need to rescind the offer if customers do not qualify for certain offerings. Additionally, participating contractors also reported differences in how utilities inspect projects during the QA/QC phase (i.e., some utilities review 1 in 10 projects while others review 1 per invoice). Finally, contractors reported that decision making related to these aspects of the program, among others (e.g., project approval), is distributed across the four utilities. While this type of distributed decision making is inherent with any type of program that is jointly administered by several different entities, it can lead to delays and confusion amongst those that implement the program.

- **Streamline program design, where possible, to create a single set of program implementation guidelines that are consistent across all four utilities.** The New Hampshire utilities have worked together to create a single program manual with guidelines for service delivery. However, there is still some confusion amongst participating contractors related to certain aspects of the program. Decision makers at utilities should work to create a single set of implementation guidelines that are common across utilities wherever possible and empower program staff to make some implementation decisions without the need for approval from decision makers across all utilities. For example, utilities should agree on a single approach for selecting and inspecting projects for QA/QC. Where a uniform set of program offerings may not be possible (e.g., on-bill financing), utilities should continue to work with contractors so they can confidently and proactively identify which offerings apply to customers prior to conducting the home energy assessment.

Instant Savings Measures

While weatherization measures are the core offering of the HPwES Program, 51% of participating households received ISMs, including LEDs and domestic hot water measures, which accounted for 30% of all ex ante savings claimed during 2016 and 2017 (i.e., both electric and fossil fuel savings). While these measures accounted for a large portion of savings (second only to weatherization measures), our process research suggests that contractors offer ISMs inconsistently. While some contractors regularly recommend and install these measures, others choose to focus on insulation and air sealing measures and rarely offer ISMs.

- **Consider exempting ISMs from the $4,000 per project rebate limit.** Several contractors indicated that they do not regularly install ISMs as it limits the amount of weatherization work covered by the HPwES program, and therefore decreases the likelihood that participants will choose to move forward with installing those measures. Exempting ISMs from the cap may encourage more contractors to install ISMs without sacrificing opportunities to install more insulation and air sealing measures.

Data Collection

The HPwES Program tracking database (OTTER) provides a range of information related to efficient measures—e.g., detailed descriptions of efficient measures installed and estimates of ex ante savings realized for different heating fuel types. However, OTTER provides limited information about existing household conditions that may aid in program planning and help improve the accuracy of ex ante savings estimates. While the overall realization rate for the 2016 and 2017 program years was 109% overall, the evaluation team observed large deviations between ex ante and ex post at the individual measure level (see Section 3.1).

- **Standardize on-site data tracking and collection of household characteristics and pre-installation conditions and enable electronic reporting through program tracking database.** The utilities should consider requiring contractors to digitally upload basic information about participating households, such as primary and secondary heating fuel types, appliance information (e.g., presence of central AC), and pre-insulation R-values to OTTER. The ability to produce digital reports on these data will allow program teams (i.e., both utility staff and HPwES contractors) to plan and forecast projected savings more precisely and with less risk of substantial deviations between ex ante and ex post savings. In addition, tracking information about the characteristics of participating households will help utility program staff better characterize the participant population from year to year and more effectively tailor future offerings to that population.

Data Collection Software

Both contractors and program staff highlighted the challenges of having two separate systems for data collection (NHSurveyor) and tracking (OTTER). Current systems require field technicians to collect data, enter information into NHSurveyor and upload those data to OTTER, before the utilities are able to review and approve individual projects. Additionally, making updates to a project due to changes in the scope, requires staff to repeat this process in both software systems.

- **Integrate data collection and data tracking systems into a single platform.** The utilities have considered transitioning to a new data tracking system in recent years. We recommend transitioning to a single platform that allows for both data collection and tracking—that is, an integrated system that allows field staff to enter project details and transfer records digitally to the utilities for verification. It is also important that the platform is conducive to onsite data collection. Currently, many auditors collect information on paper and transfer those data to NHSurveyor after completing the home energy assessment. Onsite entry would eliminate this step along with any additional time requirements of tracking the data. As many contractors already experience staff capacity issues (see Section 4.4.2), simplifying the data collection and submittal process would help save implementation crews time.

Marketing and Outreach

Based on the non-participant survey, 29% of customers that are eligible to participate in the HPwES Program would be interested in doing so (see Section 4.4.1). However, only 6% of those eligible non-participants were aware of the HPwES Program prior to taking the survey. In addition to utility marketing (e.g., direct mail, NHSaves website, etc.), non-participants prefer to receive information about energy efficiency programs through newspaper or print adds (29%), via social media (24%), or from TV and radio advertisements (21%). While 2016-17 HPwES Program participants most frequently first learned about the program through either their utility's or the NHSaves website (29%), through word of mouth (24%), or through their contractor (16%), very few of these participants learned about the program through social media or TV/radio advertisements (1% for each), indicating that there may be opportunities to reach more customers via these channels. Other similar programs that operate in nearby states also rely on mass advertising and word of mouth to fuel program awareness. Mass advertising drove awareness for Home Energy Savings Program participants in Maine (36%)[3] and NYSERDA Home Performance with ENERGY STAR participants (44%)[4]. Additionally, word of mouth drove awareness of similar programs (26% of MassSave Home Energy Services participants[5] and 24% Energy

[3] Cadmus. 2011. Pg. 44
[4] Research Into Action, Inc. 2015. Pg. 36
[5] Navigant, et al. 2018. Pg. 142

Savings Program participants in Maine[6]). The New Hampshire utilities understand this barrier and, since the evaluation period, have taken steps to address lack of awareness by seeking alternative outreach strategies to effectively reach eligible HPwES participants (e.g., paid social media advertising, additional market research, etc.).

- **The utilities should continue expanding their social media presence as a means for reaching additional participants and also leverage internal market research to identify additional outreach activities that may generate more interest in and awareness of the HPwES Program.** The utilities currently take advantage of a range of different marketing strategies identified by non-participants as their preferred ways of receiving information (e.g., TV/radio advertisements, social media, etc.). However, very few of the 2016-2017 participants surveyed first learned about the HPwES Program through those avenues. To address this, the utilities have conducted additional research aimed at building a larger social media presence as a means of attracting more interest in the program. For example, in 2019, Eversource began leveraging Facebook and Gmail advertising in a limited capacity and experienced encouraging results; achieving 2.7 million impressions and 56,000 clicks, which resulted in 645 customers completing the HHI tool. In combination with increased program budgets to enable contractors to serve more participants, these outreach efforts should be expanded along with more traditional outreach strategies to reach those who do not regularly use social media.

Participating Contractor Network

Increasing the capacity of the participating contractor network by both improving existing processes and recruiting additional contractors is key to being able to expand the reach of the program. As noted, streamlining data collection processes may help reduce staff time required on a per-project basis. Additionally, contractors indicated that high turnover rates and the need to find and train new staff both constitute a major drain on their efficiency and resources. Finally, as 16% of participants first learned about the program through their contractors, increasing the number of contractors within the preferred partner network may serve as an additional strategy for attracting more participants.

- **Provide additional training opportunities to help contractors build skills amongst their staff.** Participating contractors indicated that they have difficulty hiring and training new staff members. The utilities should consider sponsoring training opportunities for participating contractors that cover topics such as best practices for home energy assessments, installation of weatherization measures for junior staff, and how to discuss program finance offerings with customers. We recognize that the NHSaves utilities have offered training opportunities in the past and saw low participation levels, so we recommend the utilities meet with the participating contractors to understand their specific training needs and how to deliver those trainings in a way that encourages participation.
- **Consider funding BPI and installation trainings for non-participating contractors.** Other HPwES programs have addressed contractor capacity constraints by offering fully funded trainings. Specifically, Efficiency Vermont[7] is funding BPI trainings and providing bonuses to contractors who join their preferred contractor network following the training. Energy Trust of Oregon[8] and the New Jersey Clean Energy Program[9] have also funded training for HPwES contractors in the past to build capacity. By providing these offerings for both BPI and measure installation, the New Hampshire utilities can expand the pool of auditors and installation contractors throughout the state.

[6] Cadmus. 2011. Pg. 44
[7] Efficiency Vermont, slides 12-14
[8] Plympton, et. al, page 2-226
[9] Plympton, et. al, page 2-228

- **Develop participation channels for non-participating contractors who do not agree to program pricing.** These contractors would not be listed as "preferred contractors" and would not be part of the pool of contractors who are assigned utility-generated leads. However, allowing these contractors to offer program rebates will add contractor capacity, serve as another way to encourage participation, and also provide an incentive for "out-of-network" contractors to agree to the program pricing scheme and start accepting referrals from utilities. Efficiency Vermont also plans to allow "out-of-network" contractors to participate in their HPwES program. [10]

[10] Efficiency Vermont, slide 13

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. Descriptions of each activity are provided in the sections that follow.

Table 2-1. Research Methods by Corresponding Objectives

Research Objective	Review of Program Tracking Data	Program Staff Interviews	Contractor & Program Partner Interviews	Literature Review	Participant Survey	Engineering Analysis	Non-Participant Survey	Consumption Analysis
Impact Evaluation								
Verify gross savings from 2016 and 2017 HPwES participants	☑				☑	☑		☑
Compare ex post and ex ante savings and identify key contributors to differences	☑					☑		☑
Review savings calculations for 2018-2020 and recommend changes for prospective application	☑					☑		
Process Evaluation								
Review and assess effectiveness of HPwES design and delivery	☑	☑	☑		☑			
Review and assess the effectiveness of the program's ME&O strategy &		☑	☑	☑			☑	

Research Objective	Review of Program Tracking Data	Program Staff Interviews	Contractor & Program Partner Interviews	Literature Review	Participant Survey	Engineering Analysis	Non-Participant Survey	Consumption Analysis
coordination with community partners								
Collect feedback and identify opportunities for improvement		☑	☑	☑	☑			
Identify strategies to attract additional customer and contractor participation		☑	☑	☑	☑		☑	

2.1 Impact Evaluation Activities

Opinion Dynamics leveraged an engineering analysis to develop ex post savings estimates and support applicable updates to existing deemed savings assumptions. The engineering analysis provides estimated breakdowns of energy savings by end-use developed through the deemed savings review and site visits. We also conducted a consumption analysis to serve as a comparison to the engineering results. However, as the HPwES Program is "fuel blind," the consumption analysis did not capture energy savings from customers that heat their households with a non-regulated, or delivered fuel (e.g., propane, fuel oil, or wood).

2.1.1 Engineering Analysis

The following section explains Opinion Dynamics' approach to the three impact evaluation activities used to estimate ex post savings for the 2016 and 2017 HPwES Program—review of deemed savings for HPwES measures, engineering desk reviews, and site visits of participating HPwES households.

Deemed Savings Review

Opinion Dynamics conducted a review of the deemed savings estimates for measures provided through the HPwES Program. Our review assessed measure assumptions and their data sources for accuracy and appropriateness. We first reviewed a master list of measures provided by the utilities, along with each measures' corresponding ex ante per-unit savings estimate. For some measures, utilities also provided calculations used to estimate per unit savings. Where calculations were unavailable, utilities responded to questions posed by Opinion Dynamics to clarify any missing assumptions or data sources in the master file.

Opinion Dynamics made three primary updates to ex ante deemed savings estimates: (1) replacement of the 2008 Connecticut Light & Power Program Savings Documentation (CL&P PSD) with the 2017 Connecticut

Program Savings Document (CT PSD),[11] (2) incorporation of New Hampshire-specific climate zones,[12] and (3) expansion of assumptions to include New Hampshire-specific heating fuel distributions.

Many of the recommended updates to energy savings algorithms and assumptions described in later sections originate from the 2017 CT PSD. Opinion Dynamics reviewed other technical reference (TRMs) from regions similar to New Hampshire—e.g., Maine, Massachusetts, and the Mid-Atlantic TRMs. For many of the relevant measures, these TRMs either referenced the CT PSD or took the same approach to estimating savings. Further, as many of the previous deemed savings estimates referenced the 2008 version of the CL&P PSD, Opinion Dynamics opted to keep many underlying algorithms consistent by referencing the 2017 CT PSD. Where possible, we updated certain assumptions and parameters to be specific to New Hampshire and the participant population. For example, we applied the average annual heating degree days (HDD) and cooling degree days (CDD) for the two New Hampshire climate zones to the 2017 CT PSD to weather normalize savings to New Hampshire's climate. Also, data collected through site visits and the participant survey informed deemed savings assumptions, including New Hampshire residents' heating fuel type distribution.

Engineering Desk Reviews

In preparation for site visits, Opinion Dynamics conducted desk reviews to ensure that field engineers collected the appropriate information to verify measure installation, update deemed savings estimates as needed, and calculate ex post savings. For each participating site, we reviewed all available measure information in the program tracking data for completeness prior to conducting a site visit. Through the desk reviews, field engineers also separated certain measures into verifiable components (e.g., where program tracking data indicated "attic insulation," we verified that this included attic hatch, floor, and knee wall insulation). 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 deemed savings assumptions, such as counts of appliances, lighting, and heating fuel sources.

Site Visits

Opinion Dynamics conducted 67 site visits with participants from 2016 and 2017. The primary objective of the site visits was to verify installation and continued operation of incentivized measures as reported in the program tracking data. In addition, field engineers collected key building information, including, but not limited to major heating, ventilation, and air conditioning (HVAC) systems, existing lighting types, and counts of major appliances (e.g., clothes washer, dishwasher, refrigerators). Further, field engineers 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 missing wall insulation, field engineers investigated and adjusted ex post measure quantities as necessary.[13]

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 with±10% relative precision. To ensure that results represented the

[11] Opinion Dynamics selected the 2017 version of the Connecticut Program Savings Document (CT PSD), because it was the active version over the 2016 and 2017 program years.
[12] ICC. 2014. *2015 International Energy Conservation Code*, *Section C301 Climate Zones* International Code Council, Washington, D.C. Available at https://codes.iccsafe.org/content/IECC2015/chapter-3-ce-general-requirements?site_type=public
[13] Out of the 67 sites, Opinion Dynamics only made an adjustment to insulation measure quantities for one site based on IR imagery findings.

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' original intent was to develop a stratified random sample of participating HPwES households, categorized by primary fuel heating type, and weighted by overall household savings. We requested supporting data for all sampled households prior to beginning the outreach and scheduling process. Due to limitations in the availability of measure-level data and contact information for certain master-metered accounts, however, we revised the original approach. Instead, we attempted a census and contacted all HPwES participants from 2016 and 2017 with valid contact information. We offered a $100 incentive for those willing to allow our field engineers on site, plus an additional $50 incentive for 1 year of delivered fuel billing data (where applicable). To fill quotas for each of the 3 primary heating fuel types, we then randomly selected participants from those that responded with interest from our initial or follow-up outreach. We then scheduled the visit and requested additional documentation and measure details from utilities to support desk reviews and site visits. Most accounts without individual customer contact information are for households in multifamily buildings on master-metered natural gas accounts (see Section 2.3). As such, the results discussed in section 0 underrepresent those households. Further, as we attempted a census with the revised outreach approach, sampling error (i.e., confidence and precision of results) no longer applied. Confidence and precision provide estimates of sampling error. Table 2-2 below shows the number of completed site visits by primary heating fuel type, along with the share of the population that heats with each of the three fuel types. Note that, for the purposes of reporting impacts, we referenced program tracking data to estimate primary heating fuel type. However, we used participant survey data as inputs for primary and secondary heating fuel type information when updating deemed savings estimates. The program tracking data report used for this evaluation did not specify heating fuel type, but provided savings distributed by different fuel types (e.g., propane, oil, natural gas, wood, etc.), along with electric savings. When reporting savings for the population, we made assumptions as to the primary fuel source for individual households based on the fuel type with the largest share of savings reported in the program tracking data. However, we felt that, based on our need to make these assumptions, participant survey data was a more reliable source for updating deemed savings assumptions.

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

Primary Fuel Source	Completed Site Visits	Share of Site Visits	Share of 2016-2017 Participants	Participant Survey	Share of New Hampshire Residents*
Natural Gas	27	37%	43%	25%	22%
Delivered Fuels	36	54%	43%	66%	69%
Electricity	4	9%	14%	9%	10%
Total	**67**	**100%**	**100%**	**100%**	**100%**

* Energy Information Administration New Hampshire State Energy Profile.

In-Service Rates

Opinion Dynamics developed in-service rates (ISRs) for measure categories based on the presence or absence of that measure during the site visits. In preparation for each site visit, our field engineers identified ex ante measures and quantities tracked in the NHSaves program tracking database. Field engineers then verified if tracked measures remained in service. In some cases, we were unable to disaggregate the square footage of different types of insulation measures within a single location in the household (e.g., basement wall and rim joist insulation). In these instances, our field engineers verified the presence or absence of the aggregated measure location. The final ISRs for each measure represents the total quantity of measures that remained

in service at the time of the site visit, divided by the total quantity of measures that were reported in the program tacking database.

2.1.2 Consumption Analysis

To serve as an additional point of comparison to ex post savings estimates derived through engineering analyses, we conducted a consumption analysis that leveraged pre- and post-utility billing data for natural gas and electric customers that participated in the HPwES Program during 2016 and 2017. Opinion Dynamics used a linear fixed effect regression (LFER) model to provide an "average treatment effect on the treated" (ATT) estimate of savings. ATT compares the average change in energy consumption of participants before and after their treatment date, which allowed us to evaluate the change in energy consumption due to their participation in the program.

The fixed-effects modeling approach allowed us to account for time-invariant household-level factors affecting energy use (such as square footage, appliance stock, habitual behaviors, household size) without measuring those factors and entering them explicitly in the model. These factors are contained in household-specific intercepts in the equation. We also entered weather terms in the model (i.e., heating degree days and cooling degree days specific to each household, based on weather recorded at the nearest weather station), as well as interaction terms between weather and the pre- and post-program period, to account for differences in weather across years. Additionally, the final electric model included individual variables to indicate installation of key measures. Opinion Dynamics estimated separate models for electric and natural gas savings. We then tested a range of models with different covariates and interactions and selected the one that best fit according to standard econometric and evaluation measures.

Final Model Specification

Opinion Dynamics tested a range of model specifications for both electric and natural gas consumption analyses. The final electric model is specified below.

$$ADC_{it} = B_h + B_1 Post_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 HDD_{it} * Post_{it} + B_5 CDD_{it} * Post_{it} + B_6 Boil + B_7 Furn_{it} + B_8 LED_{it} + B_9 Fridge_{it} + B_{10} Month_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (in kWh) for the billing period
$Post$ = Indicator for treatment group in post-participation period (coded "0" if treatment group in pre-participation period or comparison group in all periods, coded "1" in post-participation period for treatment group)
HDD = Average daily heating degree days from NCDC
CDD = Average daily cooling degree days from NCDC
$Boil$ = Indicator for receipt of boiler replacement
$Furn$ = Indicator for receipt of furnace replacement
LED = Indicator for receipt of LEDs
$Fridge$ = Indicator for receipt of refrigerator replacement
$Month$ = Month indicator
B_h= Average household-specific constant
ε_{it} = Error term

The final natural gas model is specified below.

$$ADC_{it} = B_h + B_1 Post_{it} + B_2 HDD_{it} + B_3 HDD_{it} * Post_{it} + B_4 Month_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (in kWh) for the billing period
$Post$ = Indicator for treatment group in post-participation period (coded "0" if treatment group in pre-participation period or comparison group in all periods, coded "1" in post-participation period for treatment group)
HDD = Average daily heating degree days from NCDC
$Month$ = Month indicator
B_h= Average household-specific constant
ε_{it} = Error term

2.2 Process Evaluation Activities

Opinion Dynamics also conducted both primary and secondary research activities to contribute to the process evaluation. In the remainder of this section, we discuss each of these activities in detail.

2.2.1 Program Staff Interviews

Opinion Dynamics conducted in-depth interviews with HPwES program managers at each of the four New Hampshire Utilities. Interview topics included program design, delivery, marketing and outreach strategies, opportunities to expand the reach of the program, barriers to achieving greater participation, and opportunities to integrate emerging technologies. These interviews provided the evaluation team with a more in-depth understanding of the program design and allowed us to further refine our evaluation work plan. These interviews also informed subsequent research tasks, including in-depth interviews with contractors and program partners, interviews with non-participating contractors, and the development of participant and non-participant survey instruments.

2.2.2 In-Depth Interviews with Contractors and Program Partners

Opinion Dynamics conducted in-depth interviews with home performance contractors, and community finance partners. The goals of these interviews were to build a better understanding of contractors' experience with the program, emerging technologies that may be of interest to participants, and strategies for improving participating contractors' experience. To address these objectives, we conducted structured in-depth interviews with participating and non-participating contractors, as well as financial institutions that partner with program administrators to offer home improvement loans to participants.

Table 2-3 provides a summary of in-depth interview activity. Opinion Dynamics contacted all contractors and financial institutions between 4 and 5 times. To develop a sample of non-participating contractors, we used sources such as the Building Performance Institute "Find a Contractor" tool, Better Business Bureau, trade organization websites, and other sources for identifying home performance contractors (e.g., Angie's List, Home Advisor, etc.) serving customers in New Hampshire. Each non-participating contractor was contacted 4 times.

Table 2-3. Summary of In-Depth Interview Outreach

Program Status	Targeted Population*	Number of Interviews
Participating Financial Institution	5	3
Participating Contractor	18	10
Non-participating Contractor	66	5

* Note that Opinion Dynamics attempted a census of financial institutions and contractors that participated in the HPwES Program in 2016 and 2017.

2.2.3 Literature Review

Opinion Dynamics conducted a literature review of secondary sources to compare the NHSaves HPwES Program to others with similar designs, particularly those that offer measures to customers regardless of their primary heating fuel type. Specifically, the goals of the literature review were to:

- Compare HPwES Program performance to other programs that serve customers in rural areas with a range of water and space heating fuel types (e.g., fuel oil, propane, wood, etc.);
- Identify emerging technologies that similar programs offer to their participants; and
- Explore strategies for expanding the HPwES Program that other program administrators have employed elsewhere.

