



# Connecticut HES Air Sealing, Duct Sealing, and Insulation Practices Report (R151)

FINAL

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SUBMITTED TO:  
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## Executive Summary

This report presents the results of the Connecticut Home Energy Solutions (HES) Air Sealing, Duct Sealing, and Insulation practices study (R151). The Connecticut Energy Efficiency Board (EEB) contracted NMR Group, Inc., to conduct a study to identify opportunities for the program to increase savings related to these three measures of interest through the program. Due to the divergent ways in which participants enter the program, along with vendor and property owner decision making, this study does not include HES-Income Eligible or multifamily projects.

This study draws on multiple perspectives and consists of eight primary research tasks, as outlined below. In the detailed findings sections of the report, the related tasks and data sources are identified by the color scheme shown in Table 1. Data collection for some of these different tasks was closely coordinated with other research efforts, including R4 HES/HES-IE Process Evaluation and R157 Multifamily Initiative Process Evaluation. This coordinated approach sought to maximize efficient outreach to program stakeholders and minimize respondent fatigue.

**Table 1: Evaluation Tasks**

Task	Description	Data Source	Quantity
1	Program data tracking and document review	Data Tracking and Program Documents	17,968 homes
2	In-depth interviews with program staff	Program Staff	2
3	In-depth interviews with vendors	Vendors	23
4	On-site quality inspections	Quality Inspections	70
5	On-site in-depth interviews with program participants	Participants	70
6	On-site in-depth interviews with participating vendors	Vendors	10
7	In-depth interviews with program administrators from leading programs	Program Administrators	5
8	In-depth interview with Quality Assurance and Quality Control (QA/QC) Vendor	QA/QC Vendor	1

The research questions (detailed in the [Methodology](#) section) address five main areas: 1) energy-saving opportunities, 2) participation patterns, 3) vendor practices, 4) quality assurance and quality control (QA/QC), and 5) drivers, motivations, obstacles, and barriers. Each of the evaluation tasks addresses various aspects of these individual areas, and they collectively inform the overall objective to identify opportunities for the program to increase savings related to three specific measures through the HES program.

### Program Focus and Goals

The HES program is delivered through a collaborative process between Eversource and UI staff, program vendors, and third-party QA/QC contractors. Program staff provide oversight and funding, set and communicate program guidelines, provide technical assistance to

vendors, and coordinate program activities. Program vendors serve as the *face* of the program to customers—they conduct the energy audits, identify savings, and install energy upgrades. They also provide customer service and marketing. An assessment of the quality of vendors' work with identification of areas for improvement is carried out by a third-party QA/QC vendor. The QA/QC vendor inspects the work of HES vendors, and the HES vendors receive a program *scorecard*, rating their performance against program targets and the QA/QC criteria.

The program is designed to help participants reduce their energy consumption and related costs. While program staff and vendors' perspectives on program goals aligned, vendors expressed some concern regarding how best to achieve them. Vendors reported uncertainty as to whether the program's goal was to provide deeper services to a smaller number of participants or lower-cost services to a greater number of participants. Program staff, on the other hand, expressed clarity on this subject: that vendors should always prioritize savings in each individual home, rather than attempting to maximize the number of homes visited. Vendors believe that attempting to be profitable while still achieving high-quality, cost-effective measure installations in each and every home is a substantial challenge. Additional analysis related to program focus and goals can be found in the [Program Focus](#) section.

## FINDINGS

The following summarizes the results of NMR's research organized by the five main research topics.

### Opportunities

The evaluation identified potential opportunities for increasing program savings. Health and safety issues limit and complicate the work of the HES vendors. If the program were able to mirror other successful programs by facilitating the remediation of these issues, the program could achieve greater savings. HES vendors also may be indirectly incentivized to schedule crews at more than one site per day (lowering per-site savings), to avoid wasting a whole day for a site with a significant health and safety issue that prevents participation. Based on NMR's on-site inspection results, eleven of the visited homes has some type of health and safety issue, and three of these had issues that prevented the HES vendors from performing certain core services, such as rim joist air sealing. Gas leaks, for example, will delay work, but the issue can typically be fixed quickly, at which point work can resume. Homes with more serious problems (asbestos, mold, etc.) might require a lengthy abatement process before HES vendors can perform core services.

Based on our on-site quality inspections, and confirmed by interviews with vendors and discussions with one QA/QC vendor, we know that HES vendors also leave readily achievable savings on the table at HES participant homes.<sup>1</sup> NMR auditors saw readily accessible gaps and penetrations in the building shell or duct work in essentially every home

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<sup>1</sup> NMR auditors inspected homes without the benefit of a blower door fan running during visits. Inspections were visual, and the amount of air leakage at these penetrations was not quantified.



visited—homes that generally had not reached a minimum ventilation threshold. In cursory inspections, NMR auditors quickly saw easily visible, exposed penetrations that were sources of air leakage in basements and attics. Encouraging more time spent on-site and a greater attention to detail (including via program QA/QC oversight) could reduce this amount of *low-hanging fruit*. HES vendors indicated that much of the actual work on site is performed by an assistant technician rather than the lead, BPI-certified technician, who would typically handle the customer interactions and paperwork, resulting in work being completed by non-BPI-certified staff with limited oversight or quality review, particularly if the vendors are running short on time (based on their self-imposed time constraints).

For example, thorough attic air sealing, a program priority, is not a universal practice. NMR estimates that 42% of the accessible attics we saw (n=52) had no attic air sealing performed, and we confirmed that 46% of the attics had readily accessible air-sealing opportunities.<sup>2</sup>

Here, we briefly summarize readily achievable opportunities observed for air sealing, duct sealing, and insulation. For additional analysis and details, please see the section on [Opportunities](#) in the main body of the report.

### Air Sealing

- **Basement rim joists:** We observed readily visible and accessible opportunities for additional basement rim joist air sealing in 72% (48) of basements.
- **Basement ceilings (frame floors):** We observed readily visible and accessible opportunities for additional basement ceiling air sealing in 74% (49) of basements.
- **Attic air sealing:** We observed readily accessible opportunities for additional attic air sealing in 46% (24) of accessible attics.
- **Attic hatches:** Over one-half (56%) of attic hatches were either unsealed (33%) or poorly sealed (23%). These 56% of attic hatches represent opportunities for additional attic hatch air sealing.

### Duct Sealing

At homes where duct sealing was performed, we observed readily visible and accessible opportunities for additional duct sealing in 53% of homes. Supporting this finding, among these 40 homes, program records indicate that six showed no improvement based on pre- and post-duct blaster tests performed by vendors. Sloppy duct sealing with foil tape may also fail over time and reduce expected savings; the program encourages mastic, which is more permanent.

### Insulation

Of the 38 insulation jobs that NMR could assess on site, 23 (61%) of them were Grade I, based on RESNET standards, meaning high quality, with limited gaps and compression. Ten (24%) were Grade II (Good/Fair), and only four (11%) were Grade III (Poor). While the quality

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<sup>2</sup> This percentage likely underestimates the amount of homes with additional attic savings opportunities, as the 52 referenced attics include 16 (31%) where NMR auditors could confirm whether or not there was some amount of air sealing performed, but could not see the extent of it due to access issues. Of the homes where NMR could fully assess this (40 attics), 60% of them had air-sealing opportunities remaining.

of insulation installation through the program is mostly high (particularly in attics), an opportunity exists for improvement in installation techniques for basement ceiling (frame floors), and rim joists. The program may also have an opportunity to increase measure persistence by discouraging vendors from using lower quality fiberglass batt insulation—especially in applications where it may sag or bunch, such as frame floors. In addition, an opportunity remains for the program to increase the proportion of customers who receive recommendations for attic insulation and also increase the rate of uptake in that measure.

### Participation Patterns

The analysis of program participation sought to determine the proportion of eligible participants who received air sealing, duct sealing, and insulation, and whether any patterns emerged with regard to utility, vendor, or characteristics of particular homes. When looking at rates of overall participation, results revealed that 30 vendors provided services to 17,968 homes in 2014. Most (84%) of the 17,968 homes served were owner-occupied. One-third of these participants received two or more services (air sealing, duct sealing, insulation) through the program.

Air sealing was the most prevalent individual measure; 92% of homes received this service. These homes demonstrated an average reduction in air leakage of 21%. Homes in UI territory had slightly greater levels of reduction (24%) than those in the Eversource territory (20%), and renter-occupied homes had greater reduction (28%) than owner-occupied homes (20%). The air leakage reduction percentage that HES teams achieved also declined as homes got larger, from an average of 28% in homes with less than 1,000 sq. ft. of heated space, to a low of 12% for homes that were 5,000 sq. ft. and larger. This further suggests that when HES vendors limit the time they spend on site in order to serve more homes, they may be leaving more opportunities behind, particularly at large homes that might require more time to fully air seal.

Duct-sealing measures were installed in one-fifth of participating homes. Eversource customers and UI customers had comparable rates of average duct leakage reduction (24% and 23%, respectively). The analysis of duct leakage reduction by various home characteristics indicates that improvements in duct sealing did not vary by home age, size, heating fuel, or tenure.

Fourteen percent of participating homes received insulation through the HES program: 16% of the total Eversource homes and 9% of the total UI homes that participated in 2014. Among Eversource homes in which insulation upgrade opportunities were identified (31% of homes), renter-occupied homes were roughly four times less likely than owner-occupied homes to install insulation (14% versus 54%). The section on [Participation Patterns](#) explores these issues in greater detail and breadth, and Appendix D provides further detail on the trends found in the program data tracking records, such as the frequency and amount of air sealing, duct sealing, and insulation services performed in the utility territories and by the vendors.

### Vendor Practices

Having vendors take part in the on-site visits for this evaluation allowed for an in-person assessment of vendor practices that complemented other evaluation activities, such as

reviewing vendor's in-field protocols, the quality and comprehensiveness of their actual installations, the recommendations they make to customers, and the customer's perspectives on their practices. The [Vendor Practices](#) section of this report supplements the findings in [Opportunities](#), which details the savings that remain after the audit.

The overall quality of vendors varied from company to company and even crew to crew, with each vendor operating under different financial situations and business models.<sup>3</sup> Some vendors attempt to service as many homes as possible, while others delve deeper to achieve greater savings in each individual home (the latter strategy being the one promoted by HES program staff). Vendors agree, despite differences in their approach, that a great deal of ancillary work goes into conducting the home assessment beyond just performing air and duct sealing. Customers report overwhelming satisfaction with the technicians on site and the services offered, even in homes where the actual quality of air- and duct-sealing work was considered unsatisfactory through this study. Not surprisingly, customers appear to respond to the auditors' politeness, punctuality, and behavior rather than making a determination of the quality of their work.

The technical quality of air-sealing work was acceptable, in general, but lacked completeness—almost all homes exhibited instances where more air sealing would have been achievable. Only two of the homes with volume data that NMR inspected were near the home's minimum Building Airflow Standard—the threshold at which mechanical ventilation is required to introduce fresh air into the building. While access issues can be a problem, in most of the homes that NMR visited, access issues typically would have made the work more difficult, but rarely impossible. Only three homes had identifiable health and safety issues (one with mold, two with asbestos-like materials) that were not resolved and resulted in the HES vendors limiting services to courtesy measures.

The instances of duct sealing, however, exhibited issues with both completeness and general quality, particularly due to the widespread practice of hastily applied foil tape. Basement and wall insulation was rare in this set of site visits, although attic insulation was mostly of high quality.

A current goal of the program is increasing the *upsell* of measures—promoting add-on measures through the program once core measures have been installed. Not all HES technicians, however, possess the sales skills necessary for convincing homeowners of the benefits that come with installing add-on measures like insulation and HVAC upgrades as well as the payback that they will see from their initial investment. The [Vendor Practices](#) section goes into great detail on vendor practices related to all relevant measures and program processes.

### Quality Assurance and Quality Control

The evaluation investigated the Quality Assurance and Quality Control (QA/QC) protocols from the HES program and HES vendors with an eye toward the adequacy of these protocols

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<sup>3</sup> Importantly, the R91: Review of Impact Evaluation Best Practices notes that factors including quality of installation of measures by vendors or persistence of measures installed may contribute to lower realization rates—such as those developed as part of the previous R16 HES impact evaluation.

and any potential opportunities for improving the HES program's QA/QC. Results of this study demonstrate that, while the program has formalized protocols in place, they vary across utility jurisdictions. In Eversource territory, for example, QA/QC vendors typically evaluate core services via in-progress inspections, not post-work inspections. For in-progress inspections of core services, QA/QC vendors usually arrive at the start of the HES vendor's appointment, rather than arriving in the middle of the site visit to catch the HES vendor off guard. In addition, HES vendors do not perform internal QA/QC because of time and cost constraints. The finding that customer satisfaction does not predict the quality of service installations—discussed at length throughout this report—emphasizes the importance of the program's QA/QC inspections in ensuring that HES vendors perform quality work, because customers themselves are not be able to accurately assess these measures.

These inspections occur for at least 5% of HES projects, with an attempt to inspect homes from all vendors proportionate to the number of homes they service, targeting between 5% and 10% of homes for any given vendor. In comparison, three of the five programs benchmarked reported higher proportions of QA/QC. Additional details regarding benchmarked programs can be found in Appendix E.

- Vermont: 5% minimum (any stage)
- NYSERDA: 10-15% post-installation
- Efficiency Maine: 15% minimum (any stage)
- Mass Save: 70% in-process and 5-10% post-installation
- National Grid Rhode Island: 100% in-process and 5% post-installation

It is worth noting that, given expected programmatic changes in 2016, program staff have indicated that they will increase QA/QC inspections to 80-100% of projects to ensure that both new and pre-existing program partners are familiar with the program practices and are conducting quality work.

Vendor scorecards for inspected homes are reviewed on a monthly basis. While vendors appreciate these QA/QC efforts, they took issue with what they believed were some overly punitive inspectors, inspectors who do not offer on-site feedback, their limited opportunity to dispute negative findings, and some discord with inspectors about the most appropriate improvements.

Additional analysis of the Quality Assurance Plan and its handling of quality and completeness of work are addressed in both [Quality Assurance and Control](#) and [Appendix B](#). Note that planned programmatic changes in the coming years include ramping up the percentage of sites reviewed by the QA/QC vendor to ensure quality work for new vendors.

### Drivers, Motivations, Obstacles, and Barriers

Customers indicated that their main motivations to participate in HES were saving money, fixing their homes or identifying areas for savings, and saving energy; program staff correctly identified that participants generally seek out the audit to save money or conserve energy. A smaller contingent of the sample took part in the audit because it was a requirement for having solar panels installed. While the audit allows these customers to benefit from air and duct sealing, these customers have little motivation to pursue deeper savings.

Customers cited very few obstacles or barriers to participating: nearly nine out of ten respondents said they did not face any obstacles in their participation. The main obstacle cited by vendors and program staff was health and safety issues encountered in the home. Mold, asbestos, and gas leaks force technicians to pause or terminate the audit because measures can often not be installed until remediation. Vendors estimated that on average health and safety issues occur in roughly one-quarter of all jobs. The provision of incentives specifically to address these issues would allow for accessing greater savings.

### RECOMMENDATIONS

Based on findings from this evaluation, NMR makes the following recommendations.

**Recommendation 1:** Although the current program is not permitted to fund remediation for health and safety issues directly (financing a portion of these costs is allowed), the EEB and program staff should carefully consider whether or not the HES program can be amended to include additional incentives or other possible strategies to aid customers in addressing health and safety issues. Program staff should consider creative solutions that fall within the scope of services offered through the program.

*Rationale: According to available program records, 8% of Eversource homes have at least one health and safety issue. Some vendors estimate that the proportion of homes with health and safety issues is actually much higher—roughly 25% on average. Similar data were not available in the UI data provided. Unaddressed health and safety issues may affect customer safety, customer satisfaction, and ultimately energy savings. Our review of five other leading HES-type programs revealed that, like the CT HES program, all offer loan products which could provide limited funding to support remediation of substantial health and safety issues. Two of the five programs offer direct incentives for remediation.*

**Recommendation 2:** The HES program should reinforce proper blower door protocols with HES vendors. Specifically, the Implementation Manual should state that finished or fully heated basements should be treated as conditioned space and included in the building envelope for testing purposes, in accordance with BPI and RESNET guidelines. To ensure consistency and comparability of results between vendors, the program could also require vendors to report on the physical characteristics of basement areas, including level of finish, insulation, and type of heating system present.

*Rationale: Based on observations from quality inspection visits and walk-along visits conducted as part of a previous baseline study, NMR auditors noted that many HES vendors treat conditioned basements (finished, insulated, and/or heated) as unconditioned spaces and close them off from the house during blower door tests. Without clear guidance from the program, vendors may inflate their air sealing reductions by treating conditioned basements as unconditioned spaces, sealing penetrations between the basement and ambient conditions, and also isolating the conditioned basement from the rest of the house via weather-stripping the door to the basement. If the vendors have air-sealed a door that is not part of the thermal*

*boundary and typically left open, the real-world savings may be lower than anticipated based on the blower door results.*

**Recommendation 3:** The HES program should strongly encourage the use of mastic, rather than foil tape, for proper duct sealing, and ensure that any tape is firmly adhered to clean surfaces. *UI reported that, as of 2015 (after the period covered in this evaluation), the program now requires the use of mastic. This is an area that should be carefully monitored during future QA/QC inspections.*

*Rationale: Quality inspections revealed that in the homes we visited, HES technicians regularly used thin foil tape to seal ducts, and it was often applied to dirty surfaces, preventing firm adhesion. This leads to gaps in the duct sealing work, and premature tape failure. During on-site inspections alongside HES vendors, HES vendors occasionally expressed surprise that their teams were still using foil tape, because they knew the program encourages mastic.*

**Recommendation 4:** The HES program should promote the use of two-part spray foam to fully cover rim joists in basements, particularly in heated basements, rather than targeted air sealing of penetrations. The program could also consider minor incentives for HES vendors for this measure because it can also serve as insulation, though the insulation benefit for most homes may often be less than the air sealing benefit.

*Rationale: Quality inspections revealed that some HES technicians do not seal individual penetrations in basement rim joists, but rather coat the entire basement rim joist with spray foam. This increases the vendor's materials cost, but air seals far more effectively than sealing individual penetrations (particularly on old homes). Using a spray-apply material, technicians can more easily seal gaps that are hard to reach with a standard air-sealing foam gun/wand. In addition, this can provide a high quality insulation benefit to the homeowners that may not currently be reflected in program savings estimates because the small surface area of rim joists has limited insulation value. Targeted air sealing, when combined with less expensive insulation materials (e.g., fiberglass batts), can be an effective approach to sealing and insulating rim joists in basements, but we recommend encouraging spray foam (applied by trained technicians) given the limited air sealing seen in rim joists and the lower quality fiberglass batt installations seen in rim joists and basement ceilings. UI reported that spray foam on the rim joist is encouraged as an add-on insulation measure by some vendors as a part of the kitchen table wrap-up process.*

**Recommendation 5:** The HES program should consider incentivizing blown or spray-applied insulation materials (e.g., cellulose, fiberglass, spray foam) rather than fiberglass batts. In addition, if homeowners choose spray-foam attic encapsulation or other add-on measures that would result in decreased air leakage, the program should also consider including additional incentives for any additional air leakage reductions that result, such that vendors can be compensated for air sealing as a part of add-on measures, not just for air leakage reductions obtained during the core services visit.

*Rationale: Quality inspections revealed that the highest quality insulation installations were either blown-in or spray-applied applications, including cellulose, fiberglass, and*

*foam. While high quality fiberglass batt installations are possible, they are harder to achieve because more labor is required to ensure that the material is installed without gaps or compression, and is cut to fit around obstacles. Fiberglass batt installations in basement ceilings and basement rim joists appeared to be of particularly low quality – a problem not unique to the HES program. Finally, spray-applied foam insulation acts as an additional air sealing measure and should be treated as both an insulation and air sealing measure, recognizing the tradeoffs involved in attic encapsulation: This measure decreases air leakage and can bring mechanical equipment and ducts into the conditioned envelope, but can also increase the surface area of the conditioned envelope.*

**Recommendation 6:** The program should carefully consider if the amount of air sealing opportunities being left on the table, as shown in this evaluation, are acceptable. If not, the program should consider working with HES vendors and coordinate with both QA/QC vendors to ensure that more air sealing opportunities are captured.

*Rationale: We found that vendors left readily visible and accessible opportunities for additional air sealing at most homes. For example, NMR auditors observed readily visible and accessible opportunities for additional air sealing in 72% of basement rim joists, 74% of basement ceilings, and 46% of accessible attics. In addition, over one-half (56%) of the attic hatches were either unsealed (33%) or poorly sealed (23%). In addition, no air sealing at all was performed in 27% of basement rim joists, 27% of basement ceilings, and 42% of accessible attics.*

**Recommendation 7:** The program should carefully consider if the amount of duct sealing opportunities being left on the table, as shown in this evaluation, are acceptable. If not, the program should consider working with HES vendors and coordinate with both QA/QC vendors to ensure that more duct sealing opportunities are captured.

*Rationale: We found that vendors left readily visible and accessible opportunities for additional duct sealing at most homes with ducts present. Of the 70 homes we visited, nearly three-quarters (72%) have ducts. Of these 52 homes, program records indicate that vendors did not perform duct sealing at 12 homes (23%), and NMR was not provided with aggregated records about why sealing had not been performed. At homes where duct sealing was performed, we observed readily visible and accessible opportunities for additional duct sealing in 53% of homes.*

**Recommendation 8:** The program administrators and both QA/QC vendors should meet as a group to discuss potential changes to the QA/QC protocols based on the QA/QC vendors' field experience, findings from this evaluation, and feedback from the HES vendors. Potential changes to the QA/QC protocols could include:

- Performing both in-progress and post-completion services of core services and add-on measures
- Performing diagnostic testing to confirm the reported post-work envelope and duct leakage rates
- Increasing rate of QA/QC inspections beyond the 5-10% targets

- Regularly performing mid-visit surprise inspections, rather than arriving at the start of a visit
- Inspecting for duct surfaces to be cleaned before applying tape or mastic
- Ensuring that Implementation Manual and QA/QC criteria provide clear guidance on assessing basement conditioning (for duct sealing and blower door testing)
- Coordinating QA/QC protocols and vendor-related findings across utility territories and QA/QC vendors
- Analyzing the percent of recommended measures by type (particularly low rates of attic insulation recommendation, for example) for outliers or suspicious patterns

*Rationale: According to the QA/QC vendor, in Eversource territory, core services are only inspected by the QA/QC vendor via in-progress inspections, not after they are completed, meaning that if a QA/QC vendor does not show up at the start of an HES visit for an in-progress inspection, the HES vendor can be reasonably assured that their work is unlikely to be inspected. Neither of the interviewed QA/QC vendors felt completely confident about the work quality happening outside of their inspections. In both Eversource and UI territories, add-on measures are only inspected after the fact, not during the installation. Given the program's stated intent to perform QA/QC on 100% of projects completed early in 2016, the meeting should be scheduled after the first quarter of 2016 in order to assess the quality of work performed under the free market version of the program that is open to more vendors than in past program years. The stakeholders should also discuss their assessment of whether or not HES vendors need additional training beyond BPI certification, such as full BPI GoldStar contractor status, training from the program's QA/QC vendors, or otherwise.*

**Recommendation 9:** The program should improve its aggregated program records such that evaluators and program staff can more easily assess and report on trends in vendor behavior. Evaluators and QA/QC vendors may be able to provide assistance on useful information. Potential data points for HES and QA/QC vendors to record and provide to evaluators could include the following, many of which could be captured on-site as check-boxes in the HES mobile tool used by HES vendors to avoid unnecessary writing:

- Home volume (absent from UI's aggregated data sets)
- Site receiving courtesy air sealing
- Improvements recommended to the homeowner (e.g., insulation)
- Presence of health and safety issues
- Type of health and safety issue
  - Mold, asbestos, gas leak, inadequate duct airflow, reached minimum ventilation guidelines, etc. (The 2016-2018 Electric and Natural Gas Conservation and Load Management Plan appears to require utilities to report annually on these figures starting in March of 2017.<sup>4</sup>)

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<sup>4</sup> DEEP. Approval with Conditions of the Connecticut Energy Efficiency Fund's Electric and Natural Gas Conservation and Load Management Plan for 2016-2018, Dec. 31, 2015.  
[http://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/DEEP\\_Approval\\_with\\_Conditions\\_of\\_2016-2018\\_C&LM\\_Plan\\_with\\_Attachment\\_A\\_12-31-15.pdf](http://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/DEEP_Approval_with_Conditions_of_2016-2018_C&LM_Plan_with_Attachment_A_12-31-15.pdf).



- Location of health and safety issue
  - Attic, basement, etc.
- Impact of health and safety issue on core services
  - No impact, courtesy air sealing only, delayed work temporarily, delayed work indefinitely, etc.
- Impact of health and safety issue on add-on services
  - No impact, delayed work temporarily, delayed work indefinitely, etc.
- Explanation of sites with air sealing or duct sealing and no improvement shown
  - Services not actually performed, data entry error, etc.
- Level of basement conditioning in accordance with BPI/RESNET standards, answering the following:
  - Is the basement area fully finished or fully heated?
  - Are the foundation walls a) completely insulated, b) partially insulated, or c) uninsulated?
  - Is the frame floor above the basement insulated?
  - Are there minor vents cut into the basement ducts?
- Ducts
  - Presence
  - Location
    - Attic, unconditioned basement, conditioned basement, garage, etc.
  - Level of insulation
    - Insulated, mostly insulated, mostly uninsulated, uninsulated
  - Reason for no duct sealing (if appropriate)

*Rationale: As evaluators, it becomes difficult to assess certain program trends when there are not available explanations that might clarify what happened at particular sites in a consistent way. For example, the NMR team visited homes that had duct sealing performed according to program records, but that also showed no recorded improvement according to those records, making it difficult to ascertain if the work had actually not been done due to time constraints or a health and safety issue, or if the work had been ineffective. NMR also visited homes where no services had been performed according to program records, but when on site, we learned that courtesy air sealing had been performed due to a health and safety issue. The program likely has much of these data available, but they was not available in aggregated form for evaluators. Detailed information about the level of conditioning of basement areas, for example, can also allow QA/QC vendors to replicate blower door and duct blaster results to determine instances of HES vendors improperly defining the thermal boundary.*

## CONSIDERATIONS

In addition to recommendations, we offer a few considerations for the program.

**Consideration 1:** The program staff should clarify to HES vendors that they should implement a two-stage audit approach, where technicians perform an initial walkthrough to

identify any issues (including health and safety) that might prevent them from performing core services, along with potentially installing direct install measures, such as light bulbs and water conservation measures. Under this approach, during the initial walkthrough, vendors could assess what specific resources may be needed to achieve the greatest savings in the home, and assign the appropriate resources to return to the home and complete all core services. The program could aid in this effort by making clear to HES vendors that such an approach is allowed and encouraged—perhaps by adding it to the HES implementation manual as a recommended best practice.

*Rationale: Given the typical structure of a HES visit – energy audit along with installation of lighting and core measures – many vendors reported that they face challenges with providing adequate services, specifically air and/or duct sealing, within the self-imposed time constraints of the visit dictated by their business practices. A small number of vendors have addressed this problem by scheduling the audit prior to the core services visit for more in-depth measure installation. This approach is also supported by programs included in the study’s best practices review; many other programs like HES include an initial visit for the audit along with common direct install measures, followed by a second visit for more comprehensive services like air and duct sealing.*

**Consideration 2:** Incorporating the feedback of the both utilities’ QA/QC vendors, the program should consider adjusting the QA/QC scoring criteria such that the quality of the weatherization services is categorized via more than one metric, allowing the QA/QC vendor to more fully describe and judge the vendor’s work. For example, the program could score vendors separately for following the proper air sealing sequence (attic, basement, then conditioned space), and for the quality and thoroughness of air sealing performed in each of those spaces, providing a greater level of detail regarding the thoroughness of the vendor’s work

*Rationale: The HES Quality Assurance Plan identifies air sealing as a key priority, but the QA scoring criteria groups quality, completeness, and attic prioritization into one scoring component. The QA vendors described being able to provide additional detail in notes and written reports that are provided to the program staff, but a review of the QA/QC protocols appears to show that the scoring criteria for the quality of the work itself could be expanded.*

**Consideration 3:** Understanding that program staff are in regular contact with HES vendors, evaluators believe that the program may benefit from convening a panel of the program’s most active vendors to provide regular feedback on the program. This may be important given the upcoming changes planned for the program since it will provide a feedback loop to determine how programmatic changes are affecting vendors and the program.

*Rationale: Based on feedback from vendors solicited as part of this evaluation, many vendors do not have clarity on program goals and objectives. In addition, their efforts appear to be add odds in some cases with program focus.*

**Consideration 4:** The program should carefully consider whether the pricing structure is properly motivating vendors to go after all accessible and achievable air and duct sealing

opportunities, and consider reducing the per-home fixed incentives relative to the savings-based incentives for each home.

*Rationale: The program requires vendors to achieve a minimum savings per home on average and provides a pricing structure that rewards vendors for achieving greater savings. For the most part this structure appears to be working—80% of vendor fees were from variable incentives provided based on actual measures installed or CFM reduced. Still, fixed incentives per home are substantial as are incentives to install lighting. In addition, as discussed above, vendors are leaving air or duct sealing opportunities on the table at most homes, suggesting that the current incentive structure does not push all vendors to maximize per-home savings.*



## Section 1 Introduction

This report presents the results of the Connecticut Home Energy Solutions (HES) Air Sealing, Duct Sealing, and Insulation practices study (R151). Working with the EEB consultants, NMR designed this study with the primary objective of identifying opportunities for the program to increase savings related to these three measures through the HES program. This study does not include HES Income Eligible households due to the divergent ways in which participants enter the program and the vendor and householder decision-making process regarding which measures to install. For similar reasons, particularly related to the complexity of landlord decision making, multifamily projects are not included in this study. NMR Group, Inc. (NMR) conducted this study at the request of the Connecticut Energy Efficiency Board (EEB). The study results draw on the following eight research tasks:

1. Program data tracking review
2. In-depth interviews with program staff
3. In-depth interviews with participating vendors
4. In-depth interviews with program administrators for leading programs
5. In-depth interview with program QA/QC vendor
6. On-site visits with program participants
7. On-site in-depth interviews with program participants
8. On-site in-depth interviews with participating vendors

### 1.1 PROGRAM BACKGROUND

The HES program is Connecticut's flagship residential program designed to help customers lower their energy bills and improve their homes' safety and comfort. The program serves as the entry point for many Connecticut residents seeking to increase the efficiency of their homes.<sup>5</sup> The HES program is fuel blind<sup>6</sup> and offers single-family homeowners a thorough home energy analysis, installation of core program measures that result in immediate energy savings, and, if eligible, recommendations for deeper energy-saving measures to put the homeowner on a pathway to increase the overall efficiency of their home.

A program vendor provides "core services" in the home. For \$99, residential customers can have an energy audit conducted that will help them improve their home's energy efficiency. During that initial visit, technicians conduct an assessment and provide core services, which

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<sup>5</sup> The sister program—HES-Income Eligible—was not included in this study due to the divergent ways in which participants enter the program and the vendor and householder decision-making process regarding which measures to install.

<sup>6</sup> The program is not targeted to a specific fuel/heating source, and customers of any heating fuel type are eligible to participate.

include installing efficient light bulbs, faucet aerators, and showerheads, and performing instrumented air-sealing and duct-sealing services.<sup>7</sup>

At the end of the core services visit, vendors engage participants in the “kitchen table wrap-up” in which they discuss potential energy efficiency upgrades to the home that would result in deeper savings. Many of these upgrades, including insulation, are eligible for Connecticut Energy Efficiency Fund (CEEF) rebates and both CEEF and Connecticut Green Bank financing. Such upgrades are installed at a later date, and homeowners can choose to hire a different installation contractor than the HES vendor. The program offers some limited assistance for customers to address health and safety issues that might preclude energy efficiency upgrades, including requiring vendors to provide a list of third-party remediation contractors and working with finance partners to ensure that financing is available for remediation. In some cases, customers may be able to bundle the cost of remediation along with other rebated measures.

Figure 1 displays the number and percentage of 2014 HES participants who received any combination of air sealing, duct sealing, and insulation.<sup>8</sup> The majority (63%) of HES participants received air sealing only. Less than one-fifth (18%) of participants received air sealing and duct sealing, less than one-tenth (8%) received air sealing and insulation, and 2% received all three services. Five percent of 2014 HES participants did not receive air sealing, duct sealing, or insulation.<sup>9</sup>

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<sup>7</sup> The core services may in some cases be provided across two separate visits. For example, if an HES vendor identifies a potential health and safety issue, they may postpone completing the core services until the homeowner remedies the issue.

<sup>8</sup> Neither the Eversource database nor the UI database included a variable indicating whether participating homes had ductwork. As a result, percentages of ductwork services are calculated from all participating homes, which vastly underestimates the actual levels.

<sup>9</sup> It is important to note that homes that reportedly did not receive any of the measures of interest for this study may have received courtesy air sealing (limited weatherization services performed typically in the conditioned space without the benefit of a blower door test, such as weather stripping, installing door sweeps, performing caulking around window frames, etc.) as well as other direct-install measures such as efficient lighting or water saving measures.

Figure 1: HES Services Provided in 2014

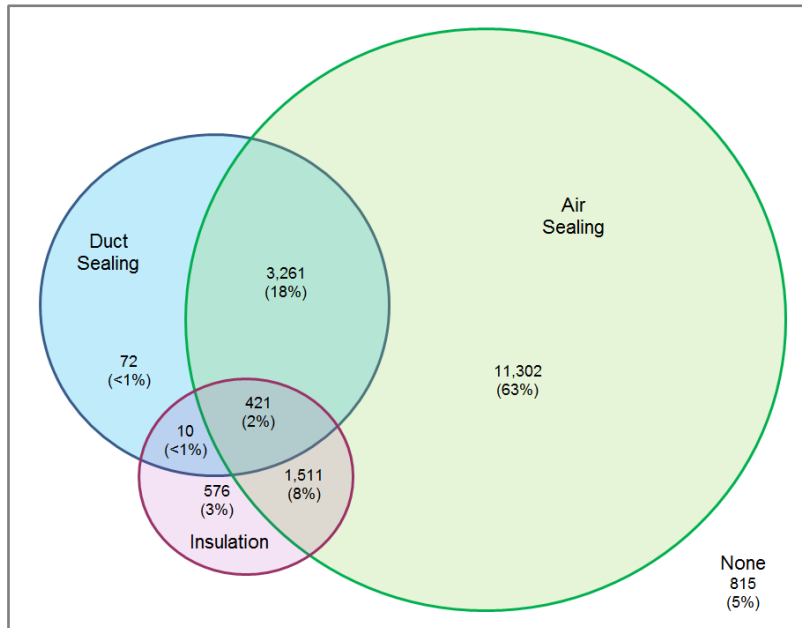


Table 2 below presents air sealing, duct sealing and insulation services by utility and overall.

**Table 2: Air Sealing, Duct Sealing, & Insulation Services Provided in 2014**

	Eversource		UI		Total	
	Count	%	Count	%	Count	%
<b>Total HES Visits</b>	<b>12,432</b>	<b>100%</b>	<b>5,536</b>	<b>100%</b>	<b>17,968</b>	<b>100%</b>
Air Sealing Only	7,568	61%	3,734	67%	11,302	63%
Air Sealing & Duct Sealing	2,229	18%	1,032	19%	3,261	18%
Air Sealing & Insulation	1,508	12%	3	<1%	1,511	8%
None	549	4%	266	5%	815	5%
Insulation Only	97	1%	479	9%	576	3%
Air Sealing, Duct Sealing & Insulation	421	3%	0	0%	421	2%
Duct Sealing Only	50	<1%	22	<1%	72	<1%
Duct Sealing & Insulation	10	<1%	0	0%	10	<1%
<b>Air Sealing Total</b>						
	<b>11,726</b>	<b>94%</b>	<b>4,769</b>	<b>86%</b>	<b>16,490</b>	<b>92%</b>
<b>Duct Sealing Total</b>						
	<b>2,710</b>	<b>22%</b>	<b>1,054</b>	<b>19%</b>	<b>3,764</b>	<b>21%</b>
<b>Insulation Total</b>						
	<b>2,036</b>	<b>16%</b>	<b>482</b>	<b>9%</b>	<b>2,518</b>	<b>14%</b>

### 1.3 STUDY OBJECTIVES

The R151 study was developed for the EEB with the objective of identifying opportunities for the program to increase savings related to three specific measures through the HES program: air sealing (core service), duct sealing (core service), and insulation. The evaluation had the following research questions:

#### 1. Opportunities

- What opportunities exist to refine program implementation to capture greater savings and increase quality of implementation?
- What effect do health and safety concerns have on opportunities?

#### 2. Participation patterns

- What proportion of eligible participants receive air sealing, duct sealing, and insulation?
- Are there any patterns by utility, vendor, or home characteristics?

#### 3. Vendor practices

- What are vendor practices related to recommending measures?
- Are all savings opportunities being identified?
- Are all cost-effective savings being captured?
- What are vendor practices related to air and duct sealing installation?
- What are contractor practices related to insulation installation?

#### 4. QA/QC protocols

- What vendor-specific and program-based QA/QC protocols or procedures are followed to ensure quality installation?
- Are current QA/QC protocols adequate? If not, what opportunities exist to improve QA/QC?
- What tools or resources would help vendors increase measure quantity or quality?
- What QA/QC practices are other leading program administrators engaged in?

#### 5. Drivers, motivations, obstacles, and barriers

- What barriers or obstacles prevent recommending or implementing measures?
- What drivers or motivations lead customers to implement measures?
- What barriers prevent customers from implementing measures?
- How have other PAs leveraged drivers and motivations to achieve greater savings?

### 1.4 METHODOLOGY

The R151 study collected and analyzed data from eight sources, outlined in Table 3. For ease in identifying the data source of findings, in the detailed findings sections of the report we adhere to a color coding scheme included in the table below.



**Table 3: Evaluation Tasks**

Task	Description	Data Source	Quantity
1	Program data tracking review	Data Tracking and Program Documents	17,968 homes
2	In-depth interviews with program staff	Program Staff	2
3	In-depth interviews with vendors	Vendors	23
4	On-site quality inspections	Quality Inspections	70
5	On-site in-depth interviews with program participants	Participants	70
6	On-site in-depth interviews with participating vendors	Vendors	10
7	In-depth interviews with program administrators from leading programs	Program Administrators	5
8	In-depth interviews with Quality Assurance and Quality Control (QA/QC) Vendors	QA/QC Vendors	2

**Research Task Descriptions**

**Program data tracking and program document review:** An analysis to explore patterns of air sealing, duct sealing, and/or insulation by utility, vendor, and home characteristics for 2014 program participants, as well as a review of relevant program documents including HES Implementation manual and QA/QC vendor manual.

**In-depth interviews with HES program staff:** One from Eversource and one from UI. These provided background on program goals, program design, program implementation, QA/QC protocols, and barriers to and opportunities for increasing savings.

**In-depth interviews with participating vendors:** Coordinated with R4 HES/HES-IE Process Evaluation and R157 Multifamily Initiative Process Evaluation. Questions focused on vendors’ practices related to air sealing, duct sealing, and insulation; barriers and opportunities for deeper energy savings; and the program’s QA/QC activities.

