

I'd Like to Fix Your Attic, But I'm Late for Another Appointment: Innovative Approaches to Uncovering the Real-World Practices of Weatherization Contractors

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ABSTRACT

The Connecticut investor-owned utilities offer a popular residential weatherization program – Home Energy Solutions – in which a team of approved contractors conducts home energy audits and makes core weatherization improvements, such as air-sealing and duct-sealing. They also provide customers with recommendations for deeper retrofits, including insulation and heating system upgrades, and describe available low-interest financing options. The evaluation team used a mixed-methods research approach that included in-depth interviews, a review of program records, in-home interviews with participating homeowners, and post-weatherization inspections by HERS (Home Energy Rating System) raters in the company of the HES contractors who actually performed the services. Through their research, the team was able to identify concrete opportunities for increasing savings and revealed a misalignment between the savings goals of program staff and the weatherization contractors. The team also found that customer perceptions of the program were consistently high, even in cases where evaluators saw work quality issues. The evaluation found significant opportunities for more effective quality control and quality assurance inspections and increasing savings. For example, over half of the attics in the 70 visited homes were left without air sealing. The team identified that the programmatic pressures vendors face can affect the comprehensiveness of their weatherization services. This provides lessons for other programs that seek to align their stated savings goals with the real-world practices of contractors.

Introduction: The Connecticut Home Energy Solutions (HES) Program

The Home Energy Solutions (HES) program is Connecticut's flagship residential program, designed to lower customers' energy bills and improve their homes' safety and comfort (Energize Connecticut). It is administered by the Connecticut investor-owned utilities, Eversource and United Illuminating, and the weatherization services are provided by program-approved contractors (also referred to as vendors). The program serves as the entry point for many Connecticut residents seeking to increase the efficiency of their homes. It provides weatherization services at the time of the initial energy audit, and access to rebates for deeper retrofit measures that can be installed later.

For a modest fee,¹ residential customers have HES vendors perform energy audits. During the initial visit, technicians provide "core services," which include installing efficient light bulbs, faucet aerators, and low-flow showerheads, and performing diagnostic tests (blower door and duct blower tests) to guide air-sealing and duct-sealing services. The HES vendor performs the air-sealing and duct sealing services during that initial visit.

At the conclusion of the core services visit, vendors engage participants in a "kitchen table wrap-up," where they discuss deeper energy efficiency upgrade opportunities. Many of these upgrades, including insulation, are eligible for Connecticut Energy Efficiency Fund (CEEF) rebates and low-interest financing available through the Connecticut Green Bank. Such upgrades are installed later and homeowners can choose to hire a different installation contractor from the HES vendor. To address health

¹ The fee was \$99 at the time of the evaluation in March 2016, and \$124 as of June 2017.

and safety issues, such as mold and asbestos, that might preclude energy efficiency upgrades, the program offers assistance. This support involves requiring vendors to provide customers 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 percentage of 2014 HES participants who received various combinations of air sealing, duct sealing, and insulation services. Over 90% received some form of air sealing services, over 20% received duct sealing, and only about 14% installed insulation – a deeper retrofit option. Receiving all three services was rare – only about 2% received air sealing, duct sealing, and had insulation work performed.

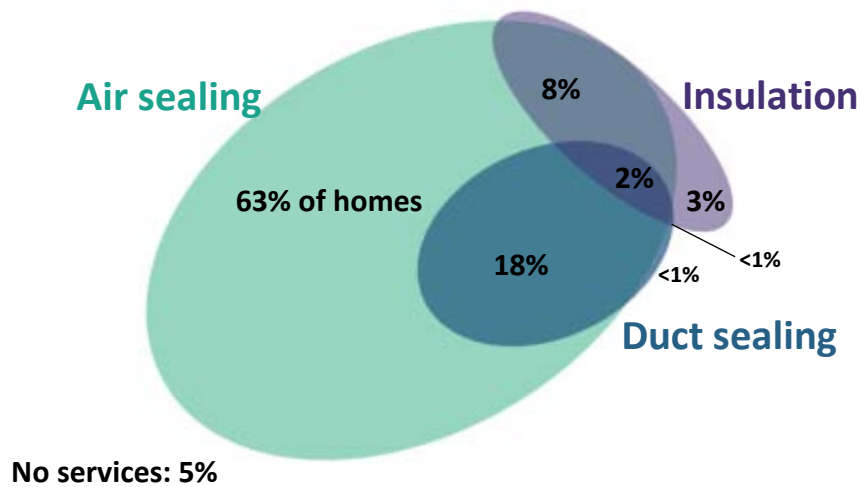


Figure 1. HES services provided in 2014.