Our team reviewed the following sources:

- ACEEE (American Council for an Energy-Efficient Economy). 2015. *Increasing Participation in Utility Energy Efficiency Programs.* American Council for an Energy-Efficient Economy.
- The Cadmus Group. 2011. *Efficiency Maine Trust Home Energy Savings Program Final Evaluation Report.*
- Efficiency Vermont. 2020. *Weatherization, A Portfolio Approach.*
- Illume (Illume Advising, LLC). 2014. *Overview of the Tier 1 Advanced Power Strip: Potential Savings and Programmatic Uses.* Madison, WI: Illume.
- Johnson, K., and J. Bradford. 2017. *Tier 2 Advanced Power Strips: Examining Energy Savings Potential in a New and Changing Market.* Frederick, MD: Johnson Consulting Group.
- King, Jen. 2018. *Energy Impacts of Smart Home Technologies*. American Council for an Energy-Efficient Economy Report A1801.
- Navigant. 2018. *Res 1 Baseline Load Shape Study.* The Electric and Gas Program Administrators of Massachusetts.
- Navigant, Illume, Cadeo, and Bellomy Research. 2018. *Home Energy Services Process Evaluation.* The Electric and Gas Program Administrators of Massachusetts.
- NYSERDA (New York State Energy Research and Development Authority). 2017. *Home Energy Management System Savings Validation Pilot.* Prepared by Lockheed Martin Energy. Albany: NYSERDA.
- PG&E (Pacific Gas and Electric Company). 2016a. *Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems.* Prepared by AESC Inc. San Francisco: PG&E.

- Plympton, P, Barbour E., Hensley R., Pollock E., Somers J., Hoffmeyer D., Phillips M., Ferington D., Hanna J., Mosser M., Jones J., and C. Dedolph. 2010. *Retrofit Program Delivery Models for Home Performance with ENERGY STAR: The Climate to Retrofit Is Now.* American Council for an Energy-Efficient Economy.
- Research Into Action, Inc. 2015. 2012-2013 *Home Performance with ENERGY STAR Process/Market Characterization Assessment.*
- United States Energy Information Administration. 2019. New Hampshire State Energy Profile.
- West Hill Energy and Computing and GDS Associates. 2013. *Efficiency Vermont's Home Performance with ENERGY STAR Program Impact Evaluation.*
- West Hill Energy and Computing. 2019. CT *Home Energy Services-Income Eligible and Home Energy Solutions Impact Evaluation Program Years 2015-2016.*
- York, D., Neubauer M., Nowak, S., and M. Molina. 2015. *Expanding the Energy Efficiency Pie: Serving More Customers, Saving More Energy Through High Program Participation*. American Council for an Energy-Efficient Economy Report U1501.
- Zimring, M., Borgeson, M., Hoffman, I., Goldman, Stuart, E., Todd, A., and M Billingsley. 2011. *Delivering Energy Efficiency to Middle Income Single Family Households.* Environmental Energy Technologies Division Lawrence Berkeley National Laboratory.

2.2.4 Participant Web Survey

Opinion Dynamics conducted an internet survey of 2016 and 2017 participants to inform both the process and impact evaluations. 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, and their awareness of and interest in the financing component of the program (see Appendix E).

Opinion Dynamics also used the participant surveys to support the impact evaluation. While we collected more detailed information on household characteristics during site visits, we used the survey to collect basic information on participating households from the larger population of participants (e.g., demographics, household type, heating fuel types, etc.). Our engineering team leveraged these data to refine per-unit savings estimates and suggest updates to parameters used in estimating ex ante savings in the future.

Opinion Dynamics fielded the participant survey between June 1st-18th, 2019. We attempted a census of 1,958 program participants with valid mailing addresses, with the goal of reaching 202 completes. Respondents who completed the survey were mailed a $10 VISA gift card. The evaluation team mailed invitation letters and follow-up post cards to participants with information about the survey and a URL to take the survey online. In total, 211 participants completed the survey resulting in a 25% response rate. Table 2-4 shows the breakdown of these completed surveys by fuel type. Note that program tracking data did not report specific fuel type information and, as such, we made assumptions based on savings information reported in the program tracking data for the purposes of setting the survey quotas shown below. We used participant self-reported primary and secondary fuel type information to update deemed savings as these data were more reliable than program tracking data based on our need to make assumptions.

Table 2-4. Participant Survey Completes by Primary Heating Fuel Type

Primary Heating Fuel Type	Population	Target Completes	Completes
Delivered Fuels	837	98	140
Natural Gas	834	84	52
Electricity	287	20	19
Total	**1,958**	**202**	**211**

2.2.5 Non-participant Web Survey

Opinion Dynamics conducted a survey with 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 HPwES Program, understand drivers and barriers to participating, and investigate the influence of program financing on customer interest. We fielded the survey in coordination with the non-participant survey for the 2016 and 2017 evaluation of the Home Energy Assistance (HEA) Program. As customers must exceed a minimum home energy use intensity score to be eligible for the HPwES Program (see Section 1.1), we developed a series of questions to mirror program eligibility and verify that customers had not participated in the HPwES Program in the past to ensure that we reached eligible non-participants.

Opinion Dynamics fielded the non-participant survey between October 25th, 2019 and November 11th, 2019. We offered $10 VISA gift cards and a chance to receive 1 of 5 $50 VISA gift cards for those that completed the survey, and $5 VISA gift cards for those that did not qualify to complete the survey[14]. Similar to our approach for the participant survey, we mailed invitation letters and follow-up post cards to introduce customers to the survey and provided them with the survey URL. We developed the non-participant survey sample from customer databases provided by the New Hampshire utilities. Prior to developing a simple random sample of 3,631 unique customers with valid mailing addresses, we removed customers that participated in the 2016 and 2017 HPwES Program through a comparison of program tracking data. Opinion Dynamics set a target of 68 completed surveys from households with each of the 3 primary heating fuel type groups displayed in Table 2-5 below with the goal of reporting results with 90% confidence and +-10% relative precision by fuel type. While electrically heated homes are not common in New Hampshire, our intent was to oversample for this group of non-participants so as to reach an adequate number of respondents to reach the confidence and precision targets. However, as the customer data we received for this evaluation did not include primary heating fuel types, we were unable to oversample and reach enough households with electric heat (see Section 2.3). The overall response rate for the survey (including HEA Program respondents) was 7%.

Table 2-5. Non-Participant Survey Completes by Primary Fuel Type

Primary Heating Fuel Type	Target Survey Completes	Survey Completes
Natural Gas	68	71
Delivered Fuels	68	92
Electricity	68	6
Total	**204**	**169**

[14] The $5 incentive was added due to the number of screener questions. Respondents would spend several minutes answering these initial questions before finding out they were ineligible for the survey.

2.3 Deviations from Evaluation Plan

During the course of 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 research activities when possible, as outlined below:

- In some cases, the program tracking data provided by the utilities lacked specific measure information and included general entries such as ""SF Fuel Neutral (Oil, [LP], [Electric], or [Wood])", ""Single Family (1-4 Units) - kWh.", "Weatherization", among others. This limited our ability to ask participants about specific measures in the participant survey. Additionally, where possible we disaggregated specific measure information where data provided detail only at the measure category level (e.g., "attic insulation"). However, for 2 of 67 projects this inhibited our ability to verify installation square footage of individual insulation measures during site visits.
- Lack of a unified site ID variable across all four utilities made it difficult to link projects completed under multiple utilities (i.e. a natural gas and electric utility tracking measure information for the same customer). This issue sometimes arises when evaluating programs where participants receive electric service from one company and natural gas service from another. In most cases, we used a combination of customer name and address to match projects across utilities. However, for multifamily sites where customer names and unit numbers were not always tracked, we were often unable to accurately link site information tracked by both natural gas and electric utilities.
- Lack of customers' primary heating fuel type prevented our ability to report non-participant survey results by fuel type, specifically for homes heated primarily with electricity. Our initial research plan involved sampling and reporting results based on customers who heat their homes primarily with natural gas, delivered fuels, and electricity. However, these data were unavailable for all customers so we relied on self-reported fuel type to both qualify customers for the survey based on HPwES eligibility requirements, and to fill quotas based on each of these three fuel type categories. We met quotas for customers that heat with natural gas and delivered fuels; however, because electrically heated homes are relatively rare in New Hampshire, we aimed to oversample these homes in the non-participant survey. Lacking information on fuel type, we were unable to develop the sample as planned and fell well below our target of 68 completed surveys for electrically heated homes. Survey responses were similar when comparing non-participants that heat with natural gas and delivered fuels and, as such, we report responses for these two groups combined in this report.
- Participants with whom we completed site visits were unable to provide reliable delivered fuel billing records. Of the 67 completed site visits, 36 homes (54%) use a delivered fuel for their primary heating source. While we successfully collected at least some records from 34 of the 36 delivered fuels homes that completed site visits, we were unable to use delivered fuel bills to compare against ex ante and ex post savings estimates due to the following factors:
  - **Inconsistencies in 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.
  - **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 projects that were completed in 2016 and 2017.
  - **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.

- Incomplete contact information presented challenges for both the site visit and customer surveys, particularly for participants located in multifamily and master-metered natural gas buildings. We were often unable to contact these customers for the participant survey and site visit tasks as we often did not have valid unit numbers, names, phone numbers, or email addresses. When possible, we filled in the missing data using utility customer contact databases. For the survey efforts, we filled in missing contact names with "Current Resident" in the hopes the mail would be delivered. Ultimately the lack of reliable contact information made this segment of customers difficult to reach, resulting in a lower than desired response rate from these customers. Below, we present a comparison of single family and multifamily households included in each primary data collection activity, and how coverage compared to the participant population.

Table 2-6. Single Family and Multifamily Households included in Primary data Collection

Home Type	Participant Population	Site Visits	Participant Survey	Non-Participant Survey
Single Family	64%	94%	90%	89%
Multifamily	34%	6%	8%	10%
Other*	2%	-	2%	1%

* Other includes mobile homes for the participant survey. For the participant population, 2% participants did not have information related to their housing type in the program tracking data.

It is important to note 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 developed gross ex post savings estimates for the 2016 and 2017 program years based on an engineering analysis that included a review of per-unit deemed savings assumptions, engineering desk reviews, and site visits at a sample of participating households (see Section 2.1.1). Overall, the program achieved 59,081 MMBTUs in ex post gross savings from all measures and fuel types (30 MMBTUs per household annually), resulting in a realization rate of 109%. Table 3-1 below shows total ex ante and ex post savings for all measures offered by the HPwES Program, separated by households primarily fuel source—that is, all savings for households that primarily heat their homes with delivered fuels (e.g., oil, propane, etc.), natural gas, or electricity. The program tracking database report used for this evaluation reported savings for individual fuels (e.g., propane, natural gas, wood, etc.) and electricity. For the purposes of reporting the impacts in the table below, we assumed each household's primary heating fuel type based on which fuel accounted for the largest share of savings claimed in the program tracking database and if they had a natural gas account. Also, note that the savings presented in the table below represent MMBTU savings for all measures, including electric savings (i.e., kWh converted to MMBTUs).[15]

Opinion Dynamics developed ex post savings estimates for a sample of households based on primary data collected during site visits with 67 households that participated in the HPwES Program during the 2016 and 2017. In conjunction with primary data collected while on site, our team used secondary sources to update deemed savings algorithms and inputs for all HPwES measures (see Appendix C). Additionally, as program tracking data did not contain specific information on primary or secondary heating fuel type for the participant population, we used participant survey data to update the heating fuel mix assumptions included in measure-specific deemed savings estimates (see Appendix A). Using the revised deemed savings for each measure, we then developed a realization rate for the sample of households (i.e., ex post divided by ex ante). Finally, we multiplied the realization rate from the sample of participants (weighted average) by the total ex ante savings tracked in the program tracking database to reach total ex post savings shown in Table 3-1.

Table 3-1. Impact Evaluation Results by Primary Heating Fuel Type

Primary Fuel Source	Ex Ante MMBTU	Ex Post MMBTU	Realization Rate	Relative Precision at the 90% Confidence Interval
Delivered Fuels	30,080	34,363	114%	11.3%
Natural Gas	19,897	20,666	104%	10.6%
Electricity	4,228	4,052	96%	32.4%
Total	**54,206**	**59,081**	**109%**	**8.0%**

The ex post savings in the table above represent the total savings for all measures (e.g., insulation, LEDs, domestic hot water, etc.) based on our team's revisions to individual measure deemed savings assumptions. Prospectively, the New Hampshire utilities should use updated measure-specific deemed savings estimates based on this evaluation for program planning (see Appendix C), and also apply the researched measure in-service rate based on our team's site visits (see Section 3.2). In the remainder of this section, we provide results from our review of per-unit deemed savings assumptions and measure-specific in-service rates developed based on site visits.

[15] 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

3.1 Deemed Savings Estimates

Opinion Dynamics recommends several updates to deemed savings algorithms and assumptions. These recommended updated result in a mix of increases and decreases to ex ante deemed savings estimates, summarized in Table 3-2. To refine the deemed savings calculations, we first adopted updated algorithms and assumptions from the 2017 CT PSD. The evaluation team utilized the 2017 CT PSD for three prominent reasons. First, the PSD provides delivered fuel assumptions that were necessary to estimate savings for participants that heat their homes with unregulated fuels (e.g., oil, propane, wood, etc.). When updating deemed savings estimates we incorporated primary and secondary heating fuel information based on participant survey data for the appropriate measures (e.g., duct air sealing, duct insulation, and DHW pipe wrap) where ex ante estimates did not include the same level of detail. Second, Connecticut's geographic proximity to New Hampshire minimizes uncertainty when adjusting weather-dependent assumptions. Finally, the PSD is a reliable source of assumptions that HPwES program staff used when determining ex ante saving estimates[16]. As such, based on a review of multiple TRMs from different jurisdictions that, in several instances, cited the CT PSD, the evaluation team did not identify a justifiable or necessary reason for moving away from this source to another TRM.

The deemed savings updates impacted the calculations for most measures but had the largest impact on hot water pipe insulation, duct air sealing and duct insulation measures. Additionally, we leveraged the International Code Council's (ICC) climate zones, New Hampshire historical weather data, heating (HDD) and cooling degree day (CDD) data, and total program savings by climate zone to update measure assumptions for weather sensitive measures, such as insulation.

We assigned projects occurring in Cheshire, Hillsborough, Rockingham, and Strafford counties to climate zone 5 and used weather data from a weather station in Nashua, NH provided historical weather data to make updates to these projects. We assigned projects occurring in Sullivan, Merrimack, Belknap, Carroll, Grafton, and Coos counties to climate zone 6 and used historical weather data pulled from a weather station in Laconia, NH when making adjustments. Comparing weather trends in terms of annual average HDD and CDD with program savings in each climate zone, resulted in weighted average adjustments of 18% for HDD and -14% for CDD; results are further detailed in Appendix B. Previous deemed values for insulation measures applied a 19% weather-normalization factor to the 2008 CL&P PSD estimates, which in 2017 was updated to 18%, leading to a slight decrease in deemed savings values for insulation measures. However, we also added cooling savings to insulation measures in accordance with the 2017 CT PSD and applied a -14% weather-normalization factor to adjust for New Hampshire's cooler climate. Lastly, we applied New Hampshire-specific fuel mixes and heating equipment mixes to further refine the deemed savings estimates. Table 3-2 shows the average ex post savings per unit for each measure category. See Appendix C for specific measure assumptions and algorithms used to develop ex post deemed savings estimates.

[16] Ex ante deemed savings based on CL&P 2008 PSD, last updated in January of 2014. Source: *HPwES_Deemed savings for NH-master_1-23-14.xlsx*.

Table 3-2. Ex Post Deemed Savings Estimates Compared with Ex Ante

Measure Category	Measure Name	Unit	Ex ante Savings (MMBTU/ Unit)	Ex post Savings (MMBTU/ Unit)	Departure from ex ante (percent change)
Attic Insulation	Heating Savings, average	100 Sq. ft	0.666	0.880	32%
Wall Insulation	Heating Savings, average	100 Sq. ft	0.932	0.792	-15%
Basement Wall Insulation	Heating Savings, average	100 Sq. ft	0.455	0.362	-21%
Floor Insulation	Heating Savings, average	100 Sq. ft	0.825	0.713	-14%
Attic Insulation	Cooling Savings, average	100 Sq. ft	-	0.007	N/A
Wall Insulation	Cooling Savings, average	100 Sq. ft	-	0.007	N/A
Basement Wall Insulation	Cooling Savings, average	100 Sq. ft	-	0.005	N/A
Infiltration Reduction	Envelope Air Sealing	CFM	0.012	0.013	8%
HVAC Ancillary, heating	Heating Furnace Fan[a]	Home	0.293	0.293	0%
HVAC Ancillary, heating	Heating Boiler Pump[a]	Home	0.031	0.031	0%
HVAC Ancillary, cooling	Cooling System Fan	100 CFM[b]	-	0.0146	N/A
HVAC Ancillary, cooling	Cooling System Fan	Home[b]	-	0.178	N/A
Duct Air Sealing	Duct Air Sealing	CFM	0.012	0.024	100%
Duct Insulation	Duct Insulation - Supply	Sq. ft	0.045	0.117	161%
Programmable Thermostat	Non-Programmable to Programmable	EA	3.100	2.799	-10%
Programmable Thermostat	Non-Programmable to Wi-fi Enabled	EA	6.900	6.900	0%
Refrigeration Voucher	1000 kWh Threshold	EA	1.619	1.647	2%
Water Heater Tank Wrap	Water Heater Tank Wrap	EA	0.903	0.259	-71%
Hot Water Pipe Insulation	Pipe Wrap on ≥3/4"pipe	ft	0.025	0.106	332%
Hot Water Temperature Setback	Hot Water Temperature Setback	15°F	0.411	0.325	-21%
Showerhead	Showerhead	EA	0.798	0.633	-21%
Aerator	Standard (maximum 1.79 GPM)	EA	0.082	0.157	90%
LED	Standard	EA	0.130	0.125	-4%
LED	Specialty	EA	0.130	0.180	38%

[a] Ancillary heating savings are applicable when air sealing and/or envelope insulation measures are implemented in a home and are dependent on the heating system distribution motor (furnace fan or boiler pump). Savings are only applicable once per home.

[b] Ancillary cooling savings are applicable when air sealing and/or envelope insulation measures are implemented in a home. When air sealing is completed in a home and CFM reductions are verified through a blower door test, use the 0.0146 MMBtu/100 CFM reduction savings value. When a blower door is not completed, or only envelop insulation measures are implemented, apply the 0.178 MMBtu/Home savings value. Savings are only applicable once per home.

The New Hampshire utilities provided Opinion Dynamics with a comprehensive list of ex ante deemed savings estimates for each measure offered through the HPwES Program. While these ex ante estimates included

source information, we received limited information regarding the underlying assumptions for several measures. As such, we are unable to identify precise reasons for differences in several cases, though, in the remainder of this subsection, discuss several key drivers for changes between ex ante and ex post deemed savings estimates.

One of the main drivers in differences between ex ante and ex post savings estimates is the use of primary data to adjust for mix of participants with delivered fuels. The 2017 CT PSD, the primary source for updates to the deemed savings, included assumptions for delivered fuels which were omitted in the ex ante assumptions calculated from the 2008 CL&P PSD. Additionally, the evaluation team's participant web survey provided the share of program participants with different heating fuel sources, which our engineering team used to update deemed savings estimates. While, in the future, program tracking data would be a better source of these data, 2016 and 2017 data did not contain information related to primary, secondary, or other heating fuel types with the same granularity we were able to obtain from the participant survey. Notably duct air sealing, duct insulation, hot water pipe insulation and faucet aerators show a significant increase in estimated savings in Table 3-2. Interestingly, showerhead, hot water tank temperature setback, and hot water tank wrap decreased in Table 3-2, counter to those similar measures reliant on fuel mix information. There are a number of potential factors driving these trends. For example, the 2008 CL&P PSD assumes an average shower length of 2.5 minutes compared with 8.3 minutes per shower assumed in the 2017 CT PSD. We did not have detailed information used to calculate ex ante assumptions for each measure. Instead, for this evaluation, we received deemed savings values and general sources of assumptions (e.g., historical program data or fixed value from CL&P) for some but not all measures. As such, we are unable to point to exact parameters driving the differences between ex ante and ex post deemed savings estimates. Moving forward, the HPwES Program team should use the detailed deemed savings workbook provided by the evaluation team to continue refining assumptions with better information as it comes available.

Recommended Updates to Deemed Savings for Future Years

We also offer the following recommendations for updates to measure offerings in the future.

- HVAC Ancillary Savings—In the 2016-2017 program, the implementation team not only claimed ancillary electric savings for furnace fans and boiler pumps, but also considered any cooling savings from weatherization measures to be ancillary. Cooling savings weighted based on shares of homes having either central air-conditioning or room air-conditioning, is now captured when calculating total deemed savings for each end-use. However, for reporting purposes, claiming separate ancillary cooling savings is still necessary and as a result we calculated ancillary cooling savings per CFM based on data from the 67 visited sites in the HPwES program evaluation to then subtract this value from air sealing deemed savings. We recommend updating the cooling savings per CFM value in the future with new program data.
- Water Heater Tank Wrap—We recommend phasing this measure out as we observed a number of boiler-fed indirect hot water heating through our site visits, and newer model DHW tanks include sufficient insulation making the additional insulation less effective.
- Programmable Thermostat—We recommend removal of programmable-to-programmable thermostat replacement scenarios, because the baseline and efficient cases have equal control over HVAC and resultant runtime reduction potential. We also recommend studying the effects of baseline thermostats, e.g., programmable and non-programmable, on Wi Fi enabled thermostat savings. Currently, savings are the same for Wi Fi enabled thermostats when replacing either a manual or programmable thermostat.