**On-site quality inspections:** NMR HERS Raters assessed the quality and completeness of the air sealing, duct sealing, and insulation work performed at HES participant homes. Most inspections lasted about an hour and focused on attic, basement, and interior work. NMR auditors inspected these homes without the benefit of having a blower door fan running during the tests; thus, these inspections were visual, and the amount of air leakage at these penetrations could not be quantified. However, NMR auditors are experienced HERS Raters and building scientists and are trained to identify signs of air leakage, even without the use of diagnostic fans. NMR targeted homes where HES vendors were willing to accompany us on-site, homes with multiple services performed, and those with low air and duct sealing improvements. Of the 70 homes visited, 70% were located in Eversource territory, and 30% were in UI territory.

**On-site in-depth interviews with program participants:** A 20- to 30-minute in-person interview conducted with the homeowner during the on-site quality inspection. The interview

discussed removal of measures, non-energy benefits, health and safety issues, financing options, recommendations, drivers of and barriers to participation, and customer satisfaction.

**On-site in-depth interviews with participating vendors:** Employees of the HES vendors that performed work at a given home accompanied NMR auditors to the site and, together, they inspected the work for quality and completeness. HES vendors provided candid feedback about their real-world practices and experiences with the HES program.

**In-depth interviews with program administrators for other programs:** Reviewed best practices from comparable programs, including reviewing program materials and interviewing program administrators in Massachusetts, Rhode Island, Maine, Vermont, and New York (see [Detailed Methodology for more information](#)). The interviews focused on increasing participation and uptake of add-on measures, and QA/QC strategies.

**In-depth interviews with program QA/QC vendors:** The interviews discussed program strengths and weaknesses, the quality of vendors' work, and drivers and barriers the vendors face in participating in the program. NMR conducted one interview with UI's vendor and another interview (in two parts) with the vendor Eversource started using in 2015, which was after the homes that NMR visited had been serviced by the HES program.

Table 4 provides a brief overview of which research tasks and methods map to research questions.

**Table 4: Research Questions and Tasks**

Research Question	Tasks	Methods
1 – Opportunities	Tasks 1 – 7	<ul style="list-style-type: none"> <li>• Data tracking and document review</li> <li>• Staff interviews</li> <li>• Vendor interviews</li> <li>• Customer interviews</li> <li>• Benchmarking</li> <li>• On-site visits</li> <li>• QA/QC interviews</li> </ul>
2 – Participation patterns	Tasks 1 and 2	<ul style="list-style-type: none"> <li>• Data tracking review</li> <li>• Staff interviews</li> </ul>
3 – Vendor practices	Tasks 2-6 and 8	<ul style="list-style-type: none"> <li>• Staff interviews</li> <li>• Vendor interviews</li> <li>• On-site visits</li> <li>• QA/QC interviews</li> </ul>
4 – QA/QC	Tasks 2-6 and 8	<ul style="list-style-type: none"> <li>• Staff interviews</li> <li>• Vendor interviews</li> <li>• QA/QC interviews</li> <li>• Customer surveys</li> <li>• Benchmarking</li> <li>• On-site visits</li> </ul>
5 – Drivers, motivations, obstacles, and barriers	Tasks 2, 3, 5, and 8	<ul style="list-style-type: none"> <li>• Staff interviews</li> <li>• Vendor interviews</li> <li>• Customer interviews</li> <li>• QA/QC interviews</li> </ul>

## 1.5 REPORT OUTLINE

This report synthesizes the overarching findings that emerged from the individual evaluation tasks. The following outlines the overall structure of the main body of the report.

- [Program Focus](#)
- [Opportunities](#)
- [Participation Patterns](#)
- [Vendor Practices](#)
- [Quality Assurance and Control](#)
- [Drivers, Motivations, Obstacles, and Barriers](#)

Each section starts with a high-level summary of findings, followed by details on related topics for the section and a table of specific results from each evaluation task, as appropriate. The appendices to this report provide detailed results for certain topics identified in the main body, including:

- [Detailed Methodology](#)

- [Potential QA/QC Protocol Opportunities](#)
- [Air Sealing, Duct Sealing, and Insulation Practices – Examples from Site Visits](#)
- [Detailed Analysis of Program Tracking Data](#)



## Section 2 Program Focus

Drawing on information from in-depth interviews with program staff, vendors, and participants, as well as program data and documents, this section summarizes the general focus of the HES program, including a description of its design, implementation, and stakeholders' perspectives on the program's goals and objectives. The overall results

are as follows.

**Design and Implementation:** Eversource and UI staff, program vendors, and third-party QA/QC contractors work together to deliver the HES program.

- Program staff, with the involvement of the EEB and its Residential Technical Consultant, are responsible for the overall design and implementation of the HES program, which includes providing the oversight and funding, setting and communicating program guidelines, providing technical assistance to vendors, and coordinating program activities.
- Program vendors are at the forefront with the public, conducting the energy audits, identifying savings, and, as appropriate, installing energy upgrades. Vendors also provide customer service and marketing activities.
- The third-party QA/QC contractors are responsible for assessing the quality of vendors' work and identifying areas for improvement.

**Program Goals and Objectives:** Program staff and vendors stated that the program is designed to help participants reduce their energy consumption and related costs. Participants supported staff and vendors' perspectives regarding these goals and objectives; approximately one-half (48%) stated that their energy bills had gone down since receiving HES services.

- Although program staff and vendors offered aligned viewpoints on the overall goals and objectives, many vendors voiced mixed opinions on how to achieve them. A number of vendors reported experiencing a tension between providing deeper services to a smaller number of participants versus shallow, lower cost services to a greater number of participants. Program staff reiterated in follow-up interviews that vendors are given explicit instructions to maximize savings in each individual home rather than prioritize the number of homes visited. Nevertheless, many vendors face a challenge with trying to maximize their profit while providing high-quality services through the program.

### 2.1 PROGRAM DESIGN AND IMPLEMENTATION

Eversource and UI staff oversee the design and implementation of the HES program with the involvement of the EEB and its Residential Technical Consultant. Program staff provide the oversight and funding for the program, while HES vendors deliver program services to customers. The Companies use third-party contractors to conduct quality assurance and quality control.

Program staff at Eversource and UI serve as the main contacts for the HES vendor network. They are responsible for setting and communicating program guidelines, providing technical assistance, and coordinating program activities.

Program vendors are primarily the public face of HES. Vendors are responsible for scheduling and conducting the energy audit, identifying savings and recommending measures, installing core measures, and, if needed, installing additional energy-saving upgrades such as insulation or providing referrals for such services. Vendors also provide general customer service and perform marketing and outreach activities for the program.

Each of the Companies uses a third-party contractor to assess the quality of vendors' work. The contractors perform in-progress and post-completion inspections for at least 5% of projects. Program staff reported that they regularly evaluate vendors' performance and take corrective measures, if needed, and vendors confirmed receiving feedback about their performance and QA/QC inspection results. Staff noted that they also use customer satisfaction surveys as another source of information regarding the vendors' performance.

Evaluators requested data on the quality of vendors' work as reported by third-party contractors as part of this evaluation. Unfortunately, after several data requests, evaluators were unable to obtain aggregate data regarding quality inspections. Instead, evaluators were provided with individual quality reports in password-protected Excel files. The format of data prevented evaluators from aggregating data to explore for patterns. During on-site inspections where HES vendors accompanied NMR, the HES vendors brought paperwork with details about what work was performed on the homes, thus providing additional information that was not otherwise available to NMR auditors.

## 2.2 PROGRAM GOALS AND OBJECTIVES

The HES program helps residential customers reduce their energy use and related costs and assists them with improving the comfort of their homes. Program participants expressed strong satisfaction with their HES experience and reported that they had recommended the program to others. Nearly one-half of customers interviewed for this study (48%) reported that they had noticed a decrease in their energy bills. The high satisfaction ratings, then, reflected more than just a potential decrease in one's energy bill, but also what participants viewed as the cost-effectiveness of the program (discussed more throughout the report). In addition to these primary goals and objectives, the staff indicated that the HES program plays an important role in helping participants to detect potential health and safety issues in their homes (e.g., gas leaks, carbon monoxide, mold, knob and tube wiring, asbestos insulation) and identify resources to remediate such concerns.

Although program staff and vendors were in agreement on the overall goals and objectives, comments from many vendors indicated a slight disconnect from program staff in terms of how to achieve the program's goals and objectives. The in-depth interviews with vendors (via telephone and on-site visits) reveal a tension between whether the aim of the program is to provide deeper services to few participants or to provide more core or low-cost services to a greater number of participants. Overall, vendors reported that they work to maximize their profit through the program and noted some difficulty in maintaining profitability while

achieving high-quality, deeper measure installations. Many, but not all, vendors cited inadequate time or incentive for high-quality installations. Faced with this challenge, most vendors indicated that energy savings opportunities often remain after completing an HES job. Balancing the directives of program staff to always prioritize achieving as many energy-saving opportunities as possible in each home while still remaining profitable, then, becomes the challenge most vendors are facing.

As the program moves toward a market-based program in 2016, it appears that there may be a need for program staff to reinforce the program's goals and objectives and how vendors are expected to support them. Since the transition to a market-based program will involve substantially more program vendors, staff noted that they plan to conduct more QA/QC activities with vendors, which will provide additional opportunities to emphasize program goals and objectives.

Aside from the challenges of balancing depth and breadth of services, vendors also noted that health and safety issues are a significant barrier to achieving the program's goals and objectives. The HES implementation manual makes it clear that energy testing and energy improvement are actually a third priority, behind safety and customer service. The manual states: "Safety takes priority over all else, including energy savings." The "Priority Pyramid" detailed in the manual is described as "a reminder that safety is top priority, followed by customer service, and then energy savings." The manual continues, "Safety is to be held as the highest priority over home energy testing and energy improvement." In addition, the focus on customer service is explicit in the manual as well as the QA/QC procedures and documentation (see [Section 6: Quality Assurance and Control](#) for more details on the QA/QC procedures). As described in more detail below, a considerable number of program participants—8%, based on program records are not able to benefit fully from the program because existing hazards prevent vendors from conducting diagnostic testing or limit measure installation.<sup>10</sup> The program currently does not offer an incentive to participants to help with remediating such issues, and customers are not able to pursue many energy-saving opportunities through the program.

## 2.3 DETAILED FINDINGS RELATED TO PROGRAM FOCUS

In this section, we present detailed findings from the study related to program focus. Findings in Table 5 are color coded based on data source, as described in the [Methodology](#) section.

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<sup>10</sup> Note that vendors estimate the number of program participants with H&S issues is as high as 40%. However, vendor data is based on anecdotes provided during in-depth and not on a systematic tracking system.

**Table 5: Detailed Findings (Program Goals and Objectives)**

Program Staff	<p>The HES program is designed to reduce energy consumption and related costs as well as improve participants’ comfort in their homes.</p>
	<p>Improved energy efficiency goes hand-in-hand with participants’ comfort. That is, if a home is warmer in the winter and cooler in the summer due to the energy efficiency upgrades, the customer will be more comfortable in his or her home.</p>
	<p>While addressing health and safety issues is not a primary goal or objective of the HES program, the energy audits help homeowners to identify such concerns, and vendors assist them in locating appropriate resources to help remediate those issues.</p>
Data Tracking Records	<p>The HES implementation manual makes it clear that energy testing and energy improvement are the third priority, behind safety and customer service. The manual states: “Safety takes priority over all else, including energy savings. The following ‘Priority Pyramid’ is a reminder that safety is top priority, followed by customer service, and then energy savings.” It continues, “Safety is to be held as the highest priority over home energy testing and energy improvement.”</p>
	<p>In addition, the focus on customer service is explicit in the manual as well as the QA/QC procedures and documentation (see section 6, Quality Assurance and Control, for more details on the QA/QC procedures).</p>
	<p>The three measures of interest for this study—air sealing, duct sealing and insulation—directly support the program’s overall goals and objectives.</p>
Vendors	<p>Vendors struggle with understanding whether or not the program goals are tied to number of homes completed or energy savings—or both. As one vendor offered, “Is energy savings the goal, or is number of houses served the goal? I’ve never gotten a clear answer on that. If goal is number of homes, then HES is really good. If it’s saving energy, then the program isn’t doing a great job.” Program staff, however, are very clear that quality work and energy savings in each and every home should always be prioritized over simply the number of homes visited. They indicate that this point is conveyed in myriad forms, through meetings with vendors, scorecard criteria, roundtable discussions, and QA/QC scoring.</p>
	<p>This disconnect or understanding transfers into the quality of work completed by vendors—with vendors prioritizing finishing work quickly and moving onto the next home vs. taking necessary time to complete all work to a high quality standard.</p>



Vendors	<p>A few vendors also thought that overall program messaging from both the utilities and EnergizeCT does not resonate well with customers and does not have much of an impact. One vendor remarked, “They have the generic EnergizeCT campaign, which absolutely means nothing and people have no idea what it means.”</p> <p>Other vendors thought that the overall marketing was a start at connecting with customers, but that the messaging needs a “call to action” or a way to communicate a pathway to greater services for the customer, as evidenced in the following comment: “They have that direct relationship with the customer, so communications through their bills and online engagement, those things are good, but it’s working on the calls to action and connecting to the actual program execution [that needs work].”</p>
	<p>Vendors were similar to the PAs in their assessment of the program’s goals and objectives. When discussing the program’s strengths, they most commonly mentioned that customers improve their energy efficiency (9), benefit from the value of the core services (7), improve their knowledge of energy-efficient practices (5), and have access to rebates and incentives to help defray the costs of the upgrades (4).</p>
	<p>Vendors mentioned the increase in administrative requirements (tablets, home energy scores) for which they are not sufficiently compensated and which eat up time at the site. On-site, one vendor said the program “keep[s] adding requirements without compensation. It seemed like the program went from helping the customer to just information gathering.”<sup>11</sup></p>
	<p>Another vendor described on-site how with a “two-man team, one is always entering data, and the other only does the [weatherization] work.”</p>
	<p>On-site, yet another vendor described the difficulty of meeting the administrative requirements, particularly using their two-person crew approach. “The lead tech has to enter so much data. They have to do paper work, but they still write everything down [by hand] because the tablet program loses data. ... We have to upsell, do paperwork, and do everything we can on-site, and we get angry letters [from the utilities] if we mess up.”</p>

<sup>11</sup> HES vendors may be financially compensated for some of these services, such as performing the Home Energy Score, but they may feel that this compensation is insufficient for the work involved.

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Vendors</p>	<p>According to vendors, in order to make a profit, vendors commonly feel pressured to complete two sites per day, using only two technicians per site. The lead technician handles the bulk of the paperwork, and the assistant performs most of the core services. After paperwork and testing, technicians may have about one and one-half hours (at most) to do air and duct sealing after they have wrapped up paperwork and testing requirements. Given the time constraint, they do not try to hit everything—just the big things or what they can accomplish in an hour and a half. Some vendors may do one site per day, but they reported that this was not a particularly profitable model.</p> <p>The QA/QC vendor reported, “I’d say the average is two hours [of air sealing], using two people . . . for an 1,800-square-foot house.”</p> <p>On-site, a vendor described how “we need a third person, because now, one person does 75% of the work due to all the tablet work and data collection. . . . A three-man team makes the work go smoother and more efficient, [but] financially that is hard to accomplish.”</p>
	<p>Multiple vendors during on-site interviews suggested that the program encourage vendors to send one auditor to do a pre-assessment of homes before completing actual weatherization work; some have already started implementing this approach.</p> <p>Under this program/business model, a single auditor visits the home, creates the home’s energy model, inspects the home for health and safety issues, and makes recommendations for core services and additional add-on measures, but typically would not perform actual weatherization work. Air sealing, duct sealing, and insulation work could then be scheduled for a subsequent appointment, and vendors could plan their staffing needs accordingly for each site, rather than risking sending too many or too few technicians to a home they have not yet inspected, as is the case with the current program model.</p> <p>Another vendor that has already started pre-inspections said that this model helpfully identifies health and safety issues before he sends an entire crew out to the site. Since the auditor has fewer weatherization tasks to perform on that first visit, that initial technician has more time to upsell measures, helping to increase customer adoption of add-on measures. “It eliminates show stoppers, and [the initial auditor] sells all the insulation before even starting the HES process.”</p>
	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Participants</p>
<p>Participants voiced strong satisfaction with the program, and many had recommended it to friends and colleagues. They see the program as a great value, expressing both surprise and satisfaction with the amount of work completed given the low upfront cost.</p>	

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Participants</p>	<p>Reductions in energy use with accompanying increases in home comfort are cited as two of the main program goals, and these are corroborated to some extent by participants' perspectives. Roughly one-half (48%) of the sample said they had noticed a decrease in their energy bill, with the remaining half not noticing a change or not being able to isolate changes to the audit. For those who saw a decrease, almost all (90%) said it was about what they expected.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">QA/QC Vendors</p>	<p>In their current form, the QA protocols have a significant focus not just on energy savings, but on customer satisfaction.</p> <p>The UI QA/QC vendor described how many of the criteria they use to evaluate the work of vendors are focused on customer satisfaction, noting that the program's QA inspection criteria have an "almost equal" focus on energy savings and customer satisfaction, with "savings a little bit more weighted."</p> <p>The Eversource vendor described how the vendor scorecard incorporates the customer's feedback to assess whether the customer has been "respected" by the HES team, and the QA/QC vendor's actual inspections are "geared towards 'Are they installing everything per the implementation manual?'"</p> <p>QA/QC is a powerful tool for achieving program objectives. The UI QA/QC vendor described their work as a tool that can implement program design changes: "The QA/QC process could be adjusted to drive whatever the program wanted to address at that particular time. If the program was having a problem, they could change their scoring so they could get that problem under control. They could use it as a tool to drive the vendors to suit the program's needs."</p>

## 3

## Section 3 Opportunities

Drawing on information from all data sources, this section explores opportunities identified as part of the R151 study through interviews, program records, research on other program's best practices, and on-site quality inspections.

The NMR team found that, while the program meets many of its energy savings and customer satisfaction goals, there are additional savings opportunities that the program could achieve. Health and safety issues remain a large opportunity for additional savings. Eight percent of HES participant homes in Eversource territory (according to program records) have at least one health and safety concern, limiting the work that can be performed in these homes.<sup>12</sup> The HES program is subject to cost-effectiveness tests that do not quantify any potential benefits associated with health and safety remediation, and accordingly, program staff report that this functionally prevents them from spending money on health and safety issues. (See 3.1 for more detail.) However, other successful programs in other states are able to offer facilitation or funding for barrier mitigations, allowing more customers to improve their homes. By pointing out health and safety issues—particularly if the program cannot help remediate them—customers may be displeased with the program. Some vendors also report that they schedule more sites per day than they would otherwise do—achieving less savings at each—because they are trying to avoid having a crew idle all day due to a health and safety issue.

HES vendors consistently do not achieve all of the readily accessible savings that they could in homes. For example, NMR auditors saw readily accessible air-sealing opportunities in 46% of attics, 74% of basement ceilings, and 72% of basement rim joists.<sup>13</sup> In homes with duct sealing, 53% still had readily visible and accessible openings that could have been sealed.<sup>14</sup> According to the implementation manual, program staff, and vendors, the program encourages vendors to prioritize attic air sealing, but this is a remaining opportunity because this is not a universal practice. The program could promote attic encapsulation with spray foam because this serves as an excellent air sealing and insulation measure. NMR saw only four homes that had this service performed through HES.

Insulation quality is high overall through the program (61% of all the installations were high quality),<sup>15</sup> particularly for attics; basement ceilings and rim joists appeared to be of generally lower quality, particularly if fiberglass batt insulation was used. In addition, one of the greatest program opportunities is to increase the proportion of customers who receive insulation

<sup>12</sup> Note that similar data were not included in the UI sample data.

<sup>13</sup> In attics, this means openings that may not be visible without moving insulation, but in basements, this includes openings that were readily visible and did not require moving any insulation in order to see them. These were visible gaps and penetrations that NMR auditors could see on a relatively brief inspection.

<sup>14</sup> Figure 2 provides counts of the number of homes where we observed opportunities, divided into the two categories: 1) homes where no HES work was done in that part of the home and 2) homes where some HES work was completed, but opportunities still remained.

<sup>15</sup> This includes attics, walls, basement ceilings, and basement rim joists. It also includes examples of air sealing in the basement rim joists that was so thorough that NMR views it as an insulation measure, though it was only recorded as an air sealing measure.

recommendations and the rate of customer uptake for insulation. In 2014, based on data available through the Connecticut Energy Dashboard,<sup>16</sup> 39% of all HES customers were recommended insulation measures, but only half of them ended up installing it. Similarly, customers may benefit from greater explanation of the savings associated with pursuing add-on measures, such as insulation. Additional explanation of these measures, along with post-audit follow-ups on the phone or via e-mail may push more customers to adopt these measures. One vendor described using a call center to follow up with their customers, with successful results.

Measure persistence, particularly low-quality or noisy door weather-stripping and door sweeps, is an opportunity detected in the field; thin plastic v-seal weather-stripping is inexpensive and easy to install, and extremely common among HES vendors, but it can eventually delaminate from high-traffic doorways. Sloppy duct sealing with poorly adhered foil tape might also result in diminished savings from the program over time.

### 3.1 HEALTHY AND SAFETY ISSUES

As discussed in the [Program Focus](#) section, the HES program strives to ensure that it does not adversely impact homeowners' health and safety. Health and safety issues are also an area of opportunity for the program—program records indicate that 8% of 2014 HES homes in Eversource territory have at least one health and safety issue.<sup>17,18</sup> This percentage also corresponds to the results of a previous NMR baseline study in Connecticut, where we found that of 180 homes we visited, 9% had identifiable asbestos-like materials present, and 4% had readily apparent mold issues.<sup>19</sup> Unaddressed health and safety issues affect each area of the Priority Pyramid described in the HES implementation manual. When issues are not addressed, customers are left in potentially unsafe homes (recognizing that the conditions existed before the program). In addition, pointing out health and safety issues to customers—particularly if the HES team cannot facilitate the remediation of the issue—could lead to dissatisfaction with the program. Finally, health and safety issues prevent the program from achieving deep energy savings.

<sup>16</sup> <http://www.ctenergydashboard.com/Public/PublicHESActivity.aspx>

<sup>17</sup> The DEEP approval of the 2016-2018 CEEF Electric and Natural Gas Conservation and Load Management Plan reported similar figures (less than 6% based on partial-year 2014 Eversource records). DEEP. "Approval with Conditions of the Connecticut Energy Efficiency Fund's Electric and Natural Gas Conservation and Load Management Plan for 2016-2018." Dec. 31, 2015. <http://www.energizect.com/sites/default/files/DEEP%20Approval%20with%20Conditions%2C%202016-2018%20C%26LM%20Plan%2C%2012-31-15.pdf>.

<sup>18</sup> In interviews, vendors generally estimated this figure is closer to 25%. We based our analysis of program records on the variable *materials*, which appeared to record health and safety issues in the Eversource data set provided by program staff. UI data was not provided in an aggregated format that would have allowed for assessment of health and safety issues.

<sup>19</sup> These reflect the health and safety issues that were readily identified within the scope of the NMR inspections for that baseline study, and did not include other possible issues, such as carbon monoxide testing or gas leaks. NMR Group, Inc. Single-Family Weatherization Baseline Assessment (R5). Submitted to CT EEB, CL&P, and UI, June 2014. <http://www.energizect.com/sites/default/files/R5-Connecticut%20Weatherization%20Baseline%20Assessment-FINAL%2006-04-14.pdf>.

Connecticut law requires that the program (as with other efficiency programs) meets cost-effectiveness criteria.<sup>20</sup> Given that health and safety impacts are not factored into the quantifiable impacts identified in the Connecticut Program Savings Document<sup>21</sup> and are not factored into the cost-benefit tests approved in Connecticut,<sup>22</sup> using ratepayer funds for this remediation would negatively impact the program's cost-effectiveness, which program staff described as being effectively prevented from spending resources on remediated health and safety issues. Still, the program offers some limited non-incentive assistance for customers to address issues, including requiring vendors to provide a list of third-party remediation contractors and working with finance partners to ensure that financing is available for remediation. In some cases, customers may be able to bundle the cost of remediation along with other rebated measures.

Our review of other leading programs revealed a similar concern with health and safety issues. All of the Program Administrators we interviewed indicated that health and safety issues were a consideration in their programs, and each program offers loan products that provide limited funding for remediation of substantial issues like vermiculite insulation removal, but do little to address more immediate concerns that would prevent initial testing during the audit. Two of the other programs NMR reviewed offer direct incentives for remediation:

- **The Mass Save Home Energy Services program** offers a pre-weatherization incentive for failed combustion safety (up to \$300), knob and tube wiring (up to \$250), and improper dryer venting (up to \$250), and, as of 2015, the program has made available additional, potentially larger grants to assist with the cost of knob and tube removal and asbestos abatement (up to \$3,000).<sup>23</sup>
- **Rhode Island's EnergyWise program** offers a similar incentive (up to \$250) for common barriers that prevent weatherization services.

By not facilitating the remediation of health and safety issues, not only are HES teams limited in the amount of savings they can generate on a given home, but it also encourages them to schedule two sites in a day rather than one (resulting in lower savings in each home) because they anticipate not being able to perform services at a high percentage of homes on the day the work was scheduled. Vendors report that if they only schedule one site per day in an attempt to get greater savings at each site, they risk leaving a crew idle for the entire day if the scheduled site has a health and safety issue that prevents them from performing the full core services. By scheduling two sites in a day, vendor crews have a greater chance of having at least one site on a day where they can perform some amount of work.

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<sup>20</sup> CT Gen Stat 16-245m, "Energy Conservation and Load Management Fund. Energy Conservation Management Board. Conservation and Load Management Plan. Assessment. Conservation adjustment mechanism." <https://www.cga.ct.gov/2011/pub/chap283.htm#Sec16-245m.htm>.

<sup>21</sup> CL&P and UI. 2015 Connecticut Program Savings Document. Nov. 11, 2014. Available at: [http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/8525797c00471adb85257db600666127/\\$FILE/2015%20Program%20Savings%20Documentation%20.pdf](http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/8525797c00471adb85257db600666127/$FILE/2015%20Program%20Savings%20Documentation%20.pdf), last accessed March 14, 2016.

<sup>22</sup> CT Utilities. "2013-2015 Electric and Natural Gas Conservation and Load Management Plan." Ch. 9. Current and past C&LM Plans with DEEP approvals available at: <http://www.energizect.com/connecticut-energy-efficiency-board/current-and-approved-clm-plans>.

<sup>23</sup> <http://www.masssave.com/residential/expanded-heat-loan>

### 3.2 CORE SERVICES REMAINING OPPORTUNITIES (LOW-HANGING FRUIT)

From the vendor in-depth interviews, both on site and over the phone, it is clear that vendors seek to address low-hanging fruit when they perform air sealing and duct sealing as part of core services, but on-site inspections showed that significant opportunities still remain in many homes. Based on site-inspections, vendors typically do not systematically seal everything that they could in a given home, and they are limited by time, effort, and access issues, in addition to health and safety issues. As detailed below, additional savings could be had by increasing the quality and completeness of air and duct sealing work. Vendors appear to run short on time when performing these services, resulting in a mix of sealed and unsealed gaps that could have been sealed given more time, attention, effort, and internal quality control.

Vendors often mentioned time constraints and the need to maintain profitability as barriers to completeness for air sealing and duct sealing. To make a profit, most vendors said they needed to do two sites per day, using two technicians per site. After paperwork and testing, technicians frequently have about two hours to perform air sealing and duct sealing, limiting the amount of air and duct sealing they can do in their allotted time per site. In comparison, during the benchmarking in-depth interviews, program staff from benchmarked programs indicated that the minimum amount of time for services is between two and six hours—although not all programs provide air sealing immediately following the audit.<sup>24</sup>

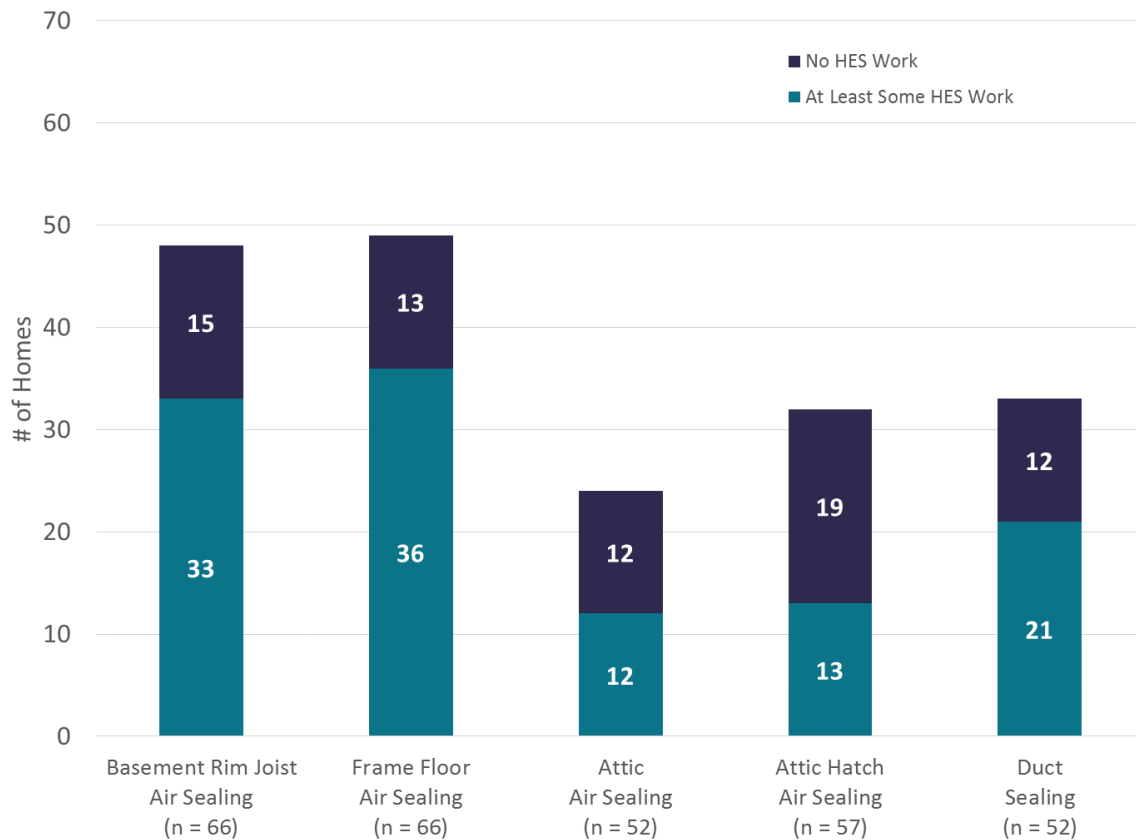
While on site, NMR auditors reviewed air sealing, duct sealing, and insulation work performed through the HES program. We found that vendors left readily visible and accessible opportunities for additional air and duct sealing at many homes. Figure 2 provides counts of the number of homes where we observed opportunities, divided into the two categories: 1) homes where no HES work was done in that part of the home and 2) homes where some HES work was completed, but opportunities still remained. In the figure, the sample sizes (n) represent how many homes the particular measure was applicable in.<sup>25</sup>

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<sup>24</sup> These time estimates were not verified with program contractors as was done with program vendors in Connecticut for this study.

<sup>25</sup> We exclude opportunities in homes where health and safety issues would have prevented work, or where access issues limited the NMR auditor's ability to make a judgment.

**Figure 2: Observed Opportunities for Additional Air and Duct Sealing**



### 3.2.1 Air Sealing

While on site, NMR auditors observed numerous readily visible and accessible opportunities for additional air sealing. We break out our observations into four important air sealing areas in homes: basement rim joists, basement ceilings (frame floors), attics, and attic hatches. See Air Sealing Practices in Appendix C for detailed descriptions and photos of specific examples from the on-site quality inspections performed by NMR.

**Basement rim joists:** In total, 66 of the 70 homes visited had basements where an HES team could have air sealed. NMR auditors observed at least some rim joist air sealing in 73% of basements and no air sealing in 27% of basements.<sup>26</sup> Looking at all homes with accessible rim joists—including those with some rim joist air sealing and those without—we observed readily visible and accessible opportunities for additional basement rim joist air sealing in 72% (48) of basements.

- Among homes that had at least some basement rim joist air sealing, NMR observed additional readily visible and accessible opportunities for further air sealing in 69% of homes.

<sup>26</sup> Note that, based on program records, post-blower door tests show that only two of these homes were close enough to the building airflow standard to have curtailed air sealing.



- Among homes that had no basement rim joist air sealing, NMR observed readily visible and accessible additional opportunities for air sealing in 83% of homes.

**Basement ceilings (frame floors):** NMR auditors observed at least some basement ceiling air sealing in 71% of basements, no basement ceiling air sealing in 27% of basements, and we were unable to observe basement ceilings in one home. Looking at all homes with accessible basement ceilings—including those with some basement ceiling air sealing and those without—we observed readily visible and accessible opportunities for additional basement ceiling air sealing in 74% (49) of basements.

- Among homes that had at least some basement ceiling air sealing, NMR observed additional readily visible and accessible opportunities for further air sealing in 77% of homes.
- Among homes that had no basement ceiling air sealing, NMR observed readily visible and accessible additional opportunities for air sealing in 72% of homes.

**Attic air sealing:** NMR was able to assess attic air sealing in 52 of 70 homes (attic spaces were inaccessible to NMR auditors for inspection at 17 homes and one of the visited homes had no attic at all). Among these homes, NMR auditors estimate that there was at least some attic air sealing in 58% of attics and no attic air sealing in 42%. Looking at all homes with accessible attics—those with at least some air sealing and those without—we observed readily accessible opportunities for additional attic air sealing in 46% (24) of accessible attics.<sup>27</sup>

- Among homes that had at least some attic air sealing, NMR observed additional readily accessible opportunities for further air sealing in 40% of homes.
- Among homes that had no attic air sealing, NMR observed readily accessible additional opportunities for air sealing in 55% of homes.

**Attic hatches:** In 57 of the 70 homes, NMR observed accessible attic hatches where they could assess whether or not the hatches had been sealed by the program. (This excludes homes with fully insulated/encapsulated attics, those without attics, or those without attic hatches, etc.) Based on observations at these 57 homes, NMR concludes that HES vendors were inconsistent with how well they sealed attic hatches. **Over one-half (56%) of the hatches were either unsealed (33%) or poorly sealed (23%). These 56% of attic hatches represent opportunities for additional attic hatch air sealing.**

### 3.2.2 Duct Sealing

Of the 70 homes we visited, nearly three-quarters (72%; 52) have ducts. Of these 52 homes, program records indicate that vendors performed duct sealing at 40 homes (77%). At homes where duct sealing was performed, we observed readily visible and accessible opportunities for additional duct sealing in 53% of homes. Supporting this finding, among these 40 homes, program records indicate that six showed no improvement based on pre- and post-sealing

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<sup>27</sup> We treat attic opportunities differently than basements. Due to the emphasis on attic air sealing (both as a program priority and building science best practice), “readily accessible opportunities” in attics include penetrations that were both readily visible and located underneath moveable insulation.

duct blaster tests performed by vendors. See section C.3 in Appendix C for detailed descriptions and photos of specific examples from the on-site quality inspections performed by NMR.

### 3.3 INSULATION

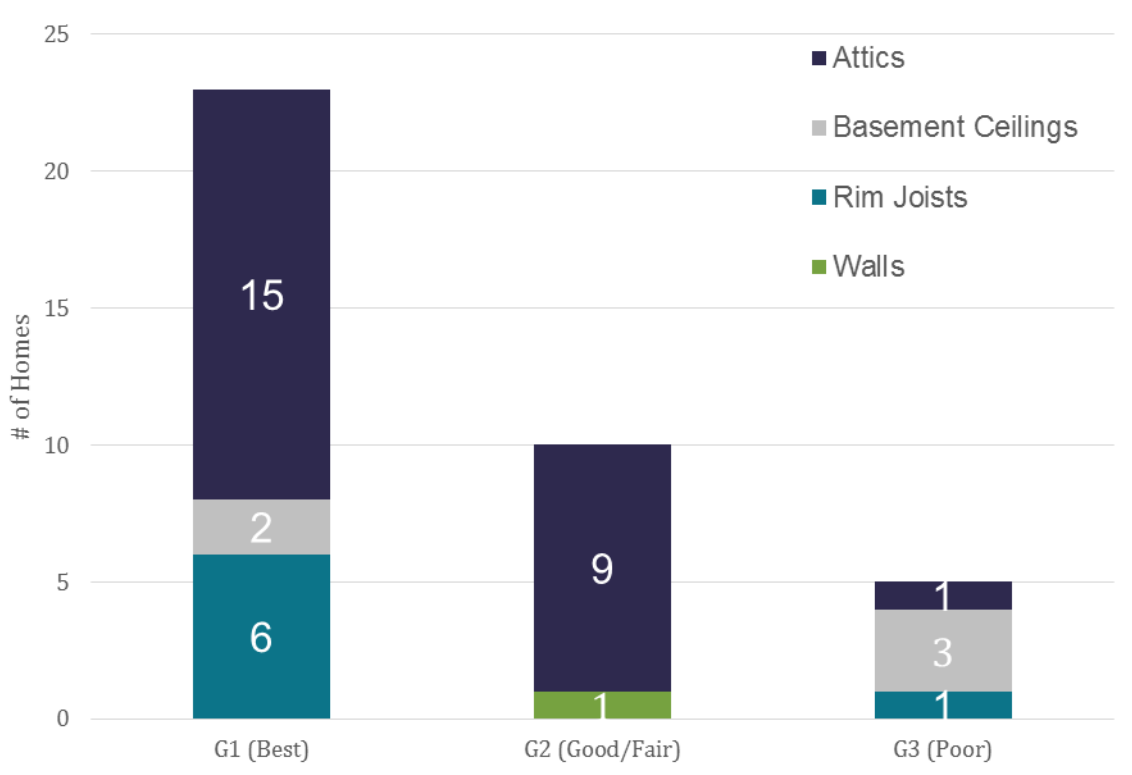
When it comes to insulation, one of the greatest opportunities for the program is in increasing the proportion of customers who follow through on recommendations to install insulation. However, it is important to note that insulation works best when installed after thorough air sealing (i.e., attic insulation works better in a tightly sealed attic). So additional insulation in the absence of increased air sealing diligence (as described above) may not result in higher realization rates. According to the Connecticut Energy Dashboard, in 2014, 39% of all HES visits included a recommendation for insulation, and one-half of these recommended rebates were completed through the program.

In general, the insulation work observed by NMR auditors in the field was good, but there was some room for improvement in installation techniques to ensure that measures performed as desired. Of all the insulation jobs that NMR could assess on site, 61% of them were Grade I based on RESNET standards, meaning high quality, with limited gaps and compression.<sup>28</sup> These higher quality installations were mostly seen in attics and in the instances where HES vendors air sealed rim joists with spray foam so thoroughly that it served as insulation, even though the customer did not pay an additional fee for that service.

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<sup>28</sup> Note that this figure and the chart below excludes installations where NMR was unable to determine the installation quality (typically due to limited access).