The HES program is delivered collaboratively by Eversource and UI staff, program vendors who provide the weatherization services, and third-party quality control and quality assurance (QA/QC) contractors who provide quality control services over the vendors’ work. Program staff perform oversight and funding, set and communicate program guidelines, provide technical assistance to vendors, and coordinate program activities. Program vendors are the face of the program – they conduct the energy audits, install energy upgrades, identify savings opportunities, and provide customer service and marketing. Third-party QA/QC contractors inspect the quality of the vendors’ work. At the time of the evaluation, the QA/QC contractors inspected at least 5% of each HES vendors’ work. This was done via in-progress inspections, where they watch the vendors perform the work and provide feedback, or via post-completion inspections of the weatherization services. The HES vendors receive a program scorecard after these inspections, rating their performance against program targets and the QA/QC criteria.

Evaluation Objectives

This process evaluation was developed for the Connecticut Energy Efficiency Board (EEB) with the objective of identifying opportunities to increase savings in single-family, non-low income households related to three HES measures: air sealing (core service), duct sealing (core service), and insulation (a rebated, add-on measure) (NMR Group, Inc. 2016). Based on real-world findings from site visits and in-person interviews with homeowners and HES vendors, this evaluation was designed to better understand the customer and HES vendor experience, to learn about possible opportunities for increasing savings, and to identify HES contractor barriers to achieving those savings. The evaluation relied heavily on the

results of the site visits, which incorporated site inspections, homeowner interviews, and on-site interviews with HES vendors. Key researchable questions included:

- **Opportunities and Vendor Practices**
 - What opportunities exist to increase savings and improve vendors’ work quality?
 - What effect do health and safety concerns have on savings opportunities?
 - What vendor practices affect implementation?
 - Are all cost-effective savings opportunities being identified and captured?
- **Participation patterns**
 - What proportion of participants receive air sealing, duct sealing, and insulation?
 - Are there any patterns by utility, vendor, or home characteristics?
- **QA/QC protocols**
 - Could the QA/QC protocols be improved?
 - What do other leading programs do for their QA/QC?
- **Drivers, motivations, obstacles, and barriers**
 - What barriers prevent vendors from recommending or implementing measures?
 - What drivers or barriers affect customers’ measure uptake?

Methodology

This evaluation collected and analyzed data from eight sources, outlined in Table 1 and described below in greater detail.

Table 1. Evaluation tasks

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

* Total population.

On-site quality inspections of air sealing, duct sealing, and insulation services: NMR HERS raters assessed the quality and completeness of the air sealing, duct sealing, and insulation work performed at a sample of 70 HES participant homes. Most inspections lasted about an hour and focused on finding instances of “low-hanging fruit” (i.e., building envelope or duct leakage points that could have been easily sealed – those that were exposed and reachable without taking down insulation or moving a customer’s belongings, but had still not been sealed by HES technicians). The evaluators targeted homes based on several factors: 1) HES vendor willingness to accompany us on-site, 2) homes with multiple services performed (such as air sealing, duct, sealing, and insulation retrofits) to give NMR auditors more instances

of work to inspect, and 3) homes with air sealing or duct sealing services showing little improvement after the HES vendors' work.

The assessments performed by NMR auditors included inspecting the following aspects of the HES vendors' work:

- Air sealing at rim joist penetrations, basement ceiling penetrations, attic penetrations (gaps at top plates, electrical penetrations, etc.), attic hatches, and interior living spaces (windows, doors, baseboards, etc.).²
- The quality and extent of duct sealing at air handler seams and accessible and visible duct seams and joints.
- The quality of HES-incentivized insulation installations in attics, basements, and exterior walls, in accordance with RESNET/HERS standards
 - The team recorded other indicators of quality installation, such as the evenness of blown-in insulation in attics.
 - The team visually inspected these installations whenever possible and used infrared cameras in the few instances of sufficiently cold weather that allowed for useful infrared imaging.
- NMR auditors inspected these homes without the benefit of a blower door or duct blaster. These inspections were visual, so the amount of air and duct leakage at these penetrations could not be quantified; however, the auditors were experienced HERS raters and building scientists, trained to identify signs of air leakage, even without the use of diagnostic fans.