3.2 In-Service Rates

Opinion Dynamics verified measure in-service rates (ISR) based on the 67 completed site visits. Table 3-3 details individual measure category in-service rates, reflective of any site visit discrepancy findings between claimed and verified quantities. For measure categories where it is possible for only part of the measure to be installed and operating, such as insulation or air sealing, our team applied quantity adjustments from site visits into the ISR values.

Table 3-3. In-service Rates by Measure Category for 67 Site Visits

Measure Category	ISR
Attic Insulation	98%
Wall Insulation	97%
Basement Wall Insulation	100%
Floor Insulation	100%
Air Sealing	99%
Duct Insulation	100%
Duct Sealing[17]	N/A
LEDs	98%
Pipe Insulation	88%
Showerheads	75%
Faucet Aerators	100%
Programmable and Wi-fi Enabled Thermostats	100%
Total*	**99%**

* Total ISR represents weighted average based on measure quantities verified on site.

3.3 Consumption Analysis

Opinion Dynamics also conducted a consumption analysis using electric and natural gas billing data. As approximately 66% of HPwES participants heat their homes primarily with a delivered fuel (e.g., fuel oil, propane, kerosene, etc.), our team was unable to capture the full impact of the HPwES Program with this analysis. As such, we estimate ex post results using an engineering analysis and use the consumption analyses as an additional point of comparison. Note that, regardless of accounting for delivered fuels, it is difficult to directly compare results from an engineering analysis that is reliant on deemed savings (i.e., population-wide averages and assumptions) and consumption analyses (i.e., based on a statistical analysis of billing data) as they are fundamentally different approaches that have different strengths and weaknesses. The evaluation team ultimately decided to pursue an engineering approach for this evaluation given the share of participants that rely on delivered fuels for some or all of their space and hot water heating.

Data Cleaning

Opinion Dynamics cleaned and standardized all billing and program tracking data in preparation for analyses. We were unable to include participants in the final models if participants:

[17] The one duct sealing record present in the 67 sites was excluded from the analysis due to no CFM reduction quantities being available.

- Did not have billing data that matched the same customer at the same address;
- Did not have at least 6 months of billing data **after** participating in the HPwES Program;
- Did not have at least 9 months of billing data **before** participating in the HPwES Program;
- Had any negative usage or 0 usage bills (these indicate potential billing issues that would confound the analysis);
- Were extremely low energy users (less than 2 kWh or 0.5 therms per day); or
- Had extremely high (more than 300 kWh or 20 therms per day).

In addition, our team chose to exclude Liberty electric participants from the final electric model. After going through each of the aforementioned data cleaning steps, 67 Liberty electric participants had billing data sufficient to be included in the final model. However, upon review of their program tracking data, individual measure data were often aggregated into broader measure groups and therefore our team was unable to estimate measure-level impacts similar to other electric utilities. Including the 67 Liberty participants in the final model created unstable and unreasonable results and, as such, our team chose to exclude these participants from the final model. Table 3-4 shows the number of accounts that our team included in these analyses after data cleaning. These represent 59% of participating electric accounts and 61% of participating natural gas accounts.

Table 3-4. Participants Included in Electric and Gas Consumption Analysis

	Unitil		Liberty	NHEC	Eversource
Reason for Dropping Accounts from Analysis	Electric	Gas	Gas	Electric	Electric
Total Unique Accounts	109	79	388	85	861
No monthly billing data	15	9	0	0	151
No post period billing data	18	14	77	3	45
Less than 6 months post data for Treatment	25	20	1	0	12
Less than 9 months pre data for Treatment	1	1	30	10	53
Accounts with negative usage bills	0	1	0	0	26
Accounts with zero usage bills	0	0	22	3	22
Low average usage (under 2 kWh/day or 0.5 thm/day)	0	0	4	0	0
High average usage (over 300 kWh/day or 20 thm/day)	0	0	5	0	0
Accounts Remaining in the Analysis	*50*	*34*	*249*	*69*	*552*

Model Results

Consumption analyses capture savings attributable to the program, including installed measures, behavioral changes, and participant spillover. We compared the energy usage of program participants prior to their HPwES treatment to their usage post-treatment to estimate gross energy savings Table 3-5 and Table 3-6 provide the results of electric and natural gas consumption analyses, respectively, for each utility.

Table 3-5. Electric Consumption Analysis Results

Variables	Results (Annual kWh)
Post	153**
Cooling Degree Days	-40**
Heating Degree Days	481*
Boiler Replacement	-434*
Furnace Replacement	-213*
LEDs	-287*
Refrigerator Replacement	-26*
Total Results	
Annual Savings per Household (Annual kWh)	-366
Baseline Annual Usage	9,039
Percent of Baseline Saved	-4.1%

*Statistically significant at the 99% confidence level

**Statistically significant at the 90% confidence level

Table 3-6. Natural Gas Consumption Analysis Results

Variables	Results (Annual Therms)
Post	106*
Post Heating Degree Days	-223*
Total Results	
Annual Savings per Household	-118
Baseline Annual Usage	1,050
Percent of Baseline Saved	-11.2%

*Statistically significant at the 99% confidence level

**Statistically significant at the 90% confidence level

The results shown above represent substantial electric savings per participating household (366 kWh annually). Additionally, for homes that have natural gas service, participants saved on average 118 therms per year. For the purposes of comparison, we have converted both electric and natural gas savings from the consumption analysis into MMBTUs (see Table 3-7).

Table 3-7. Modeled Savings per Household

Fuel Savings	Modeled Savings per Household	MMBTU Conversion
Electricity	366 kWh	1.25
Natural Gas	118 Therms	11.80

The results of this consumption analysis validate that 2016 and 2017 participants realized a considerable amount of energy savings (i.e., natural gas and electricity) from the HPwES Program. However, these results only represent a portion of the total program impacts as they include no savings from any supplemental fuel sources or primary heating fuels for the majority of participants. According to the participant survey, 66% of 2016 and 2017 participants rely on a delivered fuel as their primary heating fuel source and 38% of participants use a delivered fuel as a supplemental fuel source. The savings presented in the table above represent an estimation of the average natural gas and electric impacts (i.e., savings from measures that conserve natural gas or electricity only) across all participants included in both respective models. Even when

combined, these electric and natural gas savings results do not account for any measures that conserve delivered fuels for the large share of the participant population with using a supplemental fuel. Finally, as stated at the outset of this section, it is difficult to directly compare results from consumption analyses with those from engineering approaches based on measure-specific deemed savings estimates. Consumption analyses provide average program treatment effects, taking into account actual weather patterns and changes in participant behaviors. However, these analyses have limitations both in terms of producing more granular measure-specific results and estimating impacts where consumption data for a large share of the population is unavailable. Given the comprehensive nature of HPwES Program treatments and that such a large share of the participant population relies solely or partially on a delivered fuel, we chose to use a engineering approach to estimate ex post impacts for the 2016 and 2017 HPwES Program.

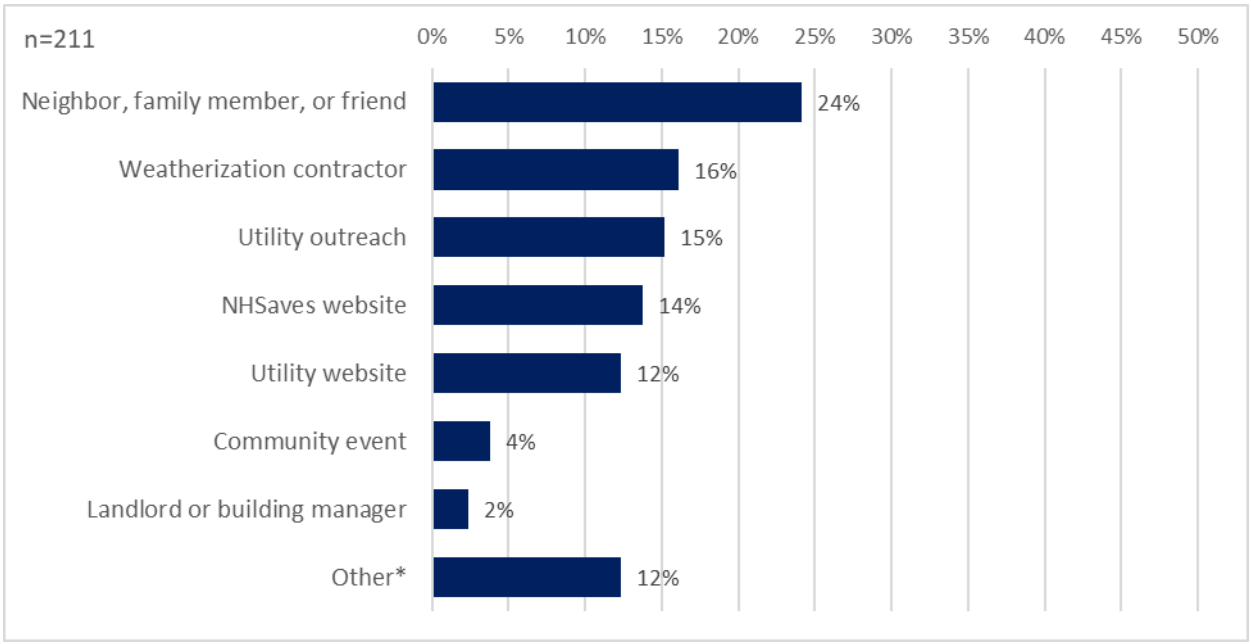
4. Process Evaluation Results

Opinion Dynamics conducted a process evaluation of the 2016 and 2017 NHSaves HPwES Program based on in-depth interviews with contractors and finance partners, a literature review, a participant survey, and non-participants survey (see Section 2.2). Below, we present the results of this research by key evaluation objectives.

4.1 Marketing and Outreach

HPwES Program staff employed a range of different marketing and outreach strategies to encourage participation in the program. Historically, substantive marketing campaigns have not been necessary to generate the demand required to meet participation goals. As such, program staff mostly leveraged low-cost outreach methods including bill inserts, direct mailings, and partnerships with local energy initiatives. However, the primary driver of program participation is word of mouth; 24% of 2016 and 2017 participants first learned about the HPwES program from a neighbor, family member, or friend. All ten contractors that we interviewed confirmed this, citing word of mouth as their primary lead generator for HPwES projects. Participants also first learned about the program through their HPwES contractor (16%), from utility outreach (15%), and from the NHSaves website (14%). Figure 4-1 shows the most commonly cited ways that participants first learned about the HPwES program.

Figure 4-1. How Participants First Learned about the HPwES Program



*Includes utility on-hold message (1%), community leader/agency (1%), TV/radio ad (1%), social media (1%) and all "other" sources reported by respondents (7%).

With some exceptions, word of mouth and engagement with contractors have fueled program awareness amongst participant populations for similar programs administered in nearby states.

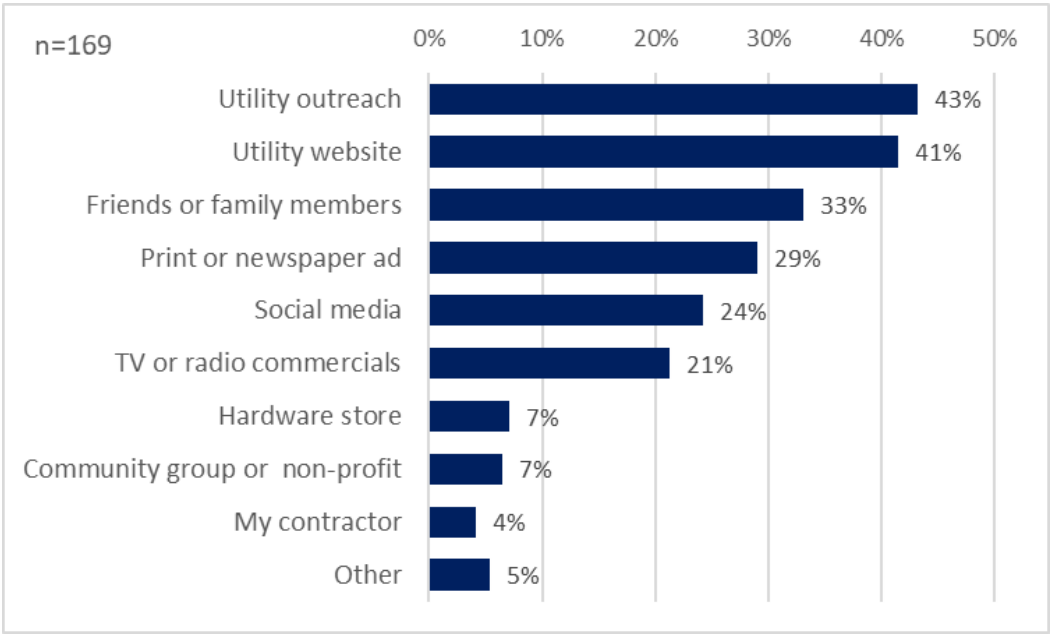
- **Efficiency Maine Trust Home Energy Savings Program**—According to process research, the largest share of participants from 2010 and 2011 first learned about the program through advertising media (36%)—these included both print media (e.g., brochures, newspaper ads, and direct

mailings) and other media sources (e.g., radio and TV). The next largest share of participants learned about the program through their contractors (27%); followed by word of mouth (24%); utility or program websites (15%); and public events (7%).[18]

- NYSERDA Home Performance with ENERGY STAR—NYSERDA leveraged both contractor branded marketing efforts (i.e., provided funding for participating contractors to invest in program-branded marketing collateral) and mass media marketing. According to participating contractors, 44% of audit-only participants reported learning about the program through mass media marketing or utility marketing efforts. Another 43% of participants learned about the program through their contractors. Additionally, 52% of participating contractors reported taking advantage of incentives to generate co-branded materials and leveraged those to generate leads.[19]
- MassSave Home Energy Services Program—Of participants that received treatment between Q2 and Q4 of 2016, 26% first learned about the availability of the energy assessment through word of mouth. Fifteen percent of participants learned about the assessment through mail they received (i.e., bill inserts or direct mail marketing materials) and another 10% through internet advertisements, online searches, or social media. Notably, very few participants learned about the availability of the assessment through their insulation contractor (1%). [20]

Though very few eligible non-participants were aware of the HPwES Program prior to taking the survey (6%), respondents indicated their preferred method of receiving information related to energy efficiency programs (Figure 4-2). The largest share of eligible non-participants preferred to receive information through their utility outreach (43%), from their utility's website (41%), or via word or mouth from friends and family members (33%).

Figure 4-2. Non-participants Preferred Source of Information About Energy-related Programs (n=169)



Note: Participants selected up to 3 preferred sources of information

[18] Cadmus. 2011. Pg. 44
[19] Research Into Action, Inc. 2015. Pg. 36
[20] Navigant, et al. 2018. Pg. 142

As noted, a small share of eligible non-participants were aware of the HPwES Program prior to completing the survey (9 respondents). Of those, 2 indicated that they learned about the program through their utility's website and 3 reported that they learned of the HPwES Program through the NHSaves website. Another 3 respondents noted that they learned about the program through direct outreach from their utility (e.g., phone call, email, or direct mail). Further, of the 9 respondents that indicated they were aware of the HPwES Program, Table 4-1 shows their preferred means of learning about energy efficiency programs.

Table 4-1. Respondents Aware of the HPwES Program Preferred Means of Outreach

Preferred Outreach Method	Count of Respondents (n=9)
Social media	5
Utility outreach	3
Utility website	3
Print ad	2
Word of mouth	2
TV or radio	1
Hardware store	1

Most residential retrofit programs rely on typical mass-marketing strategies like bill-inserts and radio/TV marketing to drive participation. However, to drive consistent and expanded participation, these traditional strategies should be supplemented with more grassroots strategies, including:

- **Community-based marketing** . Utilize trusted community messengers to spread awareness of a program. Local governments can be effective partners to promote energy efficiency programs due to their connection to networks like housing/development boards and local energy committees.[21] Town housing boards are positioned to promote the program when residents apply for permits to remodel their home and energy committees can incorporate energy efficiency programs into their initiatives.
- **Partner with local contractors.** Contractors often serve as the primary sales team for retrofit programs and are in prime position to pitch the program to customers.
- **Neighborhood targeted outreach**. This type of outreach allows for direct contact with potential participants through canvassing or partnership with community groups.[21] This strategy allows utilities to target certain communities likely to be more receptive to the services offered by a program (e.g. targeting older housing stock).[21]

Regardless of the mode of outreach, it is important that program messaging remain consistent across utility jurisdictions. It is also critical that program marketing attract interest by drawing on the right customer motivations for participation in weatherization programs.[22] In addition to the typical motivators like bill savings, other influences like improved comfort, improved indoor air quality, and increased property value should also be leveraged to reach customers that may be motivated by these factors more than bill reductions.[23] Forthcoming research related to the non-energy impacts of New Hampshire energy efficiency programs may contribute to marking of this type.

[21] American Council for an Energy-Efficient Economy
[22] Zimring et. al, pages 40-41
[23] Zimring et. al, page 11

4.2 Program Implementation

The four New Hampshire utilities administer the HPwES Program, though much of its implementation is carried out by participating home performance contractors. The program is open to all contractors that can meet the necessary requirements, including providing turnkey services[24], employing a BPI Building Analyst I certified auditor, possessing EPA lead certification, carrying a minimum of $2 million in liability insurance, and agreeing to standard measure pricing. To become a program partner, contractors must enroll separately with each utility whose customers they would like to serve. The utilities typically screen new contractors by contacting customer references for program-comparable work and performing QAQC inspections of initial projects prior to enrolling them in the program. While many contractors complete work on behalf of several different utilities, program tracking data only contains contractor information roughly half of the time. As such, we are unable to provide information on how many contractors serve customers from each utility.

Participants enroll in the HPwES Program through two avenues: (1) through a participating HPwES contractor (i.e., contractor-generated leads), or (2) by either contacting their utility or signing up directly through the NHSaves website (i.e., utility-generated leads). Contractor-generated leads typically arise by a customer contacting a participating contractor stating their interest in the program or weatherization services, at which point the contractor tells the participant about the program and directs them to the NHSaves website and the HHI tool. The utilities then assign these projects to the referring contractor. Utility-generated leads arise when customers learn about the program from a utility-sponsored action and qualify themselves through the HHI tool without a contractor referral. The utilities then randomly assign these leads to participating contractors based on the customers' location and the region served by each contractor. The program tracking data does not contain information on the lead source for each project. However, according to the participants survey, 16% of respondents first learned about the HPwES Program through their contractor.

Both the customer and contractor are alerted when a utility accepts an application. Once the utility assigns the lead, the contractor takes over management of the project and contacts the customer to schedule the Home Energy Assessment. As part of the lead assignment process, the contractor receives the customer's application materials, including home characteristics, heating system type, hot water system type, etc. While conducting the assessment, the contractor will verify the information from the application and collect additional information as needed (e.g., blower door test and insulation levels) to begin developing upgrade recommendations. While collecting this information, contractors also look for opportunities to install instant-saving-measures (ISMs) including LED lights, low-flow showerheads, faucet aerators, and hot water pipe insulation, and identify any weatherization barriers such as health and safety concerns or blocked access to basements or attics.

Following the assessment, the contractor enters the information into NHSurveyor, software that calculates measure-level cost-effectiveness, to develop a final list of energy saving upgrade recommendations for each household. Contractors typically provide these recommendations to their customers in a report that shows which measures they are eligible to receive, how much of the cost will be covered by the program, the remaining cost they will be responsible for, and any potential financing options available to them. In 2016 and 2017, the HPwES Program offered two financing options to assist customers with the remaining balance of their projects (typically referred to as the customer co-pay):

- 0% On-Bill Financing: In 2016 and 2017 only Eversource, Unitil, and NHEC customers were eligible for on-bill financing. The maximum loan each participant was eligible to receive varied for each utility

[24] Contractors must provide audit and installation services. If the contractor does not have internal weatherization crews, they must arrange for a subcontractor to complete the installations.

based on available funding, though the utilities reported a typical maximum loan of $2,000 per participant.

- **2% Utility-Subsidized Loan:** Participating customers also had the opportunity to secure a home improvement loan through a participating financial institution, subject to the underwriting criteria of that institution. The utilities subsidized the loan by buying the interest rate down from the market rate to 2 percent. Participants were eligible for loans up to $15,000.

Once the customer and contractor finalize the scope of work, they submit the scope to the utility for approval. Upon approval, the contractor either sends an internal crew or schedules a subcontractor to complete the energy efficiency upgrades. Upon completion, the contractors submit final work orders to the utilities. After PAs approve final work orders, contractors issue an invoice and utilities remit payment to contractors. PAs also complete quality assurance/quality control (QA/QC) inspections on a share of completed HPwES projects each year.[25] Note that, while we did not complete a review of QA/QC reports tracked by utilities, we did discuss these processes during interviews with program teams and HPwES contractors. Typical QA/QC inspections include inspecting include identification of any potential health and safety issues, deficient measures installed, or missed opportunities. In the event that utilities identify any of issues, QA/QC contractors report the problem(s) both to the utilities and the HPwES contractors, who are responsible for rectifying the problem(s).

Table 4-2 describes each implementation step, along with the data that utilities and contractors collect at each stage.

Table 4-2. Outline of Implementation Activities

Implementation Step	Description	Data Collected	Collecting Party
Qualification	▪ Customer enters preliminary information into HHI tool and is told if they qualify. ▪ If they qualify, they are prompted to complete an application.	Annual usage	Utility
		Zip code	Utility
		Heating fuel(s)	Utility
Enrollment	▪ To enroll, customer must complete an application which provides additional information on the household (number of occupants, heating/cooling system, etc.). ▪ Customer provides up to two years of fuel records[26] to verify qualifications and establish a "pre-condition" for consumption ▪ Once accepted, the lead is either assigned back to referring contractor or assigned by the utility.	Home characteristics	Utility
		HVAC system(s)	Utility
		Fuel history	Utility
Home Energy Assessment	▪ After lead is assigned, contractor contacts homeowner to schedule home energy assessment.	Pre-diagnostics (blower door testing, combustion safety testing, etc)	Contractor

[25] Each utility has different QA/QC processes. For example, some review every 10th project while others review one per invoice.
[26] In some cases, customers can qualify without two years of fuel records. If the customer can demonstrate the required usage in one heating system, they can qualify for the program. Additionally, the PAs also allow customers to submit previous owner's fuel usage as part of the qualification process.

