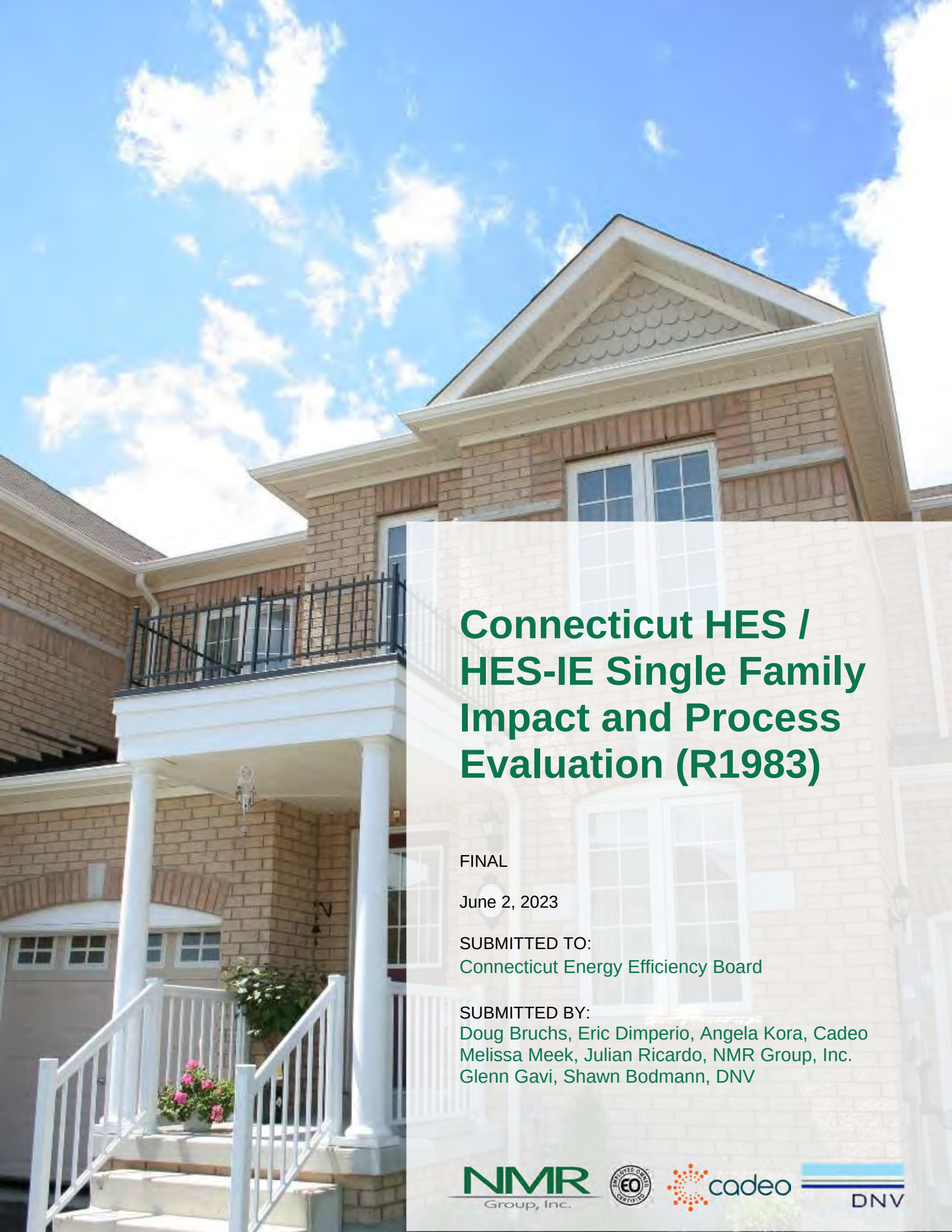

Connecticut HES / HES-IE Single Family Impact and Process Evaluation (R1983)

FINAL

June 2, 2023

SUBMITTED TO:
Connecticut Energy Efficiency Board

SUBMITTED BY:
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Key Terminology

Term	Definition
Add on Measure	Describes an efficiency measure (insulation, windows, etc.) installed in an HES-IE participant's home following the customer's assessment that was provided, by Eversource or UI. HES-IE participants receive some of these measures at no additional cost, while others receive at least the same incentive level offered to HES participants. These same measures are referred to as "Rebated" measures through HES.
Control Group	The set of customers used in a billing analysis to serve as a counterfactual for estimating the program's impact. The control group accounts (or controls) for exogenous factors such as moves and rate changes that can otherwise obscure program-generated savings. In the context of this evaluation, the study used future participants (i.e., 2020 HES participants & 2020 HES-IE participants) as the control group.
Companies	The Connecticut investor-owned utilities that administer the Energize Connecticut (EnergizeCT) programs (Eversource and the Avangrid companies, including the United Illuminating Company [UI], Connecticut Natural Gas Company [CNG], and Southern Connecticut Gas Company [SCG])
Core Participant	The subset of HES or HES-IE participants (as defined above) that did not install any "rebated" or "add-on" efficiency improvements recommended by their home energy assessor. Most, but not all, assessment-only participants received air and/or duct sealing during their home energy assessment, as well as directly installed instant savings measures (e.g., LEDs, showerheads).
Direct Install Measure	Describes an efficiency measure installed by the vendor during the participant's assessment at no additional cost. The most common direct install measure in both HES and HES-IE were LEDs.
EA Team	Connecticut Energy Efficiency Board's Evaluation Administrator Team (Lisa Skumatz, Bob Wirtshafter, and Ralph Prahl)
Ex Ante Savings	The anticipated or claimed savings associated with a measure or program prior to an evaluation. In the case of this study, HES & HES-IE ex ante savings are documented in the current PSD and were largely generated by the previous HES & HES-IE impact evaluation (R1603)
Ex Post Savings	The evaluated savings determined at the conclusion of an impact evaluation such as this one (R1983)
Free-ridership	The fraction of gross program savings that would have occurred in the absence of a Conservation and Load Management (C&LM) program.
Gross Savings	Savings generated by the program without consideration for whether the participant would have taken the same/similar actions absent R1983
Health and Safety Barrier	A health and safety issue (e.g., mold, asbestos, knob & tube wiring) identified during an in-home assessment that prevented participants from moving forward with upgrades unless the issue could be remediated.
Impact Factors	Other factors, such as in-service rate (also known as measure retention or savings persistence rate) that impact the savings generated by program measures.
Installation Rate	The fraction of recorded measures (i.e., in program tracking data) that were verified as installed
Net Savings	Savings generated by the program that account for the participant's likely action in the absence of the program.
Participant	Any individual or household (also identified by a unique account number) who receive a home energy assessment through HES or HES-IE.