On-site in-depth interviews with participating vendors: The NMR auditors conducted in-depth interviews with vendors, obtaining 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 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. Having vendors take part in the on-site visits allowed for an open and candid discussion of vendor practices that complemented other evaluation activities, such as reviewing vendors' 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.

On-site in-depth interviews with program participants: NMR staff conducted a half-hour in-person interview with the homeowner, while a second NMR technician assessed the quality of the HES work done in the home. The in-depth interview assessed the following: 1) which measures the customer had installed, 2) whether they had removed any measures, 3) whether the customer had noticed any energy or non-energy benefits since the audit, 4) whether the vendor had found any health and safety issues during the audit, 5) the customer's experience with any financing options discussed during the kitchen table wrap-up, 6) any drivers of or barriers to participation, and 7) customer satisfaction with having participated in the program.

In-depth phone interviews with HES program staff: NMR staff conducted in-depth telephone interviews with one program staff member from each of the sponsoring investor-owned utilities, Eversource and UI. These interviews provided context for the evaluation, including program goals, design, implementation, QA/QC protocols, and barriers to and opportunities for increasing savings.

² NMR 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.

In-depth phone interviews with participating HES vendors: NMR staff conducted in-depth telephone interviews with participating HES vendors. 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.

In-depth interviews with program administrators for other programs: For a review of best practices, NMR staff examined program documents and conducted in-depth interviews with administrators of other comparable programs in Massachusetts, Rhode Island, Maine, Vermont, and New York. The interviews focused on increasing participation and uptake of add-on measures (such as insulation and heating system upgrades) and successful QA/QC strategies.

In-depth interviews with program QA/QC vendors: NMR staff conducted in-depth telephone interviews with QA/QC vendors, discussing program strengths and weaknesses, the quality of HES vendors' work, and factors that impact vendor participation in the program.

Program data tracking and program document review: The team analyzed the program participation records to explore patterns of air sealing, duct sealing, and insulation by utility, HES vendor, and home characteristics for 2014 program participants. They also reviewed program documents, including the HES Implementation manual and QA/QC vendor manual.

Experience from past studies: NMR has had exposure to these HES vendors' work through prior studies, providing useful context for this HES QA/QC evaluation. In 2012, NMR conducted focus groups with homeowners to learn about their experiences with the HES program (NMR Group, Inc. 2012). In 2014, NMR conducted site visits and collected data at 180 Connecticut homes, while HES vendors performed core services, as part of a weatherization baseline study (NMR Group, Inc. 2014).

Findings

Opportunities for Increasing Savings: Core Services Missing “Low-Hanging Fruit”

Vendors target “low-hanging fruit” when they perform air sealing and duct sealing as part of the core services, but the on-site inspections revealed that significant opportunities remain in many homes. This conflicts with the program's stated goals of maximizing savings at every house. Vendors appear to run short on time when performing these core services, resulting in a mix of sealed and unsealed gaps that could have been sealed given more time, attention, effort, and internal quality control. Health and safety issues also limit their ability to perform core services.

The overall quality of vendors' work varied from company to company and even crew to crew – something acknowledged by the vendors themselves – with each vendor operating under different financial situations and business models. Vendors often mentioned self-imposed time constraints and the need to maintain profitability as barriers to completeness for air sealing and duct sealing. In conversations with vendors, we found that some vendors attempt to provide HES services to as many homes as possible, while others delve deeper to achieve greater savings in each individual home (the latter being the strategy promoted by HES program staff).

The program pays HES vendors for the work they perform in customers' homes; the incentive structure is split between a fixed, per-home incentive for some measures, and a variable incentive for others. For example, vendors were paid a flat fee just for performing a site visit, and another flat fee for performing a blower door test. Air sealing and duct sealing services are incentivized based on the improvements resulting from the HES vendors' work. Similarly, they are paid a variable incentive based on how many high efficiency light bulbs they install.