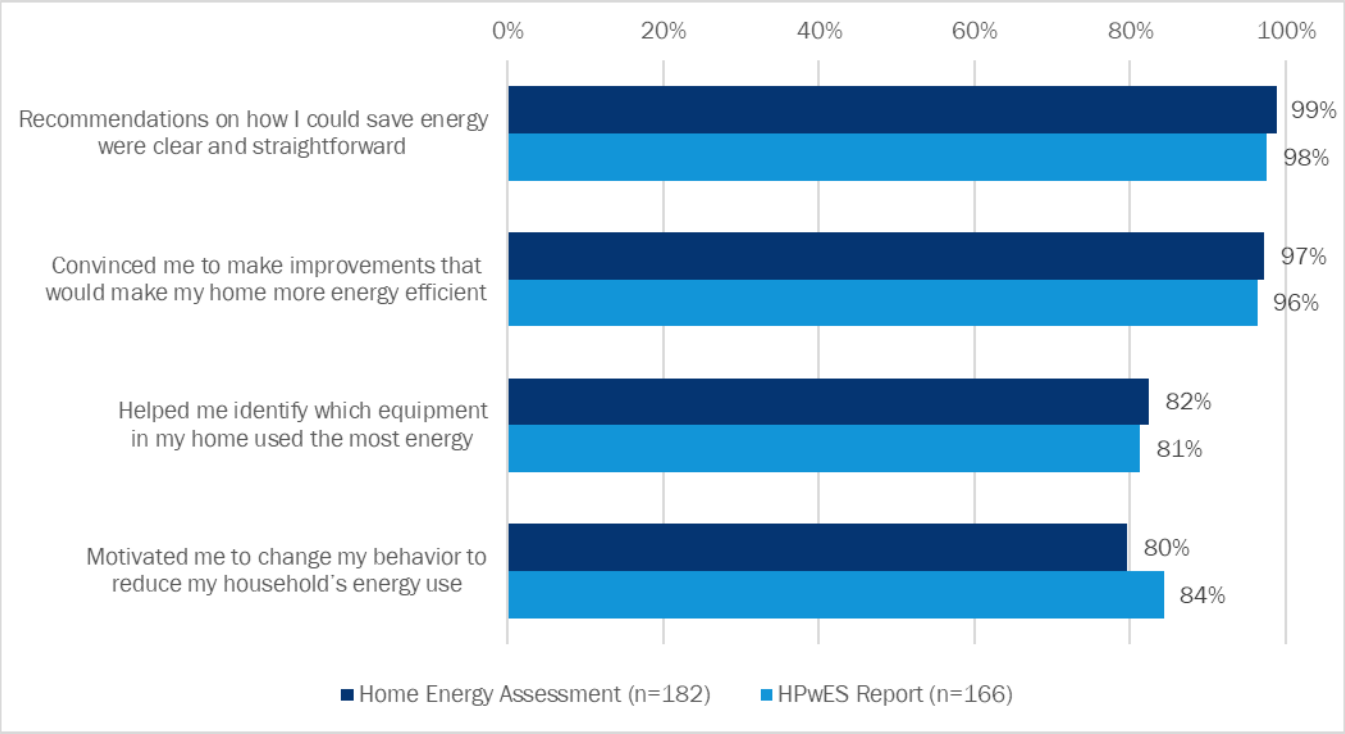
Implementation Step	Description	Data Collected	Collecting Party
	▪ While on-site, the contractor verifies application information, performs diagnostics, and documents pre-conditions of insulation. ▪ Contractor installs ISMs when opportunity exists. ▪ Contractor uses NHSurveyor to develop cost effective work scope and develops report including proposed work, estimated bill savings, total cost, cost covered by utility, remaining customer copay, and available financing options. ▪ After customer selects what work they want to move forward with, contractor makes any necessary changes to the job in NHSurveyor, exports the final work scope, and uploads to OTTER for utility approval.	Thermal scan (investigate current envelope conditions)	Contractor
		Home Energy Report	Contractor
		Proposed work scope	Contractor
Follow-up installations	▪ If the contractor has in-house crews, they dispatch them. If not, they subcontract the installations and schedules the follow up work for the customer. ▪ When the work is complete, a final work scope is generated and posted to OTTER and an invoice is generated. ▪ Utility downloads the final work scope and transfers underlying data to internal tracking system.	Post-diagnostics	Contractor
		Final work scope	Contractor
QA/QC	▪ If a job is selected for QA/QC, a reviewer is sent to review the quality of work performed and identify any potentially missed opportunities. ▪ The reviewer submits a report to the utility of their findings ▪ If the reviewer identifies any potential issues, the utility will contact the contractor. ▪ If necessary, the utility will order a request for the contractor to return and address any incomplete or poor work.	Quality of contractor work	QA/QC reviewer
		Missed opportunities	QA/QC reviewer
		Return request (if necessary)	Utility

4.2.1 Home Energy Assessment

During the home energy assessment, contractors conduct a thorough audit of the household, including a blower door test, and often provide in-person recommendations to the program participants, along with a report listing the recommended energy efficiency improvements offered through the program, and the availability of on-bill and low interest financing options (see Section 4.4). Ninety-nine percent of participants that were present during the home energy assessment reported that the auditor discussed strategies for saving energy in their home, and 79% remembered receiving a home energy assessment report following the assessment.

Participants also reported that both the home energy assessment and the report detailing recommended energy upgrades were effective and motivated them to improve their household's energy efficiency. Nearly all participants found recommendations from their contractors clear and straightforward (99%--home energy assessment/98%--HPwES report). Notably, both the energy assessment and HPwES report also motivated participants to change their behavior and reduce their household's energy use (80%--home energy assessment/84%--HPwES report). Figure 4-3 provides additional participant impressions of both the assessment and report.

Figure 4-3. Participant Impressions of the Home Energy Assessment and Report



Note: The chart indicates the share of participants that reported they "Strongly Agree" or "Somewhat Agree" with the statements related to the value of the Home Energy Assessment and subsequent report.

4.2.2 Measure Installation

Following the home energy assessment, contractors install recommended energy efficiency upgrades in participating households. In 2016 and 2017, the majority of households received at least some air sealing (76%) or insulation (77%) measures. This rate of deep measure installation is greater than other programs in the region have seen. About half the participants in NYSERDA's HPwES program receive weatherization-measures[27] and one-third of MassSave Home Energy Services participants receive major measures like insulation[28] Table 4-3 below shows each of the measure groups offered by the HPwES program in 2016 and 2017, along with the share of project sites that received at least one measure from each group.

[27] Research Into Action, page S-2.
[28] Navigant et. al, page 10.

Table 4-3. Share of Projects and Ex Ante Savings for Each Measure Group

Measure Group	Share Ex Ante Savings+	Count of Participating Households	Share of Households with Measure Group
Insulation and air sealing	50%	1,632	83%
Efficient lighting	29%	820	42%
Ancillary savings and site-level adjustments*	6%	1,387	71%
Programmable or Wi-Fi enabled thermostats	4%	126	6%
Refrigerator replacements	2%	26	1%
Domestic hot water (e.g., faucet aerators, showerheads, hot water pipe insulation, etc.)	1%	394	20%
Heating system replacements and/or tune-ups	0%	17	1%
Total Unique Sites		**1,958**	

* These are savings adjustments made to account for heating and cooling savings resulting from reduced furnace fan, boiler pump, and air conditioner run time.

+ Total does not add up to 100% as 8% of ex ante savings were associated with line items in the program tracking data with no specific measure information.

Because the ISMs are the main source of electricity savings for the HPwES program, they play an important role in the program's ability to meet its kWh goals. However, a relatively small portion of all households received ISMs (42% LEDs and 20% domestic hot water) and even fewer natural gas customers did so (11% LEDs 17% domestic hot water). Opinion Dynamics asked participating contractors about how and when they offer ISMs to their customers and their responses varied. One contractor noted that their teams always installed ISMs at the time of the home energy assessment, while others reported installing ISMs during follow-up appointments only in certain households. Contractors cited several common reasons for not installing ISMs, including:

- **Project rebates are capped at $4,000 per project**. Some contractors feel it is in the best interest of the customer to spend as much of this cap as possible on the weatherization measures. They noted most customers are capable of buying and installing the ISMs but cannot install their own insulation.
- **Lack of opportunity**. The program requires that LEDs are only installed in high use sockets (dining rooms, kitchen, exterior). Some contractors note that many customers already have LEDs installed in these fixtures. Also, some have expensive faucet or showerhead fixtures that they do not want replaced.
- **Invoicing**. One contractor mentioned if they install the ISMs, they must wait for the customer's decision on the follow up recommendations before they can invoice the ISMs. They do not want to front these measures and then wait for a customer's decision, which can sometimes take months.
- **Focus on insulation**. One contractor mentioned that their company's focus is on insulation. If a customer is not going to move forward with weatherization measures, the project typically dies there, and they do not bother with the ISMs. The focus on insulation differs from other similar home performance programs administered in nearby states. For example, in

> *I think the issue…is that it is so heavily focused on heating savings…that it is having a hard time keeping up with the kWh goals that are getting escalated through the EERS… We are investigating other electric opportunities to try to incorporate into the program, but it starts getting into bigger ticket items like appliances that folks are not always keen to replace, especially when their primary focus getting into the program has been on improving their heating.*
>
> – Program Manager

Connecticut the majority of homes receive LEDs, domestic hot water, and air sealing measures, while a relatively small portion of homes receive insulation measures (roughly 20%).

Multifamily Measure Installation

According to program tracking data, 64% of 2016 and 2017 HPwES participants lived in single family households, compared with 34% that lived in multifamily buildings. Participants in both types of households received similar measures, though fewer multifamily participants received lighting upgrades (54% SF compared with 19% in MF) and a greater share of multifamily participants received domestic hot water measures (17% SF compared with 27% MF). Though no participants living in multifamily buildings received programmable/Wi-Fi enabled thermostats or heating system replacements/upgrades, many of these participants live in master-metered natural gas buildings and so would not qualify for those measures anyway.

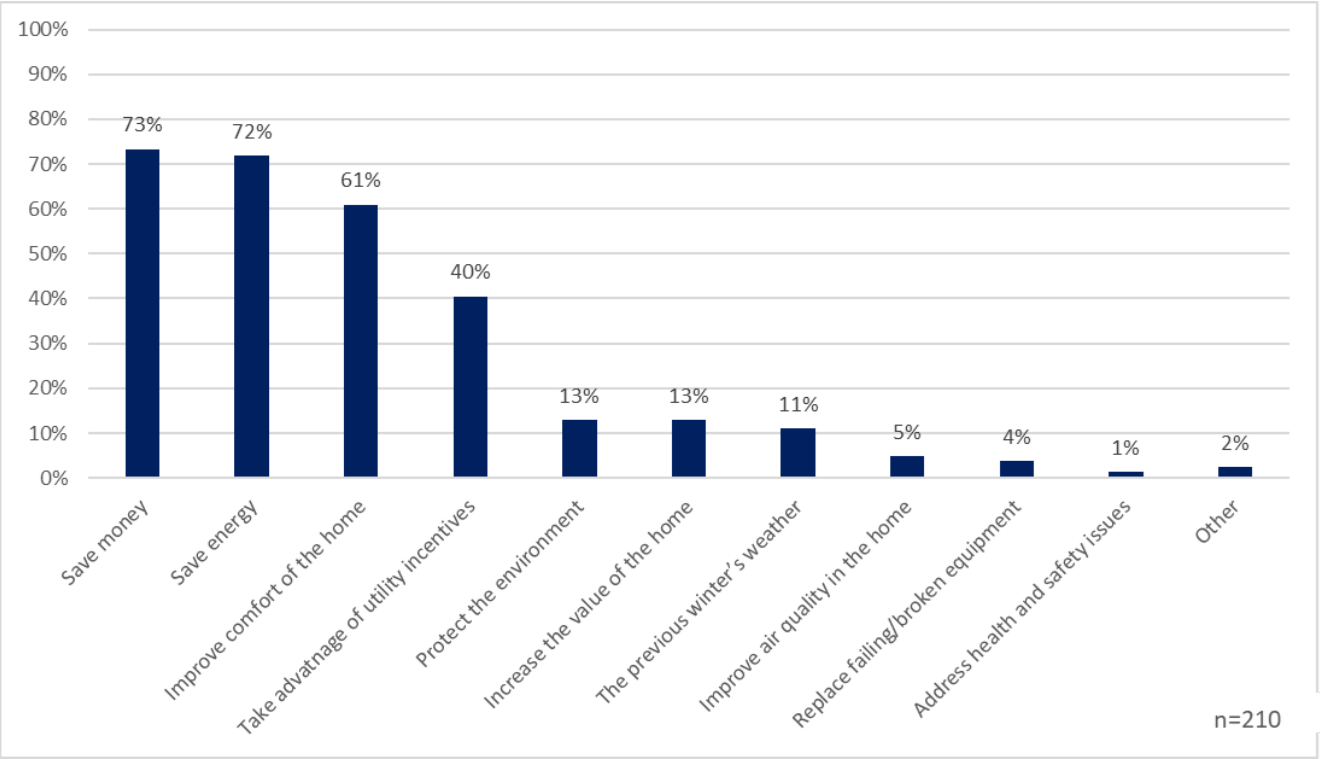
Table 4-4. Measure Installation by Housing Type

Measure Group	Single Family (N=1,246)	Multifamily (N=664)	Unknown (N=48)
Insulation and air sealing	85%	80%	98%
Lighting	54%	19%	44%
Domestic Hot Water	17%	27%	2%
Programmable/Wi-Fi Enabled Thermostats	10%	0%	4%
Refrigerator Replacements	2%	0%	6%
Heating System Tune-up and Replacements	1%	0%	0%

4.2.3 Customer Motivations

Participants are largely motivated to enroll in the program to save money (73%) and/or energy (72%). Figure 4-4 lists other factors that drove customers to participate in the 2016 and 2017 HPwES Program based on responses to the participant survey.

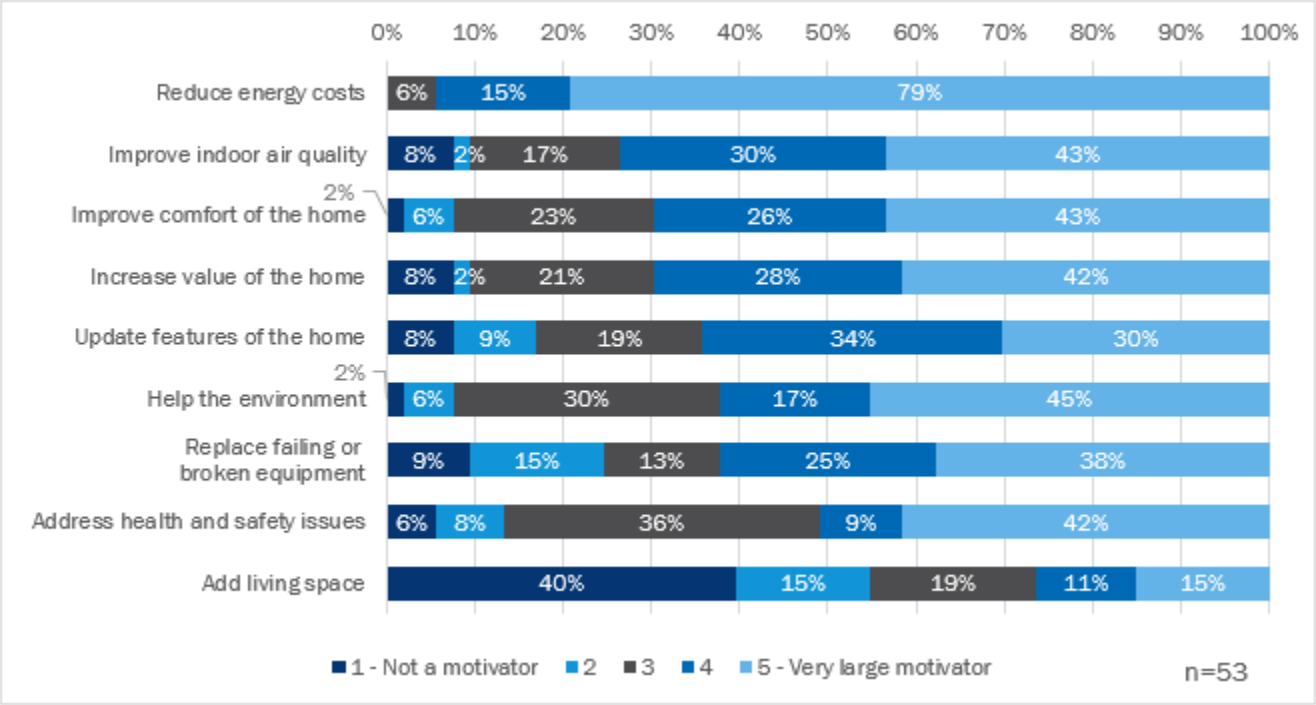
Figure 4-4. Motivations to Participation



Note: Participants selected up to 3 factors that motivated them to participate in the HPwES Program.

Twenty-nine percent of eligible non-participants are interested in participating in the HPwES Program. These eligible non-participants are motivated by similar factors as participants. Figure 4-5 below shows the degree to which several different factors would motivate eligible non-participants to enroll in the HPwES Program, on a scale from 1 to 5 where 5 was a "very large motivator" and 1 is "not a motivator at all." Similar to participants, the largest share indicated that saving money and energy drove their interest in the HPwES Program. Other motivating factors included improving indoor air quality, improving the comfort of their home, and increasing the value of their home.

Figure 4-5. Share of HPwES Eligible Non-Participants Motivated by Different Factors to Participate



Note: Participants rated each factor on a scale from 1 to 5 where 1 was "not a motivator" and 5 was a "very large motivator".

4.2.4 Customer Barriers

Contractors and customers, both participating and non-participating, provided feedback on several factors that present obstacles for greater participation in the HPwES Program. A key barrier identified through the survey with eligible non-participants and in-depth interviews with participating contractors was a lack of customer awareness. Just 6% of the eligible non-participants were aware of the HPwES Program prior to completing the non-participant survey. Participating contractors echoed this feedback, indicating that lack of awareness amongst their general customer base was a primary barrier to increasing customer participation. Historically, lack of widespread marketing and outreach has served as means of controlling demand for the program as annual budget were limited. As budgets expand, it is important that outreach efforts expand in-kind to generate customer interest.

The process by which the utilities qualify eligible participants presents additional obstacles to increasing HPwES participation. To screen for eligibility, customers must first visit the NHSaves website and fill in details related to their annual heating load for each heating fuel type, along with their household's square footage. Prospective participants then need to fill out a HPwES application and provide two years of heating bills to demonstrate that they have sufficient heating load to enroll in the program. During in-depth interviews, both contactors and program staff mentioned the utilities will make exceptions and allow participants who cannot provide the full heating bill information to participate as long as a need can be demonstrated.

Additionally, contractors indicated that some customers that do not meet the HPwES eligibility requirements fall into two specific categories.

- **"Thrifty" customers:** Customers who keep their thermostats set at low temperatures because they cannot afford to heat their homes to a comfortable level. These may be moderate-income customers who do not qualify for income-based assistance programs, but still struggle financially.
- **Recent home buyers:** Customers who recently purchased a home or have decided to turn a seasonal-home into a year-round residence typically cannot provide sufficient usage history. Even if these homes had little or no insulation, the homeowner would have to heat their under insulated home inefficiently for two years before becoming eligible for the program.

Participating contractors also reported encountering barriers with the cost-effectiveness calculations in NHSurveyor. Specifically, the low avoided cost values the tool leverages for natural gas and wood present challenges when screening deeper measures like insulation. The contractors acknowledged that the utilities only require the overall project to screen as cost-effective. However, if a resource-intensive measure like basement or attic insulation is not cost-effective, the overall project will likely not pass as cost-effective. Oftentimes, contractors leave these measures out of their proposed upgrade packages even though they see a clear need for the improvements. Contractors also raised concerns about the cost-effectiveness calculations during the EERS public hearing. Notably, the lack of ISM installations mentioned in section 4.2.2 may exacerbate this challenge as these measures could raise the overall cost-effectiveness of these projects. ISM, particularly lighting measures, may not be a long term solution to cost-effectiveness issues as lighting markets continue to move towards LEDs as the only available option. However, anecdotally, HPwES contractors still observe some opportunity to replace inefficient lamps with LEDs.

> *Natural gas is notorious for this, right, we go in and we go into a cellar and there's no insulation. We turn on the blower door and air is pouring through there, right, and we can't get the benefit cost to pass.*
>
> -- Participating contractor

Contractors also indicated that prospective participants also cite the upfront cost of upgrades (i.e., the cost after the HPwES rebate) as a limiting factor in convincing some to move forward with recommended energy efficiency improvements. Participants echoed this feedback. Of those that did not choose to have their homes insulated, 31% reported it was because the cost was too high, while 22% of participants that did insulate their home reported the cost was a challenge for them. The utilities designed program financing options to help mitigate this barrier specifically. However not all contractors are educating their customers about the availability of financing. During in-depth interviews with participating contractors, several noted that different utilities have different offerings which causes confusion. Notably, utilities and program teams have attempted to tailor offerings to customers' changing needs (e.g., adding financing various financing options over time), which may contribute some to this confusion. As a result, contractors do not uniformly discuss financing with participants. Some also noted customers often have follow up questions about the financing which they are not comfortable discussing (i.e., credit scores, rates, etc). As a result, just 52% of survey respondents reported they were aware of the finance offerings available to them. Just 32% of the respondents who knew about the offerings took advantage of them; most who did not reported it was not financially necessary. Nearly 40% of the respondents who were unaware of the financing options and did not move forward with insulation reported they would have been more likely to weatherize if they had been aware of the financing options.