**Figure 3: Quality of All Insulation Installs (Grade 1 = Best)**



When fiberglass batts are used in certain applications, even distribution and installation of insulation material is difficult and may result in lower-than-expected savings. For this reason, the program may want to carefully consider whether it continues to support fiberglass batt insulation for all applications. See Insulation Practices in Appendix C for detailed descriptions and photos of specific examples from the on-site quality inspections performed by NMR.

**Attic Insulation:** NMR visited 30 homes with program-incentivized attic insulation. For installed attic insulation, most savings opportunities come from ensuring that there are limited defects in the installations, which would result in lower realization rates than expected. A full eighty percent of the attic insulation jobs observed were of acceptable or excellent quality (Grade 1 or 2 installations), one (3%) was of particularly poor quality (Grade 3), and 17% were not observable. There is also an opportunity to ensure that blown-in insulation is installed evenly; if not, the effective R-value is lower than claimed. NMR saw 26 instances of blown or spray-applied insulation in attics; 65% were extremely or mostly level, 23% were very uneven, and 12% could not be observed.

**Rim Joist Insulation:** NMR auditors observed only one instance of rim joist insulation that had been installed using HES program incentives. In this home, the insulation chosen was fiberglass batts and was installed poorly, meaning the insulation was forced into the basement ceiling joist cavities resulting in severe gaps and compression, rather than cutting the insulation to fit around framing, wires, plumbing lines, etc. (This is a common problem in homes, not unique to the HES program.)

Interestingly, at six homes, NMR auditors observed instances where vendors had almost completely insulated the rim joist areas using two-part closed-cell spray foam as an air-sealing measure (as a core service—not an insulation rebate). The foam air sealing served as an excellent insulator. An opportunity for additional savings would be for the HES program to encourage this combined air sealing and insulation measure and take credit for savings from this dual-purpose measure.

**Frame Floor Insulation:** NMR auditors observed seven instances of HES-incentivized frame floor insulation—four with fiberglass batts, two with spray foam, and one with dense-pack cellulose. The fiberglass batt insulation jobs were relatively poor; gaps, compression, and sag from the frame floor were common, meaning the measures were unlikely to perform as desired. The homes with foam and cellulose did not suffer from these same problems.

**Wall Insulation:** NMR auditors observed only two instances of wall insulation added by the HES program. Using an infrared camera, auditors were able to assess the evenness of one dense-pack cellulose installation. While the evenness of the insulation was generally good, uninsulated stud bays remained above some of the windows. If this is common, predicted savings from the measure will likely be higher than realized savings.

### 3.4 DETAILED FINDINGS RELATED TO OPPORTUNITIES

In this section, we present detailed findings from the study related to opportunities. Findings in Table 6 are color coded based on data source, as described in the [Methodology](#) section.

**Table 6: Detailed Findings (Opportunities)**

Program Staff	According to staff, statutory limitations prevent the program from directly addressing health and safety issues. Still, identifying health and safety issues is viewed as an ancillary benefit of the program. Common health and safety issues include mold, moisture, asbestos, HVAC issues causing high CO, plumbing or gas leaks, and pests.
	While no direct incentives are available for health and safety remediation, the program does offer some indirect assistance, including the availability of financing when performing other measures. Vendors must provide a list of third-party remediators who can address health and safety issues. In some cases, vendors may also be able to address certain health and safety issues in house.
	If customers choose to have health and safety issues remediated, the program will return to their home to complete work at no additional cost—avoiding paying the \$99 fee a second time for a return visit.
	The program works with financing partners to ensure that customers who choose to remediate health and safety issues can acquire financing. In addition, in some cases, customers may be able to roll health and safety remediation into financing packages for rebated measures to help limit the upfront costs.

Program Staff	<p>As discussed in Section 2: Program Focus, the program’s objective is to achieve deep and comprehensive savings. Staff believe that the minimum savings requirements and program metrics maximize savings through the initial audit and promotion of additional measures.</p>
	<p>Although program staff reported that the program has a good representation of cost-effective offerings, they indicated that the current structure sometimes limits customers’ ability to fully pursue energy savings. For example, the ceiling insulation rebate requires that customers have less than R-30 currently installed, install a minimum of an additional R-19, and the final R-value must be greater than or equal to R-38. This means customers who are unable to reach R-38 due to space limitations (finished attics) or customers who would benefit from additional insulation but already have R-30 installed are excluded.</p>
	<p>Staff noted that the presence of health and safety issues, particularly “show stoppers,” prevent installation of measures because technicians are not always able to conduct diagnostic testing. Although the identification of such issues is helpful to the customer, staff reported that lack of funding to help remediate these hazards prevents customers from fully benefiting from program services.</p>
	<p>The incentive structure for vendors is split between a fixed per-home incentive and a variable incentive based on CFM reduction, services performed, and equipment installed. Based on data provided by program staff, the average cost per home for the program in 2014 was between \$1,100 and \$1,200. If we include the customer-paid fee of \$99, it was between \$1,200 and \$1,300 per home. This figure is for core services only and does not include rebate costs for recommended measures.</p>
	<p>Fixed incentives account for 16% to 18% of average incentives in 2014.</p> <p>The average cost breakdown across all participants is as follows: (Eversource; UI)</p> <ul style="list-style-type: none"> <li>• Air sealing: \$629 (52%); \$735 (57%) [Variable incentive CFM reduced]</li> <li>• Lighting: \$233 (19%); \$204 (16%) [Variable incentive # of bulbs installed]</li> <li>• Site visit: \$189 (16%); \$174 (14%) [Fixed incentive per home]</li> <li>• Duct sealing: \$102 (8%); \$117 (9%) [Variable incentive CFM reduced]</li> <li>• Air flow test: \$30 (2%); \$29 (2%) [Fixed incentive per home]</li> <li>• Direct hot water: \$21 (2%); \$25 (2%) [Variable incentive # of measures installed]</li> </ul>
Data Tracking and Docs	<p>In 2014, 8% of HES homes in Eversource territory were recorded as having at least one health and safety issue. Unfortunately, program records do not indicate which, if any, of these homes had issues remediated. This figure is lower than vendor estimates, and NMR on-sites confirmed that these records did not capture all health and safety issues, indicating that they are not being recorded consistently. UI records were not aggregated for the evaluators to assess this.</p>
	<p>In 2014, 8% of HES homes did not receive any air sealing services.<sup>29</sup> Health and safety issues occasionally prevent vendors from performing air sealing or duct sealing work—even running blower doors to assess air leakage.</p>

<sup>29</sup> Some of these homes could have had hourly “courtesy” air sealing performed without benefit of a blower door test to measure improvement.

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Data Tracking and Docs</p>	<p>Among 2014 participants who received at least one service, nearly two-thirds (63%) received air sealing only. These homes represent a significant opportunity for additional measures. Less than one-fifth (18%) of participants received air sealing and duct sealing, less than one-tenth (8%) received air sealing and insulation, and 2% received all three services. Five percent of 2014 HES participants did not receive air sealing, duct sealing, or insulation.<sup>30</sup></p>
	<p>According to the Connecticut Energy Dashboard, in 2014, 39% of all HES visits included a recommendation for insulation, and one-half of these recommended rebates were completed through the program. Increasing the conversion rate for insulation recommendations represents a significant opportunity for the program.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Vendors</p>	<p>Vendors indicate a potential disconnect between how they are paid and program goals. Vendors are working to be profitable in the existing system, which may mean vendors avoid homes that will be time sinks (extremely leaky or otherwise challenging homes), particularly if the homeowner does not appear to be interested in purchasing add-on measures. Vendors are incentivized to increase savings at homes, but some work to strike a balance between achieving the amount of savings that they can in the self-imposed time constraints they set per site, and maximizing the number of homes served.</p>
	<p>Given that vendors reported feeling pressure to do multiple homes per day in order to be profitable, the variable pricing mechanism does not universally motivate vendors to maximize savings, but to achieve a balance between achieving savings per site and maximizing the number of homes visited, allowing them to increase the fixed incentives received per site. As one QA/QC vendor said, "Incentives don't drive program results."</p>
	<p>Corroborating this, when asked about instances where core measures are not installed or pursued, one vendor said, "Yes, it happens frequently. They pay us to go after low-hanging fruit. Time is money, and it's easier to get first instances of air sealing done, with lesser payback as you go further. Air sealing opportunities are almost always left behind. Sometimes we can't even get a testing number to begin with; it's so leaky [at the outset] we wouldn't be able to know the savings afterwards. So we just don't pursue them." [Source: Telephone interview]</p>
	<p>Some vendors do not formally market the program and rely on word-of-mouth referrals. Some vendors indicated that they would like to market the program but believe that the PAs are too restrictive with allowing vendors to market the program as they see fit. Additionally, they noted that the turnaround for approvals of branded materials is too long.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Vendors</p>	<p>The lead technician does the majority of the customer interaction, while the assistant or secondary technicians perform the majority of upgrades and core services. Often, this results in work being completed by non-BPI-certified staff with limited oversight or quality review, particularly if the vendors are running short on time.</p>

<sup>30</sup> It is important to note that homes that reportedly did not receive any of the measures of interest for this study may have received courtesy air sealing as well as other direct-install measures such as efficient lighting or water-saving measures.

	<p>On site, a vendor estimated that about 20% of their sites have some kind of health and safety issue that causes them to delay or limit their core services. The prevalence of health and safety issues can result in some vendors rushing their work and scheduling two jobs per day because they want to avoid the lost time and wages associated with sending a crew to a site for a planned full day's work only to find a health and safety issue that prevents them from doing any work.</p>
	<p>On site, a vendor described using a call-center to follow up with customers after their audits to talk through the recommendations they received, which increased customer uptake of add-on measures.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Participants</p>	<p>Most customers (~60%) recall the auditor leaving a packet of information about available financing and rebate options for EE measures through the program.</p>
	<p>A common reason for not moving forward with recommended upgrades (other than the cost of doing so) was that the issue was not bothering the customer enough to justify moving forward with expensive upgrade—customers do not always feel comfortable replacing a working appliance/mechanical system for a more efficient version.</p>
	<p>Customers by and large thought that the information they received about financing was clear and the materials left were helpful. But since many do not have interest in moving forward with further energy upgrades, they do not spend much time looking through them.</p>
	<p>Some customers (n=~10) said that while the packet of information is very thorough, it can be overwhelming. They suggested limiting information to the measures discussed and the specific needs of the client as determined by the audit. If the tech does not recommend a specific measure (usually because the customer does not need it), then including information about that measure and the rebates/financing available for it is not particularly helpful. They would have preferred a prioritized packet of information, specific to them.</p>
	<p>“They gave us a list of things we could do and recommended some companies. Ultimately, if they had prioritized things for us, said, ‘This would be the best option for you and your home specifically,’ that would have helped. Leaving a big packet with all the options is kind of information overload.” [Source: On-site interview]</p>
	<p>Still, customers appear to have varying information needs and wants. For example, three customers expressed a desire to receive updated offers from the program via email or with their energy bill. Another customer wanted detailed information on payback periods for each measure installed—with charts and graphs.</p>
	<p>Roughly one-third of customers (32%) had removed some of the installed measures. These included CFLs (n=8 sites), weather-stripping (n=6 sites) and showerheads (n=5 sites). Reasons for removal included general quality issues with the CFLs, weather-stripping that impeded the use of doors, and issues with the water flow from the showerheads. These all represent areas for improvement in the installation/general quality realms, but are unlikely to be a large opportunity area for the program.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Quality Inspections</p>	<p>Measure persistence, particularly door weather-stripping and door sweeps, is an opportunity detected in the field. Customers do not always like the sweeps on the doors, and the plastic v-strip used to weather strip doors gets damaged over time. It works well on the initial blower door test, but has limited longevity. There are more durable door weather-stripping kits than stick-on v-seal, and while some HES vendors may use them,</p>

<p>they are more expensive and time consuming for vendors to install, so most vendors appear to use the stick-on v-seal material.</p>
<p>Some sites revealed evidence of post-audit work done outside of the program that essentially undid some of the improvements. Examples include duct system reconfigurations after sealing and new penetrations into floors due to renovations that go unsealed or uninsulated.</p>
<p><b>Air Sealing in Basement Rim Joists</b></p> <p><b>“Low-Hanging Fruit”/Readily Accessible Penetrations.</b> NMR auditors looked for “low-hanging fruit” in basements—meaning unsealed, easily accessible rim joist penetrations that did not require removing insulation to access them. In total, NMR observed readily visible and accessible opportunities for additional basement rim joist air sealing in 72% of homes.</p>
<p>NMR auditors observed rim joist air sealing in 73% of the basements they visited, and saw no rim joist air sealing in 27% of the basements.<sup>31</sup></p>
<p>In the basements where HES vendors did at least some rim joist air sealing (n=48), NMR observed readily visible and accessible additional opportunities to seal rim joist penetrations in 69% of homes.<sup>32</sup></p>
<p>In the basements where HES vendors had not done any rim joist air sealing (n=18), NMR observed readily visible and accessible additional opportunities to seal rim joist penetrations in 83% of homes. The remaining homes (3) were skipped due to health and safety issues.</p>
<p>In addition to looking for readily accessible rim joist penetrations, NMR also assessed the level of air sealing at rim joist penetrations that were accessible, but harder to see, such as those behind mechanical equipment or framing. While these were accessible areas, sealing them requires an additional level of time and effort beyond sealing those that are readily visible.<sup>33</sup></p> <p>HES vendors most commonly skipped these opportunities and left them completely unsealed (54% of basements); they sealed most of them in 24% of those basements, and sealed some of them in 21% of those basements.<sup>34</sup></p>
<p><b>Air Sealing in Basement Ceilings (Frame Floors)</b></p> <p><b>“Low-Hanging Fruit” – Readily Accessible Penetrations.</b> NMR auditors looked for “low-hanging fruit” in basements, meaning unsealed, easily accessible frame floor penetrations that did not require removing insulation to access them. In total, NMR observed readily visible and accessible opportunities for additional basement rim joist air sealing in 74% of homes.</p>

<sup>31</sup> Only two of the visited homes appeared to have been close enough to the minimum Building Airflow Standard such that vendors might have curtailed their air sealing.

<sup>32</sup> NMR auditors could see examples of sealed and unsealed penetrations in the same basement.

<sup>33</sup> NMR auditors identified that about 90% of the basements they visited had such visible rim joist penetrations that were accessible for air sealing, but harder to see.

<sup>34</sup> In one case (2%), NMR auditors could not inspect for this.



Quality Inspections	NMR auditors observed frame floor air sealing in 71% of the basements we could inspect, saw no such air sealing in 27%. <sup>35</sup>
	Where HES vendors did at least some air sealing of frame floor penetrations, we observed missed readily visible and accessible penetrations in 77% of homes.
	In the basements where HES vendors had not done any air sealing of basement ceiling penetrations, NMR observed easily accessible rim joist penetrations in 72% of homes. There were health and safety issues preventing sealing in 17% of homes (3).
	As with rim joists, NMR assessed frame floor penetrations that were not readily visible, but were still accessible, such as those concealed by mechanical equipment or behind framing in the basement ceiling. <sup>36</sup>
	HES vendors often skipped those penetrations and left them unsealed (41% of basements); they sealed some of them in 31% of those basements, and sealed most of them in 25% of those basements. <sup>37</sup>
	<b>Attic Air Sealing</b>
	<b>“Low-Hanging Fruit” – Easily Accessible Penetrations.</b> <sup>38</sup> In the 52 accessible attics where NMR auditors were able to make a determination about the presence of air sealing, we estimate that about 58% had some amount of air sealing done by the HES team, and 42% did not. <sup>39</sup> While the HES implementation and QC manuals indicate that vendors should prioritize attic air sealing before work in the basement or other areas of the home, we observed limited air sealing work in attics. It appears vendors are avoiding work in attics, which can be time consuming, and instead focusing on addressing issues in basements, which are generally more accessible.
Among the 40 attics where NMR could make a determination about the extent of additional savings opportunities from air sealing, 60% had additional savings opportunities available in the attics. <sup>40</sup>	
In attics where HES vendors did air seal, easily achievable savings remained in 40% of homes. NMR could not determine the extent of additional opportunities in 33% of those cases.	
Quality	In the attics where HES vendors did <i>not</i> air seal, easily achievable savings remained in 55% of cases. NMR could not determine the extent of additional opportunities in 27% of those cases.

<sup>35</sup> Auditors could not inspect for air sealing in the remaining one instance (2%).

<sup>36</sup> NMR auditors identified that about 87% of the basements they visited had such visible basement ceiling penetrations that were accessible for air sealing, but may not have been readily apparent to vendors.

<sup>37</sup> The remaining 3% represents two homes where the NMR auditor could not assess these penetrations.

<sup>38</sup> NMR auditors did not make a distinction for attics between “visible and accessible” and “hidden but accessible” as they did for basement penetrations, because almost all attics have some amount of insulation, making the vast majority of penetrations somewhat hidden, whereas many New England basements do not have insulation in the basement ceiling or rim joist area, making the sealing of penetrations even easier in basements.

<sup>39</sup> These percentages exclude attics that were inaccessible to HES vendors (permanently sealed with no hatch, n=4) and the attics that were both inaccessible to NMR vendors and where the homeowner did not know if air sealing had been done (n=13).

<sup>40</sup> Due to access issues, NMR auditors could not always tell if HES vendors had missed easily sealable sources of air leakage in attics—“low-hanging fruit”—but they categorized this whenever possible.

	<p><b>Air Sealing at Attic Hatches.</b> HES vendors were inconsistent with how well they sealed attic hatches, resulting in missed energy savings in many cases.</p> <ul style="list-style-type: none"> <li>• 40% of attic hatches were well sealed (fully sealed on all edges with no visible leaks).</li> <li>• 23% of cases were poorly sealed (with noticeable gaps or failing weather-stripping).</li> <li>• 33% of cases were unsealed.</li> <li>• We were unable to assess 4% of cases.</li> </ul>
	<p><b>Rim Joist Insulation.</b> NMR auditors saw only one instance of rim joist insulation (fiberglass batts) that had been installed using HES program incentives (2% of homes with basements). In six other instances (9% of basements), the initial HES vendors had almost completely insulated the rim joist areas using two-part closed cell spray foam as an air-sealing measure; this was installed at no cost to the customer, and treated as a core service. The one fiberglass installation was of low quality and the foam air sealing served as an excellent insulator apart from any gaps in its application.</p> <p>An opportunity for additional savings would be for the HES program to encourage this combined air sealing and insulation measure, and take credit for savings from this dual-purpose measure.</p>
	<p><b>Frame Floor Insulation.</b> NMR auditors observed seven instances of HES-incentivized frame floor insulation; four were insulated with fiberglass batts, two with spray foam, and one with dense-pack cellulose. Overall, the insulation quality of the fiberglass batts was relatively poor; gaps, compression, and sag from the frame floor were common.<sup>41</sup> The homes with foam and cellulose suffered less from most of these problems—not surprising, given the nature of the insulation materials themselves.</p>
	<p><b>Wall Insulation.</b> NMR auditors observed only two instances of wall insulation added by the HES program. In one instance—a dense-pack cellulose installation—uninsulated stud bays remained above some of the windows (confirmed by infrared camera). If this is common (which NMR cannot confirm based on this one home), predicted savings from this add-on measure will likely be higher than realized savings.</p>
	<p><b>Attic Insulation.</b> As with wall insulation, for installed insulation, most savings opportunities come from ensuring that there are limited defects in the installations, which would result in lower realization rates than expected. Most installations, however, were of good quality. See Vendor Practices.</p>
	<p><b>Duct Sealing.</b> Of the 70 homes visited, 74% (52) have ducts. Program records indicated that vendors had performed duct sealing in 40 of them (77%). NMR was not provided with aggregated records that would have explained why duct sealing was not performed in the remaining 12.</p>

<sup>41</sup> One homeowner would not grant access to this area for inspection.

Quality Inspections	<p><b>“Low-Hanging Fruit” – Readily Accessible Gaps in Ductwork.</b> Among the 40 homes where program records indicated duct sealing, we found:</p> <ul style="list-style-type: none"> <li>• 25% were fully sealed.</li> <li>• 53% had opportunities for additional easily achievable savings.</li> <li>• 20% were too difficult to access or had limited opportunities.</li> <li>• We were unable to determine opportunities in one home due to lack of access (3%).</li> </ul>
	<p>Additionally, among the 40 homes with duct sealing indicated in the records, six (15%) showed no improvement based on program records (0% CFM reduction based on duct blaster pre/post). In one case, NMR technicians observed duct sealing and thought that the lack of improvement might have been due to an error in duct testing or record keeping.</p>
Program Administrators	<p>All of the programs also offer loan products that provide limited funding for remediation of more substantial issues like vermiculite insulation, but do little to address more immediate concerns that would prevent initial testing during the audit.</p>
	<p>The Mass Save Home Energy Services program offers a pre-weatherization incentive for the three most prevalent issues: failed combustion safety, knob and tube wiring, and improper dryer venting (up to \$300 for combustion safety and \$250 for knob and tube wiring and/or improper dryer venting).<sup>42</sup> As of 2015, barrier mitigation grants were also made available through the program to subsidize the cost of knob and tube and asbestos removal (up to \$3,000).</p>
	<p>Rhode Island’s EnergyWise program offers a similar incentive (up to \$250) for the homeowner to address barriers (including health and safety hazards) which would prevent weatherization services.</p>

<sup>42</sup> Cape Light Compact does not include the dryer venting repair as a pre-weatherization initiative measure since it is addressed through their home energy assessments.

QA/QC Vendors

The QA/QC vendors confirmed that while savings potential obviously varies from home to home, vendors leave savings on the table that may be cost-prohibitive or not profitable for them to pursue.

UI vendor: “In some houses, [core services] can be knocked out in four hours. . . . If it was up to me, I’d love to see them do one a day for the majority of houses. . . . Every house is different, [but] you can’t do two a day on every house; if you’re in a house, are they leaving opportunity on the table because it’s not worth going back for another day?”

Eversource vendor: “I can’t say . . . we’ve seen vendors going to that degree where we say, ‘Wow, they’ve reached [beyond] the point of cost-effectiveness here.’”

Eversource vendor: [For the amount of work] “I guess it comes down to the [HES vendors’] business models.”

Eversource vendor: “Provided he’s being honest . . . there comes a time . . . where he’s got to tell his guys, ‘It is not cost-effective for us to be there,’ . . . [but the tension lies in] the contractor understanding what’s cost-effective for him, and really what the program wants him to do, and understanding that it’s more about the customer than it is the contractor.”

Eversource vendor: “Incentives don’t drive program results, so you need the QA/QC vendor.”

## 4

## Section 4 Participation Patterns

This evaluation sought to respond to two main questions regarding program participation: 1) What proportion of eligible participants receive air sealing, duct sealing, and insulation? 2) Are there any patterns by utility, vendor, or home characteristics? This section primarily relies on 2014 program data to address these questions. A high-level summary of results is included below.

- **Overall participation:** In 2014, 30 vendors provided services to 17,968 homes through the HES program. Most (84%) of the 17,968 homes served were owner-occupied. Nearly one-third of participants (29%) received a combination (two or more services) of air sealing, duct sealing, and/or insulation.
- **Air sealing:** The majority of homes (92%) received air-sealing services.
  - The average air leakage reduction per home was 21% (including all homes, even those with no improvement).
  - The average percent air leakage reduction of 24% among UI homes was slightly greater than the average of 20% among Eversource homes.
  - The average percent air leakage reduction per vendor ranged from 12% to 27% (Figure 31).
  - Renter-occupied homes experienced an average air leakage reduction of 28%, compared to 20% among owner-occupied homes.
- **Duct sealing:** Vendors conducted duct sealing at roughly one-fifth (21%) of participating homes.
  - Eversource customers had a slightly higher average duct leakage reduction of 24% compared to 23% among UI customers.
  - An analysis of home characteristics showed that improvements in duct sealing did not vary by home age, size, heating fuel, and tenure.
  - The average percent duct leakage reduction per vendor ranged from 10% to 58% (Figure 38).
- **Insulation:** Fourteen percent of participating homes received insulation through the HES program.
  - Insulation was installed in 16% of the total Eversource homes and 9% of the total UI homes that participated in 2014.
  - A review of data for homes where insulation opportunities existed in a home shows that renter-occupied homes were nearly four times less likely than owner-occupied homes to install insulation (14% versus 54%).<sup>43</sup>

The remainder of this section explores these issues in greater depth, and Appendix D provides additional detail on the trends found in the program data tracking records, such as the frequency and amount of air sealing, duct sealing, and insulation services performed in the utility territories and by the vendors.

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<sup>43</sup> The UI data set did not indicate whether or not the opportunity to upgrade insulation existed per participant home. Therefore, results regarding insulation opportunities are limited to Eversource homes.

## 4.1 SERVICES PROVIDED

According to 2014 program data, 30 vendors provided HES services to 17,968 homes. Twenty-two of the 30 vendors served both Eversource and UI customers, five served only UI customers, and three served only Eversource customers. In addition, six of the 30 vendors served over one-half (52%) of all homes that received services through HES. As noted above, the majority of HES participants (63%) only received air sealing, 18% received air sealing and duct sealing, 8% receive air sealing and insulation, and 2% received all three services. Five percent of HES participants did not receive air sealing, duct sealing, or insulation.<sup>44</sup>

## 4.2 AIR SEALING

Air sealing was performed at 16,490 of the 17,968 homes served through HES in 2014, or 92% of participating homes. Air-sealing services provided through HES reduced air leakage by an average of 21% per home. UI homes saw a slightly larger average reduction of 24% compared to 20% among Eversource homes. Overall, there was no reduction in air leakage for 755 homes (5%) that received air-sealing services.<sup>45</sup> Program staff indicated that this might occur if a home is already sealed tight and does not have any room for improvement (e.g., the pre- to post-sealing is zero). Neither the UI nor the Eversource data sets contained a unique variable to explain why there was no improvement in air leakage, so this study is not able to determine the exact reasons for this occurrence.

Figure 31 displays the average percent air leakage reduction per vendor, and additional detail can be found in Appendix D. The average percent air leakage reduction per vendor ranged from 12% to 27%.

Air leakage reduction in relation to home characteristics—including age, size, tenure, and heating fuel—are summarized below.

- **Home Age:** Newer homes (under 20 years old) had a higher average percent air leakage reduction than homes 20 years old and over (14% versus roughly 20%).
- **Home Size:** Smaller homes had a higher average percent air leakage reduction than larger homes. The average percent air leakage reduction among the smallest homes (0 to 999 heated sq. ft.) was 28%. Average air leakage reduction declined with each additional 1,000 heated sq. ft., to a low of 12% for homes with 5,000 heated sq. ft. or larger.
- **Tenure:** Renter-occupied homes had a higher average percent air leakage reduction (28%) than owner-occupied homes (20%).

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<sup>44</sup> It is important to note that homes that reportedly did not receive any of the measures of interest for this study may have received courtesy air sealing as well as other direct-install measures such as efficient lighting or water-saving measures.

<sup>45</sup> The UI and Eversource data sets contained blower door CFM<sub>pre</sub> and CFM<sub>post</sub> variables. Neither data set contained a unique variable indicating if air sealing had been performed at a home. Therefore, this study assumes that non-blank, non-zero sets of blower door CFM<sub>pre</sub> and CFM<sub>post</sub> values implied that air sealing had been performed at a home. There was no difference between the blower door CFM<sub>pre</sub> and CFM<sub>post</sub> values for 684 Eversource and 71 UI homes.

- **Heating Fuel:** Average percent air leakage reduction was similar across home heating fuels, ranging from 17% for propane to 23% for electricity.

### 4.3 DUCT SEALING

Duct sealing was performed at 3,764 of the 17,968 homes served through HES in 2014, or 21% of participating homes. Eversource customers had a slightly higher average duct leakage reduction of 24% compared to 23% among UI customers. Figure 38 displays the average percent duct leakage reduction per vendor and is color-coded based on the number of homes at which each vendor sealed ducts.<sup>46</sup> The average percent duct leakage reduction per vendor ranged from 10% to 58%.

Eight percent of the 3,764 customers that received duct-sealing services did not see any leakage reduction between the pre- and post-duct-sealing results. The data provided for this study did not indicate why the vendor's duct sealing showed no improvement, meaning that there could be multiple possible explanations, such as a health and safety issue that actually limited the work, the team could have planned to do duct sealing and run out of time (based on their own self- or customer-imposed time constraints), or the work may actually have been ineffective.

Improvement in duct leakage varies very little by home age, home size, tenure, and home heating fuel.

- **Home Age:** The average percent duct leakage reduction was similar across all home ages, ranging from 22% to 25%.
- **Home Size:** Average duct leakage reduction was similar across all home sizes, ranging from 22% to 26%.
- **Tenure:** Average duct leakage reduction was almost the same between owner-occupied (23%) and renter-occupied (22%) homes.
- **Heating Fuel:** Average duct leakage reduction was similar across all heating fuels, ranging from 22% to 24%.

### 4.4 INSULATION

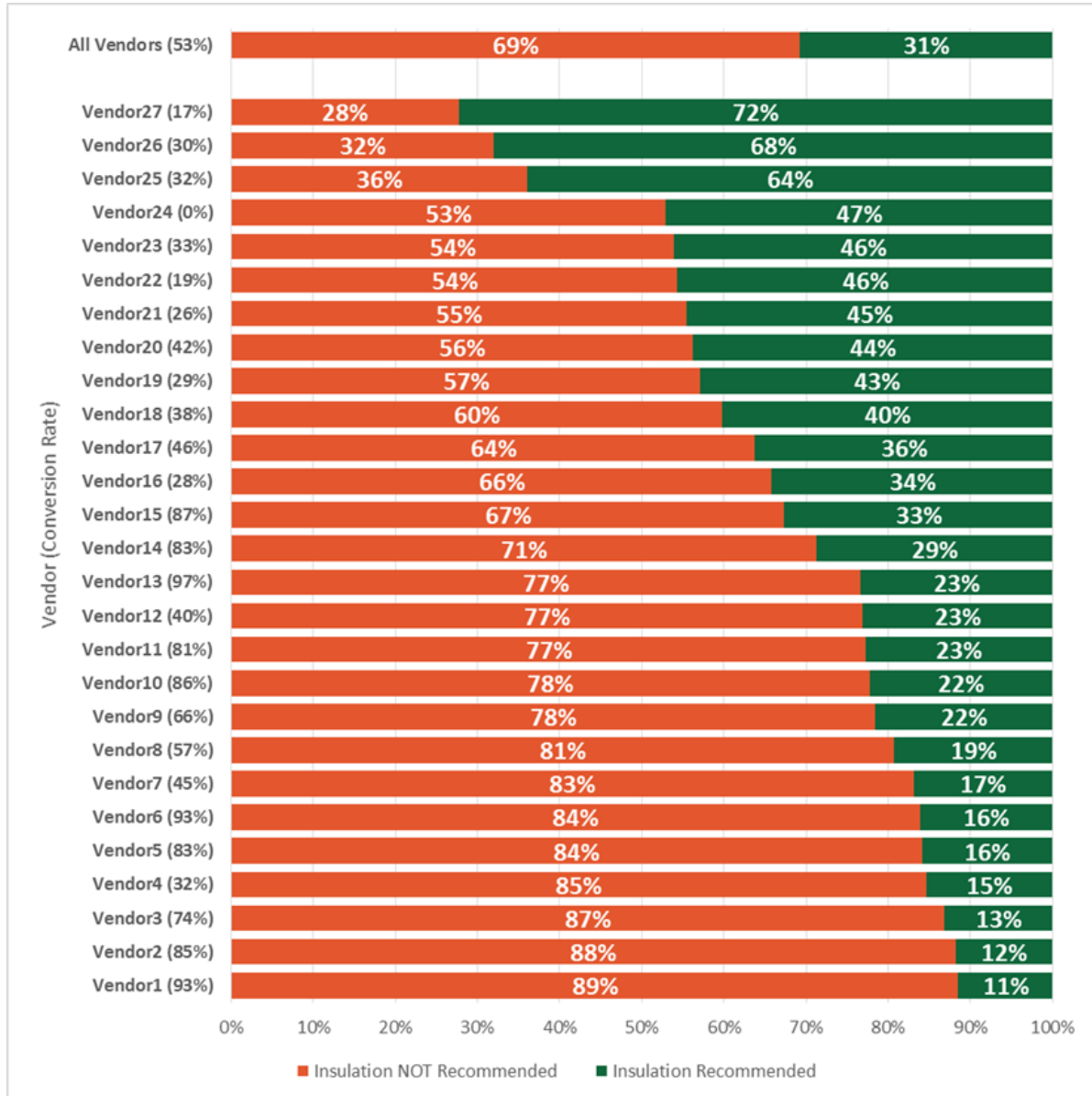
Insulation was installed at 2,518 of the 17,968 homes served through HES in 2014, or 14% of participating homes. A higher percentage of Eversource than UI homes had insulation installed through HES (16% versus 9%). Only the Eversource data set contained a variable indicating whether or not the opportunity to upgrade insulation existed per participant home. Insulation upgrade opportunities were identified in 31% of Eversource HES participant homes, and insulation was installed in 16% of participant homes. In other words, insulation was installed in just over one-half (53%) of Eversource HES participant homes in which auditors identified eligible insulation upgrade opportunities, as shown in Figure 4. The figure also shows that the percentage of Eversource homes eligible for insulation upgrades ranged

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<sup>46</sup> Three vendors that performed duct-sealing services at six or fewer homes are excluded from Figure 38. Two of these three vendors had extreme average percent duct leakage reduction values, including 0% and 100%.

from 11% to 72% per vendor, with an average of 33%. The conversion rate of homes in which insulation was recommended (the percentage of homeowners who installed a recommended insulation measure) ranged from 0% to 97% (with an average 53%).

**Figure 4: Frequency of Insulation Recommendations and Conversion Rate**



Eligible insulation upgrade opportunities were most often identified in homes that were 1) owner-occupied, 2) 1,000 to 2,999 heated sq. ft., 3) 40 to 59 years old, and 4) heated with oil. A key finding is that insulation was installed in only 14% of renter-occupied homes in which eligible insulation upgrade opportunities were identified, compared to 54% of owner-occupied homes. The considerably lower installation rate among renter-occupied homes might indicate an area where program staff and vendors could focus efforts in the future.





## 4.6 DETAILED FINDINGS RELATED TO PARTICIPATION PATTERNS

In this section, we present detailed findings from the study related to participation patterns. Findings in Table 7 are color coded based on data source as described in the [Methodology](#) section.

**Table 7: Detailed Findings (Participation Patterns)**

Data Tracking Records	Nearly one-third of participants (29%) received a combination (two or more services) of air sealing, duct sealing, and/or insulation. Eighteen percent of participants received air sealing and duct sealing in combination. Another eight percent received air sealing and insulation in combination. Two percent of participants received all three services.
	Vendors installed at least some air sealing at 92% of participating homes.
	Air-sealing services provided through HES reduced air leakage by an average of 21% per home (based on pre/post CFM reductions in program records).
	The opportunity for air-sealing savings is greater in renter-occupied homes. Renter-occupied homes, which represent a small (13%) proportion of 2014 participants, saw an average air leakage reduction of 28%, compared to 20% among owner-occupied homes.
	Smaller homes had the greatest percent air leakage reduction. Homes with fewer than 1,000 heated square feet saw the greatest average air leakage reduction of 28%, followed by 23% among homes with 1,000 to 1,999 heated square feet.
	Vendors performed duct sealing at 21% of participating homes. <sup>47</sup>
	Duct sealing provided through HES reduced duct leakage by an average of 23% per home.
	Improvement in duct leakage does not appear to be related to home characteristics such as home age, size, heating fuel, and tenure.
	Insulation was installed at 2,518 or 14% of participating homes.
	Insulation was rarely installed in renter-occupied homes. Insulation was installed in only 14% of renter-occupied homes in which eligible insulation upgrade opportunities were identified, compared to 54% of owner-occupied homes.
	Program-eligible opportunities to upgrade insulation were identified in around one-third of participating homes. Auditors identified program-eligible opportunities to upgrade insulation in 31% of Eversource participant homes. <sup>48</sup>
	Around one-half of participants eligible to upgrade insulation through the program elected to install insulation. Insulation was installed in 53% of the Eversource homes in which eligible upgrade opportunities were identified.

<sup>47</sup> Data regarding duct sealing did not identify whether ductwork was present and if a home was eligible for duct sealing. Therefore, all duct sealing results include all participating homes.

<sup>48</sup> Only the Eversource data set contained a variable indicating whether or not the opportunity to upgrade insulation existed per participant home.

## 5

## Section 5 Vendor Practices

The evaluation investigated the real-world practices of HES vendors. The NMR team assessed the vendor's in-field protocols; the factors that determine the depth vs. breadth of savings they attempt to achieve; the quality and comprehensiveness of their air sealing, duct sealing, and insulation services; the recommendations they make to customers; and the customer's perspectives on the vendors' practices. This section focuses on those issues, with a detailed discussion of the quality of the vendor's work, as seen in the Quality Inspection visits completed by NMR. This supplements the findings reported in [Opportunities](#), which details the savings opportunities that remain after the HES teams have completed their work.

In summary, the quality of HES vendors' work varies from company to company, and from crew to crew, as each company operates under different financial realities and uses different business models, with some striving to service as many homes as possible and others attempting to delve deeper and get more savings in each home. Regardless of their approach, vendors all agree that there is a great deal of ancillary work that goes into conducting an HES assessment beyond actually performing air and duct sealing. As long as the vendors were polite and hard-working (which they almost all appeared to be, according to the homeowners), customers reported that they were overwhelmingly pleased with the technicians on site and the services offered—even on homes where NMR auditors saw deficient air or duct sealing work. This may in part stem from the fact that the participant cost share (\$99) is only about 8% of the total cost of HES core services. So, even if opportunities are left (something that customers may not have the technical knowledge to assess for themselves), customers receive a high value for \$99, including other measures outside of the scope of this particular evaluation, such as efficient light bulbs and water conservation measures.

For air sealing, the technical quality of the work is generally acceptable, though completeness is lacking; for duct sealing, while completeness is also an issue, work quality is a greater concern, particularly due to the commonly seen practice of hastily applied foil tape. While basement and wall insulation was only rarely seen in site visits, attic insulation appears to be mostly of high quality.

Improving the ability to upsell measures to homeowners is a program goal, as not all HES technicians currently possess the communication and sales skills needed to convince homeowners to spend more money on add-on measures, such as installation of HVAC upgrades.

### 5.1 OVERVIEW OF HES AUDIT PROCESS

Most HES vendors schedule a single "core services" visit with a customer, though some will split the visit, particularly if a health and safety issue limits what the team can do on an initial visit. Based on vendor interviews, most HES crews try to complete one or two sites in a day. Additional measures that the homeowner decides to install, such as attic or wall insulation,

are installed at a later date, and the homeowner is free to choose a different contractor than the HES vendor that performed the core services.

During the initial core services visit, HES vendors conduct numerous activities in addition to performing energy saving measures such as air and duct sealing. These include safety tests and inspections, diagnostic tests (air flow, blower door, and duct blaster), measuring the size of the home, entering site data into program paperwork/software and calculating the Home Energy Score, making recommendations and explaining results to the homeowner, and so forth. The various tasks and data entry requirements take a substantial amount of time. Altogether, vendors estimate that site visits take between four and six hours—depending on home size and characteristics. Of this time, only a portion can be devoted to the actual air sealing and duct sealing core services.