While fixed incentives make up less than 20% of the incentives paid to HES vendors, and the remaining 80% are variable, some vendors still prefer to spend less time pursuing variable incentives. To make a profit, most vendors said they needed to do two sites per day using two technicians per site. The

majority of the work is handled by an assistant technician, while the lead, BPI-certified technician, usually handles paperwork and customer interactions.

Vendors agreed, 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. After completing program paperwork and diagnostic testing, technicians typically have about two hours to perform air sealing and duct sealing, limiting the amount of work they can do in their allotted time. In comparison, staff from similar programs indicated that the minimum amount of time for services is between two and six hours – although not all programs provide air sealing on the same day as the initial audit, like they do in Connecticut.³

Vendors struggled with understanding whether the program goals are tied to number of homes completed or energy savings per home (or both). Program staff, however, are very clear that quality work and energy savings in every home should always be prioritized over simply the number of homes visited. They indicated that this point is conveyed in myriad forms, through meetings with vendors, scorecard criteria, roundtable discussions, and QA/QC scoring.

While on site, NMR auditors (evaluators) inspected air sealing, duct sealing, and insulation work performed through the HES program. Evaluators 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 such 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 ready-achievable opportunities remained.⁴

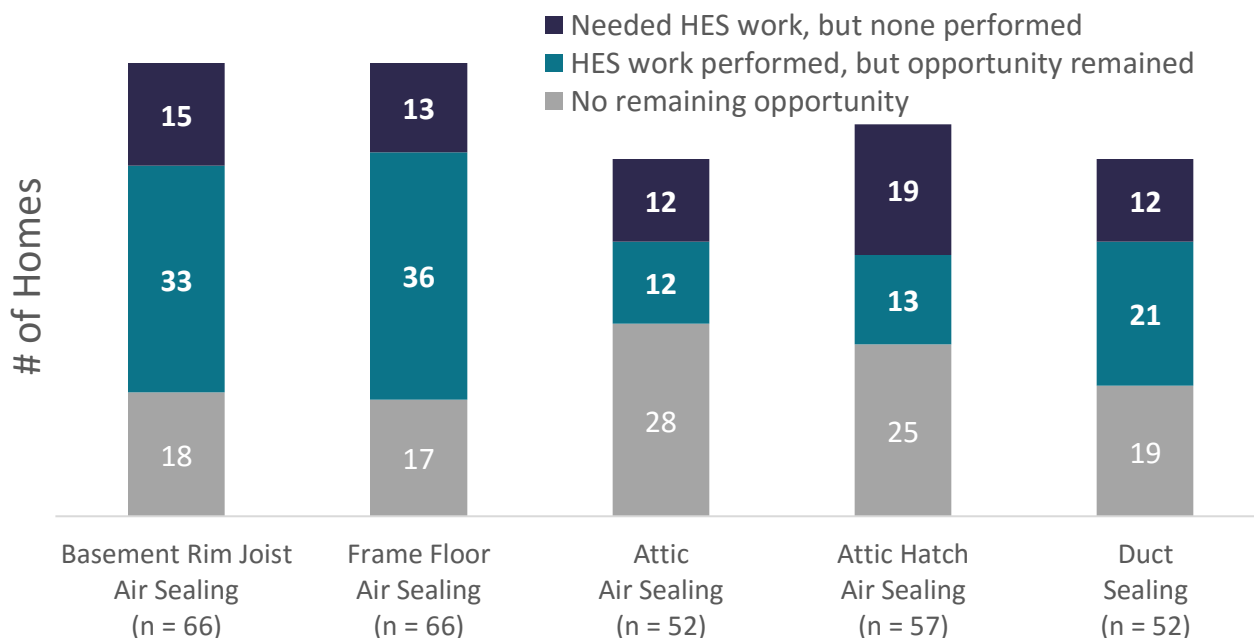


Figure 2. Identified opportunities for additional air and duct sealing.

³ These time estimates were not verified with program contractors.

⁴ 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.