4.2.5 Contractor Barriers

Participating contractors also identified several barriers to implementing the HPwES Program.

Project Screening and Data Tracking Tools

Participating contractors cited challenges working with both OTTER, the program tracking database, and NHSurveyor. NHSurveyor's inability to share project details via the internet presents obstacles for contractors to work collaboratively between field and office staff. As NHSurveyor is installed on individual devices and not cloud-based, project details reside on individual computers where the work scope was originally created. Contractors expressed a desire for a tool that allowed field staff to share work scopes remotely, so that office staff would then be able to upload the project details to OTTER for approval by the utilities, streamlining the project intake and approval processes.

Several contractors also noted that using two separate systems (i.e., OTTER and NHSurveyor) adds complexity and requires more administrative time for both field and office staff. When a field technician makes a revision to a project, they first need to make the update in NHSurveyor and re-upload the scope to OTTER for review by the utilities. As projects often require revisions due to individual household conditions, completing this process multiple times can add administrative time necessary to complete each project. Additionally, the need to revise projects in multiple software systems can add to the risk of errors in data tracking, resulting in data quality issues.

Payment Delays

Some participating contractors also indicated that the wait time between invoicing and payment can be problematic. Several contractors reported making relatively little profit on HPwES projects and, at any given time, having many projects that are in accounts receivable (i.e., completed but not paid). In one instance, a contractor noted that delays in payment diminish their already thin margins as they sometimes need to take out a line of credit to cover expenses. Similarly, another contractor indicated that delays in payments limit the number of projects they can complete in a given year.

Several contractors noted that the QA/QC process can exacerbate payment challenges. Contractors invoice the utilities for several completed projects at once. In the event that utilities select one of these projects for random QA/QC inspections, payments for all projects on the same invoice are delayed until utilities complete the inspection and issue final approval. Though contractors understood the importance of additional QA/QC and noted utility questions that often arise during inspections are legitimate, they also felt that, in most cases, the additional questions did not warrant withholding payment for completed projects. For example, one contractor agreed that withholding payment for issues related to the quality or completeness of work was understandable but delaying payment to confirm that field staff discussed the condition of a customer's appliances was not.

Contractor Training Needs and Staffing Constraints

Contractors noted that they experience high rates of turnover and have a difficult time finding experienced staff, which is common in the industry. As such, training new employees requires a considerable amount of contractors' resources. Several contractors indicated that a utility-sponsored "boot camp" would be beneficial for new staff to cover common topics, such as best practices for installation of weatherization measures for junior staff, data collection, and guidance on how to use program-specific data tracking software (e.g., NHSurveyor and OTTER). As most contractors represent small businesses, any additional training support for new employees would be of considerable benefit to participating contractors and provides opportunities for improved consistency in the delivery of the program. Historically, contractors have hesitated to make investments to grow their staff as limited program funding spawned concerns about whether there would be enough projects to support additional staff.

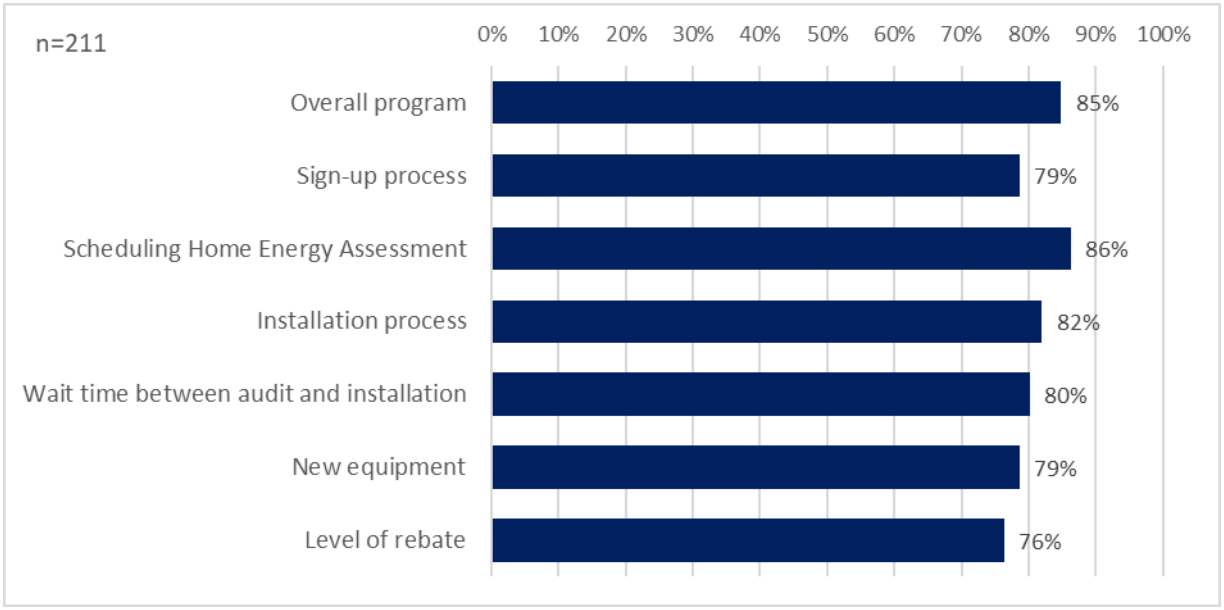
4.3 Participant Satisfaction

Overall, all participating parties are satisfied with the program. In the sections that follow we provide details on customer and program partner satisfaction with key components of the program.

4.3.1 Participating Customer Satisfaction

In our survey of program participants, we asked about their satisfaction with the program overall, and with specific program components. As Figure 4-6 shows, 85% of surveyed participants rated their satisfaction with the program at a 7 or higher, when asked to provide their satisfaction on a scale from 0-10 with 0 meaning "extremely dissatisfied" and 10 meaning "extremely satisfied".

Figure 4-6. Percentage of Participants Satisfied with Each Program Component

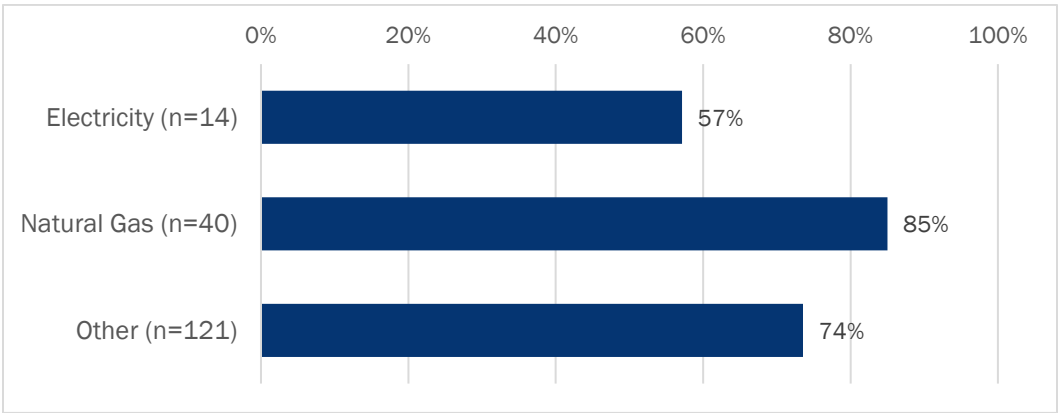


a. The chart indicates the share of respondents that provided a rating of 7 or higher on a scale from 0-10 where 0 means "extremely dissatisfied" and 10 means "extremely satisfied"

Participants cited several reasons for their satisfaction, including high quality work, an easy and informative participation process, satisfaction with savings, and the ability to complete upgrades they otherwise would not have been able to make. Thirteen respondents noted that they were unsatisfied, and five respondents specifically cited low quality work and the feeling that the improvements were not effective in reducing their household's energy consumption.

Seventy-five percent of participants also noted that they were satisfied with their household's energy savings after participating in the HPwES Program (see Figure 4-7). Notably, 52% of participants reported seeing reductions in their energy bills (32% electricity, 56% natural gas, 54% other), 22% said there has been no change in their energy bills (16% electricity, 13% natural gas, 26% other), and 9% said their bills have gone up (26% electricity, 8% natural gas, 7% Other). In addition to energy savings, 85% of participants who completed insulation upgrades reported experiencing a change in comfort levels inside their homes, with 79% noting more even temperatures throughout the home and 72% stating their homes are less drafty.

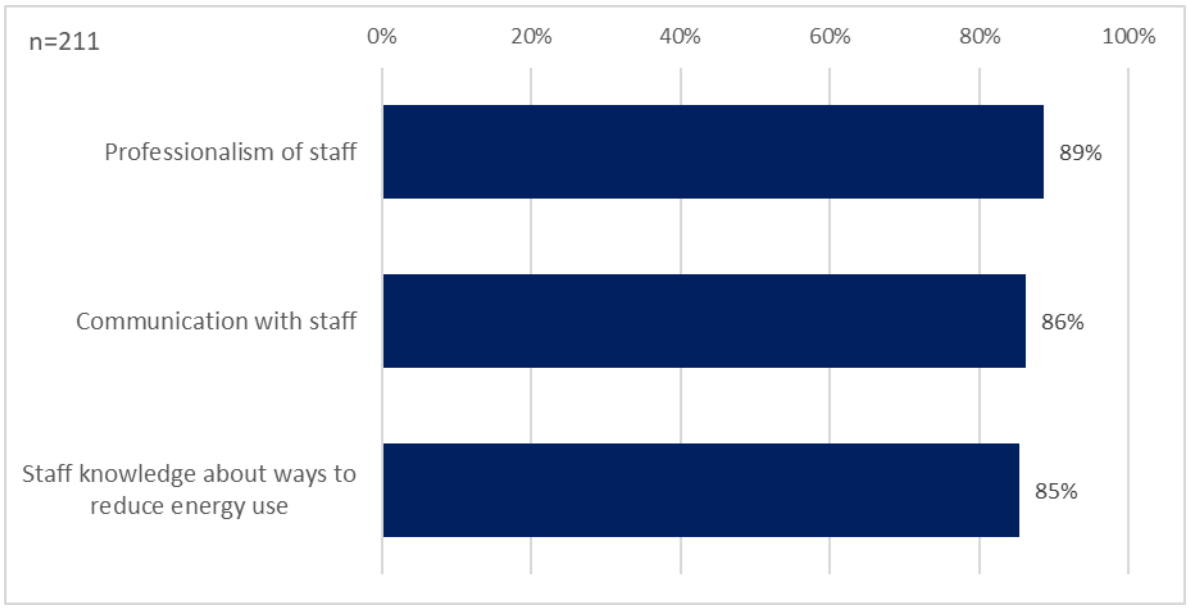
Figure 4-7. Percentage of Participants Satisfied with Impact on Energy Bills



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 were also highly satisfied with both program staff and their contractors. Figure 4-8 shows that participants were satisfied with program staff's professionalism (89%), communication (86%), and knowledge of ways to reduce energy use (85%).

Figure 4-8. Percentage of Participants Satisfied with Program Implementation Staff



Note: The chart indicates the share 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"

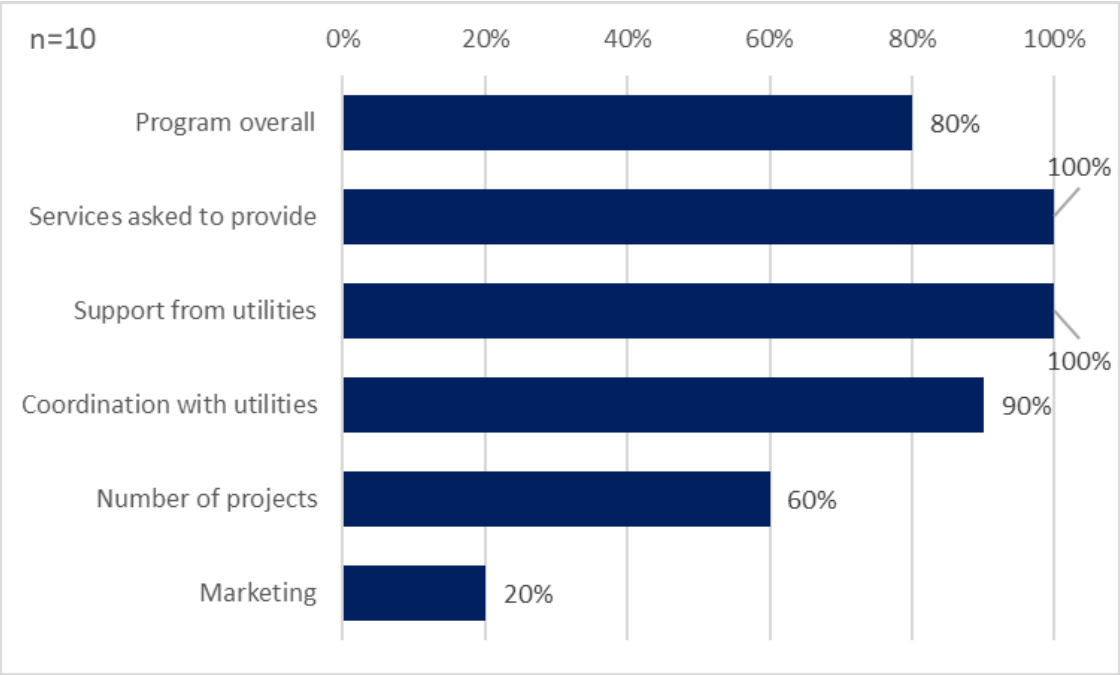
4.3.2 Program Partner Satisfaction

Participating Contractors

Participating contractors also reported high levels of satisfaction with the HPwES program overall, as well as key components of the program. As shown in Figure 4-9, 80% of the participating contractors indicated that they were satisfied with the program overall and 100% were satisfied with the services they are asked to

perform and with the support they receive from the utilities. However, only 60% of contractors indicated that they were satisfied with the number of projects they completed through the program and only 20% were satisfied with the program's marketing. Contractors mentioned overall that the program benefits their businesses and they are appreciative of the projects, however they would like to see the number grow. Admittedly, program expansion would require capacity investments by contractors who have opted to maintain lean crews due to uncertainty over program funding levels.

Figure 4-9. Percentage of Participating Contractors Satisfied with Program Components



Note: The chart indicates the share 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"

For many of the contractors, the program is an integral part of their business; some attributed 70% or more of their business to the program, while others said the program drove over 25% of their total business. Most contractors noted that the amount of jobs they are completing through the program has increased from year to year, requiring the need for additional staff to meet their needs. In most cases, beyond adding to the number of projects they complete annually, becoming a program partner has not required participating contactors to significantly change the services they offer or the way they do business.

Financial Partners

In addition to the implementation contractors, Opinion Dynamics also spoke with representatives from 3 of the participating financial institutions to understand their satisfaction with the program. The representatives of these institutions were very pleased with the program, noting that they are not asked to change their business practices to service program participants. The financial institutions already offered home improvement loans prior to becoming program partners, so participating did not require any changes to their service offerings. They also use the same qualifications and underwriting practices as they would for customers not participating in the program. The lenders reported that their largest benefit from participation is reaching and retaining customers. Serving as a program partner puts the institutions in contact with customers who may decide to take advantage of other offerings (e.g., auto loans, mortgages, etc.). Further,

financial partners may stand to lose business if HPwES participants had to go elsewhere to receive a loan through the program.

4.4 Expansion of the Program

A key research objective of the process evaluation was to explore ways to expand the program in future years as funding levels are expected to increase. In the remainder of this section, we will present strategies for increasing customer and contractor participation, and other offerings, including emerging technologies, that may be of interest to participants.

4.4.1 Increasing Customer Participation

Increased customer participation comes in two forms: increased conversion of home energy assessment to measure installation for current participants and increased customer engagement with non-participants. Contractors reported that most participants receiving a home energy assessment choose to move forward with at least some of the recommended weatherization measures (approximately 75% of participants). Contractors also reported that customers who choose not to move forward with measure installations often cite financial reasons (e.g., low cost of heating fuel compared with the high cost of the remaining customer copay).

To mitigate financial barriers and increase customer participation, contractors and participants offered the following suggestions:

- **Increase promotion of financing options**—As part of the program's design, contractors promote the different on-bill and low-interest financing options to participants during the home energy assessment. However, several contractors noted that they do not always promote the HPwES financing options as the variation in offerings by utility causes confusion. As such, only 52% of participants indicated that they were aware of the financing options. Of participants that were unaware of the financing options available to them and chose not to insulate their homes through the program, 39% said they would likely have moved forward with insulating their homes had they known about the availability of financing.
- **Exempt ISMs from the rebate cap**—While the utilities currently offer ISMs at no cost to participants, the cost of these measures counts towards the $4,000 cap. Exempting these measures would allow contractors to install more ISMs without cannibalizing deeper savings opportunities (e.g., insulation, air sealing, etc.)
- **Increase the rebate cap**—Contractors suggested that, the current rebate cap of $4,000 does not always allow participants to install all of the recommended measures.

Both contractors and customers indicated that there is a great deal of interest and need for the services offered by the HPwES program. Twenty-nine percent of eligible non-participants indicated that they were interested in participating in the HPwES Program (see Table 4-5), and 50% noted that saving energy in their homes was very important to them. Of eligible non-participants interested in participating in the program, 74% were interested in air sealing measures and 45% in insulation services (see Table 4-7). Contractors also reported that increased outreach and education of program benefits will be critical in to drive increased customer participation. These results indicate that there is a substantial portion of the eligible non-participant population that participating contractors may be able to serve through the HPwES Program.

> "About every home needs help, so it's not segmented out that way. It's just every home is under-insulated and [has] too much airflow."
>
> -- Contractor

However, either due to lack of awareness in general or understanding of the services and benefits of participation in the program, these customers have yet to enroll.

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

Interest	Share of Eligible Non-Participants (n=169)
1 – Not at all interested	30%
2	13%
3	28%
4	12%
5 – Extremely interested	17%

4.4.2 Contractor Participation

Most participating contractors indicated that they would like to take on more work through the program, however, they do not currently have the capacity to complete more HPwES projects. Contractors cited a general shortage of skilled labor in the industry and, as a result, increasing capacity would require hiring and training new staff, which can require a substantial investment. Further, as turnover in the industry is relatively high, contractors do not often realize the return on their training investments.

Contractors also expressed reticence to build capacity as they were uncertain about future program funding levels. In additional to hiring and training more staff, building general capacity often requires making other capital investments (e.g., equipment, trucks, office space, etc.). Without knowing for certain that they will have the additional volume of projects, many contractors would be unwilling to make the investments required to handle more HPwES projects.

> "I think the not knowing what the future lies as far as funding goes …I think that more than anything else prevents people from expanding. [The utilities] don't know either. They'll go like we know for two years what the funding is going to be; then after that we don't. Well I can't buy trucks and buildings and everything else and train people on a two-year window. You know my fixed cost would still be there after the program has gone away and forgotten about me. So, we just need some guidance as to hey where are we going? What do you need from us? What is the future?"
>
> ---Contractor

While non-participating contractors were aware of the program, the most common reason for not participating is uncertainty about funding levels and a reticence to commit to standard measure pricing. Notably, most non-participating contractors did not cite other program requirements as barriers. However, several mentioned that they would prefer to complete weatherization installations but were less interested in completing the home energy assessments, including blower door tests. These sentiments were echoed during the EERS public hearing by Andy Duncan, the Energy Training Manager and Workforce Development Coordinator at Lakes Region Community College. Dr. Duncan also cited paperwork and strict quality standards in difficult conditions as barriers to contractor participation but emphasized that the fixed pricing model is the primary barrier. He recommended developing a participation channel for contractors who do not want to agree to the uniform pricing. This channel would allow contractors to deliver rebates to customers but would not acknowledge or market these contractors as "preferred contractors". This would ultimately result in greater contractor capacity while still providing incentives for contractors to agree to the terms of "preferred contractors".

4.4.3 Service Offerings

Opinion Dynamics also explored opportunities to expand the measures offered through the HPwES Program. The prevailing sentiment from participating and non-participating contractors was that the current program offerings are sufficient and demand for these services remains high. Other measures that contractors indicated may be of interest to participants were solar PV[29] and water heating systems, heating system upgrades, and connected home technology.

Notably, 45% of participants reported they have made additional energy efficiency improvements to their homes since participating in the HPwES Program. Some of these upgrades are already offered by the program, and some are not, as shown in Table 4-6.

Table 4-6. Additional Upgrades Completed by Program Participants

Upgrade Category	Overall (n=95)
Window replacements	25%
Lighting replacements	19%
New appliances*	18%
Doors	17%
Heating system upgrade or tune up	13%
Insulation	12%
Other envelope/air infiltration improvements	11%
Hot water system upgrades/new water heater	6%
Thermostats	4%
Mini Splits	3%
Air conditioning	3%
Solar	2%
Boiler Replacement	1%

* Includes refrigerators, dishwashers, stoves, washers, dryers, dishwashers, ovens, dehumidifiers, and microwaves.

Of the 29% of eligible non-participants interested in participating in the HPwES Program, the most common measures of interest are air sealing and insulation services, followed by smart/Wi-Fi enabled thermostats and heating/cooling system tune-up (see Table 4-7).

[29] Renewable energy projects are not funded through energy efficiency programs under the EERS.

Table 4-7. Measures of Interest to Non-Participants Who Expressed Interest in Future Participation

Measure	Overall (n=53)
Air sealing	74%
Insulation of attic, walls, and basement	45%
Smart/Wifi-enabled thermostats	36%
Heating/cooling system tune-up	32%
Heating/cooling system replacement	28%
Hot water measures	21%
LED lights	19%
Refrigerator replacement	9%
Other	8%

Note: Includes non-participants who expressed interest in participating in the HPwES Program.