## 5.2 VENDOR PRACTICES – VENDOR BUSINESS APPROACHES

Vendors are given the freedom to meet the utilities' savings goals by visiting more homes or achieving greater savings per home, and some try to accomplish two visits per day, while others try to do one. While two technicians per site is the most common, NMR saw sites with only one technician and as many as three.

Some vendors focus exclusively on HES core services and do not install add-on measures. Such companies may have partnerships with insulation contractors and receive a fee or commission for the referral to the insulation contractor.<sup>49</sup>

### 5.2.1 Savings per Home

According to program staff, the program seeks to achieve deep savings through a combination of core services and rebated measures. The program provides direction to vendors by providing minimum savings requirements that must be achieved on average—these requirements have increased throughout the program's history—and an incentive structure that rewards vendors for achieving greater savings. Based on data provided by staff, the cost per home (paid to vendors) was between \$1,200 and \$1,300 per home, on average. More than 80% of vendor fees (~\$1,000) were from variable incentives provided based on actual measures installed or CFM reduced. Still, fixed-cost incentives per home averaged over \$200.

Unfortunately, based on vendors' interviews both on the phone and in the field, the current system may lead some vendors to avoid investing time in homes that they consider to be *time sinks*—preferring to maximize the number of homes rather than pursuing deeper savings per home, collecting more fixed incentives and variable incentives for lighting and direct hot water measures than variable incentives for envelope and duct leakage reductions.<sup>50</sup> Vendors may also be more likely to avoid trying to spend longer at homes where the

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<sup>49</sup> HVAC companies may also be HES vendors, and might achieve higher rates of add-on uptake because the customers calling them are already interested in HVAC equipment.

<sup>50</sup> Reviewing costs, this appears to be a valid strategy for vendors, but a disservice to the program. If a vendor were to visit a home and install lighting and direct hot water measures, they would be able to collect more than \$400, on average—about one-third of the total average value per home.

homeowner has little to no interest in purchasing add-on measures from the HES vendor. A vendor reported:

*They pay us to go after low-hanging fruit. Time is money, and it's easier to get first instances of air sealing done, with lesser payback as you go further. Air sealing opportunities are almost always left behind.*

NMR did identify anecdotal instances that would seem to confirm that some HES vendors did not attempt to seal readily visible leaks in the ducts or envelope, leaving NMR auditors to speculate as to why the work was performed in such a cursory manner. These included sites with minimal or no air sealing in attics or basements when there was no discernable health and safety issue that would have prevented this work. In one instance, extremely cursory and sloppy work was done, the homeowner reported a single technician had come to the home for about one and a half hours, and the homeowner had not been told about any rebates for insulation; this homeowner went on to have insulation installed on her own, outside of the HES program, and it was of egregiously poor quality (see Figure 24). Even on these sites, customers could still be happy with the value of the work they received, factoring in light bulbs, door weather-stripping installed, the courteous HES team, and so forth.

### 5.3 VENDOR PRACTICES – WORK QUALITY AND COMPLETENESS

The following explores the quality and completeness of the vendors' air sealing, duct sealing, and insulation practices. Assuming health and safety issues are not a concern, there exist two types of opportunities for additional savings within any given home after it participates in the HES program: opportunities to improve the quality of work completed through the program and opportunities to improve the completeness of work completed through the program. Quality refers to the actual work that was completed in the home—how good or bad the work is. Completeness refers to the extent to which all possible work was identified and completed.

As an illustrative example, imagine a roofing company installs a new roof to exacting standards. After completing one-half of the roof, they leave the work site, never to return. The work on the roof that was completed could be said to be of high quality, while the level of completeness would be poor.

#### 5.3.1 Air Sealing

NMR auditors typically saw air-sealing work that was of acceptable technical quality but was incomplete. Most vendors completely ignore key building components (such as attics and basement ceilings [frame floors]) or stop short of sealing all of the visible and readily accessible penetrations. Only two of the homes NMR auditors visited were close enough to the Building Airflow Standard that the vendors might have curtailed their air sealing.<sup>51</sup> NMR

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<sup>51</sup> There was no mention of meeting the BAS at these two homes in the program records provided to NMR. In one of these instances, the homeowner commented that the vendor team was concerned about hitting the BAS in the already tight home, but according to NMR's calculations, the team did not come particularly close to the BAS. In the other home, the home did appear to be near the BAS, though the homeowner had no recollection of the vendor team mentioning this.

auditors looked in basements for signs of readily visible penetrations that were not hidden behind anything—meaning not covered by insulation. Because attics are usually somewhat insulated, NMR considered readily accessible penetrations to include those that may not be visible without lifting insulation.

Examples of commonly deficient air-sealing practices include:

- HES vendors commonly perform no sealing in key building components, even when access is easy, and focus on interior air-sealing work instead (work that is more visible to the customer).
- Auditors commonly skip areas where access is complicated, including insulated attics and insulated basement ceilings.
- In the course of air sealing a given building component—e.g., a basement ceiling—vendors frequently missed penetrations that they could have easily seen and reached. Well-sealed penetrations often exist very close to completely unsealed gaps.

Health and safety issues were found in 11 of the visited homes. These issues were confirmed based on a combination of program record review and homeowner recollection, because program records alone did not consistently track these problems. The aggregated UI program records provided to evaluators did not include information about health and safety concerns, and Eversource's aggregated program records included some, but not all of these issues. Based on NMR's on-site inspection results, only three of these eleven homes had issues that prevented the HES vendors from performing certain core services, such as rim joist air sealing. Gas leaks, for example, will delay work, but the issue can typically be fixed quickly, at which point work can resume, though homes with more serious problems (asbestos, mold, etc.) might require a lengthy abatement process before HES vendors can perform core services. In one case, courtesy air sealing (weather-stripping, door sweeps, etc.) and duct sealing had still been performed in a home with attic mold; in another, the team had even done duct sealing in an attic duct system sitting on top of vermiculite insulation.

Door weather-stripping and door sweeps appear to be a weak point in the HES vendors' air sealing practices. Most HES vendors weather-strip doors with an inexpensive, stick-on plastic v-seal, which may fail in high-use doorways; door sweeps that are not perfectly installed may annoy homeowners if they render a door harder or noisier to operate.

These differing practices can largely be explained by limits to vendors' time or technician inclination (effort). Some teams might try to maneuver in tight spaces or seal top plates, but the technicians' willingness to do so varies. The QA/QC vendors confirmed this assessment, describing how the work quality can vary greatly depending on the technician's inclination or the business model of the vendor (more homes vs. greater savings in each home).

### 5.3.2 Duct Sealing

NMR auditors saw mixed quality in the duct sealing work performed by HES vendors, and poor-quality applications were seen across all of the common duct-sealing materials. NMR auditors regularly saw poorly adhered foil-face tape that was peeling off of the ducts, a key concern regarding savings persistence. NMR auditors saw HES vendors use a mix of mastic,

foil-faced tape, and, in rare instances, thick foil-faced mastic/rubber tape or the same spray foam used for air sealing.

Vendor practices vary and can include:

- Sealing all visible seams
- Sealing seams near the air handler
- Sealing specific, large gaps
- Sealing insulated duct sleeves rather than the ducts themselves

Sealing insulated ducts (other than accessible, visible seams) is uncommon; this work can be difficult (requiring removal of insulation to fully identify sealing opportunities), and customers may not approve of the potential damage to the insulation that might result from its removal and reinstallation. The program Implementation Manual appears to discourage attempting duct sealing at jobs with limited perceived opportunity. For example, the Implementation Manual, gives this guidance for assessing the level of duct sealing opportunity. HES vendors are told to confirm that “ducts are longer and have minimal transition & takeoffs (good opportunity!) If ducts are short, choked, consist primarily of flex duct or have a lot of takeoffs (bad opportunity!), do not proceed with duct sealing.”

### 5.3.3 Insulation

NMR auditors saw that HES-incentivized rim joist insulation, basement ceiling insulation, and wall insulation are all rare. Attic insulation is more common and frequently of high quality in HES homes. NMR auditors graded all insulation jobs observed based on RESNET’s standard three-point scale: Grade I (high quality), Grade II (acceptable quality), and Grade III (low quality, but within specified limits). In general, insulation work quality was good, with 87% of the 38 insulation projects that NMR could assess receiving a rating of I or II.<sup>52</sup> Figure 5 shows a high-quality example of blown-in fiberglass insulation in an attic. The insulation was deep, quite level, and also installed over a room that was difficult to access from the main attic

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<sup>52</sup> Note that this figure excludes installations where NMR was unable to determine the installation quality (typically due to limited access). All six of the Grade 1 rim joist installations are actually extremely thorough air-sealing measures that also fully insulated the rim joist, at no additional customer cost.

space. The homeowner reported having to push the insulators to get them to insulate this harder-to-access space, but the final work product appeared to be of high quality.

**Figure 5: High Quality Blown-in Attic Insulation**



Figure 6 shows a basement rim joist that was completely insulated by the HES vendor using two-part closed-cell spray foam. This was installed, however, as an air-sealing measure, meaning that the homeowner received excellent air sealing, and also an insulation benefit, without having to pay separately for rim joist insulation. NMR auditors saw that some HES vendors thoroughly seal the entire rim joist area with spray foam to achieve higher savings than might be possible with targeting individual penetrations with a spray foam gun/wand.

**Figure 6: High Quality Rim Joist Air Sealing Serving as Insulation**

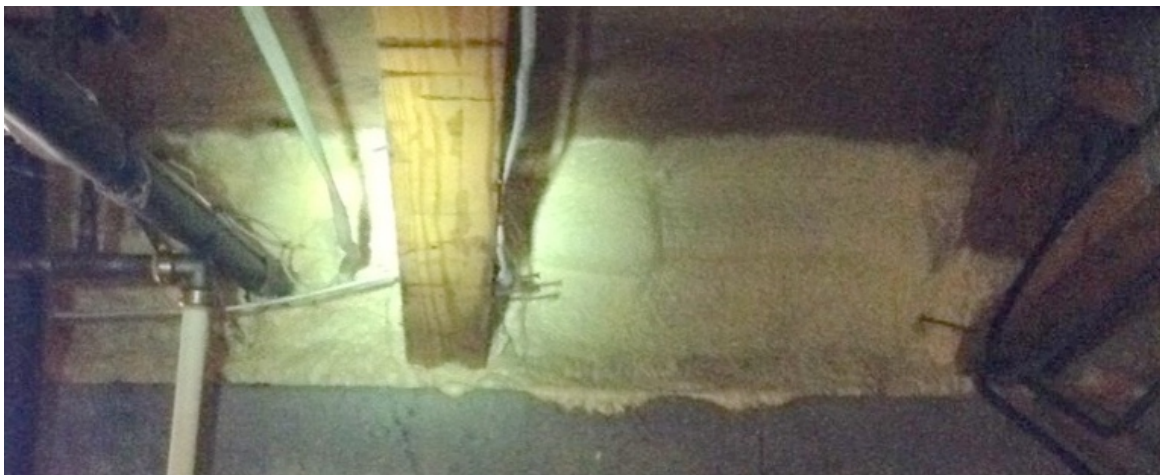


Figure 7 shows a rim joist that was well-insulated (and air sealed) with closed-cell spray foam, but an HES insulator had done a poor job of insulating the basement ceiling. The installation was extremely sloppy and had large gaps and severe compression; the fiberglass insulation was not cut or split to fit around any obstacles, and was forced into the ceiling cavities.



**Figure 7: High Quality Rim Joist Air Sealing and Low Quality Basement Ceiling Insulation**



Figure 8 shows a high quality attic insulation job done with spray foam. The HES team had encapsulated the entire attic, turning this into conditioned space.

**Figure 8: High Quality Attic Insulation with Spray Foam**

### 5.3.3.1 Basement Insulation

HES vendors rarely insulate basement ceilings or rim joists. When they do, this can be quite sloppy (Grade III, meaning severe gaps and compression<sup>53</sup>), particularly if they use fiberglass batts.

Some HES vendors offer a strong value to customers by completely or substantially covering the rim joist areas with two-part, closed cell spray foam for no additional cost. This has a higher material cost to the vendor, but they can achieve greater air sealing reductions, and it provides homeowners with the added benefit of rim joist insulation.

### 5.3.3.2 Wall Insulation

Wall insulation is also a rare measure through the HES program. NMR auditors saw reasonably good installations in the two examples seen during quality inspections, but cannot generalize more broadly, as this evaluation involved inspecting completed services, not confirming the identified opportunities.

Some vendors do not insulate walls themselves and subcontract this out. A vendor described how they preferred to do more HES audits and simpler attic insulation jobs rather than taking

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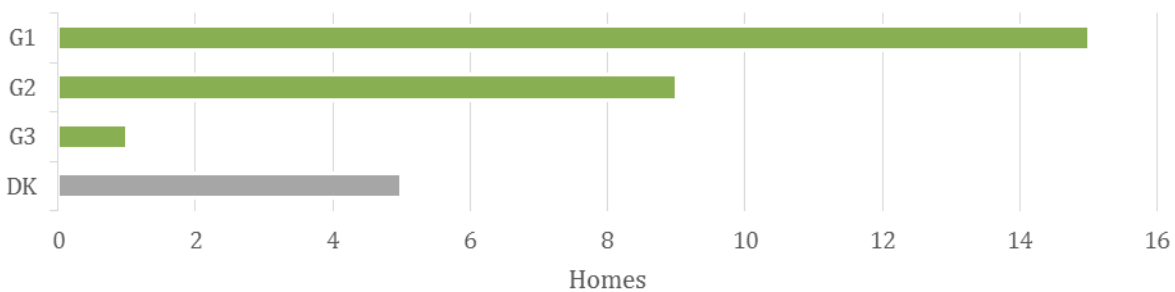
<sup>53</sup> This problem is not unique to the HES program; NMR auditors typically see poor quality installations of this insulation material in rim joists or basement ceilings, where contractors often do not cut the insulation material to fit around obstacles and instead force it into the cavities, compressing it and reducing its R-value.

on wall insulation jobs that they perceive to be labor- and time-intensive (removing siding, boring holes, risk of damaging plaster, etc.).

**5.3.3.3 Attic Insulation**

NMR auditors frequently saw high-quality installations of attic insulation, with limited compression and minimal gaps. The best installations also appeared to be the blown-in or spray-applied materials. NMR auditors estimate that about 60% of the attic insulation installs met RESNET’s Grade I standards (high quality).<sup>54</sup> Insulation defects were most commonly seen in hard-to-access areas, where vendors had to work around low ceilings, storage, or other obstacles.

**Figure 9: Quality of Attic Insulation Installs (Grade 1 = Best)**



**5.4 VENDOR PRACTICES – RECOMMENDATIONS FOR ADD-ON MEASURES**

Program staff report that while they are pleased with most of their vendors’ performance, many vendors need to improve their ability to upsell add-on measures to customers, such as insulation. Getting customers to agree to purchase additional efficiency upgrades, such as discounted insulation or HVAC equipment, requires strong sales skills that all technicians may not possess, a problem that program staff recognize.

**5.5 VENDOR PRACTICES – CUSTOMER PERCEPTIONS**

Customers are pleased with the vendors who perform work in their homes. The vendors are perceived as friendly and hard-working, and customers believe they receive a good deal of work for the cost of the co-pay and recommend it to friends and family. Though they feel that they get a good value for their co-pay, customers have a difficult time evaluating the quality or completeness of air sealing, duct sealing, and insulation work. As the Eversource QA/QC vendor reported:

*We’ve seen times where a customer is very satisfied because the crew was on time and they were neat and they were professional and they were polite, but the customer*

<sup>54</sup> RESNET standards provide detailed criteria for grading insulation on a “1” to “3” scale: Grade I (high quality), Grade II (acceptable quality), and Grade III (low quality, but within specified limits).

*does not have any knowledge base to know whether technically they completed the work effectively or not, whether or not there were any missed opportunities or such. So you might have a very happy customer, but yet not necessarily a complete and thorough job, just simply because of their lack of understanding of it from a technical nature.*

## 5.6 DETAILED FINDINGS RELATED TO VENDOR PRACTICES

In this section, we present detailed findings from the study related to vendor practices. Findings in Table 8 are color coded based on data source as described in the [Methodology](#) section.

**Table 8: Detailed Findings (Vendor Practices)**

Program Staff	<p>Program staff generally spoke positively about vendors’ performance. Areas that they said that vendors do a good job include scheduling and conducting the audit, identifying savings, collecting data during the assessment, and overall customer service.</p>
	<p>Areas where staff identified variation among vendors’ performance include their ability to recommend measures via the kitchen table wrap-up and marketing and outreach efforts. In both instances, staff noted that “some vendors are better than others.” When speaking about the kitchen table wrap-up in particular, staff stated that this task requires communication and sales-related skills that not all technicians possess; staff have noted this as an area for improvement.</p>
Data Tracking Records	<p>As discussed in the Participation Patterns section, program records indicate:</p> <ul style="list-style-type: none"> <li>• HES vendors air sealed in 92% of participant homes, and they reduced air leakage by 21%, on average.</li> <li>• HES vendors performed duct sealing at 21% of participant homes, achieving just under 25% improvement, on average.</li> <li>• HES vendors installed insulation in 14% of participant homes.</li> </ul>
Vendors	<p>Six vendors voiced mixed opinions on whether they have experienced any tension between providing comprehensive services and the demand for services—that is, how they decide whether to provide deeper services to few participants or more core or low-cost services to a greater number of participants.</p> <p>One vendor stated that they opt to provide deeper services to their customers; another vendor, who stated that their company opts for depth over breadth, stated that the program has specific guidelines, but the vendor has “leeway to decide whether to dig in or not.”</p> <p>Others stated that budget constraints as well as the structure of the visit, which involves both the audit and the installation of core measures, limits the amount of work that can be accomplished. In phone interviews and on-site visits, multiple vendors were interested in a program structure that separates the initial audit from the installation of core services.</p>

Vendors	<p>Some of the HES vendors that NMR spoke with on site do not perform wall insulation work. Some vendors subcontract the work out, while others refer homeowners to specific insulation companies that, in turn, pay the HES vendor a fee or commission for any insulation work performed for the homeowner.</p> <p>An insulation contractor on site described how some vendors—HVAC companies in particular—achieve higher rates of add-on measure uptake because the people who call them are already interested in add-on measures, whereas HES-only companies may have more customers that are not interested in pursuing additional measures.</p>
Quality Inspections	<p><b>Overall Assessment of Quality and Thoroughness of Air-Sealing Work.</b></p> <p>With occasional exceptions, NMR auditors saw good overall technical quality in the air-sealing work that was done by HES vendors, but the work was frequently incomplete.</p> <p>Some vendors do a thorough job of air sealing and seal as much as could reasonably be sealed in a single visit. As discussed in <a href="#">Opportunities</a>, a large number, however, completely ignore key building components, and most stop short of sealing everything they could, resulting in homes with a mix of well-sealed and un-sealed penetrations.</p> <p>Differing practices can largely be explained by limits to vendors' time, access issues (hard to reach, storage in the way, etc.), or technician inclination (effort). The QA/QC vendor confirmed this assessment, describing how the work quality can vary greatly depending on the technician's inclination or the business model of the vendor (more homes vs. greater savings in each home).</p> <p>Examples of commonly deficient air sealing practices include:</p> <ul style="list-style-type: none"> <li>• HES vendors commonly perform no sealing in key building components, even when access is easy, and focus on interior air-sealing work instead (work that is more visible to the customer, in many cases).</li> <li>• Auditors commonly skip areas where access is complicated, including insulated attics and insulated basement ceilings.</li> <li>• In the course of air sealing a given building component—e.g., a basement ceiling—vendors frequently missed penetrations that they could have easily seen and reached. Well-sealed penetrations often exist very close to completely unsealed gaps.</li> <li>• While health and safety issues were found in 11 of the visited homes, only three of the homes had issues that prevented the HES vendors from performing certain core services, such as rim joist air sealing.</li> </ul>

Quality Inspections	<p><b>Air Sealing in Basement Rim Joists.</b></p> <p><b>Quality.</b> Air sealing rim joist penetrations is a straightforward process from a technical perspective—injecting an expanding, liquid spray foam into cracks and crevices—and with some exceptions, HES vendors appear to do a reasonably good job of sealing these penetrations when they attempt to do so.</p> <p>Some vendors also approach this work quite differently. Some skip the rim joist penetrations entirely, some use targeted air sealing of visible penetrations, and in a minority of cases, they almost fully cover the rim joist area with two-part spray foam, providing a high level of air sealing and also insulating the area.</p> <p><b>Completeness.</b> Additional opportunities for easily achievable air sealing frequently remain; some vendors do not seal rim joist penetrations at all, and most appear to frequently miss readily visible and accessible rim joist penetrations.<sup>55</sup></p>
Quality Inspections	<p><b>Air Sealing in Basement Ceilings (Frame Floors)</b></p> <p><b>Quality.</b> By sealing cracks and penetrations in the ceilings of unconditioned basements, HES vendors can reduce air infiltration due to the stack effect. NMR auditors saw many instances of HES vendors sealing gaps in basement ceilings around electrical wiring, plumbing pipes, and similar penetrations, mostly using liquid spray foam and occasionally using other materials to span larger gaps.<sup>56</sup> This air sealing was typically of acceptable quality, acknowledging that some areas are harder to reach than others with the wand of a spray gun.</p> <p><b>Completeness.</b> As with rim joist air sealing, the completeness of basement ceiling air sealing was more of an issue than the quality of the work done. Some vendors skip frame floor air sealing entirely, and most miss at least some visible and accessible frame floor penetrations.<sup>57</sup></p> <p>HES vendors also appeared to skip sealing penetrations in basement ceilings that were insulated; vendors would have to move the insulation in order to find and seal penetrations in such basements, substantially lengthening the time required to perform air sealing in basements. Interviews with vendors during on-site inspections confirmed that pulling down insulation to air seal penetrations in basement ceilings is a rare practice and might only be expected around suspected larger penetrations (chimney chases, large plumbing drain pipes, etc.).</p>

<sup>55</sup> NMR auditors inspected these homes without the benefit of having a blower door fan running during these tests; thus, these inspections were visual, and the amount of air leakage at these penetrations could not be verified. However, NMR auditors are experienced HERS Raters and building scientists and are trained to identify signs of air leakage, even without the use of a blower door fan.

<sup>56</sup> Spray foam was overwhelmingly the most common material used to seal gaps in frame floors; occasionally, vendors used foil-faced bubble wrap or sheet metal with spray foam at the edges to seal larger openings. HES vendors typically used the yellow spray foam in the homes NMR auditors visited, though the fire-retardant bright orange variety was occasionally used.

<sup>57</sup> As previously noted, NMR auditors inspected these homes without the benefit of having a blower door fan running during these tests; thus, these inspections were visual, and the amount of air leakage at these penetrations could not be verified. However, NMR auditors are experienced HERS Raters and building scientists, and are trained to identify signs of air leakage, even without the use of a blower door fan.

### Air Sealing in Attics

**Quality.** As with air sealing in the basement, HES vendors typically appear to do a reasonable job of sealing attic penetrations when they attempt to do so, but thorough air sealing work in attics was uncommon. NMR auditors generally saw liquid spray foam used to seal cracks or penetrations, though HES vendors mentioned a recent program change that required them to use a more fire-resistant material around chimney chases.

**Completeness.** Attics are difficult places to air seal thoroughly, and outside of their own time constraints, vendor teams can be stymied by limited access or safety concerns. However, based on the attics that NMR auditors could inspect, there appear to be significant opportunities for additional savings from attic air sealing, as discussed in [Opportunities](#). Auditors saw that vendors often skipped air sealing in the attic or air sealed only the most obvious penetrations, focusing instead on air sealing in basements or interior spaces (spaces that also make for more pleasant working conditions). Homeowners with some regularity confirmed that the HES teams had entered their attics to assess insulation, but had not performed work in the attic.

Acknowledging that auditors could not fully assess the air sealing in some attics, the only methodical air sealing NMR auditors saw in attics was in those homes where the attics had been fully sealed and encapsulated at the rafters with spray foam, and in one instance where the HES team appeared to have done a thorough job of air sealing penetrations in the attic floor.<sup>58</sup> They did not see any other instances of methodical air sealing in attics, e.g., thorough sealing of top plates.

During on-site visits, the vendors that NMR interviewed acknowledged the HES program's stated goal of prioritizing air sealing in attics. They also highlighted many common challenges to actually achieving those savings, where it may be physically difficult to find and seal attic penetrations, including the following:

- Storage and clutter
- Flooring
- Low roof lines
- Small attic hatches
- Dirty working conditions
- Old insulation that may be damaged by disturbing it
- Homeowners who do not want vendors to disturb blown-in insulation
- Safety concerns
  - Unsure footing
  - Hot working conditions in summer
  - Hazardous materials (ALM, vermiculite, or mold, for example)

<sup>58</sup> NMR auditors could not fully inspect this attic as it had been newly insulated, but all penetrations and top plates that NMR auditors inspected had been nicely sealed.

Quality Inspections	<p>Vendors expressed a general desire to thoroughly air seal in attics, rather than just focusing on “big ticket” penetrations, but when asked to elaborate on their real-world practices, it did become clear that the above barriers can substantially limit the air sealing work that vendors will do in attics, and that these practices vary not just from company to company, but also from technician to technician. Some teams might try to maneuver in tight spaces, move blown-in insulation out of the way to find penetrations, or seal top plates, but the technicians’ willingness to do so varies.</p>
	<p><b>Air Sealing at Attic Hatches.</b> HES vendors typically sealed true attic hatches with a plastic weather-stripping material, and in some cases sealed them with caulk, while doors to walk-up attics were generally sealed similarly to exterior doors (weather-stripping and door sweeps).</p>
	<p><b>Weather-Stripping Doors.</b> Unlike air sealing in basements or attics, weather-stripping of doors by HES vendors was essentially ubiquitous, indicating limited opportunity here (other than for instances of failed or removed weather-stripping). NMR auditors saw HES-installed weather-stripping or door sweeps in 96% of the homes they visited—all but 3 of the 70.<sup>59</sup></p> <p>The material used for door weather-stripping typically included rubber door sweeps (a common source of customer complaints due to noise or friction with the floor), and a plastic v-seal material, which appeared to have limited durability, as it had started to fail in some of the homes visited.</p> <p>Vendors who accompanied the NMR auditors on site commented on vendors having the freedom to use their preferred material for weather-stripping doors, and that some chose to use a more durable but more expensive product, though most used the less expensive stick-on material due to its relatively low cost.</p>
	<p><b>Interior Caulking.</b> The caulking used inside homes was usually a clear material (making it hard to see except for its glossy sheen), applied along cracks at window and door frames, casings, and along baseboards and fireplaces. In one particularly egregious example of poor quality work, the vendor had used expanding liquid spray foam to seal a long seam between a wall and vaulted ceiling, leaving a large and unsightly bead of foam that the customer was left to cover themselves.</p> <p>NMR auditors could not always see signs of interior caulking, and in some cases relied on customer feedback regarding whether or not the HES team had performed this air sealing measure. Auditors confirmed some caulking had been done in 54% of the visited homes, had not been done in 19%, and were unable to tell in 32%.</p>

<sup>59</sup> NMR confirmed that the weather-stripping and door sweeps installed were put in place by the HES team.



Quality Inspections	<p><b>Duct Sealing</b></p> <p><b>Quality.</b> More than with air sealing, the quality of duct sealing was a clear issue in the homes that NMR auditors inspected. NMR auditors saw mixed quality in the duct sealing work performed by HES vendors, and poor quality applications were seen across all of the common duct-sealing materials. A key concern with poor application of foil-faced tape is the persistence of the savings from duct sealing.</p> <p>Foil-faced tape was commonly used where mastic could have been applied, and the tape was frequently poorly applied. HES vendors simply did not appear to press the tape down hard enough to firmly adhere it; in many cases had already started to peel off. Mastic applications appeared to result in a more permanent duct-sealing solution, though gaps in mastic applications were still visible in some homes.</p> <p>NMR auditors saw HES vendors use a mix of mastic, foil-faced tape, and, in rare instances, thick foil-faced mastic/rubber tape or the same spray foam used for air sealing.</p> <p>Even the HES vendors that NMR spoke with on site expressed frustration that their own technicians were using foil-faced tape when they felt that they should have been using mastic or the thicker tape.</p> <p><b>Completeness.</b> The completeness of duct sealing was also an issue. Vendor practices vary and can include:</p> <ul style="list-style-type: none"> <li>• Sealing all visible seams</li> <li>• Sealing seams near the air handler</li> <li>• Sealing specific, large gaps</li> <li>• Sealing insulated duct sleeves rather than the ducts themselves</li> </ul> <p>Sealing insulated ducts (other than accessible, visible seams) is uncommon—vendors reported that customers typically do not want them to remove insulation on ducts in order to seal them.</p>
	<p><b>Rim Joist Insulation</b></p> <p><b>Quality.</b> The sole example of fiberglass batt insulation in the rim joists—installed with program rebates—was sloppily installed. The overall installation was judged to be poor quality (Grade 3), and there were areas that had uninsulated gaps and severely compressed areas that were worse than what a Grade 3 designation would allow, under RESNET standards.</p> <p>The six foam installs—installed as a core air sealing measure, not an incentivized insulation measure—were Grade 1 installs where the foam was applied. While foam does not compress like fiberglass batts, there were gaps in five out of six installs that would be larger than what a Grade 3 designation would allow.<sup>60</sup></p>

<sup>60</sup> A reasonable approach for modeling the performance of these foamed rim joists would be to model the well-insulated areas a Grade 1, and model the uninsulated areas separately.

	<p><b>Frame Floor Insulation</b></p> <p><b>Quality.</b> Fiberglass Batts. The installation quality of the fiberglass batts was relatively poor, as is common when using fiberglass batts to insulate basement ceilings. NMR could only inspect three of these four installations.</p> <ul style="list-style-type: none"> <li>• All three earned Grade 3 installation overall.</li> <li>• All three had some severe compression that was also worse than the Grade 3 RESNET criteria.</li> <li>• Two had gaps that were worse than what a Grade 3 designation would allow. Only one had support hangers installed to keep the insulation from sagging; it was sagging in the other two homes</li> </ul> <p><b>Quality.</b> Foam and Cellulose. Two homes had spray-foam insulation installed, and one had dense-pack cellulose installed into an enclosed frame floor assembly. Compression and sag are generally less of an issue for foam and dense-pack insulation installs than fiberglass batts in frame floors. There were no noticeable gaps in the foam installs, though there were significant visible gaps in the cellulose install.</p>
<p>Quality Inspections</p>	<p><b>Wall Insulation</b></p> <p>Quality. NMR auditors only saw two instances of HES-incentivized wall insulation (3% of visited homes), making overall judgments about work quality impossible. Insufficient temperature differentials between indoor and outdoor conditions limited the NMR auditors' ability to make fully confident insulation grade designations in these cases (per RESNET standards).</p> <p>In one of those two homes, NMR auditors saw what appeared to be a reasonably good quality installation of fiberglass batts, but this judgment was based only on the homeowner's mid-construction photos. In the second home, NMR auditors saw what appeared to be a good quality dense-pack cellulose installation, except for several gaps in bays above windows that had been left uninsulated. Auditors could not determine if there had been settling in the cellulose wall insulation.</p> <p>In one home, the HES vendor had incorrectly read the infrared camera results as a result of uninsulated walls appearing to be insulated/warm due to solar loading; the vendor told the homeowner that the walls were insulated, when in fact they remained completely uninsulated; the walls were later opened by contractors installing a heat pump system, who showed the homeowner the open cavities.</p>

Quality Inspections	<p><b>Attic Insulation<sup>61</sup></b></p> <p>Overall Quality. NMR auditors frequently saw what appeared to be high-quality installations of attic insulation overall, with limited compression and minimal gaps, though some gaps and imperfections were sometimes seen in hard-to-access areas. The best installations also appeared to be the blown-in or spray-applied materials.<sup>62,63</sup></p> <p>Auditors estimate that 15 of 25<sup>64</sup> installs (60%) were Grade 1 installations (high quality, according to RESNET standards), indicating very minimal gaps or compression. Grade 2 installs—of good quality, with minor gaps or compression—were seen in nine (36%) of those attics.</p> <p>Only one—a fiberglass batt installation—was judged poor enough to be counted as a Grade 3 installation (poor) overall. An HES vendor joined NMR during that particular site visit, and judged it a "C-minus," agreeing that the batts had been sloppily installed, and pointing out that the insulators had failed to staple the baffles in place at the eaves and they were falling down as a result.</p>
	<p>As with air sealing, the insulation defects were most commonly seen in hard-to-access areas, such as near the perimeter of the house where the sloping roof rafters meet the attic floor. Attic storage was also an issue, as some homeowners did not want to give up all of their attic flooring, resulting in reduced savings in some homes.</p>
	<p><b>Blown-In Insulation Evenness</b></p> <p>NMR auditors recorded the general appearance of any blown-in or spray-applied attic insulation (n=26). In most cases, the evenness of the insulation was acceptable or quite good:</p> <ul style="list-style-type: none"> <li>• 39% of blown attic insulation installs (where we could determine the quality) showed evenly distributed insulation.</li> <li>• 35% were acceptable or somewhat even (insulation varying by a couple of inches at most).</li> <li>• 26% were very uneven, indicating a lower-than-expected effective R-value.</li> </ul>

<sup>61</sup> NMR auditors saw attic insulation that had been installed through the HES program in 30 of the visited homes with attics (44%). Auditors were able to visually inspect the attic insulation in most of these homes, and relied solely on IR cameras in only three cases. In one instance, the homeowner had photos that were taken inside the attic that had since been sealed, and the NMR auditor used those to assess the insulation quality as best as possible.

<sup>62</sup> These require less effort to fill voids around joists, electrical wiring, and mechanical equipment than do fiberglass batts.

<sup>63</sup> NMR auditors could not move freely through freshly insulated attics, but made their best assessments of the overall insulation quality. Auditors did not specifically assess the adequacy of ventilation, presence of eave baffles, or presence of depth markers for blown-in insulation, though these are important aspects of quality insulation jobs. NMR auditors focused on the quality and distribution of the insulation itself.

<sup>64</sup> These figures exclude the five attics where NMR auditors could not ascertain the installation grade due to lack of access.

Participants	<p>Participants had high praise for the technicians who conducted the audit. They described them as polite, thorough, knowledgeable, and punctual. These qualitative assessments were accompanied by high quantitative ratings of program satisfaction. These were as follows, each using a one-to-ten scale of satisfaction, with higher numbers representing higher satisfaction.</p> <p><i>Satisfaction with</i></p> <ul style="list-style-type: none"> <li>• Benefits received: 8.7/10</li> <li>• Work completed: 8.8/10</li> <li>• Program literature: 8.8/10</li> <li>• Experience overall: 8.9/10</li> </ul> <p><i>Likelihood of recommending</i></p> <ul style="list-style-type: none"> <li>• 9.3/10 (most respondents indicated they already had recommended to friends, family, and co-workers)</li> </ul>
Program Administrators	<p>PAs from other programs cited a number of key program elements which the HES program already has in place:</p> <ul style="list-style-type: none"> <li>• Using BPI standards and certified technicians</li> <li>• Incorporating a sales effort through the kitchen table wrap-up</li> <li>• Leaving materials behind outlining potential energy savings</li> <li>• Offering air sealing as a core service</li> <li>• Providing rebates and good financing options to customers</li> </ul> <p>One distinguishing feature of two of the programs included in the best practices review is that the initial audit occurs before installing the three measures of interest. This approach helps with identifying health and safety issues prior to scheduling the work, but it also helps facilitate customer buy-in as they learn about the value of energy-saving measures offered through the program.</p>
QA/QC Vendors	<p>The QA/QC vendors reported that duct sealing is an inconsistent priority, and poorly functioning duct systems may limit the work vendors do.<sup>65</sup></p> <p>UI vendor: “Very few duct systems get sealed. The majority of them don’t pass the flow test and/or are in conditioned space. . . . Originally, a lot [of vendors] just used tape; they’ve since moved to . . . mastic. Some companies do a phenomenal job; some companies try not to do it [duct seal]. A lot of . . . companies are trying to do two houses a day and not allocating enough time to properly do the work.”</p> <p>Eversource vendor: “It’s hit or miss. There are some really good contractors that use mastic and understand all the areas to air seal and duct seal, and then you’ll find a bunch of other contractors who are still trying to use metal tape to [duct] seal, and only working right around the air handler as a means of stopping that air. . . . Sometimes the [duct] cleaning just does not happen to the point where the [tape] adhesion is taking place.”</p>

<sup>65</sup> The aggregated data sets NMR was provided with for this evaluation did not include any systematic information about why duct sealing may not have been performed, so we cannot report on how well this information is recorded.

	<p>The QA/QC vendors differed in their assessment of the attic insulation.</p> <p>The UI vendor reported that attic insulation through the program is “generally . . . very good,” which supports the findings of the on-site inspections.</p> <p>The Eversource vendor reported, “We’ve seen hit or miss in the limited post inspections [of attic insulation] that we’ve done. Some are great, some are real sloppy.”</p> <p>The program does not strictly dictate the exact practices and effort that each vendor has to expend on a given home. Some vendors may be willing to serve more homes and achieve fewer energy savings at each, while others might take the opposite approach.</p> <p>UI vendor: “Each vendor has their business practices that they decide how they’re going to do it or what they’re going to do. The most important area is the attic; but if a house has 16” of cellulose [insulation], most vendors aren’t going to move the insulation to get to the leaks because they’re concerned they’re going to wreck the insulation. Everyone’s business practice dictates what they’re going to do. . . . Every company is different, and they all perform the work differently. I’ve been instructed by utilities: Some companies do it one way, some do it another way.”</p> <p>Eversource vendor: “Making sure you’re not leaving anything on the table in terms of doing quality air sealing . . . that is the [program’s] messaging. The question is, does the program design allow for the various business models [where HES vendors] might be able to make a judgment from their own perspectives as to what might be more lucrative to them—to hit more houses or spend more time?”</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">QA/QC Vendors</p>	<p>The QA/QC vendors confirmed NMR auditors’ perspectives, which is that work quality varied from job to job.</p> <p>UI vendor: “Some [vendors] do a great job and some do a poor job. It’s also crew by crew. You might have one company that some of the crews do a really good job and some do a not-so-good job. The majority of them are pretty good. . . . Some guys work hard and get everything. Some guys are just lazy and need to get weeded out of the program. I think a lot of it has to do with time constraints. That would be what I would think is the majority of what’s happening. You [NMR auditor] see what’s required [of vendors], so if they’re going for a four-hour visit, they have to test in, test out, run the blower door, and there’s not much time left for air sealing.</p> <p>UI vendor: “I think it’s company by company and crew by crew. Some companies’ main focus is in the attic, some spend a lot of time in the attic and do a great job in the attic. I see some where the crews don’t really care that much and do the minimal to get a paycheck.”</p> <p>Eversource vendor: “This is not always the easiest work to complete, from a physical perspective, or some of the most desirable, so it really comes down to how motivated that vendor is . . .do they know what they should be doing, [and] . . .how equipped are they do it. . . . So all those three things are variable on any given day and any given house.”</p> <p>Eversource vendor: “[Vendors are] not all the way there. It’s hit or miss.”</p>

According to the QA/QC vendors, some vendors may rush jobs to increase profitability, including skipping air sealing in attics or areas that are inconvenient to access.