Opportunities for Increasing Savings: Air Sealing Practices

NMR auditors inspected the quality and completeness of the HES vendors' air-sealing practices in basements, attics, and interior spaces, and found that HES vendors consistently overlook readily accessible savings. For example, NMR auditors observed readily accessible air-sealing opportunities in 46% of attics, 74% of basement ceilings, and 72% of basement rim joists.⁵ In addition, observing well-sealed and unsealed penetrations in close proximity was common in the homes NMR visited. Only two of the 70 homes NMR auditors visited appeared to be tight enough that the vendors might reasonably have curtailed their air sealing out of concern over over-tightening the building envelope.⁶

HES vendors commonly skipped air sealing in less visible – but significant – home locations, such as attics and basements, and instead focused on interior air sealing around windows and doors, which are more visible to the customer. Vendors also commonly skipped areas where access was difficult, including insulated attics and insulated basement ceilings. The program manual requires vendors to prioritize attic air sealing, but this program guideline was not followed consistently.

Door weather-stripping and door sweeps were an opportunity for improvement. Most HES vendors weather-stripped doors with an inexpensive, stick-on plastic v-seal, which may fail in high-use doorways. Door sweeps also annoyed the interviewed homeowners when they rendered a door harder or noisier to operate, and six homeowners had removed these measures.

These differing practices can largely be attributed to constraints on vendors' time or technician disinclination. Some teams might try to maneuver in tight spaces or seal top plates, but the technicians' willingness to do so varied. 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 (i.e., more homes vs. greater savings in each home).

Figure 3 shows a commonly observed problem with attic air sealing: insulation covers the attic floor, making attic penetrations hard to see. In this case, the HES vendors saw a major penetration around the black PVC pipe, but they only partially sealed it and left nearby top plate gaps unsealed. The team did not otherwise seal any top plates in this home and left a large duct chase completely open.

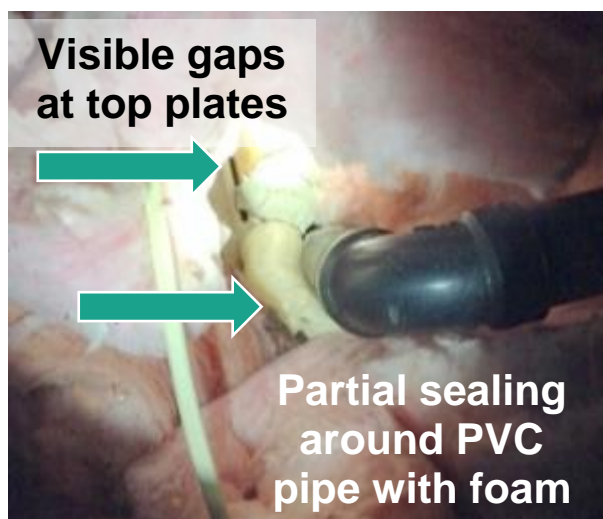


Figure 3. Incomplete attic air sealing.

⁵ In attics, this means openings that may not be visible without moving insulation. In basements, this includes openings that were readily visible. These were visible gaps that NMR could observe on a relatively cursory inspection.

⁶ The Building Airflow Standard (BAS) used by the program identifies the point at which no more air sealing can be performed without also adding mechanical ventilation. Available program records did not mention a concern about forgoing additional air sealing due to being near the BAS limit.

Figure 4 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 only about three-quarters of the large gap around the plumbing penetration.

Figure 5 shows an example of an HES team using a temporary measure – clear plastic tape – to seal a large opening in a basement ceiling. The tape the HES team applied was peeling off, and the blower door reduction numbers the HES team achieved do not represent persistent savings.

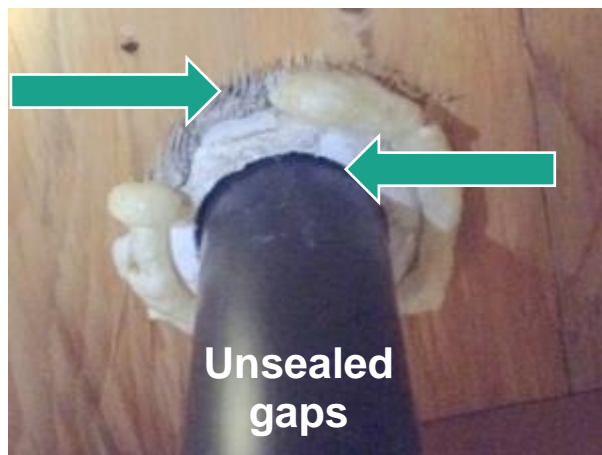


Figure 4. Incomplete basement air sealing



Figure 5. Inappropriate basement air sealing

Opportunities for Increasing Savings: Duct Sealing Practices

NMR observed readily visible and accessible opportunities for additional duct sealing in 53% of the homes where duct sealing was performed. Supporting this finding, six of the 40 homes inspected by NMR auditors 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 diminish expected savings; the program encourages mastic, which is more permanent.