Visual Audit

In general, the participating contractors reported they are satisfied with the current suite of measures offered through the HPwES Program. However, contractors expressed a range of opinions about the visual audit component which was added to the program in 2018 in an attempt to reach more customers.. This offering provides customers that fall just outside the HHI qualification threshold with a "visual audit" where the auditor completes a cursory walk through the home (i.e., not including a blower door test or other in-depth diagnostic tests) to identify opportunities to provide ISMs. While conducting this walkthrough, the auditor also looks at insulation levels to see if the home may be a good candidate for the full HPwES offering. An added benefit to the visual audit offering is it provides opportunities to reach customers who need weatherization improvements and have cost-effective upgrade opportunities, but do not qualify through the HHI tool due to errors in the customer's application, thrifty energy use, or lack of usage data covering a full heating season.

Some contractors felt there is an abundance of homes in New Hampshire that qualify for the full suite of HPwES measures. Therefore, resources would be better spent spreading awareness and enrolling these participants rather than continuing with the visual audit offering for those that do not qualify. Further, contractors suggested that, while a visual audit may be effective in reaching more customers, there is likely less opportunity in these homes and opportunities for cost-effective insulation and air sealing jobs may be scarce.

Contactors that favored the visual audit, cited that it might be a beneficial strategy for increasing participation, specifically the number of households that receive ISMs. These contractors noted that, as the comprehensive home energy assessments that generally include a blower door test take a considerable amount of time, visual audits would allow contractors to get through a larger number of households faster, which could increase the overall number of customers that install measures. Finally, some contractors mentioned that a visual audit would be particularly helpful in driving participation during warmer months when enrollment in the program is lower, during moderate winters, or reaching "thrifty customers" (see Section 4.2.4) that keep their thermostats low and so may not otherwise qualify for the HPwES Program.

Additional Measure Offerings

Opinion Dynamics also investigated opportunities to expand the program through the adoption of emerging technologies, and other additional offerings. Notably, most "emerging technologies" or peripheral measures offered in other similar home performance programs throughout the country, are already offered through the

HPwES Program, or other NHSaves programs. Common additional measures offered through home performance/weatherization programs include:

- Smart/WiFi enabled thermostats
- Cold climate heat pumps
- Heat pump water heaters
- Pool pumps
- Clothes washers and dryers
- Refrigerators
- Dehumidifiers

While several of these measures are not offered through the HPwES Program, the utilities may use the home energy assessment to identify opportunities and funnel potential participants into other NHSaves programs using the cross-promotional materials contractors currently provide. Training contractors to educate customers on these additional opportunities will lead to additional savings.

A technology that has become more common in other HPwES programs is home automation, or smart home measures (e.g., smart plugs/outlets, advanced power strips, home energy management systems, etc.). These types of measures are particularly effective at managing plug loads, which account for approximately 14% of the energy use in an average home.[30] Tier 1 advanced power strips can produce plug load savings in the range of 16-20%[31] and tier 2 strips can produce savings of 25-50%[32], depending on the devices controlled by the strip. Home energy management systems allow homeowners to control energy-using equipment and analyze data on the energy performance of the home[33]. The systems connect multiple devices and incorporate external data (e.g. weather data) to optimize the performance of the home as one system[34]. A 2017 NYSERDA study estimated energy savings from home energy management systems of up to 16% per home[35]. Importantly, home energy management systems enable load shifting away from peak times[36]. Savings from home energy management systems can be a challenge to measure accurately and can vary significantly with climate, occupancy patterns, and behavior.[37] Additionally, these types of systems can be complicated and energy savings may be improved dramatically where homeowners have some assistance completing the installation process and information on best practices for operating over the long term.

[30] Navigant, 19
[31] Illume, page 12
[32] PG&E, page 7
[33] King, page 20
[34] Ibid, page 21
[35] NYSERDA, page 21
[36] King, page 20
[37] Ibid, page 22

5. Findings and Recommendations

The following sections outline our findings and recommendations from the NHSaves HPwES Program impact and process evaluation for 2016 and 2017. We outline several of the program's key strengths 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.

5.1 Program Impacts

The HPwES Program realized 109% of ex ante savings in 2016 and 2017 (59,081 MMBTUs) from all measures, as shown in Table 5-1. This amounted to 30 MMBTUs of annual energy savings per participating household over the two-year period, which include both fossil fuel and electric savings (kWh converted to MMBTUs[38]). The core measures offered by the program are insulation and air sealing treatments; installed in 83% of participating households and accounting for half of ex ante energy savings for all fuels (i.e., electric and fossil fuel savings). Efficient lighting is the next most prominent measure offered through the program. LEDs accounted for 42% of all ex ante energy savings and were installed in 29% of participating households.

Opinion Dynamics developed ex post savings estimates for a sample of households based on primary data collected during site visits with 67 households that participated in the HPwES Program during the 2016 and 2017 calendar years. In conjunction with primary data collected while on site, our team used secondary sources to update deemed savings algorithms and inputs for all HPwES measures (see Appendix C). Additionally, as program tracking data did not contain specific information on primary or secondary heating fuel type for the participant population, we used participant survey data to update the heating fuel mix assumptions included in measure-specific deemed savings estimates (see Appendix A). Using the revised deemed savings for each measure, we then developed a realization rate for the sample of households (i.e., ex post divided by ex ante). Finally, we multiplied the realization rate from the sample of participants (weighted average) by the total ex ante savings tracked in the program tracking database to reach total ex post savings shown in Table 5-1. Additionally, we provide savings for all measure separated by households primary fuel source—that is delivered fuels (e.g., oil, propane, etc.), natural gas, and electricity.

The ex post savings in the table below represent the total savings for all measures (e.g., insulation, LEDs, domestic hot water, etc.) based on our team's revisions to individual measure deemed savings assumptions. Prospectively, the New Hampshire utilities should use updated measure-specific deemed savings estimates based on this evaluation for program planning (see Appendix C), and also apply the researched measure in-service rate based on our team's site visits (see Section 3.2).

Table 5-1. Impact Evaluation Results by Primary Heating Fuel Type

Primary Fuel Source	Ex Ante MMBTU	Ex Post MMBTU*	Realization Rate
Delivered Fuels	30,080	34,363	114%
Natural Gas	19,897	20,666	104%
Electricity	4,228	4,052	96%
Total	**54,206**	**59,081**	**109%**

* Results are valid at the 90% confidence level +- 8% relative precision

[38] 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

While the overall realization rate for the 2016 and 2017 program period was 109%, Opinion Dynamics observed large deviations between ex ante and ex post savings at the individual measure level. Our impact evaluation included a review of the engineering algorithms and assumptions used to develop the ex ante savings for each program measures and we identified the source of any deviation between ex ante and ex post savings. When necessary, we recommended changes and updates to deemed savings assumptions that will better align ex ante measure savings with evaluated savings in the future (see Appendix C).

- **HVAC Ancillary Savings**—In the 2016-2017 program, the implementation team not only claimed ancillary savings for furnace fans and boiler pumps, but also considered any cooling savings from weatherization measures to be ancillary. Cooling savings weighted based on shares of homes having either central air-conditioning or room air-conditioning, is now captured when calculating total deemed savings for each end-use. However, for accounting purposes, claiming separate ancillary cooling savings is still necessary and as a result we calculated ancillary cooling savings per CFM based on data from the 67 visited sites in the HPwES program evaluation to then subtract this value from air sealing deemed savings. We recommend updating the cooling savings per CFM value in the future with new program data.
- **Water Heater Tank Wrap**—We recommend phasing this measure out as we observed a number of boiler-fed indirect hot water heating through our site visits, and newer model DHW tanks include sufficient insulation making the additional insulation less effective.
- **Programmable Thermostat**—We recommend removal of programmable-to-programmable thermostat replacement scenarios, because the baseline and efficient cases have equal control over HVAC and resultant runtime reduction potential. We also recommend studying the effects of baseline thermostats, e.g., programmable and non-programmable, on Wi Fi enabled thermostat savings; currently savings are the same for Wi Fi enabled thermostats when replacing either a manual or programmable thermostat.

Instant Savings Measures

While weatherization measures are the core offering of the HPwES Program, 51% of participating households received ISMs, including LEDs and domestic hot water measures, which accounted for 30% of ex ante savings. While these measures accounted for a large portion of savings (second only to weatherization measures), our process research suggests that contractors offer ISMs inconsistently. While some contractors regularly recommend and install these measures, others choose to focus on insulation and air sealing measures and rarely offer ISMs.

- **Consider exempting ISMs from the $4,000 per project rebate limit.** Several contractors indicated that they do not regularly install ISMs as it limits the amount of weatherization work covered by the HPwES program, and therefore decreases the likelihood that participants will choose to move forward with installing those measures. Exempting ISMs from the cap may encourage more contractors to install ISMs without sacrificing opportunities to install more insulation and air sealing measures. Current data systems cannot accommodate ISM exemptions, so the evaluation team recommends raising the rebate limit to $4,500 for participants who receive ISMs until a new data tracking system is implemented. Notably, evaluations of other HPwES programs indicate contractors do not install ISMs due to time constraints.[39] The utilities should monitor whether adjustments to the rebate structures for ISMs result in increased installations, or if time constraints restrict the installation of these measures.

[39] Navigant et. al, page 6.

5.2 Consistency of Program Delivery Across All Utilities

Opinion Dynamics found that that there are subtle differences in how some utilities deliver certain aspects of the program. For example, some utilities offer on-bill financing, while others do not. As such, while utilities instruct contractors to share details related to financing during the home energy assessment, contractors do not always do this as for fear that they may later need to rescind the offer if customers do not qualify for certain offerings. Additionally, participating contractors also reported differences in how utilities inspect projects during the QA/QC phase (i.e., some utilities review 1 in 10 projects while others review 1 per invoice). Finally, contractors reported that decision making related to these aspects of the program, among others (e.g., project approval), is distributed across the four utilities. While this type of distributed decision making is inherent with any type of program that is jointly administered by several different entities, it can lead to delays and confusion amongst those that implement the program.

- **Streamline program design, where possible, to create a single set of program implementation guidelines that are consistent across all four utilities.** The New Hampshire utilities have worked together to create a single program manual with guidelines for service delivery. However, there is still some confusion amongst participating contractors related to certain aspects of the program. Decision makers at utilities should work to create a single set of implementation guidelines that are common across utilities wherever possible and empower program staff to make some implementation decisions without the need for approval from decision makers across all utilities. For example, utilities should agree on a single approach for selecting and inspecting projects for QA/QC. Where a uniform set of program offerings may not be possible (e.g., on-bill financing), utilities should continue to work with contractors so they can confidently and proactively identify which offerings apply to customers prior to conducting the home energy assessment.

5.3 Data Tracking

Throughout the course of both impact and process evaluations, Opinion Dynamics identified a number of challenges related to program data tracking.

Data Collection

The HPwES Program tracking database (OTTER) provides a range of information related to efficient measures—e.g., detailed descriptions of efficient measures installed and estimates of ex ante savings realized for different heating fuel types. However, OTTER provides limited information about existing household conditions that may aid in program planning and help improve the accuracy of ex ante savings estimates. While the overall realization rate for the 2016 and 2017 program years was 109% overall, the evaluation team observed large deviations between ex ante and ex post at the individual measure level (see Section 3.1).

- **Standardize on-site data tracking and collection of household characteristics and pre-installation conditions and enable electronic reporting through program tracking database.** The utilities should consider requiring contractors to digitally upload basic information about participating households, such as primary and secondary heating fuel types, appliance information (e.g., presence of central AC), and pre-insulation R-values to OTTER. The ability to produce digital reports on these data will allow program teams (i.e., both utility staff and HPwES contractors) to plan and forecast projected savings more precisely and with less risk of substantial deviations between ex ante and ex post savings. In addition, tracking information about the characteristics of participating households will help utility program staff better characterize the participant population from year to year and more effectively tailor future offerings to that population.

Data Collection Software

Both contractors and program staff highlighted the challenges of having two separate systems for data collection (NHSurveyor) and tracking (OTTER). Current systems require field technicians to collect data, enter it in NHSurveyor and upload those data to OTTER, before the utilities are able to review and approve individual projects. Additionally, making updates to a project due to changes in the scope, requires staff to repeat this process in both software systems.

- **Integrate data collection and data tracking systems into a single platform.** The utilities have considered transitioning to a new data platform in recent years. The evaluation team recommends the program move to a single platform that allows for both data collection and tracking. An integrated system should also allow field staff to enter project details and transfer records digitally to the utilities for verification. It is also important that the platform is conducive to onsite data collection. Currently, many auditors collect information on paper and transfer those data to NHSurveyor after completing the home energy assessment. Onsite entry would eliminate this step along with any additional time requirements of tracking the data. As many contractors already experience staff capacity issues (see Section 4.4.2), simplifying the data collection and submittal process would help save implementation crews time.

5.4 Expanding Program Reach

Identifying strategies to expand the reach of the program both in terms of customers and participating contractors, were key objectives of this evaluation. Based on the non-participant survey, 29% of customers that are eligible to participate in the HPwES Program are interested in doing so (see Section 4.4.1). However, only 6% of those eligible non-participants were aware of the HPwES Program. Additionally, given current contractor capacity issues (see 4.4.2), any efforts to increase customer participation may require recruiting additional contractors to partner with the utilities to offer the program.

Marketing and Outreach

Based on the non-participant survey, 29% of customers that are eligible to participate in the HPwES Program would be interested in doing so (see Section 4.4.1). However, only 6% of those eligible non-participants were aware of the HPwES Program and its benefits prior to taking the survey. In addition to utility outreach (e.g., direct mail, NHSaves website, etc.), non-participants prefer to receive information about energy efficiency programs through newspaper or print adds (29%), via social media (24%), or from TV and radio advertisements (21%). While 2016-17 HPwES Program participants most frequently first learned about the program through either their utility's or the NHSaves website (29%), through word of mouth (24%), or through their contractor (16%), very few of these participants learned about the program through social media or TV/radio advertisements (1% for each), indicating that there may be opportunities to reach more customers via these channels. Other similar programs that operate in nearby States also rely on mass advertising and word of mouth as drivers of program awareness. Mass advertising drove awareness for Home Energy Savings Program participants in Maine (36%)[40] and NYSERDA Home Performance with ENERGY STAR participants (44%)[41]. Additionally, word of mouth drove awareness of similar programs (26% of MassSave Home Energy Services participants[42] and 24% Energy Savings Program participants in Maine[43]). The New Hampshire utilities understand this barrier and, since the evaluation period, have taken steps to address lack of awareness by

[40] Cadmus. 2011. Pg. 44
[41] Research Into Action, Inc. 2015. Pg. 36
[42] Navigant, et al. 2018. Pg. 142
[43] Cadmus. 2011. Pg. 44

seeking alternative outreach strategies to effectively reach eligible HPwES participants (e.g., paid social media advertising, additional market research, etc.).

- **The utilities should continue expanding their social media presence as a means for reaching additional participants and also leverage internal market research to identify additional outreach activities that may generate more interest in and awareness of the HPwES Program.** The utilities currently take advantage of a range of different marketing strategies identified by non-participants as their preferred ways of receiving information (e.g., TV/radio advertisements, social media, etc.). However, very few of the 2016-2017 participants surveyed first learned about the HPwES Program through those avenues. To address this, the utilities have conducted additional research aimed at building a larger social media presence as a means of attracting more interest in the program. We understand that past marketing strategies have primarily been determined by available budget and building a larger social media presence could serve as a cost-effective strategy to increase awareness of NHSaves and its programs. For example, in 2019, Eversource began leveraging Facebook and Gmail advertising in a limited capacity and experienced encouraging results; achieving 2.7 million impressions and 56,000 clicks, which resulted in 645 customers completing the HHI tool. These efforts should be expanded along with more traditional outreach strategies to reach those who do not regularly use social media.

Participating Contractor Network

Increasing the capacity of the participating contractor network by both improving existing processes and recruiting additional contractors is key to being able to expand the reach of the program. As noted, streamlining data collection processes may help reduce staff time required on a per-project basis, which may help the existing workforce serve more participants. Additionally, contractors indicated that high turnover rates and the need to find and train new staff both constitute a major drain on their efficiency and resources. Finally, as 16% of participants first learn about the program through their contractors, increasing the number of contractors within the preferred partner network may serve as an additional strategy for attracting more participants.

- **Provide additional training opportunities to help contractors build skills amongst their staff.** Participating contractors indicated that they have difficulty hiring and training new staff members. The utilities should consider sponsoring training opportunities for participating contractors that cover topics such as best practices for installation of weatherization measures for junior staff, data collection and tracking (including program software), and program finance offerings and how to discuss them with customers. We recognize that the NHSaves utilities have offered training opportunities in the past and saw low participation levels, so we recommend the utilities meet with the participating contractors to understand their specific training needs and how to deliver those trainings in a way that encourages participation.
- **Consider funding BPI and installation trainings for non-participating contractors.** Other HPwES programs have addressed contractor capacity constraints by offering fully funded trainings. Specifically, Efficiency Vermont[44] is funding BPI trainings and providing bonuses to contractors who join their preferred contractor network following the training. Energy Trust of Oregon[45] and the New Jersey Clean Energy Program[46] have also funded training for HPwES contractors in the past to build

[44] Efficiency Vermont, slides 12-14
[45] Plympton, et. al, page 2-226
[46] Plympton, et. al, page 2-228

capacity. By providing these offerings for both BPI and measure installation, the New Hampshire utilities can expand the pool of auditors and installation contractors throughout the state.

- **Develop participation channels for non-participating contractors who do not agree to program pricing.** These contractors would not be listed as "preferred contractors" and would not be part of the pool of contractors who are assigned utility-generated leads. Allowing these contractors to offer program rebates will add contractor capacity and allow participants to use a preferred contractor, while also providing incentive for contractors to agree to the program pricing scheme. Efficiency VT also plans to allow "out-of-network" contractors to participate in their HPwES program. [47]

[47] Efficiency Vermont, slide 13

Appendix A. Distribution of Space Heating and Domestic Hot Water Heating Fuel Types

Opinion Dynamics administered a survey of 2016-2017 NHSaves HPwES participants. A goal of this survey was to quantify the distribution of fuels used for space heating and domestic hot water heating (DHW) in the homes of HPwES participants. Opinion Dynamics used the distribution of fuel types (e.g., natural gas, heating oil, propane, etc.) to derive fuel-specific weights for measures where savings are dependent on the fuel. Resulting fuel mixes are applied to TRM measures' assumptions to calculate fuel-neutral deemed savings.

Primary space heating fuel survey results were leveraged for the following end-uses:

- Air sealing
- Duct Sealing
- Duct Insulation

Domestic hot water heating fuel survey results were leveraged for the following end-uses[48]:

- Pipe Insulation
- Showerhead
- Faucet Aerator

Through the participants survey, Opinion Dynamics received 210 valid responses for primary space heating fuel sources, 103 for secondary space heating fuel sources, and 211 for domestic hot water heating fuel sources. Table A-2 show the results of the breakdown of responses for these metrics by providing the count of responses as well as their percentage of the total.

Table A-2. Breakdown of Primary Heating Fuel, Secondary Heating Fuel, and Domestic Hot Water Heating Fuel Reported by Participant Survey Respondents

Fuel Type	Primary Heating Fuel	Secondary Heating Fuel*	Domestic Hot Water Heating
Electricity	9%	28%	24%
Natural Gas	25%	3%	21%
Propane	15%	20%	22%
#2 Oil/Kerosene	39%	16%	32%
Wood	5%	27%	0%
Wood Pellets	7%	15%	0%
Other	0%	0%	0%

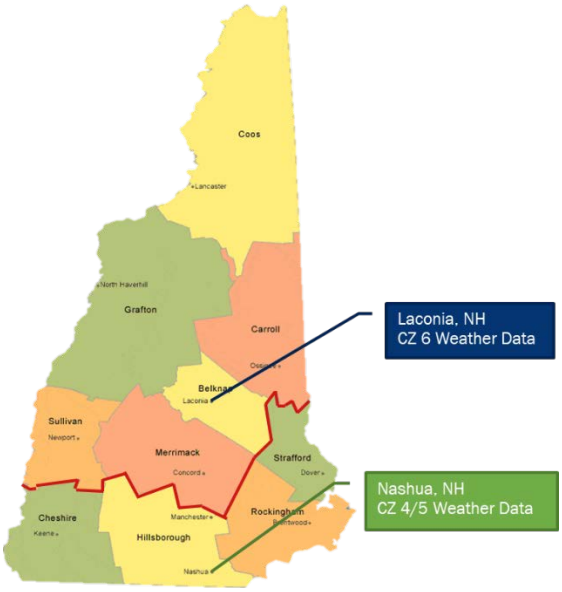
* Participants chose up to 3 secondary heating fuel types.

[48] The one response indicating a DHW fuel of wood, representing a share of less than 0.5%, was not used in weighting for any of the DHW end-uses due to lack of reliable assumptions for quantifying wood DHW fuel impacts.

Appendix B. Climate Zone Specific Parameter Weighting

To adjust assumptions in the Connecticut Potential Savings Document (PSD) for New Hampshire's unique climate, we used International Code Council's (ICC) climate zones, historical weather data, and program savings to determine climate adjustment factors for heating and cooling seasons. We used ICC climate zones for New Hampshire, illustrated in Figure B-1, and program tracking data to assign each HPwES project to a corresponding climate zone.

Figure B-1. International Code Council New Hampshire Climate Zones



Opinion Dynamics assigned projects occurring in Cheshire, Hillsborough, Rockingham, and Strafford counties to climate zone 5, and those that fell within Sullivan, Merrimack, Belknap, Carroll, Grafton, and Coos counties to climate zone 6. Table B-3 below summarizes claimed MMBTU savings for both climate zones.