UI vendor: “A lot of . . . companies are trying to do two houses a day and not allocating enough time to properly do the work.”

Eversource vendor: After starting as the Eversource vendor, “We quickly realized in a short period of time there was a big area [vendors] were neglecting and I don’t know if a lot of that had to do with training, but clearly [the program] told contractors what they call the ABC’s of air sealing—attic, basement, and conditioned space—and what we were finding is that, yeah, [vendors are doing] not so much of that attic stuff, but clearly a lot of caulking in the conditioned space. And that basement stuff’s easy to get to, too, so they would seal that. . . . [Vendors] definitely cut a lot of corners here, and I didn’t know if it was a lack of understanding of the ABC’s [of air sealing], or it was just, ‘Nobody ever really looked at us, so we didn’t care.’ Well, we found it’s a little bit of both.”

Eversource vendor: “I can certainly say that when we [QA/QC inspector] are on site, when the contractor first gets there, he does a much better job of getting into the attic first and starting with air sealing there. As opposed to we show up maybe in the middle, he might’ve said, ‘Eh, I’m not going to prioritize in the attic right away.’ We have to come in and reinforce [attic prioritization]—yes, that’s where the prioritization has to happen, not just doing the caulking gun [inside the conditioned area].”

## 6

## Section 6 Quality Assurance and Control

Quality assurance and quality control protocols (QA/QC) involve inspecting the work performed by a program vendor to ensure that the work is of high quality and is achieving the program's goals. For the HES program, QA/QC is critical for ensuring that savings are realized, that customers are satisfied with the work, and that work is performed safely. This evaluation investigated the QA/QC protocols used by the HES program and HES vendors themselves, the adequacy of these protocols, what protocols are used by other programs outside of HES, and potential opportunities for improving the HES program's QA/QC. Overall, HES vendors practice limited internal QA/QC. The HES program has formalized QA/QC protocols that the QA/QC vendors find useful for judging work quality, but only a small percentage of projects get inspected (approximately 5% to 10% of a vendor's projects), and in Eversource territory, post-work inspections are focused on add-on measures, not core services.

Because homeowners are not experts, and because much of the core services work may occur outside of the customer's view, customer satisfaction is not always related to the quality of the air sealing, duct sealing, and insulation work, emphasizing the importance of the program's QA/QC inspections.

*We've seen times where a customer is very satisfied because the crew was on time and they were neat and they were professional and they were polite, but the customer does not have any knowledge base to know whether technically they completed the work effectively or not, [or] whether or not there were any missed opportunities.*  
– Eversource QA/QC vendor

QA/QC vendors perform both in-progress inspections (monitoring an HES team while they perform core services) and post-inspections (visiting the home after the services are complete). However, post-inspections, which QA/QC vendors describe as critical to assuring quality work, are not typically performed for core services in Eversource territory, though as of 2015, they are now performed in UI territory. Eversource's QA/QC vendor explained that core services (air sealing and duct sealing) are almost exclusively inspected during in-progress inspections, and other than in the case of serious problems such as customer complaints, their post-inspections are designed for inspecting add-on measures, such as insulation.

For most in-progress inspections, QA/QC vendors show up at the home at the start of the core services visit, but the QA/QC vendors expressed the value in showing up while a visit is ongoing, to “catch the contractor off guard a little bit more.”

Despite any training or instruction QA/QC vendors may offer to vendors while performing in-progress inspections of the HES vendors' core services work, the QA/QC vendors are unsure of the quality of work that happens outside of their inspections, because when an inspector is present, the vendor is “on their best behavior,” and without an inspector present, the program is relying on “the honor system” for reported envelope and duct leakage reductions.

The Eversource QA/QC vendor suggested that post-inspections being limited almost entirely to add-on measures is not the best approach to fully assess the quality of HES core services.

*Obviously post-inspections ... would want to be the type of inspection I would want to do most because ... when you're standing over the person's shoulder watching him do the job, he's going to do it right, but when I'm not around or when he doesn't think I'm going to be around then the question is if he'll really follow those same rules.*

*There has been a lot of improvement [in the QA inspection process since they were hired by Eversource], and I think there's been a lot that's gone on since that sample that [NMR] saw was treated as well. As for how much adoption of the rules was followed in the 91.5% where we were not there, that's the big question.*

*Overall, if they [the HES vendors] get out of there and you [QA/QC vendor] never showed up, then [they know] no one's ever going back to that job to tell them that they didn't do something.*

*-Eversource QA/QC vendor*

QA/QC vendors inspect the work of HES vendors via on-site visits, either during or after the completion of the HES services. If the HES vendors are present, the QA/QC vendors will provide immediate feedback (which is supposed to be done outside of the customer's presence) in the case of safety hazards. During an in-progress inspection, the QA/QC vendors view their responsibility mostly as providing oversight and assessment of the work being performed, but they can provide some real-time feedback if vendors ask questions. Most of the mentoring and feedback that the QA/QC vendors provide on site typically happens after the completion of the work, in order to assess the HES vendor's performance and to avoid giving the homeowner the impression that they are receiving subpar work. After the visit, the QA/QC vendor submits to the program a scored assessment of the HES vendor's performance based on the scored criteria in the HES Quality Assurance Plan (discussed in more detail in Appendix B), along with any photos and comments. The program can follow up with HES vendors based on problematic QA/QC findings, and the HES vendors receive a monthly scorecard from the program that rates their performance against program targets and the QA/QC criteria laid out in the program's Quality Assurance Plan. The specific program guidance for providing this feedback is discussed in the "Communication of Inspection Results" section of the HES Quality Assurance Plan.

Program staff and the QA/QC vendors reported inspecting at least 5% of HES projects. The program attempts to inspect a number of homes from all vendors that is roughly proportionate to the number of homes serviced by each vendor. The program reviews vendor scorecards on a monthly basis and supplements these QA/QC scorecards with findings from customer surveys.

Based on our observations on site and discussions with HES vendors, vendors are not universally taking the time to check their own work while on site, nor do they typically perform their own post-inspections, making the program's QA/QC processes all the more important. Time and cost appear to be key reasons they do not perform thorough internal QA/QC. As the Eversource QA/QC vendor noted:



*We try to catch those [HES vendors] where a business model may be to act differently depending on whether or not the inspector was in the home from the beginning. Contractors have ability to set their own business model. Incentives don't drive program results, so you need the QA/QC vendor.*

HES vendors support the program's QA/QC efforts (particularly when the inspectors provide real-time or on-site feedback about best practices), but many HES vendors complained about specific issues, including the following:

- Overly punitive QA/QC inspectors
- Inspectors who do not offer on-site feedback
- Limited recourse to dispute negative findings
- Disagreements with inspectors about the most cost-effective or appropriate improvements on site

The UI QA/QC vendor also noted that getting homeowners to agree to post-inspections can be challenging because the audit has already been conducted and they view their participation as complete.

The QA/QC vendors confirmed that inspections are critical to ensuring that program implementation follows program design, and in-progress inspections can also serve as mentoring opportunities for interested technicians. New HES vendors may “benefit more from the in-process [inspections] because you're there ... to help provide that mentoring ... or to provide any clarity. ... Once somebody has ... gone through that process ... time may be better spent on post-inspections or some more part in-progress inspections,” where the QA/QC vendor shows up in the middle of a core services visit rather than at the beginning.

Both QA/QC vendors confirmed that incomplete and inadequate air sealing and duct sealing occurred when not subject to QA/QC inspections, but the Eversource contractor specifically highlighted concerns about the qualifications of program vendors and lack of training, opining that achieving a one-time BPI certification is insufficient to achieve ongoing proficiency in performing weatherization services. “I definitely think that contractors need more training other than just walking through the door with BPI certifications so you know you have the most qualified contractors on site at all times.”

The QA/QC vendors inspect the HES vendors' work based on criteria laid out in the HES Quality Assurance Plan. Many of these categories focus on safety practices and the overall customer experience, fewer (mostly in the “Blower Door / Flow Test / Duct Blaster” section) focus on the quality and extent of the actual air sealing and duct sealing work itself. There may be additional opportunity to separate the scoring of quality and completeness of work, such that these important metrics of performance can be more fully incorporated into the vendor scoring. Additional analysis of the Quality Assurance Plan and its handling of quality and completeness of work are addressed in Appendix B. It is also worth noting that, given expected programmatic changes in 2016 and onward which will involve increasing the number of HES vendors, program staff anticipate drastically ramping up QA/QC practices in order to ensure that both new and pre-existing program partners are familiar with the program practices and are conducting quality work.

The Quality Assurance Plan includes six categories of inspection areas, each with five or more sub-categories. The general categories are listed below. A complete list of categories can be found in Appendix B, where they are discussed in more detail.

1. **General HES Safety, Site Arrival, and Visual Inspection**
2. **Safety Testing & Environmental Assessment**
3. **Blower Door / Flow Test / Duct Blaster**
4. **Other Measures**
5. **Kitchen Table Sales and Closing**
6. **Customer Service**

**Table 9: Perspectives on QA/QC**

Program Staff	<p>The Companies have implemented QA/QC procedures to ensure quality services and positive customer experiences. The QA/QC checks assess vendors’ performance in a number of areas, including health and safety testing, audit procedures and measure installation, kitchen table wrap-up, and overall customer service.</p>
	<p>Program staff and vendors reported that their QA/QC contractors conduct in-progress inspections and post-inspections for at least 5% of projects.</p>
	<p>Program staff stated that they review results from the vendor scorecards on a monthly basis and take corrective measures as needed. Staff also stated that they use customer satisfaction surveys as another source of information about vendors’ performance.</p>
Data Tracking/Program Documents	<p>QA/QC protocols for judging air sealing and duct sealing quality and completeness are described in the program’s Quality Assurance Plan, particularly in the “Category C: Blower Door/Flow Test/Duct Blaster” section, with relevant scoring categories including the following:</p> <ul style="list-style-type: none"> <li>• Blower door in good condition/calibrated</li> <li>• Blower door operated correctly</li> <li>• Air sealing prioritized correctly (attic, then basement)</li> <li>• HVAC Minimum Flow Test performed correctly</li> <li>• Duct Blaster functional/calibrated</li> <li>• Duct Blaster operated correctly</li> <li>• Duct sealing prioritized correctly</li> </ul> <p>The air sealing and duct sealing prioritization categories appear to consider the quality and completeness of work together as one metric for each of those core services rather than more fully separating the issue of quality and completeness.</p>
	<p>In general, vendors indicated that they support QA/QC activities. Using a scale of one to five, where one equals “not at all effective” and five equals “very effective,” vendors’ average rating was 3.3.</p>
Vendors	<p>Although vendors said that they see the value in the QA/QC activities, the majority of vendors voiced concerns about how it is implemented, including challenges with inconsistent ratings from inspectors, technicians feeling that inspectors were there to harshly critique them rather than help them do better, and lack of opportunity to dispute QA/QC ratings.</p>

	<p>During on-site visits with vendors, HES vendors described how they preferred QA/QC inspections to serve as training opportunities, rather than purely observational (or punitive, if the QA/QC vendor observes issues with the work).</p> <p>The QA feels “punitive rather than rewarding or praising of good work. [As a manager] I want to focus on the positives for my own staff, not just the problems. More money and praise from the program [for good work] would show that they’re not just paying attention to the negative. The score card feels punitive, not rewarding.”</p> <p>During on-site visits with vendors, a vendor described how they might have different perspectives on what air-sealing measures are worth pursuing than what the QA/QC vendor might prefer—particularly in cases where the customer is uninterested in add-on measures—which can result in being penalized on the vendor’s QA/QC scorecard.</p> <p>“In [uninsulated] balloon-framed houses, the utility [QA/QC vendor] pushes blocking balloon framing at the rim joist, but that doesn’t pay. . . . They tell us to block balloon frame openings when my guys know what to seal and we waste time on site listening to the QA guy, because blocking those won’t get savings without insulating the walls too.”</p> <p>When talking with vendors on site, many of them expressed concerns about the importance of QA/QC inspections to verify the blower door and duct blaster results and ensure that technicians’ reported work is verified.</p> <p>Some “technicians just aren’t honest, it’s easy to cheat on test-in and test-out . . . and the QA inspector doesn’t show up on all the jobs. QC should show up mid-job, and could catch doing whatever they’re doing.”</p> <p>Vendors appear to practice limited internal QA/QC of their own work. On site, lead technicians may feel that they are too busy to fully check the work of their assistant technician, and return visits for QA purposes appear to be uncommon.</p> <p>On site, an HES vendor looking at their company’s work said, “I think the [HES] company should do more quality inspections because of what I saw here today. . . . I try to inspect my guys, but we’re short on time. If we didn’t have enough time [on this site], we should have come back a second day. . . . Duct sealing is worth a second day, and a full house with attic and basement and ducts is too much [for one day].”</p>
<p>Vendors</p>	<p>HES vendors confirmed the presence of low-quality work during on-site visits, and in some instances took photos to bring back to their technicians to discuss how to perform core services properly. In one instance, a vendor looked at his team’s work and said, “They were just rushed and didn’t do a good job. . . . [To prevent this in the future] we could do more internal follow-up inspections, [maybe] random inspection of the jobs being done.” If the utility company QC inspector had been on this site, they would point at these and say, “missed opportunity, missed opportunity, missed opportunity.”</p>

Quality Inspections	On-site visits with HES vendors confirmed the lack of internal QA/QC practices with some vendors. The managers and lead technicians were frequently surprised and disappointed with what they saw, and in some instances took photos of the work NMR auditors pointed out to bring back to their teams to instruct them on improper air/duct sealing and insulation practices.
Participants	Not being experts in the field of energy efficiency, the participants are not particularly well-placed to comment on the quality of the work conducted in their homes, or the QA/QC practices of the vendors. Homeowners are not expert building scientists and much of the core services happen out of their view. The evaluation did reveal that participants' high ratings of program satisfaction did not necessarily correlate with the quality of the actual installations in homes which showed large variations.
Program Administrators	<p>The PAs of other programs outside of CT all conduct QA/QC activities to assess contractors' performance. When asked about the strengths of their QA/QC process, they mentioned the following:</p> <ul style="list-style-type: none"> <li>• Using in-progress inspections to monitor vendors and make real-time corrections.             <ul style="list-style-type: none"> <li>• The HES program utilizes in-progress inspections, but QA/QC vendors appear to withhold feedback until the end of visits.</li> </ul> </li> <li>• Using a "carrot and stick" approach to provide both positive reinforcement and negative consequences. For example, a few different programs tie vendors' customer leads to their performance in the program.             <ul style="list-style-type: none"> <li>• HES vendors seemed to feel that the inspections were often punitive rather than rewarding.</li> </ul> </li> <li>• Having the inspector utilize QA/QC activities as training opportunities or "teachable moments." The PAs stated that this helps foster more of a mentorship relationship between the inspector and technician.</li> </ul>

QA/QC Vendors

UI's QA/QC vendor reported that they regularly inspect the core services via in-progress and post-inspections. In contrast, Eversource's QA/QC vendor reported that they are generally tasked with evaluating core services during in-progress inspections, but post-inspections are almost entirely limited to inspecting rebated add-on measures (insulation, etc.), unless the vendor chooses to inspect the core services as well.

"We don't go in post-audit to do QA on the audit itself. ... [During post-inspections,] we wouldn't look at air sealing or any stuff like that, per se, we'd just be looking at the insulation work that the contractor did after the core services had been performed."

Post-inspections for core services are "usually only when there's an issue with the customer. ... The in-progress inspections are for the core services."

Comprehensive "soup to nuts inspections" of core services and add-on measures could be requested by the client, but that is "very much an outlier."

During post-inspections, "If we look at attic insulation, regardless if there were specific [instructions from the program] about checking to see if there's air sealing, we always check and just make sure of that in our overall notes back to the program. We still like to inform even though we're not asked to do that."

In-progress (when a QA/QC vendor accompanies the HES vendor on site) and post-inspections are valuable indicators of HES vendor quality. For in-progress inspections, QA/QC inspectors monitor the work, may ask questions about the team's practices, may provide feedback at the end of the visit about problematic practices, and submit a report to the utility that gets conveyed to the vendor.

UI vendor: "We have in-progress and post-inspections. For in-progress inspections, [HES vendors] typically do a good job. The in-progress inspections are great because you can see what the technicians do. If you have a guy who follows the rules all the time, he's going to be smooth and polished and be able to do it. If you've got a guy who cheats and shortcuts, he's not going to be, and you're going to know."

UI vendor: "The value [of post-inspections] is very good; we can really go in and see what they did and talk with the homeowner. The homeowner is more comfortable talking to us when the people who did bad work are not present. We can validate what the vendor said they did—what did they miss, what else could they have done?"

UI vendor: "For in-progress inspections, we can see if they're doing everything properly, but they're on their best behavior. With random post-inspections, they're going to do their job and not know we're there until after we've done the inspection."

Eversource vendor: "To not ever get a look at that post work that's being done out there really is not telling you the whole story of what is actually happening at most houses you go to. ... We think the most effective is a combination of in-process and post [inspections]. It gives you the most complete picture overall."

QA/QC Vendors

For in-progress inspections of core services, QA/QC vendors typically arrive at the start of a visit and watch the HES vendor perform the entire visit. Occasionally, QA/QC vendors arrive mid-visit and are able to see the HES vendors' process after having already started the work. This is not common practice, though Eversource's QA/QC vendor reported that they had started to do this more frequently, and with good results.

Eversource vendor: "If for some reason you arrive truly in-progress, halfway, maybe two hours into a job, the contractor ... can't always figure that the inspection won't be forthcoming. So there are other ways to assure that the contractors will always be performing as if there were in-progress presence. ... It's actually something we've started to do a little bit more of, and it has opened up some things that we've discussed with the client."

Eversource vendor: To achieve better results from QA/QC, the program needs a "higher percentage of inspections than are happening now, a variety of inspection types, and then, if possible, if you can do a post-inspection of the HES work. That's truly when you're going start making contractors [be] held accountable, when they know that the inspector will come after the job is done. Now they know we come in the beginning, might show up in the middle, but overall if they get out of there and you never showed up, then no one's ever going back to that job to tell them that they didn't do something."

The QA/QC vendors recognize the importance of providing real-time mentoring and feedback to HES vendors. The UI QA/QC vendor reported feedback from HES vendors in Eversource territory that the former QA/QC inspectors there did not always provide feedback about vendor practices during QA/QC in-progress inspections, and did not always provide feedback immediately after the visit. Both QA/QC vendors reported favoring a mentoring relationship with HES vendors.

UI vendor: "One thing I hear a lot of the vendors [in Eversource territory] complaining about is [not getting] feedback until they get the report two weeks later. I think it's very important that they get feedback right then. If they get something wrong, they can correct it on the next job. I think it's very important that it be used as a teaching tool. If there's somebody new, you can help them refine or learn how to do a better job."

Eversource vendor: "We're not just a fly on the wall—we will speak up at certain times to ensure that work is being done safely and holistically. We are also there to mentor the technicians. We are there to mentor them if they ask us questions. We do that outside of earshot of the customer so they don't think they're receiving substandard service. Sometimes there's only so much you can do, and sometimes it's totally dependent on the technicians. Sometimes technicians think BPI is enough, don't want mentoring."

QA/QC Vendors	<p>The QA/QC vendors see their role as ensuring quality work, but also enforcing the rules of the HES program as stated.</p> <p>UI vendor: “We have to do what it says based on the HES implementation manual.”</p> <p>Eversource vendor: “As the new QC vendor, we were given a program implementation manual that told contractors what they needed to do, and we quickly realized in a short period that there was a big area they were neglecting,” namely attic air sealing.</p> <p>Eversource vendor: “The goal here is to help the contractors be successful in doing quality work. So where we would identify ... patterns, we would use that as an opportunity for feedback to the contractors through ... technical bulletins coming from the client, part of the discussion at regular contractor meetings, or whether or not we were given some instruction to do some mentoring there in the field and some training.”</p>
	<p>QA/QC vendors only inspect add-on measures via post-inspections, which may be too late to influence the quality of the practices, though they do look for qualities such as ventilation, insulated hatches, depth measurement markers, and evenness of blown-in insulation.</p> <p>UI vendor: “The only time we see [insulation] is on a post-inspection. We wouldn’t see insulation [being installed] on an in-progress.”</p>
	<p>In its current form, the QA protocols have a significant focus not just on energy savings, but also on the customer experience. The UI QA/QC vendor described how many of the criteria they use to evaluate the work of vendors are focused on customer satisfaction, noting that the program’s QA inspection criteria have an “almost equal” focus on energy savings and customer satisfaction, with “savings a little bit more weighted.”</p>
	<p>Training and quality QA/QC processes build vendor skill, but remaining profitable and retaining skilled technicians can be a challenge for vendors.</p> <p>UI vendor: “Some of the newer, smaller companies may not know as much as they possibly should [about program protocols or weatherizing]. You’ve got to expect a guy who’s just started not to know what a guy who’s been doing it five years would know. The ability to retain some of the seasoned professionals is an important thing.”</p>

QA/QC Vendors	<p>The UI QA/QC vendor confirmed that the quality and completeness of air and duct sealing work is combined into one metric for each of these core services, and that there was room to separate out the assessment of these services into more factors that could be counted in the HES vendor’s QA/QC scorecard. The Eversource vendor felt satisfied overall with QA/QC scoring criteria they were asked to follow, partly because they had been in dialogue with Eversource about refining it.</p> <p>UI vendor: "Maybe there should be more scoring components for air sealing; maybe some kind of completeness issue. . . . Did they miss things? Right now, it’s all lumped into one category: priority air sealing with attic, then basement, then conditioned space. You know, it’s kind of lumped in one. I guess it works the way it is, but maybe it would be better if there were two items: 1) if they hit all the areas, 2) completeness."</p> <p>Eversource vendor: The QA/QC scoring tools “cut to the chase, they address the proper diagnostics, the proper way of moving through and auditing a home, and then culminating obviously in the customer education that needs to go along with that. . . . The tool itself changed . . . so there has been a lot of improvement.”</p> <p>The Eversource vendor was concerned about BPI certifications not being sufficient to ensure quality weatherization work. “The problem is, you can pass those tests [BPI], but can you demonstrate those skills out in the field? That’s really where we find that their contractors are falling short—understanding that they’re saying they’re qualified, but they’re not performing as if they’re qualified. When it comes to contractors, you really need to provide ongoing training either in the field or off site. BPI is not enough; contractors need to prove to us that they know what they’re doing. I think the utilities who we work with understand that training is something that contractors could benefit from.”</p> <p>Judging the quality and completeness of work is “subjective,” but the UI QC vendor inspects the home to look for “areas they didn’t seal that are readily accessible, and try and see did they miss anything? Is there areas that they just didn’t do? And why didn’t they do them? So then you interview the homeowner . . . did you tell them you didn’t want them to work in some areas, [etc.]?”</p>
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## Section 7 Drivers, Motivations, Obstacles and Barriers

A focus of the evaluation was assessing what motivates customers to participate in the program, as well as the obstacles or barriers they face in that decision. When asking customers themselves to cite their greatest motivations to participate, saving money (48%), fixing their homes or identifying areas for savings (41%), and saving energy (35%) were the most common responses. These same reasons were echoed by program staff both from the HES program and from those working in similar program capacities from the best practices interviews who correctly identified that customers tend to be motivated by wanting to save money on their energy costs or by conserving energy in general. While mentioned by fewer customers (16%), another interesting theme across interviews was the motivation to participate in the program simply as a prerequisite for solar panel installation. Vendors corroborated that while the audit requirement for panel installation can be a driver for core measures, it may actually act as a barrier to add-on energy upgrades. The audit allows solar customers to benefit from the HES visit, but these customers tend to have little motivation to pursue deeper savings because their interest in the audit only extended to qualifying for solar panel loans.

Interestingly, customers themselves cited very few obstacles or barriers to participating in the HES program. The majority of respondents (85%) said they did not face any obstacles to participation. Those who did mention obstacles discussed difficulties they had with figuring out and completing the rebate application, issues with scheduling the visit, or procrastination on their own part.

The main obstacle cited by vendors (and confirmed by program staff) were the health and safety issues they often face when conducting the audit. The discovery of mold, asbestos, knob and tube wiring, vermiculite insulation, gas leaks, etc., frequently force technicians to halt the audit because some core measures cannot be installed until the issues are remediated. Vendors estimated that health and safety issues occur in roughly one-quarter of all jobs (with estimates ranging between 5% and 40%). Allowing the program administrators to provide incentives to help address health and safety issues would allow vendors to access greater savings in these homes.

Ultimately, the approach of sending a pre-inspector to observe homes before committing full vendor resources would likely be a benefit, particularly for addressing health and safety issues. The program as it is currently designed can accommodate this technique, but few vendors take the approach or believe that it is not a sanctioned strategy. Program administrators could consider revising training and making it a recommendation, perhaps by providing part of the incentive for the pre-inspection or allowing some vendors to *only* do pre-inspections and then pass homes to other vendors.

**Table 10: Perspectives on Drivers, Motivations, Obstacles, and Barriers**

Program Staff	<p>Program staff said that customers’ decisions primarily stemmed from a desire to save money on energy costs or conserve energy.</p>
	<p>Program staff and vendors consistently reported that health and safety issues are a significant barrier to program participation. Vendors estimated that the presence of health and safety issues prevents them from performing core services.</p>
	<p>Besides health and safety issues, the upfront cost of the energy upgrades was frequently cited as a considerable barrier for customers.</p>
Vendors	<p>Vendors felt that the decisions to pursue deeper savings through add-on measures were driven by customers’ energy cost concerns; 22 vendors cited this a primary driver. Other reasons for participating in HES, according to vendors, include improved comfort (14), program rebates and incentives (9), energy savings (5), and environmental concerns (3).</p>
	<p>Participating in HES as a prerequisite for solar panels was mentioned as a driver for core measures but a barrier to add-on energy upgrades. Some vendors stated that the visit allowed those seeking solar panel loans to benefit from the HES visit, while others stated that some customers who participated for this reason did not pursue deeper savings (insulation) because they were only interested in the HES visit to qualify for their solar panel loans.</p>
	<p>Like program staff, vendors stated that health and safety issues present significant barriers to program participation. The most common issues cited by vendors include asbestos, mold, carbon monoxide leaks, and gas leaks. On average, vendors stated that health and safety issues represented roughly 25% of all jobs (their estimates ranged between 5% and 40% and were based on respondent recall—not detailed records). This was confirmed during on-site interviews with HES vendors, a couple of whom estimated that about 20% of their jobs have health and safety issues. As discussed in Table 6, in 2014, 8% of HES homes in Eversource territory were recorded as having at least one health and safety issue. Program records do not indicate which, if any, of these homes had issues remediated. This figure is lower than vendor estimates, and NMR on-sites confirmed that these records did not capture all health and safety issues, indicating it is not being recorded consistently. UI records were not aggregated for the evaluators to assess this.</p>
	<p>Vendors reported that gas leaks are most likely to be remediated because of the immediate danger involved; asbestos is least likely because of the cost to the homeowner.</p>
	<p>Other common barriers identified by vendors that might not completely prevent work but can limit the amount of work they can do include lack of access to equipment or areas of the customer’s house, as well as customers’ refusal to install measures because of aesthetics or fear of potential damage to the home.</p>

Vendors	<p>On site, a vendor reported that it is easier for some types of vendors to meet the Companies' MMbtu goals than it is for others.</p> <p>"We are graded by program on MMbtu savings per house, but we can't meet that goal without up-sell measures. . . . We have to service people fast, and because we are an insulation company, there is risk that all our customers don't want services beyond the HES core services, whereas HVAC [HES] people are selling [up-sell measures] to every customer. We are taking a risk by not being guaranteed a sale."</p>
Quality Inspections	<p><b>Barriers to Air Sealing</b></p> <p>During on-site visits, HES vendors described—and this was confirmed via inspections—that their work could be limited by time, access issues (hard-to-reach, hidden behind insulation, storage in attics and basements, etc.) and technician effort. While access issues can be a problem, in most of the homes that NMR visited, access issues typically would have made the work more difficult, but rarely impossible.</p> <p>Attic air sealing, a program priority, can be limited by:</p> <ul style="list-style-type: none"> <li>• Storage and clutter</li> <li>• Flooring</li> <li>• Low roof lines</li> <li>• Small attic hatches</li> <li>• Dirty working conditions</li> <li>• Old insulation that may be damaged by disturbing it</li> <li>• Homeowners who do not want vendors to disturb blown-in insulation</li> <li>• Safety concerns             <ul style="list-style-type: none"> <li>○ Unsure footing</li> <li>○ Hot working conditions in summer</li> <li>○ Hazardous materials (ALM, vermiculite, or mold, for example)</li> </ul> </li> </ul> <p><b>Barriers to Duct Sealing</b></p> <p>Most of the barriers to performing complete air sealing apply to duct sealing as well, such as time limits, access issues, and limits to technician effort. In addition, duct sealing can be a challenge because when ducts are insulated, HES vendors are hesitant or unwilling to remove insulation in order to find and seal potential leaks, and customers usually seem to be unwilling to have vendors remove this insulation, according to HES vendors.</p>

Quality Inspections	<p><b>Barriers to Installing Insulation</b></p> <p>The HES vendors that accompanied NMR on site visits described some of the challenges that insulators face in retrofitting insulation into homes.</p> <ul style="list-style-type: none"> <li>○ Hassle             <ul style="list-style-type: none"> <li>▪ Preference of some vendors to avoid complicated/multi-day wall insulation jobs in favor of core measures, referring the work to other companies rather than doing it themselves                 <ul style="list-style-type: none"> <li>• “We don’t do much [wall insulating]. I use wall affiliates, and we get money back from them for sending them the work. . . . I like one-day jobs, like [insulating] attics, rather than walls.”</li> </ul> </li> </ul> </li> <li>○ Safety issues             <ul style="list-style-type: none"> <li>▪ Knob and tube wiring</li> <li>▪ Asbestos-containing siding</li> </ul> </li> <li>○ Physical barriers             <ul style="list-style-type: none"> <li>▪ Hard-to-remove siding (fragile or multiple layers)</li> <li>▪ Brick facades requiring interior installation of insulation</li> <li>▪ Pipes, wiring, hidden framing members, etc., inside wall cavities</li> <li>▪ Pre-existing insulation preventing the addition of new insulation<sup>66</sup></li> </ul> </li> </ul>
Participants	<p>85% of customers did not think there were any obstacles or barriers to participating in the program. Those that cited any obstacles did not respond in one accord—issues included scheduling, procrastination on their own part, the rebate period having run out, or the rebate application being complicated. Of those who had insulation installed, 75% said there were no obstacles particular to the insulation installation.</p> <p>Participants’ main motivations to be part of the program were saving money (48%), fixing their homes/identifying areas for savings (41%), and saving energy (35%).</p> <p>Some customers (~16% of visits) participate in HES only because it is a requirement of having solar or other energy efficiency measures installed. In these instances, their insights are not likely to be as useful to the program because they have trouble differentiating any changes they have seen in their energy/electric bill between the audit and the solar measures. Most felt that solar panels have had more of an impact on any of the changes they have seen. There were also instances (n=~5) where the audit was a requirement for obtaining rebates for new windows or insulation that the homeowner already wanted to purchase prior to the HES audit.</p>

<sup>66</sup> Auditors did not specifically address this point, but this is an issue of which NMR analysts are aware.

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Program Administrators</p>	<p>Other PAs expressed that they experienced similar drivers of and barriers to participation with their programs.</p>
	<p>Other programs have found a limited number of ways to address health and safety issues.</p> <ul style="list-style-type: none"> <li>• The Mass Save Home Energy Services program offers a pre-weatherization incentive for the three most prevalent issues: failed combustion safety, knob and tube wiring, and improper dryer venting (up to \$300 for combustion safety and \$250 for knob and tube wiring and/or improper dryer venting).<sup>67</sup></li> <li>• Rhode Island’s EnergyWise program offers a similar incentive (up to \$250) for the homeowner to address barriers (including health and safety hazards) which would prevent weatherization services.</li> </ul> <p>All of the programs also offer loan products which provide limited funding for remediation of more substantial issues like vermiculite insulation, but do little to address more immediate concerns that would prevent initial testing during the audit.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">QA/QC Vendors</p>	<p>The Eversource vendor described how some of the barriers HES vendors describe are not insurmountable, particularly with the right training. “It just comes down to the training for the contractors and helping them understand what and how to go after things [savings]. These things that they’re calling obstacles aren’t necessarily obstacles; they’re just things that they don’t want to do.”</p>
	<p>The UI QA/QC vendor reported that HES vendors face challenges in retaining skilled technicians. They say that their “pay is getting cut, benefits are being lost. So the morale is not very good. . . . The big picture of what these guys are complaining about is the bid prices continually get lower and lower . . . so the guys are expected to do more work for less pay and less benefits. . . . Some of the good companies that historically have been in the program are able to keep their better people . . . who can train the new people how to do the job properly.”</p>

<sup>67</sup> Cape Light Compact does not include the dryer venting repair as a pre-weatherization initiative measure since it is addressed through their home energy assessments.



## Appendix A Detailed Methodology

The R151 study collected and analyzed data from eight sources, including program data tracking records, program staff, participating vendors, program administrators at other leading programs, program participants, on-site quality inspections, and a program QA/QC vendor. Work completed for the study can be categorized into eight key evaluation tasks, as outlined in Table 3. For ease in identifying the data source of findings, throughout this report we adhere to a color coding scheme included in the table below.

**Table 11: Evaluation Tasks**

Task	Description	Data Source	Quantity
1	Program data tracking and document review	Data Tracking and Program Documents	17,968 homes
2	In-depth interviews with program staff	Program Staff	2
3	In-depth interviews with vendors	Vendors	23
4	On-site quality inspections	Quality Inspections	70
5	On-site in-depth interviews with program participants	Participants	70
6	On-site in-depth interviews with participating vendors	Vendors	10
7	In-depth interviews with program administrators from leading programs	Program Administrators	5
8	In-depth interviews with Quality Assurance and Quality Control (QA/QC) Vendors	QA/QC Vendors	2

### A.1 DESCRIPTION OF EVALUATION ELEMENTS

#### A.1.1 Program data tracking review

The evaluation includes an analysis of program tracking data to explore and identify any patterns of air sealing, duct sealing, and/or insulation by utility, vendor, and home characteristics. The review included 2014 participant program databases from Eversource and UI. The team reviewed the available aggregated information about health and safety issues contained in the provided program records.

##### A.1.1.1 Program data issues

The data NMR were provided with by program staff did not contain a consistently recorded health and safety variable other than a variable called “materials” in the Eversource data, which appeared to be a log of health and safety issues. This variable does not appear to record health and safety issues consistently, given the rates of health and safety issues reported by vendors and the fact that during on-sites NMR auditors saw homes that had health and safety issues (based on the homeowner’s recollection) that had not been identified as having a health and safety issue in the data set. Courtesy air sealing—modest air sealing performed in the presence of certain health and safety issues that prevent the use of a blower door—was also performed at some of these homes, but this was not recorded in the

aggregated data sets. UI data were not provided in an aggregated format that would have allowed for assessment of health and safety issues.

The provided data sets did not provide enough information to fully understand the services that had been performed at the sites. For example, a home might have been logged as having duct sealing performed, and that there was no improvement, but with no explanation, NMR auditors could not determine if there actually had been no improvement, or if the duct sealing had been planned, but then not performed for some reason. When they met with HES vendors on site, NMR auditors did confirm that the HES vendor reports contain some detail about what services were and were not performed, but those detailed records were not part of the aggregated data provided to NMR for this evaluation.

The data sets also lacked information on the opportunities for services and improvements at sites, and whether they were recommended to the homeowners. For example, neither the Eversource nor UI data sets tracked the presence of ducts at sites, which would have indicated the opportunity for duct sealing at a site. In addition, only one of the two data sets (Eversource) tracked whether the opportunity for insulation upgrades existed at sites.

### **A.1.2 In-depth interviews with program staff**

An initial task of the evaluation included in-depth interviews with two members of the HES program staff, one from Eversource and one from UI. These interviews served as a method for understanding program goals and objectives; providing background on the program's design and implementation; identifying common barriers to and opportunities for expanding air sealing, duct sealing, and insulation; and determining current program QA/QC activities and program staff perceptions on the quality of installation of these three measures of interest.

### **A.1.3 In-depth interviews with participating vendors**

Given the relatively small pool of vendors and overlapping research objectives, in-depth interviews with program vendors were coordinated with R4 HES/HES-IE Process Evaluation as well as R157 Multifamily Process Evaluation. This coordinated approach endeavored to maximize efficient outreach to program stakeholders and minimize respondent fatigue. The questions for this evaluation focused primarily on understanding vendors' practices related to air sealing, duct sealing, and insulation, including assessing program protocols regarding quality installation, identifying common barriers and opportunities for deeper energy savings, and outlining the program's QA/QC activities.

### **A.1.4 On-site quality inspections**

During on-site inspections of HES-participant homes, NMR HERS Raters assessed the quality and completeness of the air sealing, duct sealing, and insulation work performed through the program. Most inspections lasted about an hour, and they ranged from about 30 to 90 minutes.

NMR auditors assessed the air sealing at the following locations, with a particular focus on finding readily accessible gaps that were not sealed and looking for signs of low- and high-quality sealing work:

- Rim joist penetrations
- Basement ceiling<sup>68</sup> penetrations
- Attic penetrations (in accessible attics)
- Attic hatches
- Doors
- Interior living spaces

Auditors recorded the material used and assessed the quality and extent of duct sealing at:

- Air handler seams
- Accessible/visible duct seams/joints

Auditors rated the quality of HES-incentivized insulation installations in accordance with RESNET standards and recorded other indicators of quality installation, such as the evenness of blown-in insulation. They visually inspected these installations whenever possible and used infrared cameras in the few instances of sufficiently cold weather that allowed for useful infrared imaging. Auditors assessed insulation installed in:

- Attics
- Exterior walls
- Knee walls and foundation walls<sup>69</sup>

NMR targeted homes where HES vendors were willing to accompany us on-site, homes with multiple services performed, and those with low air and duct sealing improvements. Of the 70 homes visited, 70% were located in Eversource territory, and 30% were in UI territory.

### A.1.5 On-site in-depth interviews with program participants

A 20- to 30-minute in-person interview was conducted with the homeowner by NMR staff while a second NMR technician proceeded throughout the home to assess the quality of installations. The in-depth interview assessed which measures the customer had installed and whether they had removed any measures, whether the customer had noticed any energy or non-energy benefits since having the audit completed, whether the vendor had found any health and safety issues during the audit, customers' experience with financing options discussed during the kitchen table wrap-up, any drivers of or barriers to their participation, and their satisfaction with having been a program participant.

### A.1.6 On-site in-depth interviews with participating vendors

In 10 instances, employees of the HES vendors that performed work at a given home accompanied NMR auditors to the site visit. The NMR auditors conducted in-depth interviews with vendors and asked them for candid feedback about their real-world air sealing, duct sealing, and insulation practices, as well as their experiences working with the HES program. In addition, the NMR auditor and HES vendor walked through the homes together, looked at

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<sup>68</sup> These can also be referred to as frame floors; this is the framed basement ceiling that supports the floor above.