NMR auditors regularly observed poorly adhered foil-face tape that was peeling off of the ducts, a key concern regarding savings persistence. NMR auditors also 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. Sealing insulated ducts 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 following photos show a mix of good and bad work quality on the part of the HES vendors.

Figure 6 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. Failing tape applications were a common problem in the homes visited.

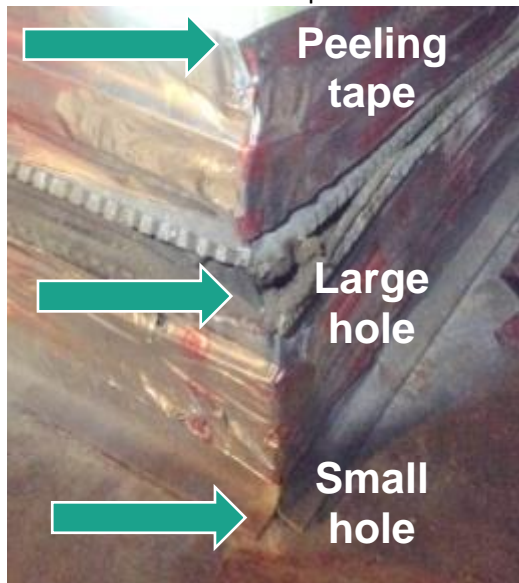


Figure 6. Poorly sealed ducts.

Figure 7 shows an example of high-quality duct sealing with mastic. The mastic was thick and covered all accessible seams. NMR auditors saw multiple instances of high-quality duct sealing services during on-site visits.

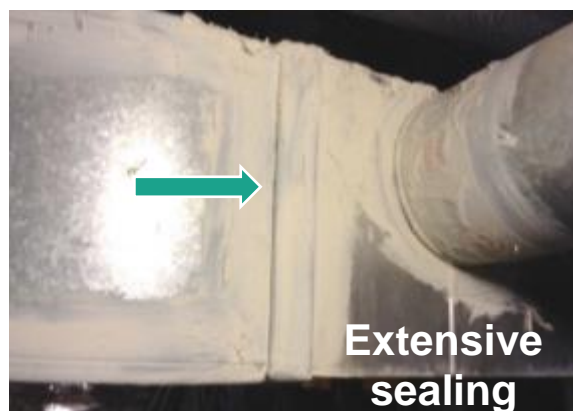


Figure 7. High-quality duct sealing with mastic.

Insulation Opportunities – High Quality Installs in Attics, Lower Quality in Basements

Of the 38 insulation jobs that NMR could assess on site, 23 (61%) of them were Grade I, based on RESNET standards, which suggests they were 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 of insulation installation through the program was high, NMR auditors observed opportunities for improvement in basement ceiling and rim joist installation techniques, which were often lower quality, particularly if fiberglass batts were used. Auditors also identified potential opportunities 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.

One of the greatest program opportunities identified was to increase the proportion of customers who receive insulation recommendations and the rate of customer uptake for insulation. In 2014, 39% of

all HES customers were recommended insulation measures, but only one-half of them ended up installing it. Not all HES technicians possess the necessary sales skills to convince homeowners of the benefits that come with installing add-on measures like insulation and HVAC upgrades, such as the payback that they would see from their investment.

Figure 8 shows an example of high-quality blown-in fiberglass insulation in an attic. The insulation was deep, quite level, and 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 appeared to be of high quality.



Figure 8. High-quality blown-in attic insulation

Figure 9 shows a basement rim joist that was covered by the HES vendor using two-part closed-cell spray foam. NMR auditors observed that some HES vendors thoroughly sealed 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.