Table B-3. Claimed Savings by Climate Zone

Climate Zone	Claimed MMBTU Savings	Weight
Climate Zone 5	8,589.6	60.3%
Climate Zone 6	5,653.8	39.7%

Opinion Dynamics also collected the most recent 5-year (2013-2018) historical weather data for heating degree days (HDD) and cooling degree days (CDD) from weather stations located in Nashua, NH and Laconia, NH, summarized in Table B-4. We selected these weather stations as they were both close to major population centers and each had a large amount of historical weather data to draw upon for this analysis. Our team used the calculated Climate Zone Weights (see Table B-4) to derive weighted average HDD and CDD values. We used the final adjusted HDD and CDD values as paraments, where necessary, in algorithms to develop final deemed savings values.

Table B-4. Degree days by climate zone and weighted average based on claimed MMBTU savings by zone

Weather Station	Climate Zone	HDD	CDD	HDD% Change from 2017 CT PSD	CDD% Change from 2017 CT PSD
Nashua, NH	Climate Zone 5	6,836	510	16.2%	-15.4%
Laconia, NH	Climate Zone 6	7,129	530	21.1%	-12.1%
2017 CT PSD	Climate Zone 5	5,885	603	0%	0%
Weighted Average	**Climate Adjusted**	**6,952**	**518**	**18.1%**	**-14.1%**

Appendix C. Engineering Algorithms and Assumptions Overview of Deemed Savings Review

Opinion Dynamics conducted a review of the deemed savings assumptions for the 2016–2017 NHSaves HPwES Program. These deemed values serve as the primary source for 2016–2017 evaluated program savings. We leveraged the 2017 Connecticut Potential Savings Document (CT PSD) to align with the previous sources of savings and to minimize the impact of climate adjustments when adjusting for dissimilar geographies. Additionally, we utilized results of the participant survey, see Appendix A, and adjusted the 2017 CT PSD for New Hampshire's climate, discussed in Appendix B. The following sections describe the methods for estimating savings from each measure in more detail.

LEDs

LED measures include standard and specialty lamp types. Standard and specialty bulbs use common parameters except for baseline wattage values (Wpre). Table C5-5 summarizes the parameters and sources of assumptions for LED measures.

Table C-5. Algorithms and Inputs for LEDs

Algorithms Used		Notes/Source
$MMBTU/yr = 1.04\ x\ ((\ [\![Watt]\!]\_(pre\ ) - [\![Watt]\!]\_post\ )\ x\ h\_d\ x\ 365) /1000\ x\ 1kWh/(0.0034\ MMBTU)$		Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
Energy factor due to lighting interactive effect	1.04	2017 CT PSD
$Watt_{pre}$, $LED_{standard}$	43.00	EISA 2007 code baseline for standard bulbs
$Watt_{pre}$, $LED_{specialty}$	57.00	EISA exempt bulb type; 2016 NHSaves Deemed Savings Assumption
$Watt_{post}$, LED	10.79	NEEP (2016) Residential Lighting Deep Dive Brief: A Comparison of Savings Assumptions across the Northeast and Mid-Atlantic
h_d	3.00	Operating Hours per day; NHSaves Program requisite

Table C5-6 summarizes the resulting deemed savings for the different types of LEDs offered through the program.

Table C-6. Per-Measure Savings for LEDs

Description	Wattage pre	Wattage post	ΔWatt	Hours	Deemed Value (MMBtu/bulb)
ENERGY STAR A19 LED, standard	43.00	10.79	32.21	3	0.1251
ENERGY STAR >15W Reflector LED, specialty	57.00	10.79	46.21	3	0.1795
ENERGY STAR <15W Reflector LED, specialty	57.00	10.79	46.21	3	0.1795
ENERGY STAR Candelabra LED, specialty	57.00	10.79	46.21	3	0.1795
ENERGY STAR 4-inch LED Retrofit Downlight Module, specialty	57.00	10.79	46.21	3	0.1795

Description	Wattage pre	Wattage post	ΔWatt	Hours	Deemed Value (MMBtu/bulb)
ENERGY STAR 6-inch LED Retrofit Downlight Module, specialty	57.00	10.79	46.21	3	0.1795
ENERGY STAR Globe LED, specialty	57.00	10.79	46.21	3	0.1795

Low-flow Showerheads

Low-flow showerhead measures replace existing inefficient showerheads (flow rate of 2.5 gallons per minute (gpm) or greater) with a low-flow unit (2.0 gpm or less). To account for differences in recovery efficiencies for electric and fossil fuel water heaters we applied the results of the participant survey for domestic water heating fuel share to calculate a weighted average savings value.49 Table C5-7 summarizes the parameters and sources of assumptions for low-flow showerhead measures.

Table C-7. Algorithms and Inputs for Efficient Showerheads

Algorithms Used		Notes/Source
$S\_W = n\_e \ x \ d\_e \ x \ 365 \ days \ / \ yr \ x \ (\Delta gpm)/n\_a$		Annual water savings per showerhead; Adapted from 2019 CT PSD
$MMBTU \ / \ yr = (T\_shower - T\_supply) \ x \ d\_W \ x \ [\![SH]\!] \_W \ x \ S\_W \ x \ (([\![RE]\!] \_E * [\![We]\!] \_EDHW) + ([\![RE]\!] \_F * [\![We]\!] \_FDHW))/ [\![10]\!] \text{^}6 \ Btu \ / \ MMBTU$		Annual MMBTU savings per showerhead; Adapted from 2019 CT PSD
Parameter	**Value**	**Notes/Source**
ne	1.97	Average number of showers per household per day; 2017 CT PSD
de	8.30	Median duration of shower (min); 2017 CT PSD
Δ gpm	0.48	NHSaves Program requisite, difference in flow rate of water before and after showerhead installation (gpm)
na	2.30	Number of showerheads per household; 2017 CT PSD
Tshower	105 °F	Temperature of water from shower
Tsupply	55 °F	Temperature of water into house
dW	8.345	Density of water (lb/gal); 2017 CT PSD
SHw	1.00	Specific heat of water (Btu/lb-F); 2017 CT PSD
SW	Calculated	Annual water savings per household
REE	0.98	Recovery efficiency of electric water heater; 2017 CT PSD
WeEDHW	0.24	Weight of electric DHW fuel from participant survey; See appendix Aa
REF	0.78	Recovery efficiency of fossil fuel (natural gas, oil, or propane) water heater in single family household; 2017 CT PSD
WeFDHW	0.75	Some of weights for fossil fuel DHW fuels; See appendix A*

[49] See Appendix A for DHW fuel shares from the responses of the HPwES participant survey.

* Weights do not add to 100% due to exclusion of one wood DHW fuel response from the participant survey.

Table C-8 presents the overall deemed savings for low-flow showerheads.

Table C-8. Per-Measure Savings for Efficient Showerheads

Water Heating Fuel	Deemed Value (MMBtu/showerhead)
Showerhead	0.6333

Low-flow Faucet Aerators

Low-flow faucet aerator measures generate savings by restricting water flow to 1.5 gpm or less, and subsequently minimizes water heating needs. We calculate savings for two types of faucet; standard and on/off faucet. Table C-9 summarizes the parameters and sources of assumptions for low-flow aerator measures.

Table C-9. Algorithms and Inputs for Faucet Aerators

Algorithms Used		Notes/Source
$S\_W = n\_e \ x \ d\_(e) \ x \ 365 \ days / yr \ x \ DF \ x \ (\Delta gpm)/n\_a$		Adapted from 2017 CT PSD
$MMBTU / yr = (T\_Faucet - T\_Supply) \ x \ d\_W \ x \ 〚SH〛\_W \ x \ S\_W \ x \ (〚RE〛\_E * 〚We〛\_EDHW) + (〚RE〛\_F * 〚We〛\_FDHW) / 〚10〛\^6 \ Btu / MMBTU$		Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
n_e	42.90	Number of uses per household per day; 2017 CT PSD
d_e	0.6167	Median duration of faucet use (min); 2017 CT PSD
DF	0.795	Drain factor; 2017 CT PSD
Δgpm, On/Off	0.17	NHSaves Program requisite (On/Off), difference in flow rate of water before and after aerator installation (gpm)
Δgpm, Standard	0.41	NHSaves Program requisite (Standard), difference in flow rate of water before and after aerator installation (gpm)
n_a	5.10	Number of faucets per household; 2017 CT PSD
T_{Faucet}	80 °F	Temperature of water from faucet; 2017 CT PSD
T_{Supply}	55 °F	Temperature of water into house; 2017 CT PSD
d_W	8.345	Density of water (lb/gal); 2017 CT PSD
SH_w	1.00	Specific heat of water (Btu/lb-F); 2017 CT PSD
S_W	Calculated	Annual water savings per household
RE_E	0.98	Recovery efficiency of electric water heater; 2017 CT PSD
We_{EDHW}	0.24	Weight of electric DHW fuel from participant survey; See appendix A[a]

Algorithms Used		Notes/Source
RE_F	0.78	Recovery efficiency of fossil fuel (natural gas, oil, or propane) water heater in single family household; 2017 CT PSD
We_{FDHW}	0.75	Some of weights for fossil fuel DHW fuels; See appendix A[a]

a. Weights do not add to 100% due to exclusion of one wood DHW fuel response from the participant survey.

Table C-10 displays the deemed savings for both on/off and standard faucet aerators.

Table C-10. Per-Measure Savings for Faucet Aerators

Type of Aerator	Deemed Value (MMBtu/aerator)
On/off (maximum 2.03 GPM)	0.06499
Standard (maximum 1.79 GPM)	0.15674

Attic Insulation

Attic insulation measures insulate at thermal boundaries between and unconditioned attic and conditioned space below. Examples of attic insulation measures include blow in cellulose on top of an attic floor and an attic hatch insulating cover. Table C-11 summarizes the parameters and sources of assumptions for attic insulation measures.

Table C-11. Algorithms and Inputs for Attic Insulation

Algorithms Used		Notes/Source
$(\ 〚MMBTU〛\_Heating\ /\ year)\ /\ (sq\ ft) = (1/R\_existing - 1/R\_new\ )x\ HDD\ x\ 24\ x\ F\_Adj\ \ x\ \ 1/(\ 〚10〛\ ^6\ \ Btu\ /\ MMBTU)$		Heating savings; Adapted from 2017 CT PSD
$(\ 〚MMBTU〛\_Cooling\ /\ year)\ /\ (sq\ ft) = (1/R\_existing - 1/R\_new\ )x\ \Delta T\_Bin\ \ x\ \ 1\ /(\ 〚SEER〛\_(B,combined)\ x\ 1{,}000)\ x\ 1/(\ 〚10〛\ ^6\ \ Btu\ /\ MMBTU)$		Cooling savings using weighted average of SEER for CACs and RACs with the portion of CACs and RACs in NH; Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
$R_{existing}$	Various	Existing R-value; From actual
R_{New}	Various	New R-Value; From actual
HDD	6,952	Weighted heating degree days, see Appendix B for details.
F_{adj}	0.64	ASHRAE adjustment factor; 2017 CT PSD
ΔT_{BIN}	3,340	Value of 3,888 from 2017 CT PSD adjusted and weighted based on 15% and 12% decrease in CDD for zones 4/4 and 6, respectively; See Appendix B for details

Algorithms Used		Notes/Source
$SEER_{B, Combined}$	12.63	Weighted average of SEER values for CAC and RAC[a]
[a] Based on baseline SEER values of 14.00 for CAC and 11.90 for RAC, both from federal code CFR 1-1-17, section 430.32. Weighted average calculated using CAC and RAC shares in NH homes of 23% and 43%, respectively, taken from *New Hampshire HVAC Load and Savings Research - Final Report 040513*.		

Table C-12 displays the heating deemed savings for attic insulation savings.

Table C-12. Attic Insulation Heating Savings (MMBtu/ft2)

Pre \ Post	20	30	40	50	60
3	0.0303	0.0320	0.0329	0.0335	0.0338
6	0.0125	0.0142	0.0151	0.0157	0.0160
9	0.0065	0.0083	0.0092	0.0097	0.0101
15	0.0018	0.0036	0.0044	0.0050	0.0053
20	0.0000	0.0018	0.0027	0.0032	0.0036

Table C-13 displays the cooling deemed savings for Attic insulation savings.

Table C-13. Attic Insulation Cooling Savings (MMBtu/ft2)

Pre \ Post	20	30	40	50	60
3	0.0003	0.0003	0.0003	0.0003	0.0003
6	0.0001	0.0001	0.0001	0.0001	0.0001
9	0.0001	0.0001	0.0001	0.0001	0.0001
15	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000

Exterior Wall Insulation

Exterior wall insulation measures insulate at exterior wall thermal boundaries between interior conditioned spaces and the outdoors. Examples include spray-in insulation underneath exterior siding. Table C-14 summarizes the parameters and sources of assumptions for exterior wall insulation measures.

Table C-14. Algorithms and Inputs for Exterior Wall Insulation

Algorithms Used	Notes/Source
$(〚MMBTU〛\_Heating\ /\ year)\ /\ (sq\ ft) = (1/R\_existing - 1/R\_new)\ x\ HDD\ x\ 24\ x\ F\_Adj\ \ x\ GF\ x\ 1\ /(〚10〛\ ^6\ Btu\ /\ MMBTU)$	Heating savings; Adapted from 2017 CT PSD

Algorithms Used		Notes/Source
$(\ 〚MMBTU〛\ \_Cooling\ /\ year)\ /\ (sq\ ft)$ $= (1/R\_existing$ $- 1/R\_new\ )x\ \Delta T\_Bin\ \ x\ \ 1$ $/(\ 〚SEER〛\ \_(B, combined)\ x\ 1{,}000)\ x\ 1$ $/(\ 〚10〛\ \hat{}6\ \ Btu\ /\ MMBTU)$		Cooling savings using weighted average of SEER for CACs and RACs with the portion of CACs and RACs in NHa; Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
Rexisting	Various	Existing R-value; From actual
RNew	Various	New R-Value; From actual
HDD	6,952	Weighted heating degree days, see Appendix B for details.
Fadj	0.64	ASHRAE adjustment factor; 2017 CT PSD
GF, above grade	1.00	Grade Factor, assuming all above grade; 2017 CT PSD
ΔTBIN	3,340	Value of 3,888 from 2017 CT PSD adjusted and weighted based on 15% and 12% decrease in CDD for zones 4/4 and 6, respectively; See Appendix B for details
SEERB, Combined	12.63	Weighted average of SEER values for CAC and RAC[a]
a Based on baseline SEER values of 14.00 for CAC and 11.90 for RAC, both from federal code CFR 1-1-17, section 430.32. Weighted average calculated using CAC and RAC shares in NH homes of 23% and 43%, respectively, taken from New Hampshire HVAC Load and Savings Research - Final Report 040513.		

Table C-15 displays the deemed heating savings for exterior wall insulation.

Table C-15. Exterior Wall Insulation Heating Savings (MMBtu/ft2)

Post / Pre	10	13	17	20	23
4	0.0160	0.0185	0.0204	0.0214	0.0221
5	0.0107	0.0131	0.0151	0.0160	0.0167
6	0.0071	0.0096	0.0115	0.0125	0.0132
8	0.0027	0.0051	0.0071	0.0080	0.0087
10	-	0.0025	0.0044	0.0053	0.0060

Table C-16 displays the deemed cooling savings for exterior wall insulation.

Table C-16. Exterior Wall Insulation Cooling Savings (MMBtu/ft2)

Post / Pre	10	13	17	20	23
4	0.00013	0.00015	0.00017	0.00018	0.00018
5	0.00009	0.00011	0.00013	0.00013	0.00014
6	0.00006	0.00008	0.00010	0.00010	0.00011
8	0.00002	0.00004	0.00006	0.00007	0.00007

Pre \ Post	10	13	17	20	23
10	-	0.00002	0.00004	0.00004	0.00005

Floor Insulation

Floor insulation measures in the HPwES Program include those installed beneath the floor of a conditioned space separated by a below unconditioned space. An example of this is insulation on the ceiling of an unconditioned basement separating a conditioned first floor. Table C-17 summarizes the parameters and sources of assumptions for floor insulation measures.

Table C-17. Algorithms and Inputs for Floor Insulation

Algorithms Used		Notes/Source
$(MMBTU\ /\ year)\ /\ (sq\ ft)$ $= (1/R\_existing$ $- 1/R\_new\ )x\ HDD\ x\ 24\ x\ F\_Adj\ \ x\ GF\ x\ 1$ $/(\ 〚10〛\ ^6\ Btu\ /\ MMBTU)$		Heating savings only for this measure; Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
$R_{existing}$	Various	Existing R-value; From actual
R_{new}	Various	New R-Value; From actual
HDD	6,952	Weighted heating degree days, see Appendix B for details.
F_{adj}	0.64	ASHRAE adjustment factor; 2017 CT PSD
GF, above grade	1.00	Adjustment for a floor over unconditioned space which is 100% above grade; 2017 CT PSD

Table C-18 displays the deemed savings for floor insulation measures.

Table C-18. Floor Insulation (MMBtu/ft2)

Pre \ Post	10	13	17	20	23
4	0.0160	0.0185	0.0204	0.0214	0.0221
5	0.0107	0.0131	0.0151	0.0160	0.0167
6	0.0071	0.0096	0.0115	0.0125	0.0132
8	0.0027	0.0051	0.0071	0.0080	0.0087
10	-	0.0025	0.0044	0.0053	0.0060

Basement Wall Insulation

Basement wall insulation in the HPwES Program include measures both above and below grade. Examples include foam board material installed between the rim joist and spray foam on basement walls. Table C-19 summarizes the parameters and sources of assumptions for basement wall insulation measures.

Table C-19. Algorithms and Inputs for Basement Wall Insulation

Algorithms Used		
$(\ 〚MMBTU〛\_Heating\ /\ year)\ /\ (sq\ ft)$ $= (1/R\_existing$ $- 1/R\_new\ )x\ HDD\ x\ 24\ x\ F\_Adj\ \ x\ GF\ x\ 1/(\ 〚10〛\ ^6\ \ Btu\ /\ MMBTU)$		Heating savings; Adapted from 2017 CT PSD
$(\ 〚MMBTU〛\ \_Cooling\ /\ year)\ /\ (sq\ ft)$ $= (1/R\_existing$ $- 1/R\_new\ )x\ \Delta T\_Bin\ \ x\ \ 1/(\ 〚SEER〛\ \_(B, combined)\ x\ 1{,}000)\ x\ 1$ $/(\ 〚10〛\ ^6\ \ Btu\ /\ MMBTU)$		Cooling savings using weighted average of SEER for CACs and RACs with the portion of CACs and RACs in NH; Adapted from 2017 CT PSD
Parameter	**Value**	**Notes/Source**
Rexisting	Various	Existing R-value; From actual
RNew	Various	New R-Value; From actual
HDD	6,952	Weighted heating degree days, see Appendix B for details.
Fadj	0.64	ASHRAE adjustment factor; 2017 CT PSD
GF, below grade	0.60	Grade factor assuming all below grade; 2017 CT PSD
ΔTBIN	3,340	Value of 3,888 from 2017 CT PSD adjusted and weighted based on 15% and 12% decrease in CDD for zones 4/4 and 6, respectively; See Appendix B for details
SEERB, Combined	12.63	Weighted average of SEER values for CAC and RAC[a].
a Based on baseline SEER values of 14.00 for CAC and 11.90 for RAC, both from federal code CFR 1-1-17, section 430.32. Weighted average calculated using CAC and RAC shares in NH homes of 23% and 43%, respectively, taken from New Hampshire HVAC Load and Savings Research - Final Report 040513.		

Table C-20 displays the heating deemed savings for basement wall insulation.

Table C-20. Basement Wall Insulation Heating Savings (MMBtu/ft2)

Post / Pre	10	13	17	20	23
4	0.00961	0.01109	0.01225	0.01281	0.01323
5	0.00641	0.00789	0.00905	0.00961	0.01003
6	0.00427	0.00575	0.00691	0.00748	0.00789

Pre \ Post	10	13	17	20	23
8	0.00160	0.00308	0.00424	0.00481	0.00522
10	-	0.00148	0.00264	0.00320	0.00362

Table C-21 displays the cooling deemed savings for basement wall insulation.

Table C-21. Basement Wall Insulation Cooling Savings (MMBtu/ft2)

Pre \ Post	10	13	17	20	23
4	0.00961	0.01109	0.01225	0.01281	0.01323
5	0.00641	0.00789	0.00905	0.00961	0.01003
6	0.00427	0.00575	0.00691	0.00748	0.00789
8	0.00002	0.00308	0.00424	0.00481	0.00522
10	-	0.00148	0.00264	0.00320	0.00362

Air Sealing

Air sealing measures derive savings from CFM reductions verified by blower-door tests performed before and after implementation. Examples of air sealing measures could include spray foam in cracks, door weather-stripping, and door sweeps.

The 2017 CT PSD provides deemed heating and cooling savings values per CFM reduction by air sealing measure type obtained through Residential Energy Modeling (REM). Table C-22 provides a summary of these values.

Table C-22. Heating and cooling savings per CFM reduction by heating fuel from 2017 CT PSD sec. 4.4.4

Heating					Cooling		
Electric Resistance (kWh/CFM)	Heat Pump (kWh/CFM)	Natural Gas (Ccf/CFM)	Oil (Gal/CFM)	Propane (Gal/CFM)	CAC (kWh/CFM)	RAC (kWh/CFM)	PTAC (kWh/CFM)
2.64	1.32	0.117	0.087	0.131	0.06	0.02	0.02

To account for climate differences between Connecticut and New Hampshire, we adjust the values by the weighted NH statewide average percent change in both heating and cooling degree days[50]. These adjusted values were then converted into common units of MMBTU/CFM and weighted with the shares of their respective heating and cooling types from the participant survey resulting in a weighted average deemed value for air sealing per CFM reduction shown in Table C-2351.