<sup>69</sup> NMR auditors were prepared to assess such installations, but saw no examples of either in the field.



the air sealing, duct sealing, and insulation performed at the homes, and talked about the quality of the work they saw; the NMR auditors probed the HES vendors to rate the work of their teams and discuss any challenges that the vendor faced at the home.

### A.1.7 In-depth interviews with program administrators for other leading programs

The evaluation also included a review of best practices from other programs that address air sealing, duct sealing, and/or insulation. This involved a review of available program reports and documents as well as in-depth interviews with program administrators. The interviews focused on programs' practices related to greater levels of installation of the measures of interest, strategies for increasing customer adoption, and approaches to QA/QC to assure that savings are being achieved. The programs included in the review of best practices are as follows:

- Mass Save Home Energy Savings Program
- National Grid Rhode Island EnergyWise Program
- Efficiency Maine Home Energy Savings Program
- Efficiency Vermont Home Performance with ENERGY STAR Program
- NYSERDA Home Performance with ENERGY STAR Program

### A.1.8 In-depth interviews with program QA/QC vendors

The NMR team conducted an interview with one of the HES program's QA/QC vendors, which lasted over an hour. The interview discussed strengths and weakness of the QA/QC protocols, the quality of HES vendors' work, and drivers and barriers the vendors face in implementing the services and participating in the program. NMR conducted one interview with UI's vendor and another interview (in two parts) with the vendor Eversource started using in 2015, which was after the homes that NMR visited had been serviced by the HES program.

## A.2 DESCRIPTION OF ON-SITE INSPECTION PROTOCOLS

### A.2.1 Basement Air Sealing

NMR auditors looked for signs of air sealing by the HES vendors in the basements they visited. They visually assessed the amount of air sealing at the following locations:

- 1) Rim joist penetrations at the tops of basement walls, where ambient air can leak into basements
- 2) Penetrations in the ceilings of unconditioned basements (also referred to as frame floors), where unconditioned basement air can enter the conditioned spaces above

In many cases, these penetrations are accessible and visible to HES vendors and are excellent opportunities for air sealing. However, NMR recognizes that some of these penetrations can be quite difficult to seal. Some are hidden behind insulation, framing, or other mechanical equipment, while others might be difficult to access due to an excessive amount of storage in a basement. In basements, NMR looked particularly for instances of "low-hanging fruit," or penetrations that could have been easily sealed—those that were

exposed and reachable without taking down insulation or moving a customer's belongings—but had not been sealed by HES technicians.

### A.2.2 Attic Air Sealing

Whenever possible,<sup>70</sup> NMR auditors looked for signs of air-sealing work done in the attics of the homes they visited. They visually assessed whether or not the HES vendors had performed air sealing at:

- 1) Attic penetrations visible from the attic space (gaps at top plates, electrical penetrations, and so forth)
- 2) Attic hatches

In accessible attics, NMR auditors lifted easily accessible batt insulation and looked for reachable and visible penetrations near attic hatches that vendors would have been expected to target, but avoided disrupting freshly blown-in or deteriorating insulation. NMR auditors also asked homeowners to describe whether or not they recalled the HES vendors entering or spending time in the attics in order to provide clues about the level of air sealing done.

### A.2.3 Interior Air Sealing: Weather-Stripping Doors and Caulking

As a part of the work plan for this project, NMR auditors did not plan to inspect for signs of interior air sealing, such as weather-stripping of doors or interior caulking of cracks, but the team decided to collect this information as an additional resource regarding HES practices.

NMR auditors looked for signs that the HES vendors had weather-stripped doors and done any interior caulking around baseboards, fireplaces, or window and door frames. Auditors did not assess the quality or amount of these air sealing measures because that would best be accomplished with a blower door running or with a vendor present, which was not always the case.

### A.2.4 Insulation

NMR auditors inspected the insulation quality of building components that were insulated through the HES program, including the following:

- Wall insulation in exterior walls
- Attic insulation
- Rim joist insulation
- Frame floor/basement ceiling insulation
- Knee wall insulation

When possible, they inspected insulation visually and used an infrared camera in the few instances where it was sufficiently cold to render clear infrared images. Auditors attempted to record the following:

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<sup>70</sup> Some attics were inaccessible to HES vendors (permanently sealed with no hatch, n=4) and there were attics that were both inaccessible to NMR vendors and where the homeowner did not know if air sealing had been done (n=13). One additional home had no attic.

## HES SEALING AND INSULATION PRACTICES REPORT (R151)

- Overall insulation grade (Grade 1: best, Grade 2: acceptable, Grade 3: fair/poor)
- Presence of gaps and/or compression worse than a Grade 3 install
- Visible settling at tops of walls or sag from the subfloor



## Appendix B Potential QA/QC Protocol Opportunities

To ensure quality retrofit work, the Connecticut Home Energy Solutions (HES) program periodically assesses the performance of its vendors using Quality Assurance inspectors who accompany the vendors to customers' homes. The inspectors evaluate the vendors' performance against various criteria identified on the program's Quality Inspections Form (QI Form), described fully in the program's Quality Assurance plan (QAP).<sup>71</sup> In order to ensure that customers have a positive experience with the HES program, many of the vendor behaviors subject to review go well beyond the actual performance of the weatherization work and relate to the vendors' customer service and safety protocols.

This appendix discusses some of the specific practices mentioned in the QAP and the 2015 draft HES Implementation Manual<sup>72</sup> to identify potential opportunities for providing additional guidance to HES vendors on how to meet the program's goals.

### B.1 HES QUALITY ASSURANCE PLAN CRITERIA

The QI Form requires QA inspectors to rate HES vendors on the following criteria. This memo discusses only those in bold in the third category, including blower door, air sealing, and duct sealing practices.

#### Category A: General HES Safety, Site Arrival, and Visual Inspection

- On-time arrival
- Parked safely/with HES logo
- Program explained to customer/obtain signed customer form
- Tech has synced on-site app prior to visit
- Walkthrough visual inspection
- Home area, volume measured, and maximum air-sealing limits calculated prior to sealing
- Fireplace checked/secured
- MSDS sheets available
- First aid kit available
- Fire extinguisher available
- HES vendor supplies and uses tools properly
- PPE worn
- Ladders used properly

#### Category B: Safety Testing & Environmental Assessment

- Report hazardous conditions (asbestos, CO, etc.)

<sup>71</sup> Home Energy Solutions: Vendor Evaluations (Quality Assurance). Revision 10-13c.

<sup>72</sup> March 13, 2015, draft version.

- Ambient CO>35ppm = no blower door test
- Gas leak test
- Worst case depressurization test (back drafting)
- Test for flame interference from furnace burner
- Combustion appliance flue gas spillage tests
- Measure draft in flue pipes
- CO measured in combustion flue pipes
- Test out
  - CAZ, CO, draft, spillage, minimum duct airflow

### Category C: Blower Door / Flow Test / Duct Blaster

- Blower door in good condition/calibrated
- **Blower door operated correctly**
- **Air sealing prioritized correctly (attic, then basement)**
- HVAC Minimum Flow Test performed correctly
- Duct Blaster functional/calibrated
- Duct Blaster operated correctly
- **Duct sealing prioritized correctly**

### Category D: Other Measures

- CFL mercury clean-up explained
- Light sockets inspected for bulb replacement
- Bulb installation and customer engagement
- Hot water pipes wrapped
- Water-saving hardware installed and explained

### Category E: “Kitchen Table” Sales and Closing

- Restore power and original settings to equipment
- Clean up and remove waste
- Summarize work to customer
- Summarize potential work, rebates, and financing options
- Leave survey form

### Category F: Customer Service

- Techs introduce themselves, present ID
- Proper language used
- No smoking
- Clean attire and appropriately dressed

## B.2 BLOWER DOOR OPERATION: ASSESSING BASEMENT CONDITIONING

To properly perform blower door tests and perform air sealing, HES auditors must use their judgment and experience to determine the boundaries of a home’s thermal envelope. Basements in existing homes can prove to be particularly challenging because it may not be

immediately clear, even to those with building science training, whether a given basement is best considered to be within the thermal envelope or outside of it. To decide if a basement is fully conditioned, building scientists have to consider the level of finish of the basement, the amount of insulation in the basement, and the type and amount of intentional heating or cooling being introduced to the space.

The HES implementation manual itself provides limited guidance for vendors on this topic, relying instead on the program’s training and the vendors’ own experience and certifications to ensure that they are adequately trained to make such determinations. The following excerpts from the March 2015 draft implementation manual comprise the HES implementation manual’s sole references to identifying the level of conditioning of basements:

- “Note at this time whether the basement is conditioned, unconditioned, or ‘hybrid.’” (Section II.E.3)
- “If the basement is deemed intentionally ‘conditioned,’ the door to the basement should remain open during the [blower door] test.” (Section II.G.1.c)

If there is ambiguity in the HES guidelines, vendors may be unintentionally incentivized to err on the side of whichever option allows them the greater CFM50 reduction. For example, vendors may achieve better blower door results by treating partially conditioned basements as unconditioned spaces, sealing penetrations between the basement and ambient conditions, and isolating the partially conditioned basement from the rest of the house, thus resulting in improved blower door results. On a previous baseline study where NMR auditors accompanied HES vendors to customer homes, NMR auditors did notice that the HES vendors often considered basements to be unconditioned, even when they arguably could have been considered conditioned spaces (such as if they were finished and insulated).

To ensure consistency and comparability of results between vendors—and to ensure that vendors are not sealing off finished areas that would typically be included in blower door tests—the program could require vendors to report on the following physical characteristics for each distinct basement area:

- Is the basement area fully finished or fully heated?
- Are the foundation walls a) completely insulated, b) partially insulated, or c) uninsulated?
- Is the frame floor above the basement insulated?
- Are there minor vents cut into the basement ducts?

### Key Questions

How do vendors assess basement conditioning?

Are vendors indirectly incentivized to call basements “unconditioned”?

## B.3 AIR SEALING PRACTICES

### B.3.1 HES Implementation Manual Guidelines for Air Sealing

While the evaluation criteria measure performance relative to approved HES practices, the 2015 draft HES implementation manual provides little in the way of specific air-sealing instruction for vendors (Section II.G.1.). Along with identifying seven unacceptable temporary measures, a summary of the program's guidance for air-sealing practices includes the following:

- Use foam, caulk, or weather-stripping
- Seal the attic, then basement, and then living space
- Seal large leaks first
- Do not seal homes tighter than the calculated minimum Building Airflow Standard (BAS; this would trigger mechanical ventilation to offset the tightened envelope)

The program appears to offer mostly general rather than detailed guidance in the implementation manual regarding air-sealing practices, indicating that the program prefers to rely less on the implementation manual and more on the program trainings and vendors' own professional experience and certifications to ensure best practices for air sealing.

Just as the manual identifies seven clearly unacceptable practices, the program could consider adding a greatly abbreviated version of some of the training materials from its own vendor trainings (or from BPI) to provide reminders of specific best practices, such as a checklist of common air-sealing opportunities, in addition to the limited and general guidance identified above.

### B.3.2 HES Quality Assurance Plan Guidelines for Air Sealing

The HES QAP identifies air sealing as a key program priority. Quality assurance inspectors rate the HES vendors' air-sealing practices against the following statement using the four criteria that follow:

**“Priority blower door sealing was done starting with attic first and then basement.**

- **“E**[xceeds program expectations]: Priority sealing performed properly as per approved procedures, opportunities for sealing identified and performed; exceptional effort expended to seal in attic, basement and attached garage (if present).
- **“M**[eets program expectations]: Priority sealing performed properly as per approved HES core procedure. All program level opportunities for sealing are addressed.
- **“P**[artially meets program expectations]: Envelope sealing not prioritized or outside the heated envelope barrier, an obvious opportunity skipped (inspector to document what is missed here)

- “U[nsatisfactory; has not met program expectations]: Envelope sealing not prioritized, several obvious opportunities missed, areas not accessed for invalid reasons, areas sealed in error, sealing inefficiently beyond scope, sealing outside of customer direction (inspector to document these items)”

A key difference between receiving an assessment that the vendor’s work “exceeds” or “meets” program standards for air sealing revolves around the vendor’s use of “exceptional effort” to seal the home. In some instances, HES vendors will be able to tighten a home’s envelope sufficiently to reach the home’s minimum Building Airflow Standard—the threshold at which mechanical ventilation is needed to introduce fresh air into the building; the QA standards do not address how “exceptional effort” relates to the building’s performance relative to the BAS. The program could consider clarifying for HES vendors how the QA inspectors assess the performance of vendors who meet the minimum BAS during their air-sealing work, particularly in those instances where “exceptional effort” was *not needed* to meet that goal, such as a home that was already relatively well sealed.

If it does not do so already, the program could track homes that were sealed to the minimum BAS and use them as an additional performance metric for vendors. Vendors may not always need to exert exceptional effort to meet the BAS (though they typically will) and, conversely, they may not always be able to meet the BAS even if they do exert exceptional effort, but this is likely a good indicator of consistent, high levels of performance.<sup>73</sup>

## B.4 DUCT SEALING PRACTICES

### B.4.1 HES Quality Assurance Plan Guidelines for Air Sealing

The HES QAP identifies duct sealing as a key program priority. Quality assurance inspectors rate the HES vendors’ duct-sealing practices using the following rating criteria:

**“Priority Duct Blaster sealing was done.**

- “E[xceeds program expectations]: Exceptional effort expended when properly performing sealing per the HES Implementation Manual and BPI Standards. All opportunities for sealing identified and performed.
- “M[eets program expectations]: Sealing performed properly as per HES Implementation Manual.
- “P[artially meets program expectations]: At least one obvious sealing opportunity missed as documented by inspector.
- “U[nsatisfactory; has not met program expectations]: More than one obvious sealing opportunity missed as documented by inspector.”

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<sup>73</sup> If the program tracks frequency of meeting the BAS standard, it might also consider separately analyzing the results in older, uninsulated homes. In a limited amount of time, one would not necessarily expect a vendor team to bring an uninsulated, balloon-framed home (with a great deal of potential for air movement through building cavities) to the minimum BAS.



The QAP guidelines defer to external criteria such as the HES implementation manual and BPI standards, but the implementation manual provides little specific guidance for duct-sealing practices. Other than the proper materials (mastic or the appropriate tape) and direction to focus on areas near the air handler, the manual defers to the vendors' experience or participation in program training to ensure that they are adequately trained to best seal ducts.



## Appendix C Air Sealing, Duct Sealing, and Insulation Practices – Examples from Site Visits

During their visits to HES participant homes, NMR auditors photographed examples of the air sealing, duct sealing, and insulation practices seen on site in order to show examples of good, bad, and typical practices. Below are examples of the practices that auditors saw in homes during these quality inspections, with photos and brief descriptions.

### C.1 AIR SEALING PRACTICES

NMR auditors inspected the quality and completeness of the HES vendors' air-sealing practices in basements, attics, and interior spaces.

Figure 10 shows a common problem with attic air sealing; insulation covers the attic floor, making attic penetrations harder to see. In this case, however, the HES vendors saw a major penetration around the black PVC pipe, but they only partially sealed it and left the top plate gaps right next to it unsealed. The team did not otherwise seal any top plates in this home and left a large duct chase completely open.

**Figure 10: Incomplete Attic Air Sealing**

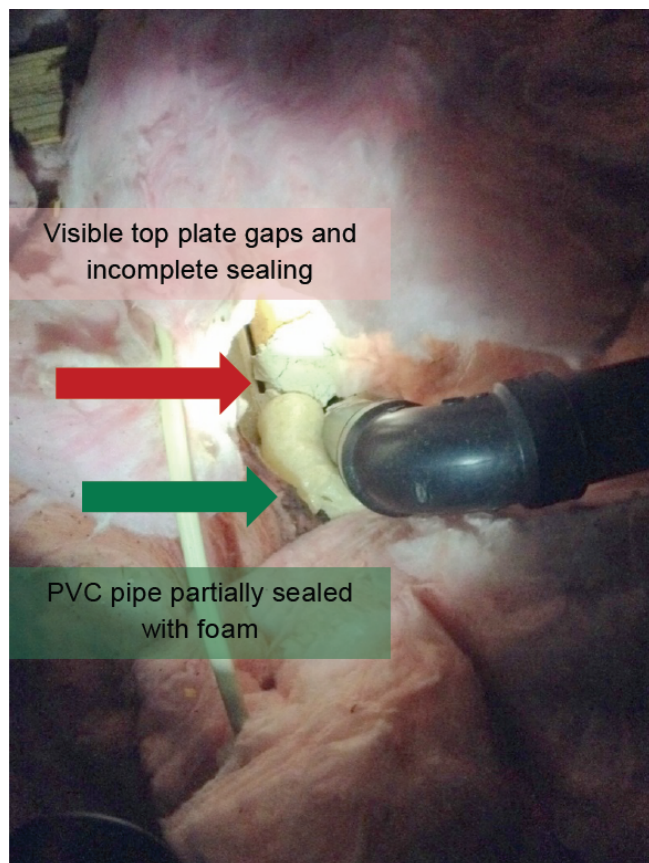


Figure 11 shows the ceiling of an unconditioned basement. On the right, the HES vendors sealed a large penetration around water lines and framing members using a combination of tape, bubble wrap, and spray foam. However, on the left, a large gap around framing members that was only one foot away was left unsealed; seeing well-sealed and unsealed penetrations in close proximity was common in the homes NMR visited.

**Figure 11: Incomplete Basement Ceiling Air Sealing**

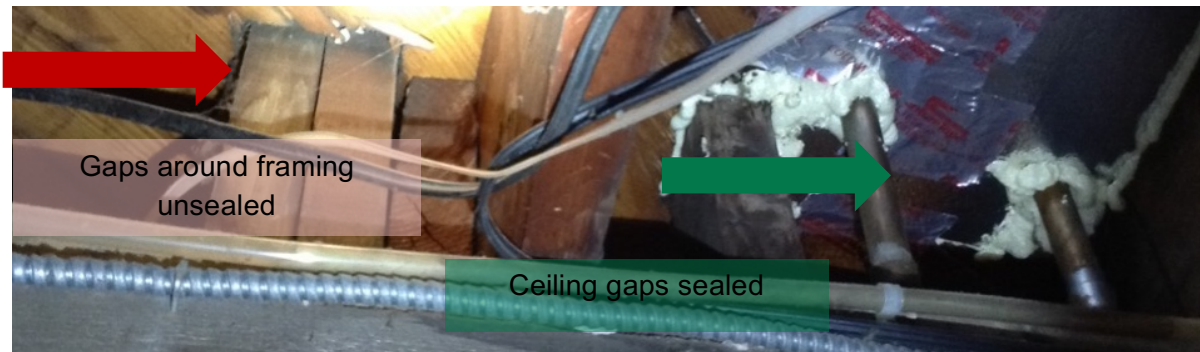


Figure 12 shows air sealing around a plumbing drain pipe that comes down from the first floor into the basement. The HES vendor used spray foam to seal about three-quarters of the large gap around the plumbing penetration. A gap also remains between the black pipe and the white sheathing material.

**Figure 12: Incomplete Sealing around Basement Ceiling Penetrations**



Figure 13 shows a basement rim joist that the HES team mostly covered with two-part closed cell spray foam as an air-sealing measure. It was applied at no additional cost to the customer, and where it covered the wood it served as an insulation measure as well.

However, the team missed a large, visible hole around a water line, which remained as a source of air leakage into the basement.

**Figure 13: Rim Joist Insulation and Incomplete Air Sealing**

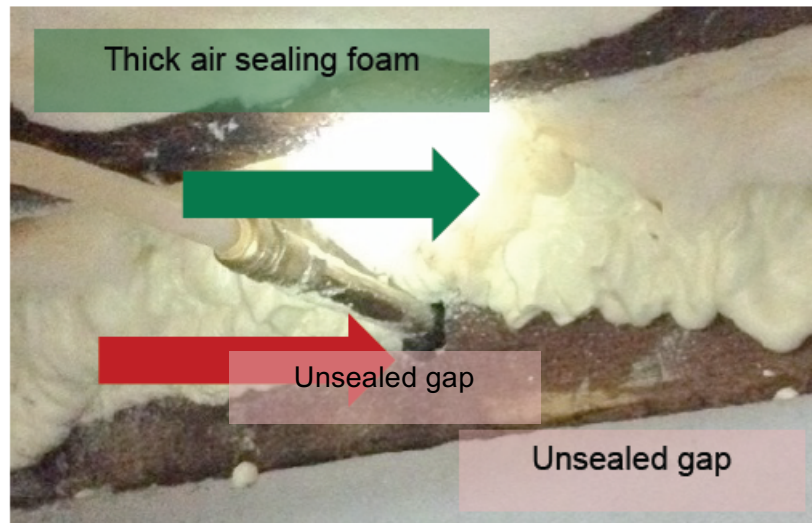


Figure 14 shows an example of an HES team using a temporary measure—clear plastic tape—to seal a large opening in a basement ceiling. This was an intentional opening/grate (over one square foot) that was likely used to allow warm air from a since-removed basement heating system to rise up into the first floor living space. The tape the HES team applied was peeling off, and the initial blower door reduction numbers the HES team achieved do not represent persistent savings.

**Figure 14: Inappropriate Basement Ceiling Air Sealing**



## C.2 DUCT SEALING PRACTICES

NMR auditors also inspected the quality and thoroughness of duct sealing seen in HES participant homes. The following photos show a mix of good and bad work quality on the part of the HES vendors.

Figure 15 shows a poorly sealed duct system. This portion of duct work was located at chest height and was readily accessible. The photo shows poorly adhered foil tape that was peeling off, a large hole that could fit at least two fingers into the opening, and a smaller, unsealed hole at a junction between duct sections. Sloppy tape applications were a common problem in the visited homes.

**Figure 15: Poorly Sealed Ducts**



Figure 16 shows an attic duct system where the HES technician had sloppily applied foil tape, and it was peeling off. The technician had also not applied tape to the underside of the flex

duct junction, leaving it unsealed. This was a particularly poor example of duct sealing seen during on-sites.

**Figure 16: Poor Quality and Incomplete Duct Sealing**

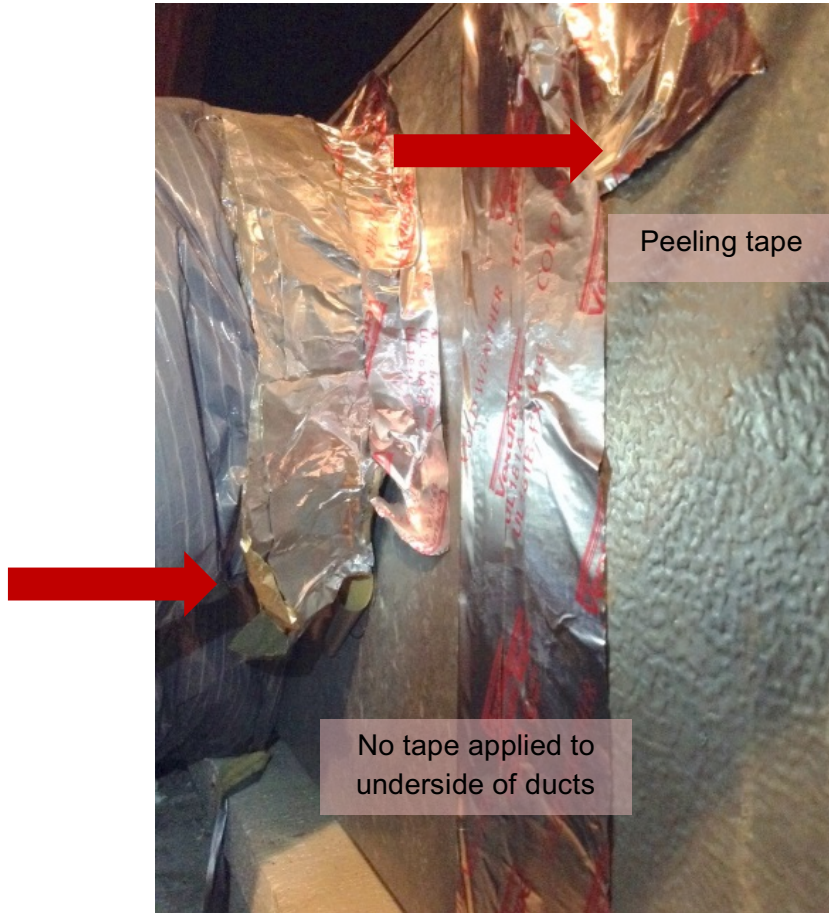


Figure 17 shows a high-quality example of duct sealing with mastic. The mastic was thick and covered all accessible seams. NMR auditors saw multiple instances of such high-quality duct sealing services during on-site visits.

**Figure 17: High-Quality Duct Sealing with Mastic**



Figure 18 shows an example of a poorly sealed duct system in an attic. The photo shows the panned return cavity on the attic floor; the sheet metal enclosing the wood return cavity was completely unsealed (the gap was about 10 linear feet in all), and there was a large opening at the bottom of the return cavity—it was not sealed to the attic floor. A large amount of attic air was pulled into this HVAC system, and even though the HES vendor had done some air sealing, they had not sealed this readily accessible source of duct leakage that was located directly in front of the attic hatch.

**Figure 18: Unsealed Attic Ducts**

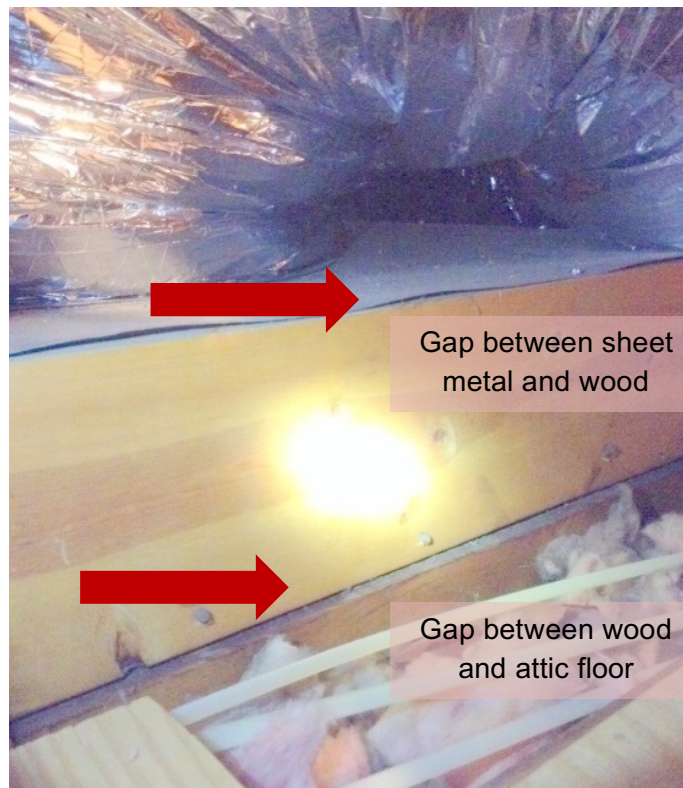




Figure 19 shows a future health and safety issue that the HES team did not address, but likely could have. The last few inches of an AC refrigerant line were uninsulated, and condensation was forming and dripping onto the furnace's exhaust vent, causing rust and corrosion. A pie plate below was catching the condensate. Fixing this may not have strictly been within the scope of the HES team's work, but they most likely had foam pipe insulation (that they use for insulating domestic hot water lines) that could have been used to fix this problem for the homeowner.

**Figure 19: Future Health and Safety Issue – Condensation Rusting Exhaust Vent**



### C.3 INSULATION PRACTICES

The following are examples of good, bad, and typical practices related to insulation installations by HES vendors.

Figure 20 shows a high-quality example of blown-in fiberglass insulation in an attic. The insulation was deep, quite level, and also installed over a room that was difficult to access from the main attic space. The homeowner reported having to push the insulators to get them

to insulate this harder-to-access space, but the final work product appeared to be of high quality.

**Figure 20: High Quality Blown-in Attic Insulation**



Figure 21 shows a basement rim joist that was completely insulated by the HES vendor using two-part closed-cell spray foam. This was installed, however, as an air-sealing measure, meaning that the homeowner received excellent air sealing and also an insulation benefit without having to pay separately for rim joist insulation. NMR auditors saw that some HES vendors thoroughly seal the entire rim joist area with spray foam to achieve higher savings than might be possible with targeting individual penetrations with a spray foam gun/wand.

**Figure 21: High Quality Rim Joist Air Sealing Serving as Insulation**

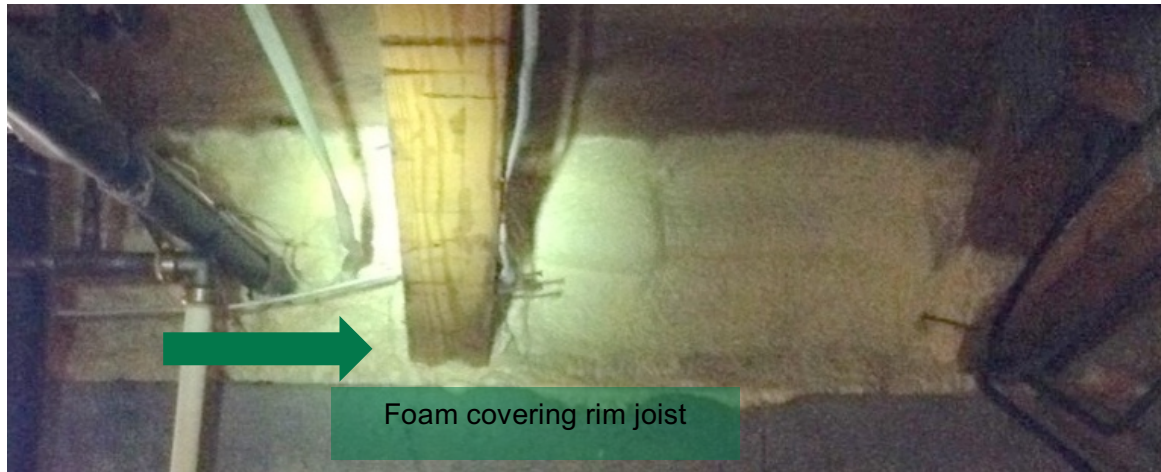


Figure 22 shows a rim joist that was well-insulated (and air sealed) with closed-cell spray foam, but an HES insulator had done a poor job of insulating the basement ceiling. The installation was extremely sloppy and had large gaps and severe compression; the fiberglass insulation was not cut or split to fit around any obstacles and was forced into the ceiling cavities.

**Figure 22: High-Quality Rim Joist Air Sealing and Low Quality Basement Ceiling Insulation**

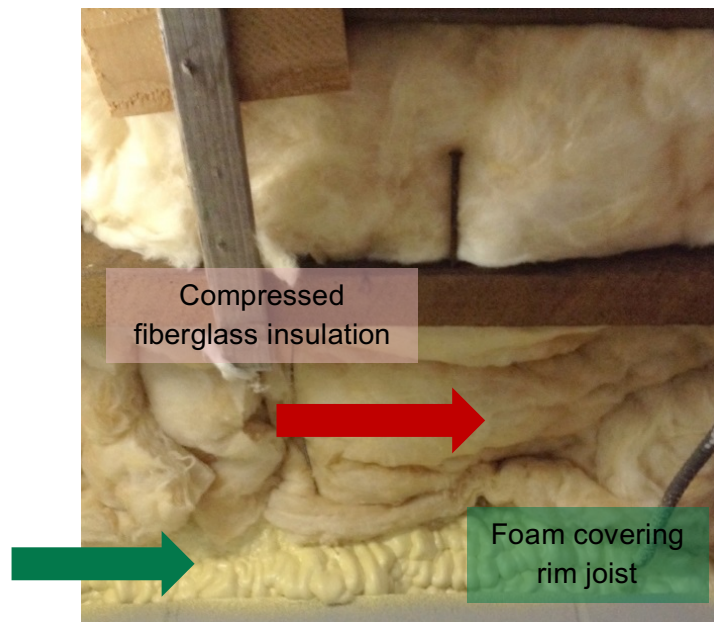


Figure 23 shows a high-quality attic insulation job done with spray foam. The HES team had encapsulated the entire attic, turning this into conditioned space.

**Figure 23: High Quality Attic Insulation with Spray Foam**

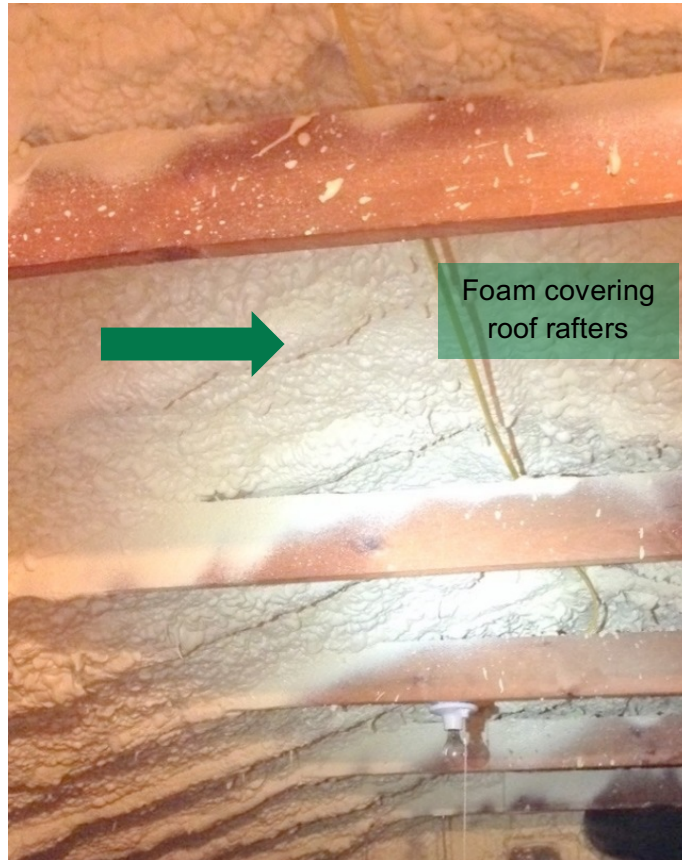


Figure 24 shows an egregiously bad example of attic insulation, but this had not been installed by an HES contractor. The homeowner participated in an HES core services visit and, according to the homeowner, the HES vendor did not tell the homeowner about the available incentives for insulation, and the homeowner had hired someone to install the attic insulation without benefit of any rebate or discount. The insulation job—performed outside the HES program—was an inferior installation; the insulator had rolled out the thin fiberglass material and draped it over the ducts on the attic floor, lifting the insulation over a foot off the attic floor. They had also failed to insulate the whole attic, leaving over half of the attic completely uninsulated.

Figure 24: Low-Quality, Non-HES Attic Insulation



# D

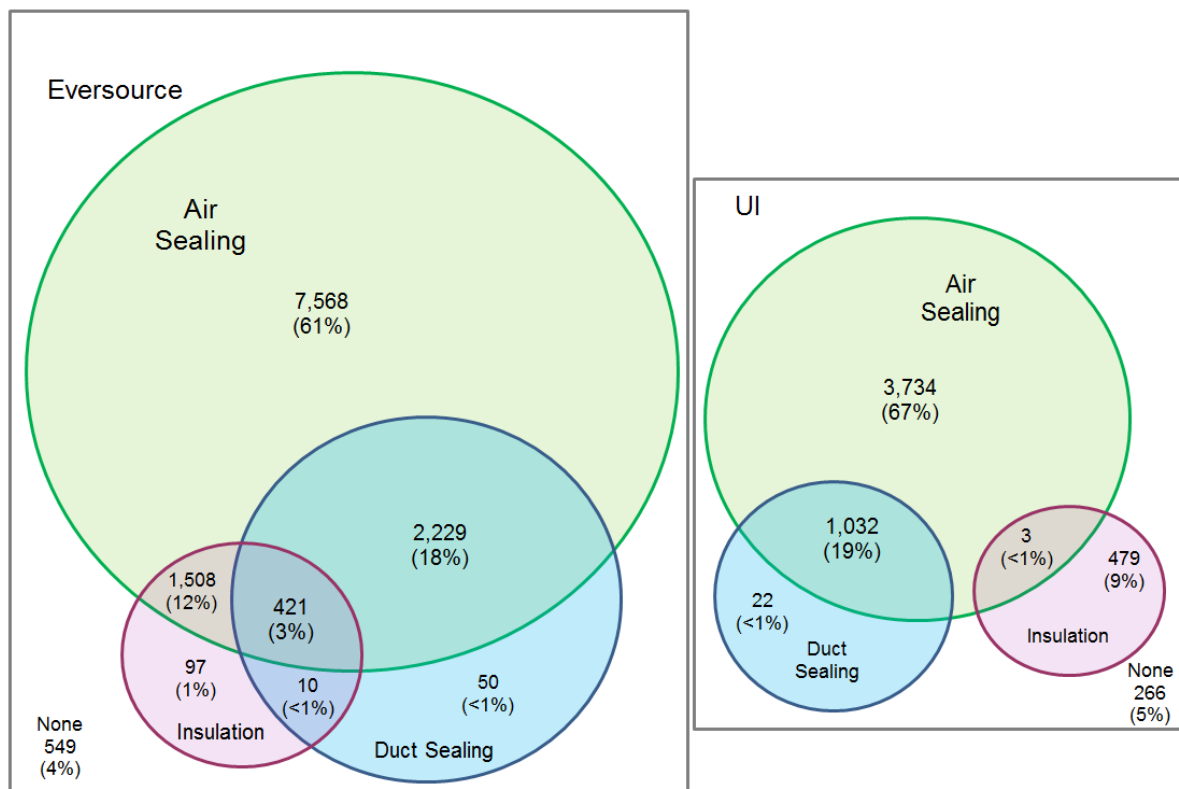
## Appendix D Detailed Analysis of Program Tracking Data

The following examines findings from 2014 HES program data. Results include in-depth analyses of air-sealing, duct-sealing, and insulation services and patterns in program participation by utility, vendor, and home characteristics.

### D.1 SERVICES PROVIDED BY UTILITY

Eversource customers made up the majority (69%) of the 17,968 HES participating homes that were served by Eversource and UI combined. Eversource (18%) and UI (19%) customers were about equally as likely to receive air sealing and duct sealing in combination (Figure 25). UI customers were more likely than Eversource customers to receive insulation or air sealing in isolation of each other. All 421 of the HES participants who received the combination of air sealing, duct sealing, and insulation were Eversource customers.