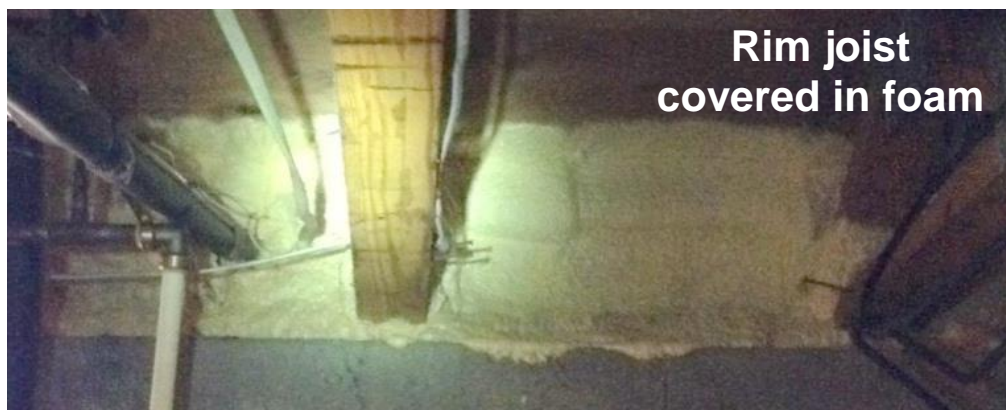


Figure 9. High-quality rim joist air sealing serving as insulation

Program Participation Patterns

The analysis of program participation records sought to determine the proportion of eligible participants who received air sealing, duct sealing, and insulation, and to detect any patterns with respect to utilities, vendors, or housing characteristics. This analysis found that 30 vendors provided services to 17,968 homes in 2014.

Air sealing was the single most prevalent measure; 92% of homes received this service. These homes demonstrated an average reduction in air leakage of 21%. The air leakage reduction percentage

that HES teams achieved 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 behind more opportunities, particularly at large homes that might require more time to fully air seal.

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

Quality Assurance and Quality Control

The evaluation reviewed the Quality Assurance and Quality Control (QA/QC) protocols from the HES program and HES vendors to assess the adequacy of these protocols and to identify any potential opportunities for improving the HES program's QA/QC work. This review revealed that, while the program had formalized protocols in place, they vary across utility jurisdictions. In Eversource territory, for example, QA/QC vendors typically evaluated core services via in-progress inspections, not post-work inspections. For in-progress inspections of core services, QA/QC vendors usually arrived 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 said they did not perform internal QA/QC of their own work because of time and cost constraints. The finding that customer satisfaction is not correlated with the quality of service emphasizes the importance of the program's QA/QC inspections in ensuring that HES vendors perform quality work, as customers are not able to accurately assess the quality of the work themselves.

The program reviews vendor scorecards for inspected homes on a monthly basis and provides feedback to vendors about their work. While vendors reported that they appreciate these QA/QC efforts, some described overly punitive inspectors who gave them poor marks without offering on-site feedback. The vendors also asked for more opportunities to dispute negative findings about their work.

Drivers, Motivations, Obstacles, and Barriers

Customers indicated that their primary motivations for participating in HES were saving money, fixing their homes or identifying areas for savings, and saving energy. Customers cited very few obstacles or barriers to participating: nearly nine out of ten interviewed respondents said they did not face any obstacles in their participation. The chief obstacle cited by vendors and program staff was health and safety issues in the home. Mold, asbestos, and gas leaks often force technicians to pause or terminate the audit until remediation is performed. Based on program records, 8% of Eversource homes had at least one health and safety issue. However, vendors estimated that health and safety issues occur in roughly one-quarter of all jobs – some of which can be resolved relatively quickly, such as a gas leak, while others take more time and expense to fix, such as a mold problem. Some issues may not ever be fixed by the homeowner, limiting the program's ability to achieve savings in those homes.

Addressing health and safety issues remains a large opportunity for additional energy savings. Since vendors faced the possibility of coming to a home where they could not perform weatherization services due to a health and safety issue, some vendors reported that they scheduled more sites per day than they would otherwise – achieving less savings at each. This was done to avoid having a crew idle all day if they could not work due to a health and safety issue.

Program staff reported that HES cost-effectiveness tests deterred them from spending money on remediating health issues. However, successful programs in other states are able to weatherize more homes because they can offer facilitation or funding for barrier mitigations, allowing more customers to improve their homes.