However, the 2017 CT PSD approach to evaluating air sealing measure savings incorporates ancillary cooling savings in the algorithm assumptions, preventing the extraction and reporting of ancillary cooling savings. Therefore, at the request of the NHSaves program administrators, the evaluation team calculated a weighted average ancillary cooling savings per CFM from the 63 visited sites in the HPwES program evaluation receiving air sealing or weatherization treatments, and their individual cooling equipment, resulting in an ancillary

[50] See Appendix B for New Hampshire climate zone methodology.
[51] See Appendix A for home heating and cooling type shares from the responses of the HPwES participant survey.

savings of 0.000146 MMBTU/CFM. Subtracting that value from the 2017 CT PSD deemed value, results in a per CFM air sealing measure savings value listed in Table C-23.

Table C-23. Per-Unit Savings for Air Sealing

	Evaluation Value (MMBTU/CFM)
Savings per CFM reduction	0.012787

HVAC Ancillary Savings

Heating ancillary savings arise from both reduced furnace fan runtime or reduced boiler pump operation due to HVAC load reductions resulting from weatherization measures. The evaluation team reviewed the deemed savings presented in the 2013 New Hampshire HVAC Load and Savings Research report and determined that the savings are reasonable and appropriate for continued application.

In the 2017 updated deemed savings assumptions, ancillary cooling savings are accounted for in air sealing and weatherization measures. To isolate program ancillary cooling savings , the evaluation team calculated a per home ancillary cooling savings value from the 63visited sites receiving air sealing or weatherization measures in the HPwES program evaluation , their individual cooling equipment, and the cumulative CFM reductions at each site. Table C-24 displays the deemed savings for HVAC Ancillary Savings as well as the evaluated per home average savings from the 63 sites.

Table C-24. Per-Measure Savings for HVAC Ancillary Savings

Equipment Impact (If primary)	Ancillary Savings Type	Deemed Value (MMBtu/home)	Source/Notes
Furnace	Furnace fan	0.2934	New Hampshire HVAC Load and Savings Research, Final Report, Cadmus April 5, 2013
Boiler	HW boiler circulation pump	0.0307	
CAC	Reduced cooling runtime	0.2627	
RAC (per unit)		0.0785	
RAC (per home)		0.1706	
Evaluated Average Cooling	Average System Fan Runtime Reduction	0.1780	Derived from 63 HPwES site visits receiving air sealing or weatherization measures, where 60% had RACs, 29% CAC, and 11% had no cooling.

Duct Air Sealing

Duct air sealing measures improve efficiency of air distribution systems by mitigating leakage of conditioned air from the ductwork. To quantify savings, a duct blaster test must be performed before and after implementation at a constant home pressure of 25 Pascal, supplied by a blower door.

The 2017 CT PSD provides deemed heating and cooling savings values per CFM reduction by type obtained through Residential Energy Modeling (REM). Table C-25 provides a summary of these values organized by grouping savings type by electric and fossil fuels.

Table C-25. Savings in units per CFMs reduced at 25 Pa for heating and cooling types by fuel category from the 2017 CT PSD

Electric Fuel					Fossil Fuel		
Electric Forced Air (kWh/CFM)	Heat Pumps (kWh/CFM)	Geothermal (kWh/CFM)	Heating Fan (kWh/CFM)	Central AC Cooling (kWh/CFM)	Natural Gas (Ccf/CFM)	Oil (gallons/CFM)	Propane (gallons/CFM)
7.693	3.847	2.564	1.100	1.059	0.340	0.252	0.383

To account for climate differences between Connecticut and New Hampshire, we adjust the values by the weighted NH statewide average percent change in both heating and cooling degree days52. These adjusted values were then converted into common units of MMBTU/CFM and weighted with the shares of their respective heating and cooling types from the participant survey resulting in a weighted average deemed value for air sealing per CFM reduction shown in Table C-26.53

Table C-26. Per-Unit Savings for Duct Air Sealing

	Deemed Value (MMBTU/CFM)
Savings per CFM Reduction	0.0236

Duct Insulation

Duct Insulation in the HPwES Program includes measures for reducing heating and cooling losses by insulating ductwork in an unconditioned space with material having an equal to or greater than R value of 6.

The 2017 CT PSD provides deemed heating and cooling savings values per square foot insulation by type obtained through NAIMA 3E Plus modeling software. Table 23 provides a summary of these values by duct location (basement or attic) and type (supply or return).

Table C-27 summarizes the parameters and sources of assumptions for calculating duct insulation savings.

Table C-27. Duct insulation heating and cooling savings per sq ft by type from the 2017 CT PSD

Duct location	Heating		Cooling
	Heat Pump (kWh/ft2)	All Fossil Fuels (MMBTU/ft2)	CAC (kWh/ft2)
Return basement	3.15	0.02866	0.2327
Supply basement	13.05	0.1187	0.7721
Return Attic	4.194	0.03816	0.8209
Supply Attic	14.46	0.1316	1.425

To account for climate differences between Connecticut and New Hampshire, we adjust the values by the weighted NH statewide average percent change in both heating and cooling degree days52. These adjusted values were then weighted with the shares of their respective heating and cooling types from the participant survey resulting in a weighted average deemed value for air sealing per CFM reduction shown in Table C-2853.

[52] See Appendix B for New Hampshire climate zone methodology.
[53] See Appendix A for home heating and cooling type shares from the responses of the HPwES participant survey.

Table C-28. Per-Unit Savings for Duct Insulation

Duct Branch	Deemed Value (MMBtu/ft2)
Return	0.0314
Supply	0.1174

Programmable Thermostats

The 2016-2017 HPwES program offer both a programmable thermostat as well as a Wi FI enabled thermostat measure. Deemed savings values from previous evaluation research were carried over. Table C-29 summarizes the parameters and sources of assumptions for calculating programmable thermostat savings.

Table C-29. Per-Measure Savings for Programmable Thermostats

Base Thermostat Type	Efficient Thermostat Type	Deemed Value (MMBtu/thermostat)	Source/ Notes
Non-programmable	Programmable	2.799	New Hampshire HPwES Impact Evaluation Report. Cadmus, 2011
Programmable	Programmable	2.799	New Hampshire HPwES Impact Evaluation Report. Cadmus, 2011
Non-programmable	Wi Fi Enabled	6.900	WI-FI Programmable Thermostat Pilot Program Evaluation. Cadmus 2013, performed for Liberty Utilities
Programmable	Wi Fi Enabled	6.900	WI-FI Programmable Thermostat Pilot Program Evaluation. Cadmus 2013, performed for Liberty Utilities

Refrigerator Vouchers

Refrigerator replacement savings are calculated from the difference between metered energy consumption categorized into eight strata and the equivalent ENERGY STAR standard energy consumption with an adjustment factor applied to account for in-situ performance. Table C-25 summarizes the parameters and sources of assumptions for calculating savings for refrigerator replacement measures.

Table C-30. Parameter assumptions for refrigeration voucher measure

Parameter	Value	Notes/Source
ENERGY Star Standard Refrigerator Annual Consumption (kWh)	452	www.energystar.gov/products/spec (Refrigeration Version 5)
SLF_new	0.881	Site/Lab Factor, an adjustment for real-world performance (site) versus testing (lab); 2017 CT PSD

Table C-26 summarizes the deemed savings for each metered energy strata threshold.

Table C-31. Per-Unit Savings for Refrigerator Vouchers

Voucher Amount	PSNH Metered KWH Usage Threshold	ENERGY Star Standard	KWH Savings per unit	Deemed Value (MMBtu/unit)
$ 100	0 to 1,000	452	483	1.647
$ 150	1,001 to 1,200	452	659	2.248
$ 200	1,201 to 1,400	452	835	2.850
$ 250	1,401 to 1,600	452	1,011	3.451
$ 300	1,601 to 1,800	452	1,188	4.052
$ 350	1,801 to 2,000	452	1,364	4.653
$ 400	2,001 to 2,200	452	1,540	5.254
$ 450	2,201 to 2,400	452	1,716	5.855

Domestic Hot Water Heater Tank Wrap

Domestic hot water heater tank wrap measures generate energy savings by reducing standby heat loss through insulating the exterior of hot water heater tanks with a fiberglass insulation blanket. Table C-27 summarizes the parameters and sources of assumptions for calculating domestic hot water heater tank wrap savings.

Table C-32. Algorithms and Inputs for Tank Wraps

Algorithms Used		Notes/Source
$ADHW = GPY\ x\ 8.3\ lbs\ /\ gal\ \ x\ (T\_dhw - T\_aiw)$		Annual domestic hot water load; Adapted from the 2017 CT PSD
$MMBTU\ /\ yr = ADHW\ x\ (1/\ [\![EF]\!]\ \_B - 1/\ [\![EF]\!]\ \_I\ )x\ 1/(\ [\![10]\!]\ ^6\ Btu\ /\ MMBTU)$		Annual BTU savings from water heating; Adapted from the 2017 CT PSD
Parameter	**Value**	**Notes/Source**
GPY	17,289	DHW Event Generator (NREL 2010) referenced in the 2017 CT PSD
Dw	8.3	Density of water (lb/gal); 2017 CT PSD
Tdhw	125	Domestic hot water heater set point (◦F); 2017 CT PSD
Taiw	57	Average annual incoming water temperature (◦F); 2017 CT PSD
EFB	0.860	Energy factor of uninsulated water heater tank; 2017 CT PSD
EFI	0.880	Energy factor of insulated water heater tank; 2017 CT PSD

Table C-28 displays the deemed savings for tank wrap savings.

Table C-33. Per-Measure Savings for Tank Wraps

	Deemed Value (MMBtu/install)
Savings per Water Heater Tank Wrap	0.259

Pipe Insulation

Pipe insulation measures reduce heat loss by insulating hot water pipes in unconditioned spaces. Table C-34 provides a summary of the 2017 CT PSD deemed savings for DHW pipe insulation by fuel type and pipe diameter.

Table C-34. Fuel-specific annual savings per linear foot of pipe insulation for two pipe diameter ranges.

Pipe Diameter (inches)	Electric (kWh/ft)	Gas (Ccf/ft)	Oil (Gallons/ft)	Propane (Gallons/ft)
<3/4"pipe	14.10	0.75	0.63	0.82
≥3/4"pipe	20.50	1.10	0.91	1.20

To arrive at a weighted average annual MMBTU/ft savings values by pipe diameter, we applied the distribution of DHW fuel types from the participant survey54 against the 2017 CT PSD deemed savings by fuel type. Table C-35 displays the calculated weighted average MMBTU/ft values by pipe diameter range.

Table C-35. Per-Measure Savings for Pipe Insulation

Pipe Diameter (in)	Deemed Value (MMBtu/ft)
<3/4"pipe	0.0729
≥3/4"pipe	0.1062

Hot Water Temperature Setback

Hot water temperature setback in the HPwES Program involves lowering the setpoint of a domestic hot water heater. Savings from this measure only arrive from clothes washers with dishwashers having been shown to have an increased electricity consumption after a water temperature setback. Thus, savings for this measure is calculated by subtracting the increased dishwasher electricity usage from the clothes washer energy savings. Table C-36 documents the inputs and methodology for estimating hot water temperature setback savings for the 2016-2017 HPwES program.

Table C-36. Algorithms and Inputs for Hot Water Temperature Setback

Algorithms Used	Notes/Source
$MMBTU\ /\ yr = [\![MMBTU]\!]\_EDHW\ /\ yr * [\![We]\!]\_EDHW + [\![MMBTU]\!]\_GDHW\ /\ yr * [\![We]\!]\_GDHW + [\![MMBTU]\!]\_ODHW\ /\ yr * [\![We]\!]\_ODHW + [\![MMBTU]\!]\_PDHW\ /\ yr * [\![We]\!]\_PDHW$	Weighted average watering heating savings given shares of water heating fuel types from the HPwES participant survey

[54] See Appendix A for DHW fuel shares from the responses of the HPwES participant survey.

Algorithms Used		Notes/Source
$[\![MMBTU]\!]\_EDHW / yr = ((D\_w \ x \ W\_cw \ x \ (T\_BR - T\_AR))/(3412 \ x \ [\![EF]\!]\_E) * [\![\%Homes]\!]\_cw - (D\_w \ x \ W\_dw \ x \ (T\_BR - T\_AR))/3412 * [\![\%Homes]\!]\_dw) * [\![Fuel]\!]\_conv$		Electric water heating fuel savings per home at population level; Adapted from 2017 CT PSD
$[\![MMBTU]\!]\_GDHW / yr = (D\_w * W\_cw \ x \ (T\_BR - T\_AR))/(102{,}900 * [\![EF]\!]\_F) * [\![Fuel]\!]\_conv$		Natural Gas water heating fuel savings; Adapted from 2017 CT PSD
$[\![MMBTU]\!]\_ODHW / yr = (D\_w * W\_cw \ x \ (T\_BR - T\_AR))/(138{,}690 * [\![EF]\!]\_F) * [\![Fuel]\!]\_conv$		Oil water heating fuel savings per home at population level; Adapted from 2017 CT PSD
$[\![MMBTU]\!]\_PDHW / yr = (D\_w * W\_cw \ x \ (T\_BR - T\_AR))/(91{,}330 * [\![EF]\!]\_F) * [\![Fuel]\!]\_conv$		Propane water heating fuel savings per home at population level; Adapted from 2017 CT PSDa
Parameters	**Value**	**Notes/Source**
Dw	8.3	Density of water (lb/gal); 2017 CT PSD[a]
Wcw	2065.8	Annual clothes washer hot water consumption (gal); 2017 CT PSD[a]
TBR	140	Temperature of hot water from tank before reset; 2017 CT PSD[a]
TAR	125	Temperature of hot water from tank after reset; 2017 CT PSD[a]
EFE	0.95	Energy factor of electric water heater; 2017 CT PSD[a]
%Homescw	98.5%	Share of homes having a clothes washer from 2016-2017 program evaluation site visit observations for 67 homes
Wdw	933.1	Annual dishwasher hot water consumption (gal); 2017 CT PSD[a]
%Homesdw	80.6%	Share of homes having a dishwasher from 2016-2017 program evaluation site visit observations for 67 homes
EFF	0.62	Energy factor of fossil fuel water heater; 2017 CT PSD[a]
Fuelconv	Varies	Conversion of fuel type quantity to common energy units (MMBTU). See Table C-37.
WeEDHW	10%	Electric water heating fuel share from the responses of the HPwES participant survey[b]
WeGDHW	25%	Natural gas water heating fuel share from the responses of the HPwES participant survey[b]
WeODHW	38%	Oil water heating fuel share from the responses of the HPwES participant survey[b]
WePDHW	15%	Propane water heating fuel share from the responses of the HPwES participant survey[b]
a Measure removed for 2017 CT PSD.		

Algorithms Used	Notes/Source
b See Appendix A for DHW fuel shares from the responses of the HPwES participant survey	

Table C-37 summarizes conversion factors for the different fuel types used in domestic hot water heating.

Table C-37. Fuel type conversion factors

Fuel Type	Fuel Conversion
Electricity	0.0034 MMBTU/1 kWh
Natural Gas	0.1037 MMBTU/1 ccf
#2 Oil/Kerosene	0.1385 MMBTU/1 gal
Propane	0.0913 MMBTU/1 gal

Table C-38 displays the deemed savings for hot water temperature setback measures.

Table C-38. Per-Measure Savings for Hot Water Temperature Setback

Water Heating Fuel	Deemed Value (MMBtu/install)
New Hampshire DHW Fuel Mix	0.325

Appendix D. Consumption Analysis Model Results

Opinion Dynamics also conducted a consumption analysis using electric and natural gas billing data. As approximately 43% of HPwES participants heat their homes primarily with a delivered fuel (e.g., fuel oil, propane, kerosene, etc.), our team was unable to capture the full impact of the HPwES Program with this analysis. As such, we estimate ex post results using an engineering analysis (see Section 0) and use the consumption analyses as an additional point of comparison.

Model Results

The final electric model is specified below, along with complete model results (see Table D-39).

$$ADC_{it} = B_h + B_1 Post_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 HDD_{it} * Post_{it} + B_5 CDD_{it} * Post_{it} + B_6 Boil + B_7 Furn_{it} + B_8 LED_{it} + B_9 Fridge_{it} + B_{10} Month_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (in kWh) for the billing period
$Post$ = Indicator for treatment group in post-participation period (coded "0" if treatment group in pre-participation period or comparison group in all periods, coded "1" in post-participation period for treatment group)
HDD = Average daily heating degree days from NCDC
CDD = Average daily cooling degree days from NCDC
$Boil$ = Indicator for receipt of boiler replacement
$Furn$ = Indicator for receipt of furnace replacement
LED = Indicator for receipt of LEDs
$Fridge$ = Indicator for receipt of refrigerator replacement
$Month$ = Month indicator
B_h= Average household-specific constant
ε_{it} = Error term

Table D-39. Final Electric Model Results

Term	Estimate	Standard Error	Statistic	P Value
Post	0.46839	0.24772	1.89	0.0587
CDD	4.90286	0.19589	25.03	<.0001
HDD	0.26673	0.01247	21.4	<.0001
Post * CDD	-0.46841	0.25226	-1.86	0.0633
Post* HDD	0.03146	0.00918	3.43	0.0006
Boiler	-0.09086	0.00823	-11.04	<.0001
Furnace	-0.07471	0.00935	-7.99	<.0001
LED	-1.05751	0.22107	-4.78	<.0001
Refrigerator	-2.60784	0.63626	-4.10	<.0001
DiffMonth2	-1.25713	0.23171	-5.43	<.0001
DiffMonth3	-2.11073	0.24833	-8.5	<.0001

Term	Estimate	Standard Error	Statistic	P Value
DiffMonth4	-2.20279	0.34615	-6.36	<.0001
DiffMonth5	-0.93215	0.45872	-2.03	0.0422
DiffMonth6	3.10207	0.53185	5.83	<.0001
DiffMonth7	4.55573	0.57276	7.95	<.0001
DiffMonth8	5.24464	0.55706	9.41	<.0001
DiffMonth9	2.47041	0.50787	4.86	<.0001
DiffMonth10	-0.58166	0.40509	-1.44	0.151
DiffMonth11	-0.90756	0.29238	-3.1	0.0019
DiffMonth12	0.91014	0.24223	3.76	0.0002

The final gas model is specified below, along with complete model results (see Table D-40).

$$ADC_{it} = B_h + B_1 Post_{it} + B_2 HDD_{it} + B_3 HDD_{it} * Post_{it} + B_4 Month_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (in kWh) for the billing period
$Post$ = Indicator for treatment group in post-participation period (coded "0" if treatment group in pre-participation period or comparison group in all periods, coded "1" in post-participation period for treatment group)
HDD = Average daily heating degree days from NCDC
$Month$ = Month indicator
B_h = Average household-specific constant

Table D-40. Final Gas Model Results

Term	Estimate	Standard Error	Statistic	P Value
Post	0.28931	0.05875	4.92	<.0001
HDD	0.13263	0.0048	27.66	<.0001
Post * HDD	-0.03211	0.00241	-13.33	<.0001
month2	-0.185	0.08571	-2.16	0.0309
month3	-0.24531	0.09419	-2.6	0.0092
month4	-0.47753	0.12478	-3.83	0.0001
month5	-0.5881	0.16958	-3.47	0.0005
month6	-0.40536	0.19695	-2.06	0.0396
month7	-0.35687	0.20585	-1.73	0.083
month8	-0.49406	0.20501	-2.41	0.016
month9	-0.50818	0.19352	-2.63	0.0086

Term	Estimate	Standard Error	Statistic	P Value
month10	-0.8439	0.15876	-5.32	<.0001
month11	-0.74102	0.11435	-6.48	<.0001
month12	-0.40135	0.08857	-4.53	<.0001

Appendix E. Participant and Non-Participant Survey Instruments

New Hampshire Utilities

Home Performance with ENERGY STAR Program

Final Draft Participant Survey
May 2019

Sample Variables

<HEAT_FUEL> = Primary Heating Fuel
<PY> = Program Year
<WX> = Participant received insulation measures
<ADDR> = Participant street address

Objectives

This survey supports the evaluation of the New Hampshire Utilities 2016 and 2017 Home Performance with ENERGY STAR Program. Opinion Dynamics will mail all participants from 2016 and 2017 invitations to complete the survey online. The key objectives of this survey are to:

- Assess the effectiveness of program design and delivery; and
- Gauge participant satisfaction and identify opportunities for improvement;

Secondary objectives of this survey are to:

- Identify strategies to attract interest in the program; and
- Verify gross savings from HPwES participants.

Introduction

Thank you very much for taking the time to complete this survey based on your participation in the <PY> Home Performance with ENERGY STAR Program. As a thank you for completing the survey, you will receive a $10 VISA gift card.

New Hampshire Utilities

Home Energy Assistance and Home Performance with Energy Star

Draft Non - Participant Survey
October 2019

Sample Variables

Variable	Description
<UTILITY>	Eversource, Liberty, NHEC, or Unitil
<ADDR>	Address
<LI>	Low income flag based on rate information

Programming Variables

Price per square foot of each fuel type at the threshold that qualifies for the HPwES program based on HHI.

[GEN gas_price = $0.73/sq. ft]
[GEN elec_HP_price = $1.17/sq. ft]
[GEN elec_res_price = $2.93/sq. ft]
[GEN oil_price = $1.50/sq. ft]
[GEN prop_price = $2.17/sq. ft]
[GEN wood_price= $1.37/sq. ft]
[GEN pellet_price = $1.26/sq. ft]
[GEN kero_price = $1.84/sq. ft]
[GEN coal_price = $1.04/sq. ft]

Objectives

This survey supports the evaluation of the New Hampshire Utilities 2016 and 2017 Home Energy Assistance (HEA) and Home Performance with ENERGY STAR (HPwES) programs. Opinion Dynamics will mail non-participants from 2016 and 2017 invitations to complete the survey online or, for pre-identified HEA-eligible non-participants, by dialing in to complete the survey over the telephone. The primary objectives of this survey are to:

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