Figure 25: HES Services Provided by Utility



### D.2 AIR SEALING

Air sealing was performed at 16,490 of the 17,968 homes served through HES in 2014, or 92% of participating homes. Air leakage is commonly measured in air changes per hour at a specific air pressure (typically 50 pascals), and is calculated as follows:

$$ACH50 = \frac{CFM50 \times 60}{volume}$$

Where CFM50 is the rate of airflow between a building and its environment in cubic feet per minute when the building is depressurized to 50 pascals. Pre- and post-air sealing CFM50 rates and heated area (square feet) were available in both the Eversource and UI data sets; however, heated volume (cubic feet) was available only in the Eversource data set. As a result, *we can calculate ACH50 values only for Eversource customers*. However, because volume and minutes/hour are constants that apply to both the pre- and post-air sealing ACH50 values, *we can still estimate the percent air leakage improvement for both Eversource and UI homes with the CFM50 data alone*, as follows:

$$\left[ \left( \frac{CFM50_{pre} \times 60}{volume} - \frac{CFM50_{post} \times 60}{volume} \right) \div \frac{CFM50_{pre} \times 60}{volume} \right] \times 100$$

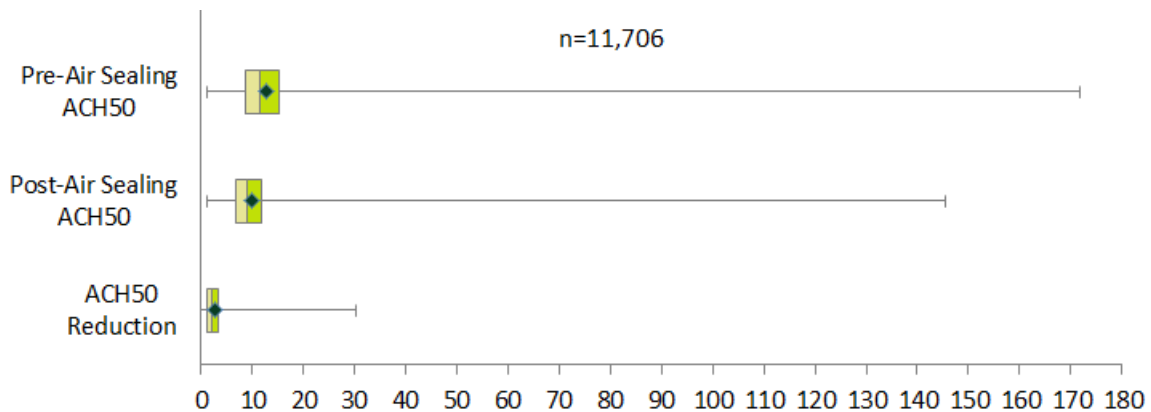
Where CFM50<sub>pre</sub> is the pre-air sealing airflow rate and CFM50<sub>post</sub> is the post-air sealing airflow rate. In the remainder of this section, we present results in units of ACH50 for Eversource customers, followed by CFM50/square foot (sq. ft.) of heated area and percent air leakage reduction for both UI and Eversource customers.

A total of 11,726 Eversource homes received air sealing services through HES in 2014.<sup>74</sup> This analysis used the CFM50<sub>pre</sub>, CFM50<sub>post</sub>, and heated volume values to calculate the pre-air sealing ACH50, post-air sealing ACH50, and the reduction in ACH50 per home. The box plots in Figure 26 characterize the distribution of the pre-air sealing ACH50, post-air sealing ACH50, and ACH50 reduction among Eversource homes that received air-sealing services. The pre-air sealing ACH50 ranged from 1.3 to 171.7, with an average of 12.7 ACH50. The post-air sealing ACH50 among these homes ranged from 1.3 to 145.6, with an average of 10.0 ACH50. The difference between the pre- and post-sealing ACH50 (i.e., ACH50 reduction) ranged from 0.0 to 30.2, with an average of 2.8 ACH50. There was no difference between the pre- and post-air sealing ACH50 for 684 (about 6%) of these 11,706 Eversource homes.

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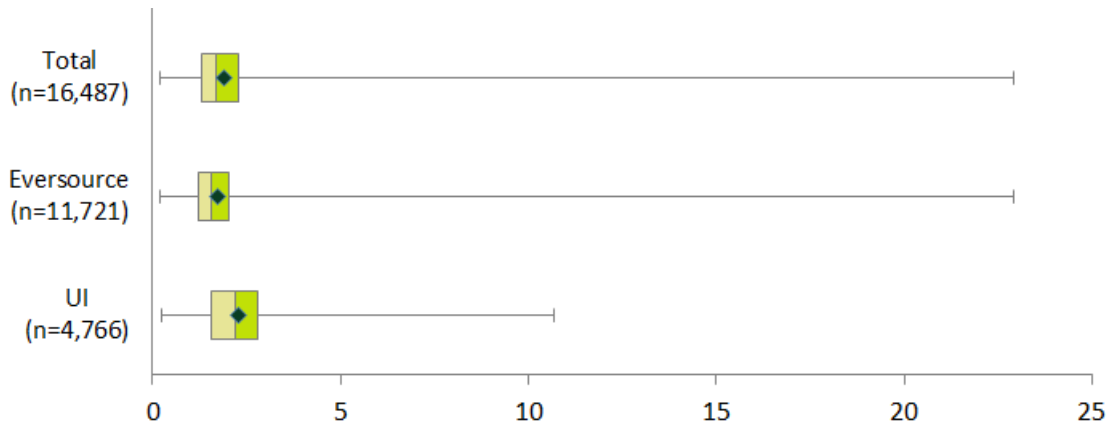
<sup>74</sup> Of the 11,726 homes that received air sealing, there were valid CFM50<sub>pre</sub>, CFM50<sub>post</sub>, and heated volume values for 11,706 homes in the Eversource data set.

**Figure 26: Eversource Pre- and Post-Air Sealing ACH50**



This study estimated the air leakage relative to home size by dividing the pre- and post-air sealing CFM50 measurements by the heated area (sq. ft.) per home for the 16,490<sup>75</sup> homes that received air-sealing services. Prior to air sealing, air leakage among all participating homes ranged from 0.2 to 22.9 CFM50/heated sq. ft., with an average of 1.9 CFM50/heated sq. ft. (Figure 27). On average, UI homes (2.3 CFM50/heated sq. ft.) were associated with higher leakage rates than Eversource homes (1.7 CFM50/heated sq. ft.), although among all participants, the home with the highest leakage rate was an Eversource home.

**Figure 27: Pre-Air Sealing CFM50/Heated Sq. Ft.**

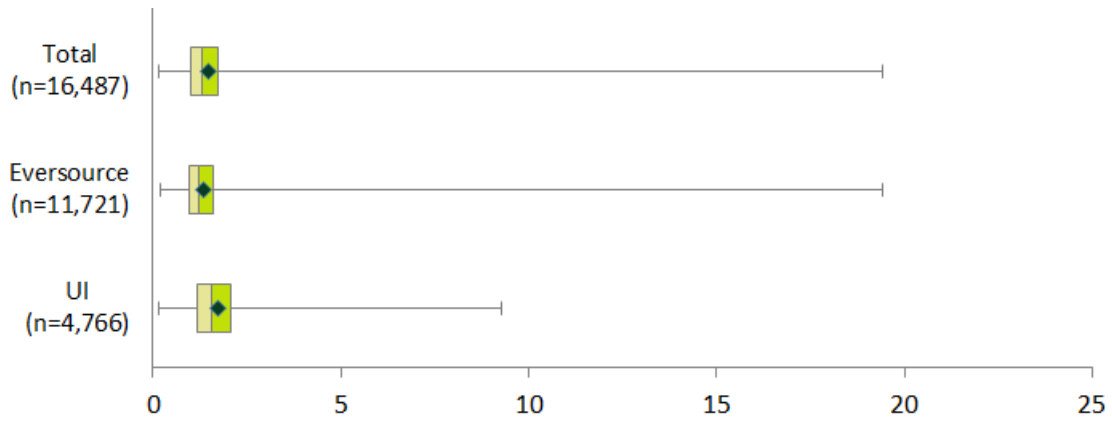


After receiving air-sealing services through HES, air leakage among participating homes ranged from 0.2 to 19.4 CFM50/heated sq. ft., with an average of 1.5 CFM50/heated sq. ft. (Figure 28). The post-air sealing airflow rate among Eversource homes was 1.3 CFM50/heated sq. ft., compared to 1.7 CFM50/heated sq. ft. among UI homes.

<sup>75</sup> Of the 16,490 homes that received air sealing, there were valid CFM50<sub>pre</sub>, CFM50<sub>post</sub>, and heated area values for 16,487 homes.

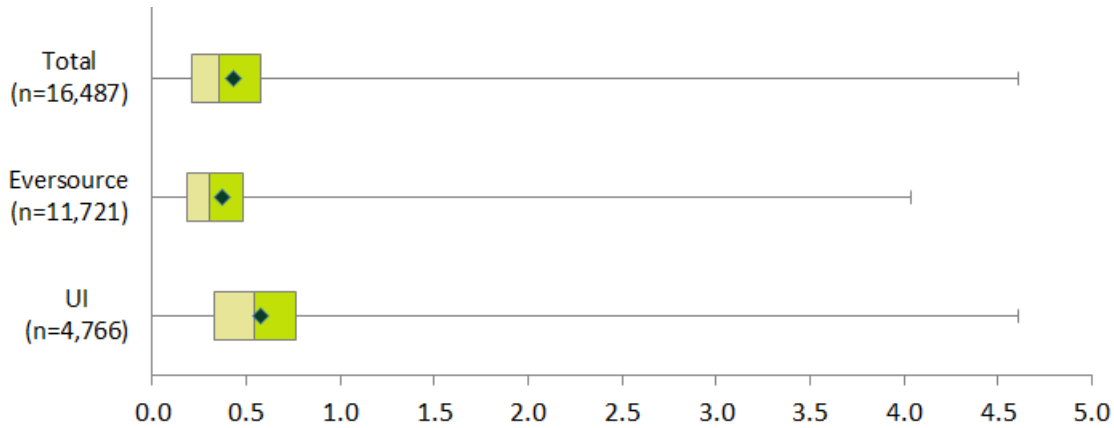


Figure 28: Post-Air Sealing CFM50/Heated Sq. Ft.



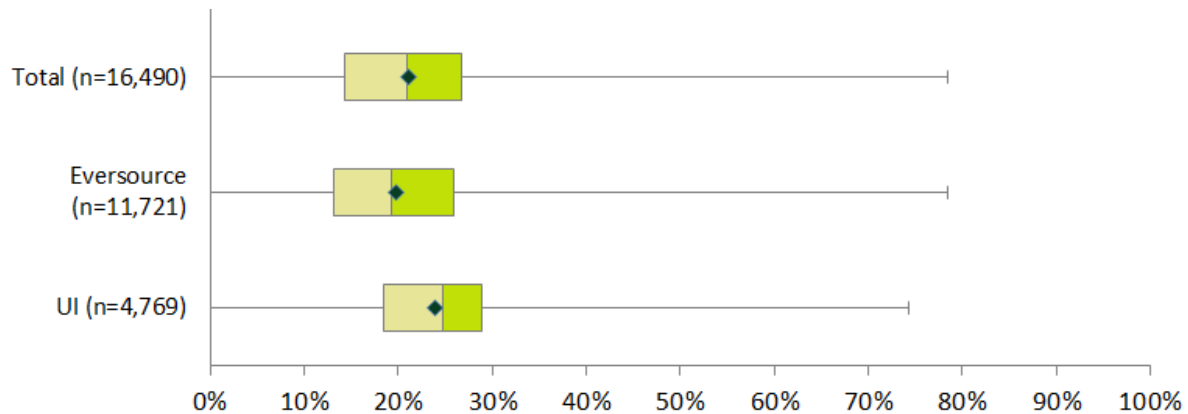
Air leakage reduction per home ranged from 0.00 to 4.61 CFM50/ heated sq. ft., with an average of 0.43 CFM50/heated sq. ft. (Figure 29). UI homes saw a larger average reduction in air leakage of 0.57 CFM50/heated sq. ft. compared to 0.37 CFM50/heated sq. ft. among Eversource homes.

**Figure 29: CFM50/Heated Sq. Ft. Reduction**



Air-sealing services provided through HES reduced air leakage by an average of 21% per home (Figure 30). UI homes saw a larger average reduction of 24% compared to 20% among Eversource homes. There was no reduction in air leakage for 755 homes (5%) that received air-sealing services.<sup>76</sup> Program staff indicated that this might occur if a home is already sealed tight and does not have any room for improvement (e.g., the pre- to post-sealing is zero). Neither the UI nor the Eversource data sets contained a unique variable to explain why there was no improvement in air leakage, so this study is not able to determine the exact reasons for this occurrence.

**Figure 30: Air Sealing Percent Air Leakage Reduction**

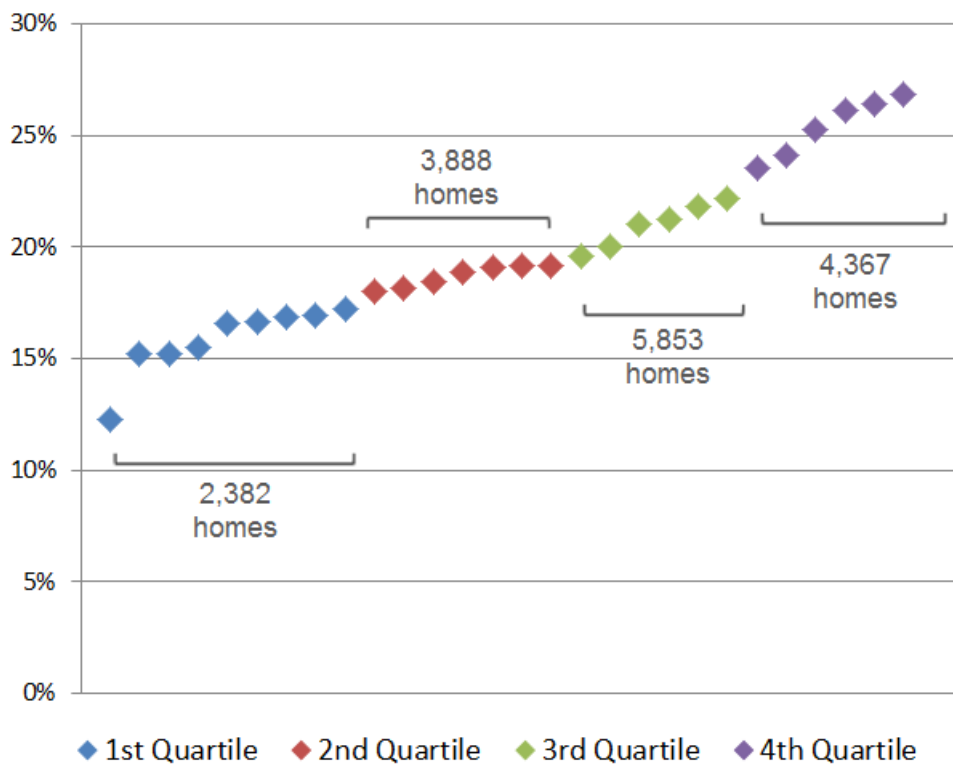


<sup>76</sup> The UI and Eversource data sets contained blower door CFM<sub>pre</sub> and CFM<sub>post</sub> variables. Neither data set contained a unique variable indicating if air sealing had been performed at a home. Therefore, we assumed non-blank, non-zero sets of blower door CFM<sub>pre</sub> and CFM<sub>post</sub> values implied that air sealing had been performed at a home. There was no difference between the blower door CFM<sub>pre</sub> and CFM<sub>post</sub> values for 684 Eversource and 71 UI homes. Note that this unit of analysis is different from the ACH50 air sealing reported above.

### D.2.1 Air Sealing Services by Vendor

Twenty-eight of the thirty HES vendors performed air-sealing services in 2014. Figure 31 displays the average percent air leakage reduction per vendor, which ranged from 12% to 27%. This analysis groups the 28 vendors that performed air sealing services into quartiles based on the average percent air leakage reduction in order to identify characteristics common to the top- and bottom-performing air-sealing vendors.<sup>77</sup> Vendors in the third quartile provided air sealing services to the most homes (5,853), while vendors in the first quartile provided air sealing services to the fewest homes (2,382).

**Figure 31: Percent Air Leakage Reduction by Vendor**



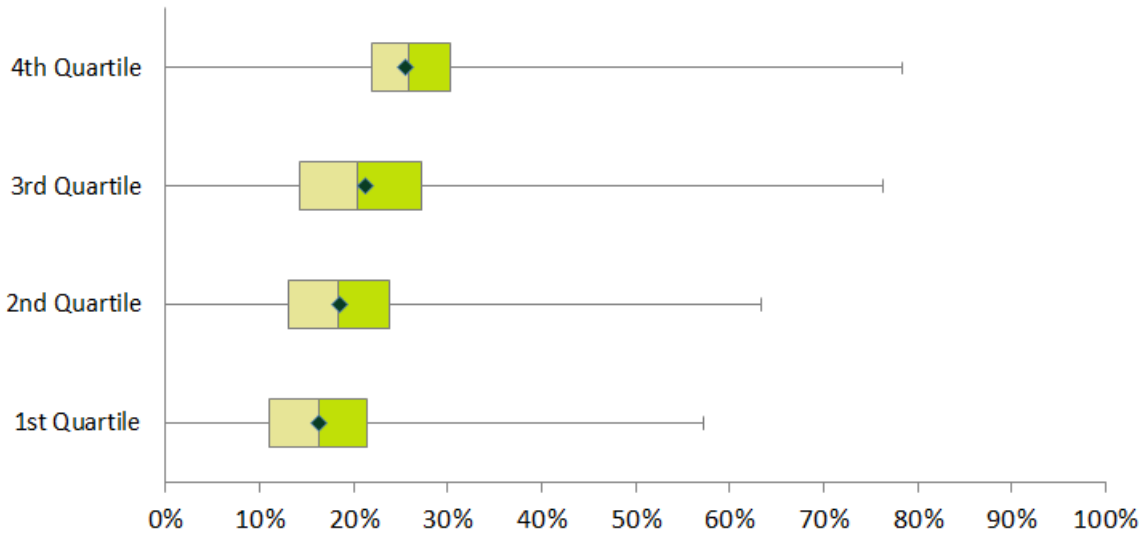
Differences in vendor performance appear to be explained by differences in the types of homes they served. Vendors in the fourth (i.e., top-performing) air-sealing quartile served smaller homes, on average, than vendors in the three other quartiles. Conversely, vendors in the first (i.e., bottom-performing) air-sealing quartile served the largest homes, on average. In addition, vendors in the fourth quartile served the largest proportion of renter-occupied homes: 46% of homes served by vendors in the fourth quartile were renter-occupied, compared to less than 5% of homes in the three other quartiles.

<sup>77</sup> These figures are based on the percentage change from the pre- and post-work blower door values. The percentage change would be the same if we were to plot ACH50 values.

### D.2.2 Air Sealing by Home Characteristics

This analysis grouped vendors that performed air-sealing services into quartiles based on the average percent air leakage reduction per vendor in order to identify characteristics common to the top- and bottom-performing air-sealing vendors. The average percent air leakage reduction among vendors in the fourth air-sealing quartile was 25%, compared to 21% among the third quartile, 19% among the second quartile, and 16% among the first quartile (Figure 32).

**Figure 32: Percent Air Leakage Reduction by Vendor Quartile**



With the exception of the newest homes, air leakage reduction was similar across all home ages. Homes 40 to 59 years old represent the largest group (6,153) and had the highest

average percent air leakage reduction of 23% (Table 12). Not surprisingly, newer homes (less than 20 years old) had the smallest percent air leakage reduction (14%).

**Table 12: Percent Air Leakage Reduction by Home Age**

Home Age (Years)	Count of Homes	Average Air Leakage Reduction
100 or more	885	20%
80 to 99	1,422	23%
60 to 79	2,177	22%
40 to 59	6,153	23%
20 to 39	3,813	20%
0 to 19	2,009	14%
Unknown	11	--
<b>Total</b>	<b>16,490</b>	<b>21%</b>

The average age of homes served was similar across vendor quartiles, ranging from 48 to 56 years (Figure 33).

**Figure 33: Home Age by Vendor Air Sealing Quartile**

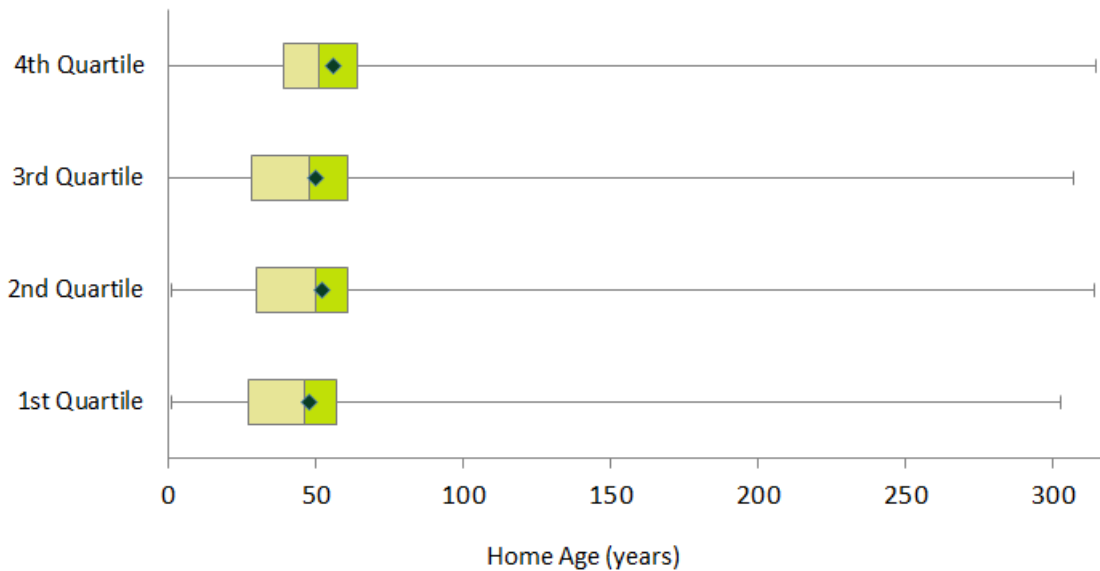


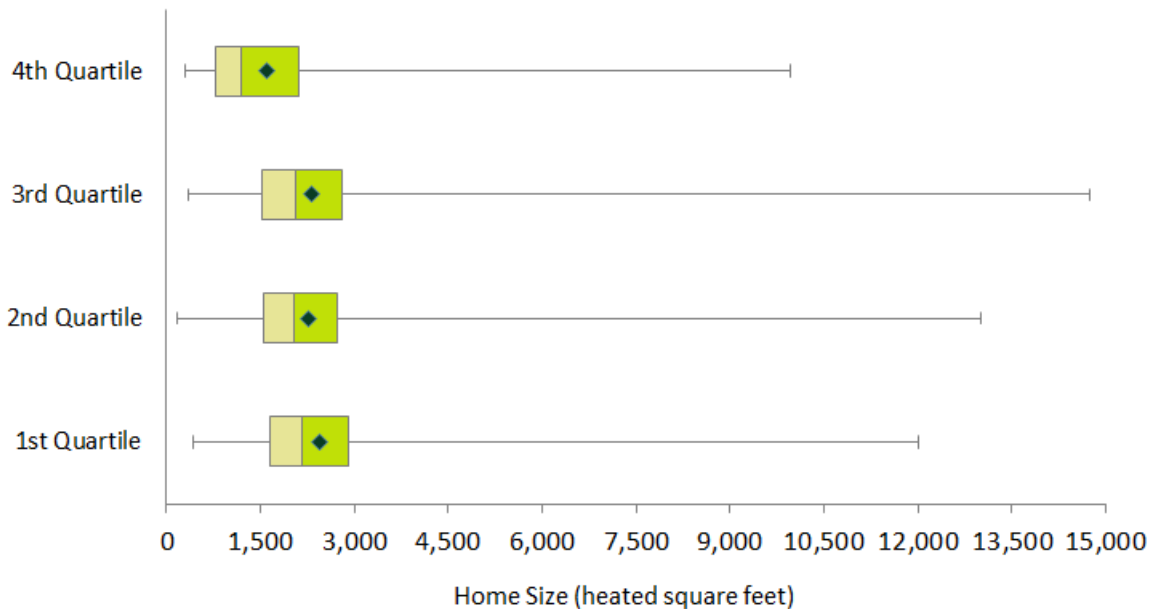
Table 13 displays a pattern of increased air leakage percent improvement as home size decreases. The smallest homes (0 to 999 heated sq. ft.) had the greatest average percent air leakage reduction (28%), while the largest homes (5,000 or more heated sq. ft.) had the smallest average percent air leakage reduction (12%).

**Table 13: Percent Air Leakage Reduction by Home Size**

Home Size (Heated Square Feet)	Count of Homes	Average Air Leakage Reduction
5,000 or more	470	12%
4,000 to 4,999	646	13%
3,000 to 3,999	1,886	15%
2,000 to 2,999	4,778	19%
1,000 to 1,999	6,279	23%
0 to 999	2,431	28%
<b>Total</b>	<b>16,490</b>	<b>21%</b>

On average, vendors in the fourth air-sealing quartile served the smallest homes (1,590 heated sq. ft.), while vendors in the first, second, and third air-sealing quartiles served larger homes. The average home size was similar across vendors in the first, second, and third air-sealing quartiles, ranging from 2,270 heated sq. ft. for the second quartile to 2,435 heated sq. ft. for the first quartile (Figure 34).

**Figure 34: Home Size by Vendor Air-Sealing Quartile**



The majority (14,128, or 84%) of homes that received air-sealing services were owner-occupied. Renter-occupied homes had a greater (28%) average air leakage reduction than owner-occupied homes (20%; Table 14). When asked about this difference between owner- and renter-occupied homes, one program administrator posited that the difference may be

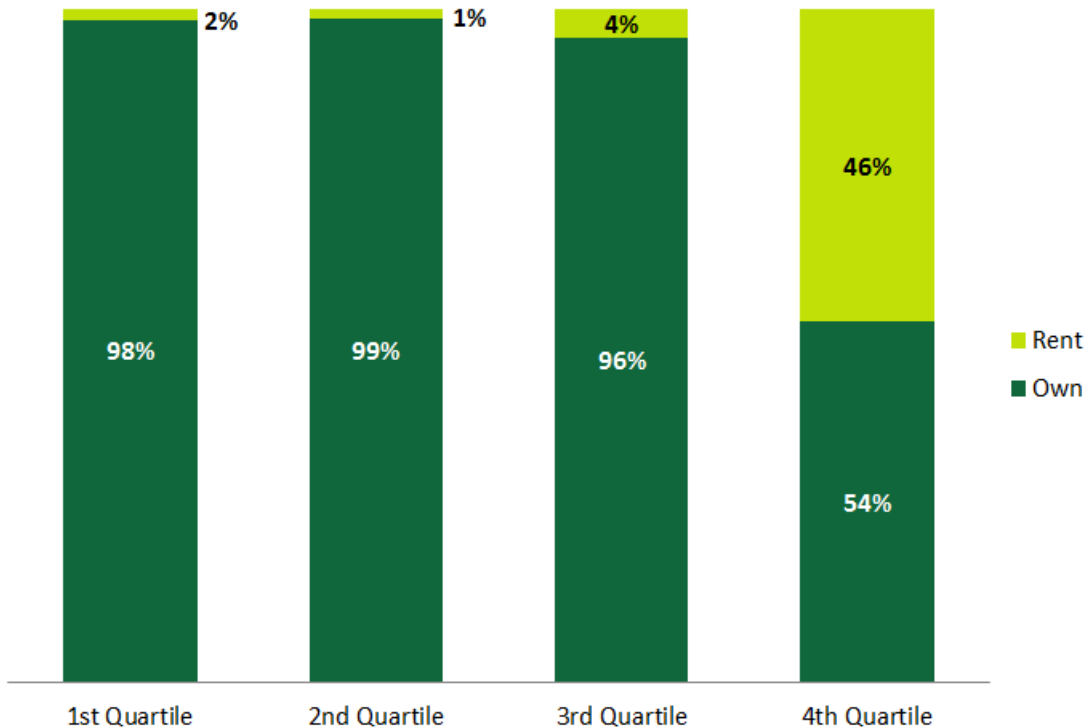
due to more rental properties being older buildings, which is consistent with the finding above regarding greater air leakage reduction in older homes.

**Table 14: Percent Air Leakage Reduction by Tenure**

Tenure	Count of Homes	Average Air Leakage Reduction
Own	14,128	20%
Rent	2,360	28%
Unknown	2	--
<b>All Homes</b>	<b>16,490</b>	<b>21%</b>

Vendors in the fourth air-sealing quartile served the largest (46%) proportion of renter-occupied homes than any of the other quartiles (Figure 35). Vendors in the first, second, and third quartiles served relatively few renter-occupied homes (4% or less).

**Figure 35: Tenure by Vendor Air-Sealing Quartile**



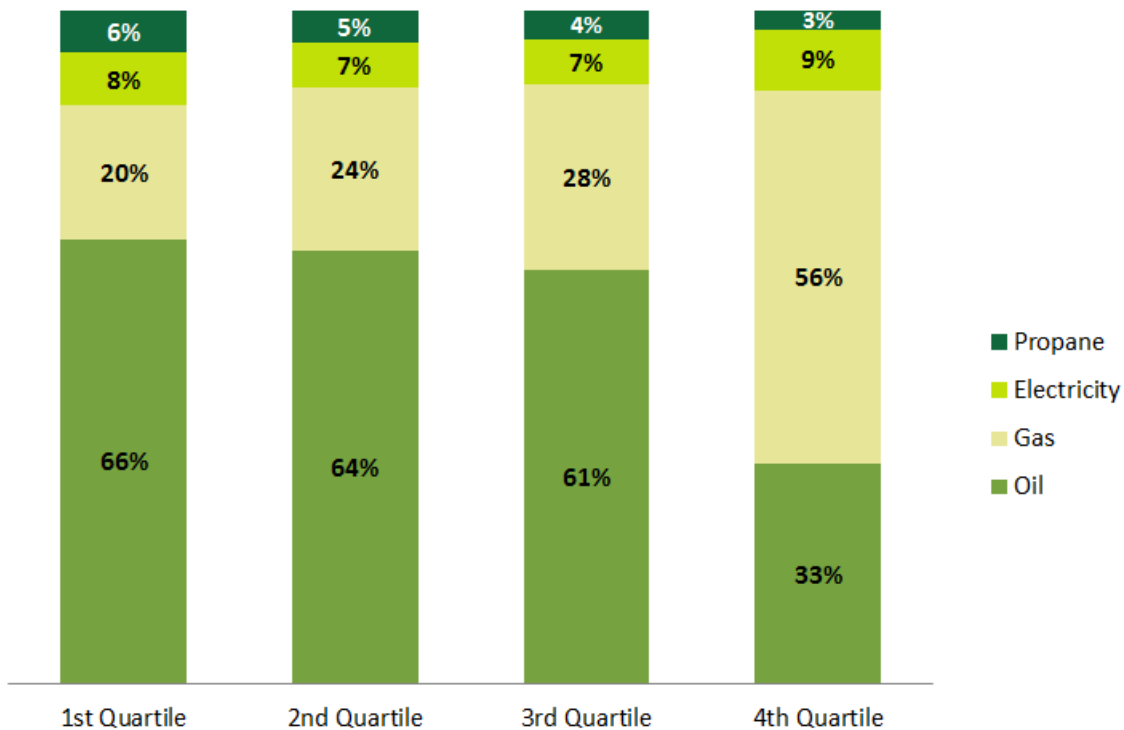
Air leakage reduction was similar across all home heating fuels, ranging from 17% for propane to 23% for electricity (Table 15).

**Table 15: Percent Air Leakage Reduction by Home Heating Fuel**

Heating Fuel	Count of Homes	Average Air Leakage Reduction
Electricity	1,237	23%
Gas	5,466	22%
Oil	9,102	20%
Propane	685	17%
<b>Total</b>	<b>16,490</b>	<b>21%</b>

Vendors in the fourth air-sealing quartile served the largest proportion of homes fueled by electricity (9%) and natural gas (56%) and the smallest proportion of homes fueled by propane (3%) and oil (33%) compared to the three other quartiles (Figure 36).

**Figure 36: Heating Fuel by Vendor Air Sealing Quartile**

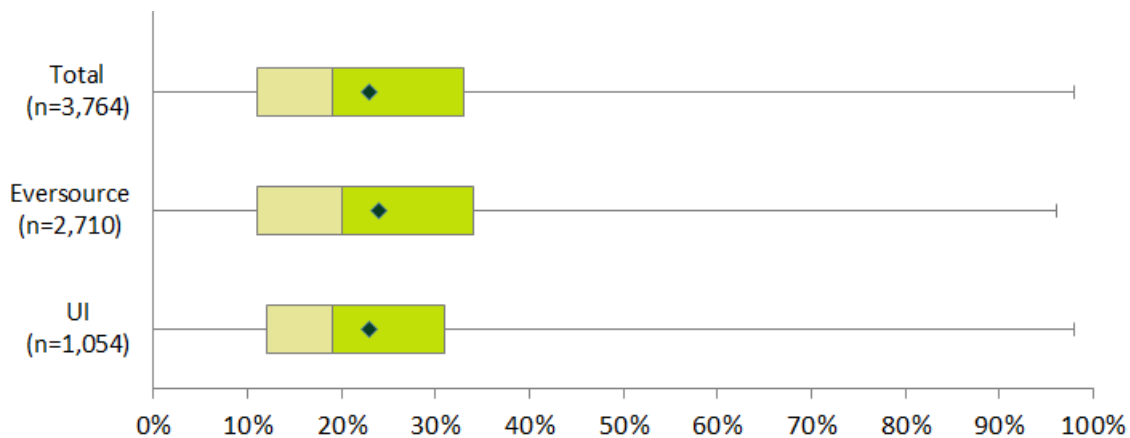




### D.3 DUCT SEALING

Duct sealing was performed at 3,764 of the 17,968 homes served through HES in 2014, or 21% of participating homes. Duct leakage is measured in cubic feet of air flow per minute at 25 pascals (CFM25). The percent duct leakage reduction per home was calculated by dividing the difference between the pre- and post-duct sealing CFM25 (i.e., the reduction in duct leakage) by the pre-duct sealing CFM25. On average, duct leakage was reduced by 23% for homes that received duct-sealing services through HES in 2014 (Figure 37). Eversource customers had a slightly higher average duct leakage reduction of 24% compared to 23% among UI customers. Eight percent of the 3,764 customers that received duct sealing services did not see any reduction between the pre- and post-duct sealing CFM25s. The data provided for this study did not indicate why the vendors' duct sealing showed no improvement.

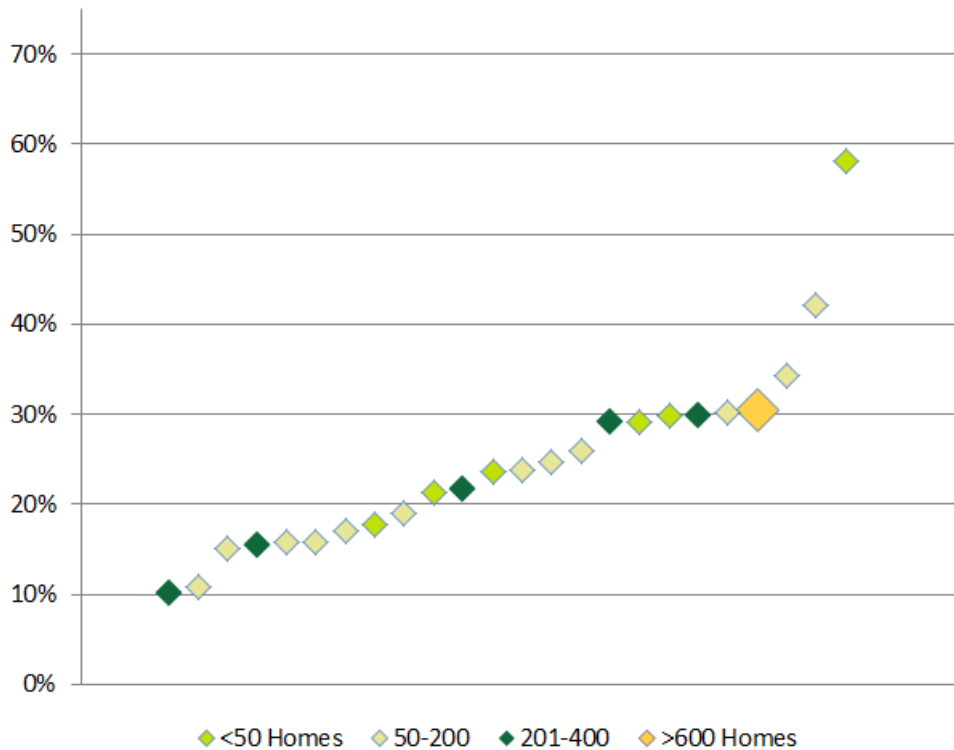
**Figure 37: Percent Duct Leakage Reduction by Utility**



### D.3.1 Duct Sealing Services by Vendor

Twenty-seven of the thirty HES vendors performed duct-sealing services in 2014. Figure 38 displays the average percent duct leakage reduction per vendor and is color coded based on the number of homes at which each vendor sealed ducts.<sup>78</sup> The average percent duct leakage reduction per vendor ranged from 10% to 58%. Most vendors performed duct sealing at 200 or fewer homes in 2014. One vendor performed duct sealing at over 600 homes, with an average duct leakage reduction of 30% per home.

**Figure 38: Percent Duct Leakage Reduction by Vendor**



<sup>78</sup> Three vendors that performed duct-sealing services at six or fewer homes are excluded from Figure 38. Two of these three vendors had extreme average percent duct leakage reduction values, including 0% and 100%.

### D.3.2 Duct Sealing by Home Characteristics

While there is a pattern of increased duct leakage reduction as home age increases, in general duct leakage reduction was similar across all home ages and ranged from 22% to 25% (Table 16).

**Table 16: Percent Duct Leakage Reduction by Home Age**

Home Age (Years)	Count of Homes	Average Duct Leakage Reduction
100 or more	191	25%
80 to 99	174	24%
60 to 79	549	24%
40 to 59	1,291	24%
20 to 39	940	23%
0 to 19	618	22%
Unknown	1	--
<b>Total</b>	<b>3,764</b>	<b>23%</b>

Duct leakage reduction was similar across all home sizes, ranging from 22% to 26% (Table 17).

**Table 17: Percent Duct Leakage Reduction by Home Size**

Home Size (Heated Square Feet)	Count of Homes	Average Duct Leakage Reduction
5,000 or more	225	22%
4,000 to 4,999	229	24%
3,000 to 3,999	570	23%
2,000 to 2,999	1,160	23%
1,000 to 1,999	1,372	24%
0 to 999	208	26%
<b>Total</b>	<b>3,764</b>	<b>23%</b>

Improvement in duct leakage was almost the same between owner-occupied (23%) and renter-occupied (22%) homes (Table 18).

**Table 18: Percent Duct Leakage Reduction by Tenure**

Tenure	Count of Homes	Average Duct Leakage Reduction
Own	3,542	23%
Rent	222	22%
<b>All Homes</b>	<b>3,764</b>	<b>23%</b>

Duct leakage reduction was similar across all home heating fuels, ranging from 22% for propane to 24% for oil (Table 19).