Conclusions and Recommendations

The HES program is extremely popular, and in general, interviewed homeowners had extremely high opinions of the program and the HES vendors who provided the core services. Homeowners felt like they got a great value for their co-pay. From their perspective, they paid a reasonable fee for a team of multiple weatherization professionals to spend several hours in their home, providing them with efficient light bulbs, shower heads, and faucet aerators. The HES team sealed air and duct leaks (when appropriate), and told the homeowners about available rebates and financing through the program for additional measures, adding to the value that they received from the core services visit. That said, homeowners are not technical experts, and there are limits to their ability to assess the work of weatherization teams. Through this evaluation, NMR auditors looked for signs that opportunities did remain – even in homes with highly satisfied customers. In the final report, available online (NMR Group, Inc. 2016), the team made the following recommendations to the program sponsors and implementers.

Recommendation 1: The program should consider working with HES vendors and coordinate with both QA/QC vendors to ensure that more air sealing and duct sealing opportunities are captured. The program should also consider reducing fixed incentives per home served relative to the variable incentives that increase as the vendor captures more savings (via air sealing and duct sealing).

Rationale: While the program required vendors to achieve a minimum savings per home on average and used a pricing structure that rewarded vendors for achieving greater savings, vendors left readily visible and accessible opportunities for additional air sealing at most homes. This suggests that the current incentive structure did not push all vendors to maximize per-home savings.

Recommendation 2: The HES program should adjust the specific materials and methods it encourages vendors to use, including 1) enforcing the use of mastic, rather than foil tape, for proper duct sealing, and ensuring that any tape is firmly adhered to clean surfaces; 2) promoting the use of two-part spray foam to fully cover rim joists in basements, rather than targeted air sealing of penetrations; 3) incentivizing blown or spray-applied insulation materials (e.g., cellulose, fiberglass, spray foam), rather than fiberglass batts; and 4) allowing vendors to obtain incentives for air sealing improvements resulting from encapsulating attics with spray foam.⁷

Rationale: HES technicians regularly used thin foil tape to seal ducts, and it was often applied to dirty surfaces, preventing firm adhesion. The program already promoted the use of mastic rather than foil tape, but inspections showed that foil tape was still being used.

For rim joist improvements, the quality inspections revealed that some HES technicians did not seal individual penetrations in basement rim joists, but rather coated 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.

Regarding the insulation installations, the highest quality were either blown-in or spray-applied applications, including cellulose, fiberglass, and foam. Fiberglass batt installations in basement ceilings and rim joists appeared to be of particularly low quality – a problem not unique to the HES program.

Recommendation 3: Consider allowing the program to incentivize health and safety issue remediation. Program staff should consider creative solutions that fall within the scope of services offered through the program.

Rationale: Health and safety issues were relatively common in homes – some vendors estimate they saw such issues in 25% of homes. Additionally, some vendors will book two audits per day – a busy day for an HES team – in case a health and safety issue prevents them from being able to do work at one of the scheduled homes. When neither home has a health or safety issue, the teams may not have time to

⁷ 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.

perform work thoroughly in both homes. Other leading HES-type programs offer loan products and some offer direct incentives to support remediation of substantial health and safety issues, making it easier for customers to resolve these issues and thereby move forward with weatherization work.

Recommendation 4: The program administrators and QA/QC vendors should meet 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 are detailed in the full report.

Rationale: According to the QA/QC vendor in Eversource territory, core services were only inspected by the QA/QC vendor via in-progress inspections, not after they were completed. If a QA/QC vendor did not show up at the start of an HES visit for an in-progress inspection, the HES vendor could be reasonably assured that their work was 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 were only inspected after the fact, not during the installation.

In addition to recommendations, we offered the following consideration for the program.

Consideration: The program staff could encourage HES vendors to implement a two-stage audit approach. In the first stage, technicians would perform an initial walkthrough to identify any issues (including health and safety) that might prevent them from performing core services. In this stage, they could also install measures such as efficient light bulbs, faucet aerators, and low-flow shower heads. 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.

Rationale: Many vendors reported that they faced 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 addressed this problem by scheduling the audit prior to the core services visit for more in-depth measure installation. This approach was also supported by programs included in the study's best practices review; many other programs like HES include an initial visit for the audit and common direct install measures, followed by a second visit for more comprehensive services like air and duct sealing.

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