**Table 19: Percent Duct Leakage Reduction by Home Heating Fuel**

Heating Fuel	Count of Homes	Average Duct Leakage Reduction
Oil	2,215	24%
Electricity	127	23%
Gas	1,197	23%
Propane	225	22%
<b>Total</b>	<b>3,764</b>	<b>23%</b>

#### D.4 INSULATION

Insulation was installed at 2,518 of the 17,968 homes served through HES in 2014, or 14% of participating homes (Table 20). The percentage of homes in which insulation was installed is greater for Eversource customers (16%) than UI customers (9%). The Eversource data set contained a variable indicating whether or not the opportunity to upgrade insulation existed per participant home. Insulation upgrade opportunities were identified in 31% of Eversource HES participant homes, and insulation was installed in 16% of participant homes. In other words, insulation was installed in just over one-half (53%) of Eversource HES participant homes in which auditors identified eligible insulation upgrade opportunities. In the remainder

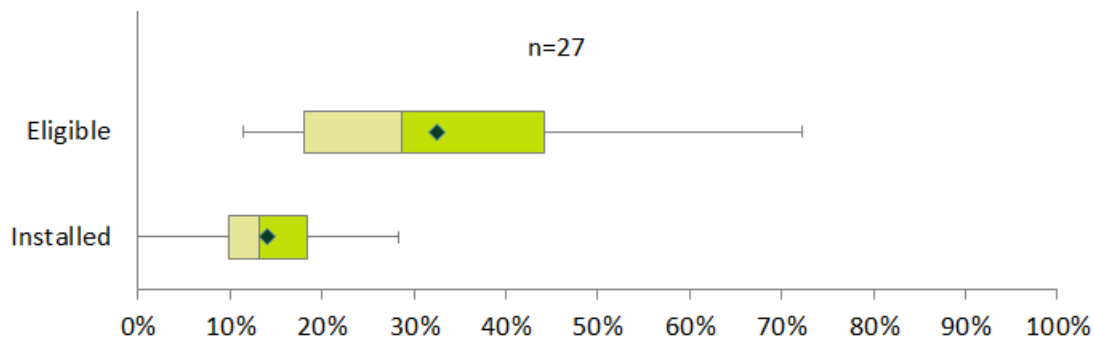
of this section, we focus on the 3,825 Eversource homes in which eligible insulation upgrade opportunities were identified.

**Table 20: Homes that Installed Insulation**

	Eversource		UI		Total	
	Count	%	Count	%	Count	%
Total HES Visits	12,432	100%	5,536	100%	17,968	100%
Insulation Upgrade Eligible	3,825	31%	--	--	--	--
Insulation Installed	2,036	16%	482	9%	2,518	14%

Twenty-seven of the thirty HES vendors installed insulation in 2014. The box plots in Figure 39 display the distribution of 1) the average percentage of homes in which insulation upgrade opportunities were identified per vendor among Eversource homes, and 2) the average percentage of homes in which insulation was installed per vendor among Eversource homes. The percentage of Eversource homes eligible for insulation upgrades ranged from 11% to 72% per vendor, with an average of 33%. The percentage of Eversource homes in which insulation was installed ranged from 0% to 25% per vendor, with an average of 14%.

**Figure 39: Eversource Vendor Insulation Upgrade Eligibility and Installation Rates**



Eligible insulation upgrade opportunities were most often identified in homes that were 1) owner-occupied, 2) 1,000 to 2,999 heated sq. ft., 3) 40 to 59 years old, and 4) heated with oil. Insulation was installed in only 14% of renter-occupied homes in which eligible insulation upgrade opportunities were identified, compared to 54% of owner-occupied homes. The installation rate of 60% among homes 40 to 59 years old was higher than the overall installation rate of 53%. More detailed information on the characteristics of homes in which insulation was installed is provided in D.4.1.

**D.4.1 Insulation by Home Characteristics**

Table 21 breaks out the installation rate among homes eligible for insulation upgrades by homes grouped by age. Insulation installation rates range from 38% to 60% by home age category. Homes that are 40 to 59 years old represent the largest group with eligible insulation upgrade opportunities (1,616) and were most likely to receive insulation (60%).

**Table 21: Insulation Installation among Upgrade Eligible Homes by Home Age**

Home Age (Years)	Count of Homes Eligible for Insulation Upgrade	Percent of Eligible Homes that Installed Insulation
100 or more	295	42%
80 to 99	233	38%
60 to 79	652	53%
40 to 59	1,616	60%
20 to 39	787	51%
0 to 19	240	45%
Unknown	2	--
<b>Total</b>	<b>3,825</b>	<b>53%</b>

Table 22 breaks out the insulation installation rate among homes eligible for insulation upgrades by homes grouped by size. Insulation installation rates range from 46% to 55% by home size category. Homes of 1,000 to 1,999 heated sq. ft. represent the largest group with eligible insulation upgrade opportunities (1,798) and were the most likely to receive insulation (55%).

**Table 22: Insulation Installation among Upgrade Eligible Homes by Home Size**

Home Size (Heated Square Feet)	Count of Homes Eligible for Insulation Upgrade	Percent of Eligible Homes that Installed Insulation
5,000 or more	93	46%
4,000 to 4,999	127	51%
3,000 to 3,999	448	52%
2,000 to 2,999	1,223	52%
1,000 to 1,999	1,798	55%
0 to 999	136	47%
<b>Total</b>	<b>3,825</b>	<b>53%</b>

The majority of 2014 HES homes were owner-occupied. Table 23 shows that renter-occupied homes were much less likely than owner-occupied homes to receive insulation.

**Table 23: Insulation Installation among Upgrade Eligible Homes by Tenure**

Tenure	Count of Homes Eligible for Insulation Upgrade	Percent of Eligible Homes that Installed Insulation
Own	3,742	54%
Rent	83	14%
<b>Total</b>	<b>3,825</b>	<b>53%</b>

As shown in Table 24, the majority of homes eligible for insulation upgrades heat with oil (2,614). Insulation installation rates range from 44% to 57% by home heating fuel among homes eligible for insulation upgrades.

**Table 24: Insulation Installation among Upgrade Eligible Homes by Heating Fuel**

Heating Fuel	Count of Homes Eligible for Insulation Upgrade	Percent of Eligible Homes that Installed Insulation
Oil	2,614	55%
Gas	798	50%
Electricity	257	44%
Propane	156	57%
<b>Total</b>	<b>3,825</b>	<b>53%</b>

## D.5 2014 HES VENDORS

Table 25 displays all of the vendors that provided HES services in 2014, including the number and percent of homes served by each vendor. Next Step Living performed the most HES visits in 2014 (16%), followed by Lantern Energy (12%), EcoSmart by R Pelton Builders (7%), and New England Smart Energy (7%).

**Table 25: 2014 HES Homes Served by Vendors**

Vendor	Eversource		UI		Total	
Next Step Living	2,078	17%	730	13%	2,808	16%
Lantern Energy	525	4%	1,708	31%	2,233	12%

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Vendor	Eversource		UI		Total	
EcoSmart by R Pelton Builders	1,124	9%	139	3%	1,263	7%
New England Smart Energy	936	8%	269	5%	1,205	7%
Victory Energy Solutions	780	6%	193	3%	973	5%
Energy Efficiencies Solutions	858	7%	54	1%	912	5%
Energy Resource Group	378	6%	97	2%	840	5%
Competitive Resources	480	4%	297	5%	777	4%
New England Conservation	578	5%	194	4%	772	4%
Wesson Energy	641	5%	66	1%	707	4%
Aiello Home Services	575	5%	51	1%	626	3%
Handyman Express Energy Solutions	172	1%	430	8%	602	3%
EFI	0	0%	541	10%	541	3%
Tri City Home Energy Services	287	2%	234	4%	521	3%
Energy PRZ	743	3%	37	1%	415	2%
Gulick Building & Development	302	2%	100	2%	402	2%
Santa Fuel	236	2%	100	2%	336	2%
Uplands Construction	241	2%	46	1%	287	2%
BCB Conservation Group	247	2%	35	1%	282	2%
Home Doctor of America	233	2%	42	1%	275	2%
A Plus Installation	229	2%	0	0%	229	1%
Climate Partners	93	1%	96	2%	189	1%
Molina & Associates	127	1%	46	1%	173	1%
Greenbuilt Connecticut	167	1%	0	0%	167	1%
Fox Heating Services	155	1%	0	0%	155	1%
Hoffman Energy	108	1%	28	1%	136	1%
R&W Heating	122	1%	0	0%	122	1%
AC Development	17	<1%	0	0%	17	<1%
Nutmeg	0	0%	2	<1%	2	<1%
MAZ	0	0%	1	<1%	1	<1%
<b>Total</b>	<b>12,432</b>	<b>100%</b>	<b>5,536</b>	<b>100%</b>	<b>17,968</b>	<b>100%</b>

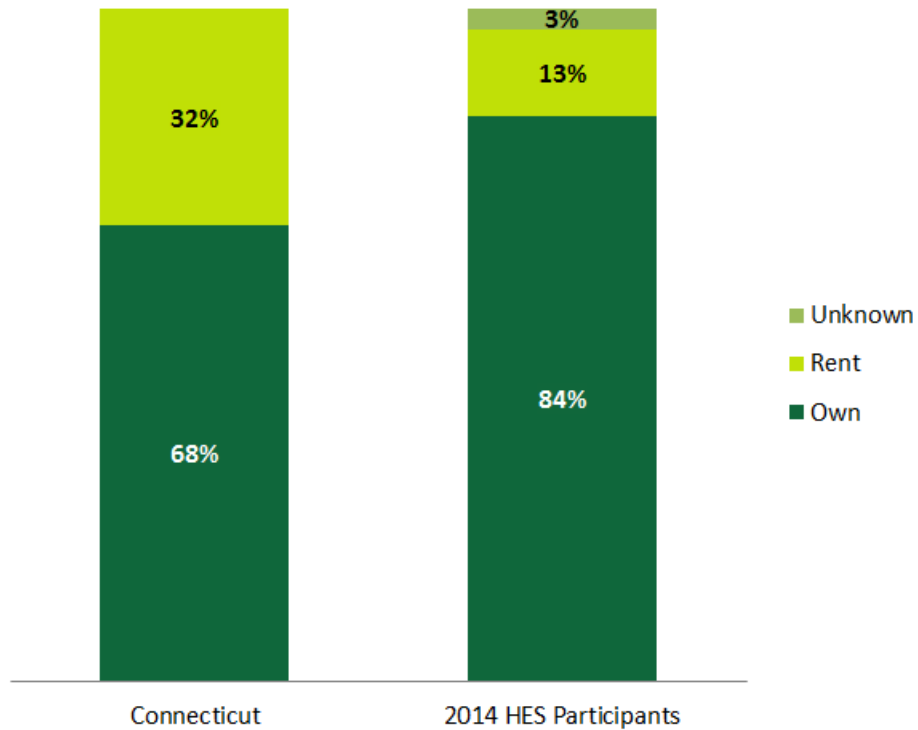




## D.6 PARTICIPANT HOME CHARACTERISTICS

This section compares 2014 HES participants' home characteristics to those of the state of Connecticut overall.<sup>79</sup> The majority (84%) of 2014 HES participants own their home, compared to 68% of Connecticut residents (Figure 40).

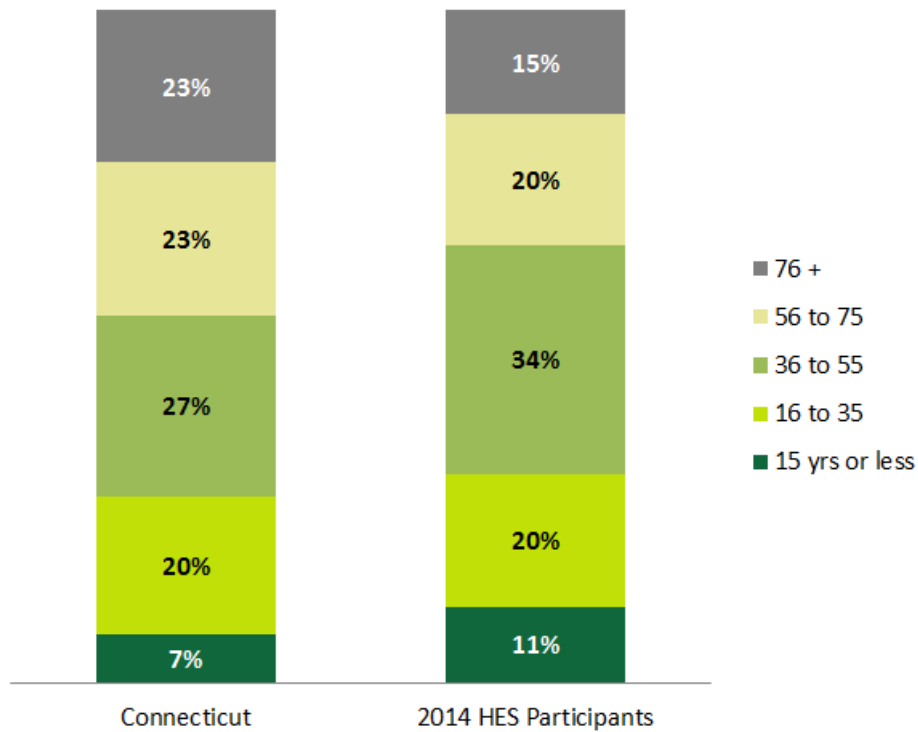
**Figure 40: Tenure**



<sup>79</sup> The source for statewide data is the American Community Survey 2013 five-year estimates.

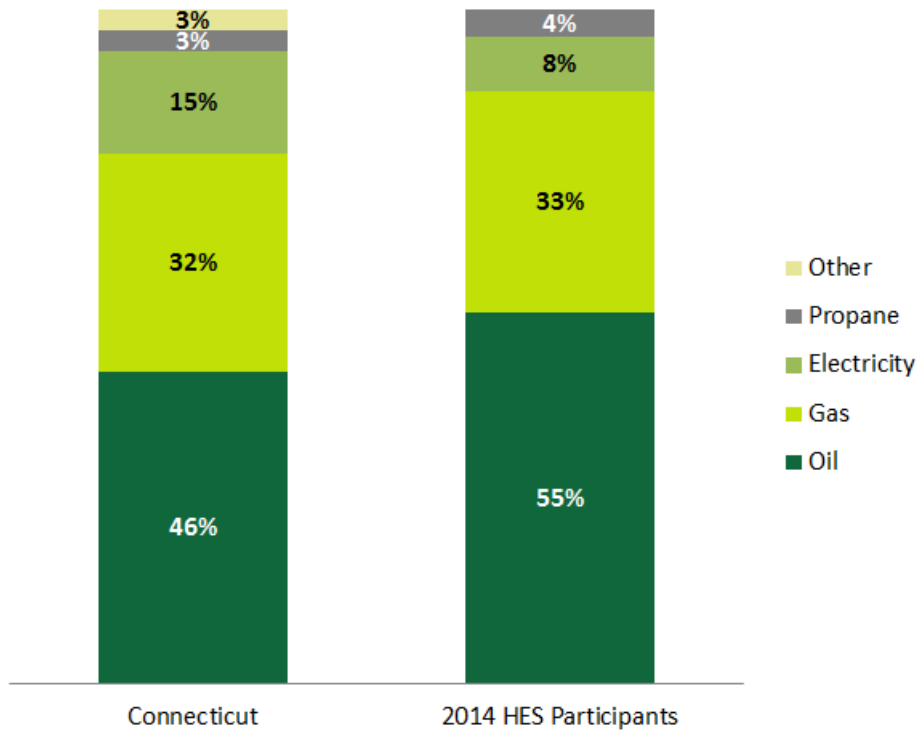
Just over one-third (34%) of 2014 HES participants reside in homes that are 36 to 55 years old. Thirty-one percent of 2014 HES participants reside in homes 35 years old and newer, while 35% live in homes over 55 years old. Figure 41 shows that the homes served by HES in 2014 included 1) a larger proportion of homes 15 years old or less and 2) a smaller proportion of homes over 75 years old compared to the Connecticut housing stock.

**Figure 41: Home Age**



Over one-half (55%) of 2014 HES participants heat their homes with oil. Compared to the Connecticut housing stock, 2014 HES participants were more likely to heat with oil and less likely to heat with electricity (Figure 42).

**Figure 42: Primary Heating Fuel**



The Residential Energy Consumption Survey (RECS) reports total heated square footage of homes and total housing units by census division and for certain states. Dividing total housing units by total heated square footage yields average home size in heated square feet. The most current year for which RECS data are available is 2009, and the smallest geographic area encompassing CT comprises the combination of the following states: CT, ME, NH, RI, and VT. As shown in Table 26, the average home size for CT, ME, NH, RI, and VT in 2009 was 1,800 heated square feet. This compares to an average home size of 2,057 heated square feet among 2014 HES participants.

**Table 26: Average Home Size**

Average Heated Area	CT, ME, NH, RI, VT	HES Participants
Square Feet	1,800	2,057



## Appendix E Best Practices Programs

This appendix provides brief descriptions of the programs included in the review of best practices. Since the focus of this study was on single-family, non-low-income households eligible for air sealing, duct sealing, or insulation, our examination of these programs is limited to these specific features and characteristics. Some programs may offer services to broader populations (e.g., multifamily or low-income households) and provide a wider range of services than the three measures of interest, but we did not explore these aspects of these programs for this study.

### E.1 MASS SAVE HOME ENERGY SAVINGS PROGRAM

**Website:** <http://www.masssave.com/residential/home-energy-assessments>

**Program Structure:** The Mass Save Home Energy Services (HES) program offers free home energy assessments or audits to homeowners, which include the installation of direct-install measures and recommendations for further energy-saving opportunities and improvements. The program provides incentives for weatherization measures, including air sealing and insulation, and coordinates services for electric, propane, and oil and water heating systems through other residential programs. The HES program is implemented through a network of lead vendors and home performance contractors. The lead vendors contract directly with the PAs and manage the delivery of services. Lead vendors employ Energy Specialists who conduct the energy assessments and coordinate with independent installation contractors who install recommended measures through the program. The home performance contractors similarly employ Energy Specialists to conduct energy assessments and may have staff who install recommended measures or, in some territories, subcontract this work to independent contractors. With the lead vendor model, participants are assigned to lead vendors, while home performance contractors recruit their own potential participants.

**QA/QC Practices:** Roughly 70% of projects completed by home performance contractors and installation contractors are inspected by the lead vendor. This QA/QC includes in-process (during and post-assessment) and post-installation inspections. The third-party QA/QC auditor additionally inspects 5%-10% of assessments and installations conducted by lead vendors, home performance contractors, and installation contractors.

**Financing and Health and Safety Remediation:** The HEAT Loan offers 0% interest financing of loans from \$500-\$25,000 with terms from two to seven years to approved customers for qualified measures. In addition to the pre-weatherization barrier incentive (up to \$300 towards the inspection or repair of knob and tube wiring, carbon monoxide leads, and improper dryer venting), customers may finance up to \$1,000 to remediate pre-weatherization barriers using the HEAT loan, provided they install recommended measures. Additionally, through expanded HEAT Loan offerings funded by the Massachusetts Department of Energy Resources, incremental grants are available to HES participants for removing asbestos and upgrading knob and tube wiring.

**Related Evaluation Reports and Documents:**

- Cadmus, Tetra Tech, Navigant, and DNV-GL. “Home Energy Services Initiative and HEAT Loan Delivery Assessment.” Prepared for The Electric and Gas Program Administrators of Massachusetts. July 31, 2015. <http://ma-eeac.org/wordpress/wp-content/uploads/HES-and-HEAT-Loan-Program-Assessment-Final-Report.pdf>.
- Cadmus. “2012 Home Energy Services Pre-Weatherization Initiative Evaluation.” Prepared for The Electric and Gas Program Administrators of Massachusetts. April 2013. <http://ma-eeac.org/wordpress/wp-content/uploads/Year-2012-Home-Energy-Services-Pre-Weatherization-Initiative-Evaluation-Final-Report-April-2013.pdf>.
- Berkshire Gas, Blackstone Gas Company, Cape Light Compact, Columbia Gas of Massachusetts, Eversource, Liberty Utilities, National Grid, Unitil. “2016-2018 Massachusetts Statewide Three-Year Electric and Gas Energy Efficiency Plan.” October 30, 2015. <http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-1-Gas-and-Electric-PAs-Plan-2016-2018-with-App-except-App-U.pdf>.
- Berkshire Gas, Cape Light Compact, Columbia Gas of Massachusetts, National Grid, New England Gas, NSTAR Electric & Gas, Unitil, Western Massachusetts Electric. “Mass Save Home Energy Services Program Standard for Materials, Installation, and Conduct for Energy Efficiency Measure Installation Contractors.” January 25, 2012.
- National Grid, NSTAR Electric & Gas, Western Massachusetts Electric, Cape Light Compact, Columbia Gas, Berkshire Gas, New England Gas, Unitil. “Mass Save Home Energy Services Energy Assessment Standards Version 2.0.” March 31, 2012.

## E.2 NATIONAL GRID RHODE ISLAND ENERGYWISE PROGRAM

**Website:** <https://www.nationalgridus.com/RI-Home/Energy-Saving-Programs/Home-Checkups-Weatherization>

**Program Structure:** National Grid Rhode Island’s EnergyWise Program provides free home energy audits to homeowners. During the initial visit, a program contractor conducts an assessment of energy-saving opportunities and may directly install measures that achieve immediate savings such as efficient lighting, water-saving measures, hot water pipe wrap. Depending on the opportunities in the home, the auditor ends the visit with a set of recommendations for further energy savings. The EnergyWise program offers a range of incentives and financing options for additional energy upgrades. Like the Mass Save HES program, the EnergyWise program uses a lead vendor model for program delivery and implementation.

**QA/QC Practices:** The program’s lead vendor performs QA/QC inspections on 100% of jobs during or after the process. In addition, a third-party contractor inspects 5% of all completed projects.

**Financing and Health and Safety Remediation:** Like the Mass Save HES program, the EnergyWise program offers a pre-weatherization barrier incentive for health and safety issues. Up to \$250 can be used to address issues such as assessing knob and tube wiring or mechanical venting. In addition, the program partners with a number of lending institutions that offer 0% financing to eligible customers; PAs did not specify how and to what extent customers use a portion of this funding to remediate health and safety issues.

**Related Evaluation Reports and Documents:**

- The Cadmus Group, Inc. “EnergyWise 2008 Program Evaluation.” Prepared for National Grid. May 24, 2010. [http://www.riermc.ri.gov/documents/evaluationstudies/2010/EnergyWise\\_Final\\_Report\\_08June\\_clean.pdf](http://www.riermc.ri.gov/documents/evaluationstudies/2010/EnergyWise_Final_Report_08June_clean.pdf).
- The Cadmus Group, Inc. “Rhode Island EnergyWise Single Family Impact Evaluation.” Prepared for National Grid. October 2012. [http://www.riermc.ri.gov/documents/evaluationstudies/2012/National%20Grid%20Rhode%20Island%20-%20EnergyWise%20Single%20Family%20Impact%20Evaluation\\_FINAL\\_31OCT2012.pdf](http://www.riermc.ri.gov/documents/evaluationstudies/2012/National%20Grid%20Rhode%20Island%20-%20EnergyWise%20Single%20Family%20Impact%20Evaluation_FINAL_31OCT2012.pdf).
- National Grid. “0% Financing Participating Lender List.” November 2014. [https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/ee5387\\_8\\_14\\_part\\_lender\\_list.pdf](https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/ee5387_8_14_part_lender_list.pdf).

**E.3 EFFICIENCY MAINE HOME ENERGY SAVINGS PROGRAM**

**Website:** <http://www.energymaine.com/at-home/home-energy-savings-program/>

**Program Structure:** The Home Energy Savings Program (HESP) is a market-based program that uses a network of contractors to deliver energy services to residential customers. The program-approved contractors or Energy Advisors are responsible for conducting energy assessments, gaining pre-approval for loans from program staff, and completing or overseeing home energy efficiency improvements. The program offers incentives and financing options to help defray the cost of approved energy upgrades performed by participating contractors. Homeowners have an initial \$200 minimum co-pay for the energy assessment and air sealing services, and the program includes a structured pathway for additional prescriptive measures and related incentives.

**QA/QC Practices:** Program staff conduct random as well as targeted inspections on a minimum of 15% of projects in different stages—pre-installation, in-process, and post-installation. In addition to the on-site inspection, staff review each request for an incentive or loan for both accuracy and completeness.

**Financing and Health and Safety Remediation:** Maine’s residential PACE and unsecured Energy Loans are available for amounts up to \$15,000 at 4.99% fixed APR. Ten-year terms are available on unsecured loans, while terms of up to 15 years are available for residential PACE loans. \$16.7 million in loan funds have been disbursed in support of energy efficiency projects on more than 1,600 Maine homes in the past five years. Smaller Energy loans up to \$4,000 are available to homeowners with credit scores as low as 580 and debt-to-income ratios as high as 70% at 5.99% APR over 10 years.

As long as at least one prescriptive energy-saving measure is included in the financed project, any amount of health and safety measures can be included in the financed amount up to the loan limit or the capacity of the borrower to meet underwriting. Less than 10% of projects include health and safety measures like asbestos, mold, or radon mitigation, and rarely do the financed costs for health and safety measures exceed \$2,500.

**Related Evaluation Reports and Documents:**

- Opinion Dynamics Corporation “Evaluation of the Efficiency Maine Trust PACE, PowerSaver, and RDI Programs, Volume II: Residential Direct Install Programs.” Prepared for Efficiency Maine. October 23, 2013. <http://www.energymaine.com/docs/RDI-Final-Evaluation-Report-FINAL.pdf>.
- Efficiency Maine. “Efficiency Maine Home Energy Savings Program Manual.” October 14, 2015. <http://www.energymaine.com/docs/HESP-Program-Manual.pdf>.
- Efficiency Maine. “Efficiency Maine 2015 Annual Report.” 2016. <http://www.energymaine.com/docs/2015-Efficiency-Maine-Annual-Report.pdf>.

## E.4 EFFICIENCY VERMONT HOME PERFORMANCE WITH ENERGY STAR PROGRAM

**Website:** <https://www.energymaine.com/for-my-home/ways-to-save-and-rebates/audits-insulation-air-sealing/Overview>

**Program Structure:** As part of the national brand managed by the US Department of Energy, the Efficiency Vermont Home Performance with ENERGY STAR program (HPwES) is designed to help homeowners improve the efficiency and comfort of their homes. The program uses a network of home performance contractors to provide services. As a market-based program, the cost for services is determined by participating contractors. Through the program, homeowners receive a \$100 discount off the contractors’ price for the energy assessment, and they can access additional incentives up to \$2,100 through the program for the installation of eligible envelope measures.

**QA/QC Practices:** Following DOE guidelines, Efficiency Vermont performs QA/QC on a minimum of 5% of projects, and inspections may occur during initial testing, during installation, or post-installation. The QA/QC is conducted by energy consultants, who are engineers employed by the program.

**Financing and Health and Safety Remediation:** The Heat Saver loan offers low- or no-interest loans of up to \$35,000 with 100% financing available. Homeowners can access this option by working with an Efficiency Excellence Network contractor. With the exception of vermiculite abatement, the Heat Saver loan covers health and safety measures and repairs up to 50% of the total project cost needed for the specific type of approved thermal system and energy efficiency measures.

The program also offers the no- or low-interest PACE loan with up to \$30,000, with 100% financing available. To qualify for this loan, the participating homeowner must be in a PACE district. Health and safety measures may be included in PACE financing if they are necessary to safely complete proposed efficiency measures (e.g., ventilation, venting, moisture remediation, vermiculite remediation, removal of knob and tube wiring, etc.), but the cost may not exceed more than 50% of the total efficiency project cost.

**Related Evaluation Reports and Documents:**



- Efficiency Vermont. “Efficiency Vermont’s Home Performance with ENERGY STAR® Program Report and Analysis.” June 16, 2014. <https://www.encyvermont.com/Media/Default/docs/white-papers/encyvermont-encyvermonts-home-performance-energy-star-program-report-analysis-white-paper.pdf>.
- Efficiency Vermont. “Home Performance with ENERGY STAR® 2015 Incentives.” 2015.
- GDS Associates, Inc. “Vermont Single-Family Retrofit Market Research Final Report.” Prepared by High Meadows Fund, Inc. in association with Vermont Public Service Department. February 15, 2013. <https://www.encyvermont.com/Media/Default/docs/white-papers/encyvermont-market-research-barriers-motivations-home-energy-encyimprovements-white-paper.pdf>.
- West Hill Energy and Computing, Inc. “Efficiency Vermont’s Home Performance with ENERGY STAR® Program Impact Evaluation Final Report.” Prepared for the Vermont Department of Public Service. June 3, 2013. <http://www.neep.org/sites/default/files/resources/EVImpactEvaluationFinalReport2013.pdf>.

## E.5 NYSERDA HOME PERFORMANCE WITH ENERGY STAR PROGRAM

**Website:** <http://www.nyserda.ny.gov/All-Programs/Programs/Home-Performance-With-ENERGY-STAR/How-the-Program-Works>

**Program Structure:** NYSERDA’s HPwES program is designed to reduce homeowners’ energy use through heating fuel and electricity-related savings. The program uses a market-based model where participating contractors provide services to customers. The initial energy assessment is free for most homeowners, and the program offers a 10% discount up to \$3,000 on the costs for recommended measures, including air sealing, insulation, high efficiency heating and cooling systems, hot-water heaters, ENERGY STAR appliances, and lighting.

**QA/QC Practices:** The NYSERDA HPwES program uses a third-party contractor to conduct QA/QC on 10%-15% of completed projects. The QA/QC process takes a comprehensive approach to ensuring quality installations, whereby contractors’ performance is based on both positive ratings as well as areas for improvement.

**Financing and Health and Safety Remediation:** HPwES offers two low-interest loan options on a statewide basis through Green Jobs – Green NY. The On-Bill Recovery (OBR) Loan provides homeowners with the convenience of paying for energy improvements on their utility bill at a 3.49% interest rate. The Smart Energy Loan offers a 3.99% interest rate (or 3.49% if paid through automatic bank withdrawals). Both loan options are available for up to \$13,000 per applicant, and up to \$25,000 if the project meets additional cost-effectiveness standards. Both options offer repayment periods of 5, 10, or 15 years, and may be combined with the discount offered through the program. With both of these financing alternatives, customers may use up to 15% or no more than \$2,000 to address health and safety issues, including asbestos abatement, knob and tube wiring upgrades, and repairs due to water damage, mold, and mildew.

**Related Evaluation Reports and Documents:**

- Megdal & Associates, LLC. “NYSERDA 2007-2008 Home Performance with ENERGY STAR® Program Impact Evaluation Report.” Prepared for the New York State Energy Research and Development Authority. September 2012. <https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2012ContractorReports/2012-NYESH-Impact-Report.pdf>.
- Research Into Action, Inc. “Home Performance with ENERGY STAR® Logic Model Final Report.” Prepared for New York State Energy Research and Development Authority. March 2014. Home Performance with ENERGY STAR® Logic Model Final Report <https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2014ContractorReports/2014-PLM-Home-Performance-Energy-Star.pdf>.
- NYSERDA. “Eligible Home Energy Improvements Home Performance with ENERGY STAR®.” March 2015. <http://www.nyserda.ny.gov/-/media/Files/EERP/Residential/Programs/Existing-Home-Renovations/Consumer-Eligible-Measures.pdf>.
- NYSERDA. “NYSERDA Home Performance with ENERGY STAR & EmPower Programs Material & Installation Guidelines.” February 2015. [http://hpwescontractorsupport.com/wp-content/uploads/2014/09/Material-and-Installation-Guidelines\\_FINAL.pdf](http://hpwescontractorsupport.com/wp-content/uploads/2014/09/Material-and-Installation-Guidelines_FINAL.pdf).

Table 27: Program Comparison

Program	Supports Statewide Weatherization Goal	Initial Cost	Related Envelope Measures			Direct Install Measures	Two-stage audit process	Health and Safety Remediation		% of Projects that Receive QA/QC
			Air Sealing	Duct Sealing	Insulation			Incentive	Financing	
Mass Save Home Energy Savings Program		Free audit which identifies potential energy savings	✓		✓	✓	✓	✓	✓	~70% in-process or post-audit; 5-10% post-installation
National Grid Rhode Island EnergyWise Program		Free audit which identifies potential energy savings	✓	✓	✓	✓	✓	✓	✓	100% in-process or post-audit; 5% post-installation
Efficiency Maine Home Energy Savings Program	✓	Minimum \$200 co-pay for audit and air sealing	✓	✓	✓				✓	15% minimum during any stage
Efficiency Vermont Home Performance with ENERGY STAR	✓	Varies – customer receives \$100 discount off market-driven contractor price	✓	✓	✓		✓ (depends on contractor's business model)		✓	5% minimum during any stage
NYSERDA Home Performance with ENERGY STAR		\$0-\$250 depending on income	✓	✓	✓	✓	✓		✓	10-15% post-installation



## Appendix F HES 2015 Pricing Structure

This section includes a copy of the 2015 HES pricing structure document that describes the rates that HES vendors are paid by the program for performing various HES-related services.

### 2015 Home Energy Solutions Program Pricing

Effective as of 02/01/2015

<u>Measure</u>	<u>Price</u>	
Site Visit	\$ 180.58	
Blower Door Air Sealing @ 50CFM	\$ 0.90	Per CFM
HEScore w/ HES Core Services	\$ 71.59	
HEScore (standalone)	\$ 152.93	
Air Flow Test	\$ 43.29	
Duct Sealing @ 25CFM	\$ 2.61	Per CFM
Courtesy Air Sealing (for ALM only, or other instance with prior PA approval)*	\$ 60.00	Per Hour
<b>DHW MEASURES</b>	<b>Labor</b>	<b>Material</b> <b>Total</b>
Low Flow Showerhead	\$ 4.37	\$ 3.54    \$ 7.91
Showerstart	\$ 6.09	\$ 24.05    \$ 30.14
Handheld Showerhead * Only available when replacing handheld or elderly/disabled occupant present	\$ 5.45	\$ 9.41    \$ 14.86
Faucet Head On/Off	\$ 4.13	\$ 2.36    \$ 6.48
Dual Thread Aerator	\$ 2.12	\$ 0.89    \$ 3.02
Flip & Swivel	\$ 2.67	\$ 2.37    \$ 5.05
Pipe Wrap 1/2"	\$ 4.70	\$ 3.38    \$ 8.08
Pipe Wrap 3/4"	\$ 4.76	\$ 3.75    \$ 8.52
<b>LIGHTING</b>	<b>Labor</b>	<b>Material</b> <b>Total</b>
<b>Compact Fluorescent Lights</b>		
60 Watt	\$ 3.53	\$ 1.78    \$ 5.32
75 Watt	\$ 3.47	\$ 2.15    \$ 5.62
100 Watt	\$ 3.53	\$ 2.26    \$ 5.79
40 Watt Globe (Specialty)	\$ 4.40	\$ 3.94    \$ 8.34
60 Watt Globe (Specialty)	\$ 4.44	\$ 4.13    \$ 8.58
Three-Way Circuline (Specialty)	\$ 5.55	\$ 10.94    \$ 16.49
Three-Way CFL (Specialty)	\$ 4.51	\$ 7.19    \$ 11.69
Outdoor Flood - 100 Watt (Specialty)	\$ 5.99	\$ 6.82    \$ 12.81
A-Line 60 Watt	\$ 4.50	\$ 4.40    \$ 8.90
A-Line 75 Watt	\$ 4.46	\$ 5.28    \$ 9.74
Marathon R30 (Specialty)	\$ 5.09	\$ 5.98    \$ 11.07
Candelabra 25 Watt (Specialty)	\$ 4.21	\$ 3.72    \$ 7.93
<b>LEDs</b>	<b>Labor</b>	<b>Material</b> <b>Total</b>
Dimmable, 65 Watt Equivalent LED recessed can with integrated trim - 5" & 6", Energy Star rated	\$ 8.20	\$ 17.61    \$ 25.82    Courtesy
Dimmable, 65 Watt Equivalent LED recessed can with integrated trim - 4", Energy Star rated	\$ 8.20	\$ 17.61    \$ 25.82    Courtesy
Dimmable, Omnidirectional 40 Watt equivalent LED, Energy Star rated	\$ 4.41	\$ 8.90    \$ 13.31    Courtesy
Dimmable, Omnidirectional 60 Watt equivalent LED, Energy Star rated	\$ 4.39	\$ 9.19    \$ 13.59    Courtesy
Dimmable, Omnidirectional 75 Watt equivalent LED, Energy Star rated	\$ 4.95	\$ 13.60    \$ 18.55    Courtesy
Dimmable R20 50 Watt equivalent LED, Energy Star rated	\$ 4.40	\$ 9.90    \$ 14.30    Courtesy
Dimmable BR30 65 Watt equivalent LED, Energy Star rated	\$ 5.01	\$ 10.29    \$ 15.29    Courtesy
Dimmable BR40 85 Watt equivalent LED	\$ 4.83	\$ 13.34    \$ 18.16    Courtesy
Dimmable, Clear Candle with E12 Candelabra base 40 Watt equivalent LED (torpedo tip), Energy Star rated	\$ 4.25	\$ 7.60    \$ 11.85
Dimmable, Clear Candle with E26 Medium base 40 Watt equivalent LED (torpedo tip), Energy Star rated	\$ 4.25	\$ 7.60    \$ 11.85
Dimmable, Clear Candle with E12 Candelabra base 40 Watt equivalent LED (flame tip), Energy Star rated	\$ 4.45	\$ 9.32    \$ 13.78
Dimmable MR16 with GU5.3 base - 50w equivalent LED	\$ 4.77	\$ 15.45    \$ 20.22    Courtesy
Dimmable PAR38 Reflector LED Exterior/Weatherproof, Energy Star rated	\$ 5.56	\$ 20.29    \$ 25.85    Courtesy
Dimmable Globe 40 Watt Equivalent LED, Energy Star rated	\$ 4.27	\$ 9.64    \$ 13.91
<b>INSULATION</b>	<b>Price</b>	
Attic - Install blown-in cellulose or fiberglass insulation to BPI standards, including "test-in and test-out"	\$ 1.45	
Wall - Install blown-in cellulose or fiberglass insulation to BPI standards, including a "test-in and test-out"	\$ 1.85	
Basement - Install blown-in cellulose or fiberglass insulation to BPI standards, including a "test-in and test-out"	\$ 1.60	
Attic - Install spray-foam insulation to manufacturer and BPI standards, including "test-in and test-out"	\$ 2.36	
Wall - Install spray-foam insulation to manufacturer and BPI standards, including "test-in and test-out"	\$ 2.24	
Basement - Install spray-foam insulation to manufacturer and BPI standards, including "test-in and test-out"	\$ 2.28	
<b>ADDITIONAL MEASURES</b>	<b>Labor</b>	<b>Material</b> <b>Total</b>
Install attic hatch covers	\$ 60.39	\$ 122.36    \$ 182.75
Install WiFi Thermostat	\$ 105.99	\$ 160.67    \$ 266.66
Install Electronically Commutated Motor (ECM) circulator pumps	\$ 199.13	\$ 227.67    \$ 426.80
Natural Gas Boiler Water Temperature Reset Control	\$ 246.33	\$ 269.33    \$ 515.67
Clean, Tune & Test Heating System	\$ 158.75	\$ 31.60    \$ 190.35
Water Heater Tune-up	\$ 108.53	\$ 21.67    \$ 130.20

\*Pricing for courtesy air sealing was not included in the 2015 RFP proposal, and is only required when the presence of ALM prevents a blower door test. The 2013 - 2014 pricing will be extended for this measure.