Term	Definition
Pre-weatherization Barrier	Typically, a health and safety (e.g., mold, failed combustion test) or clutter issue identified prior to an in-home assessment, which limits or prevents participants from receiving certain elements of the assessment (e.g., blower door assisted infiltration testing) and/or moving forward with identified efficiency improvements (e.g., insulation) until the issue(s) are remediated. These barriers are typically unknown until the assessment itself.
Realization Rate	The ratio of ex ante and ex post savings
Rebated Measure	Describes an efficiency measure (insulation, windows, etc.) installed in an HES participant's home following the customer's assessment that was partially paid for by Eversource or UI. These same measures are referred to as "Add on" measures through HES-IE.
Rebated or Add-on Participant	The subset of HES or HES-IE participants that installed at least one "rebated" (HES) or "add-on" (HES-IE) efficiency improvements recommended by their home energy assessor.
Savings Rate	Total first year program savings occurring in a census block group divided by the total consumption in that block group (used as part of the customer profiling task)
Spillover	The savings attributable to a C&LM program in addition to gross savings. Spillover savings may result from participants who install additional energy-efficient measures due to their previous involvement with the program, and non-participants that the program nonetheless influences to install energy-efficient measures.
Treatment Group	The HES and HES-IE participants for whom the study estimated ex post savings: customers who received HES or HES-IE measures in program year 2019.[1] The HES participants serve as a separate treatment group from the HES-IE participants. The study matched each treatment group to its corresponding control group.
Weatherization	A general term used to describe air sealing and/or insulation (one or more of attic, wall, or floor insulation). References to air sealing or insulation in the report are specific to that measure, whereas weatherization refers to one or both measures.

Acronyms

Acronym	Meaning
AC	Air Conditioning
ACS	American Community Survey
AFUE	Annual Fuel Utilization Efficiency
AMI	Area Median Income
AMI	Area Median Income
BPI	Building Performance Institute
BTU	British Thermal Unit
C&LM Plan	Conservation and Load Management Plan
CAA	Community Action Agencies
CAC	Central Air Conditioner
CATI	Computer-Assisted Telephone Interview
CEEF	Connecticut Energy Efficiency Fund

[1] The billing analysis began with each participant's post-installation period with the second full billing cycle after the participant's final measure installation date, which allows for at least one full month of "transition time" between pre- and post- period.

Acronym	Meaning
DEEP	Department of Energy and Environmental Protection
DHW	Domestic Hot Water
DOE	Department of Energy
EER	Energy Efficiency Ratio, a measure of cooling efficiency
EF	Energy Factor, a measure of energy conversion efficiency, typical of residential appliances
FR	Free-ridership
HES	Home Energy Solutions
HES-IE	Home Energy Solutions-Income Eligible
HMFA	Department of Housing and Urban Development Metropolitan Fair Market Rent Area
HSPF2	Heating Season Performance Factor, a measure of heating efficiency
HTR	Hard-to-reach
HVAC	Heating, Ventilation, and Air Conditioning
ICAST	International Center for Appropriate and Sustainable Technology
IES	Income Eligible Service
ISR	Installation Rate
LIHEAP	Low Income Energy Assistance Program
MCG	Matched Control Group
MF	Multifamily
MLS	Multiple Listing Service
DHW	Domestic Hot Water
NEIs	Non-Energy Impacts
NOAA	National Oceanic and Atmospheric Administration
NPSO	Non-Participant Spillover
NRZ	Neighborhood Revitalization Zone
NTG	Net-to-Gross
PA	Program Administer
POD	Print On Demand
PPR	Post-Program Regression
PSD	Connecticut Program Savings Document
PSO	Participant-spillover
PV	Photovoltaic
RCD	Residential Coordinated Delivery
RR	Realization Rate
SEER2	Season Energy Efficiency Ratio, a measure of cooling efficiency
SF	Single Family
SO	Spillover
TRC	Total Resource Cost
UEF	Uniform Energy Factor
WAP	Weatherization Assistance Program

ABSTRACT

This report, developed for the Connecticut Evaluation Administrator (EA) Team, summarizes the findings of Home Energy Solutions (HES) and Home Energy Solutions-Income Eligible (HES-IE) Single Family Impact and Process Evaluation (R1983). This report also includes the results of a Residential Customer Profiling effort that assessed statewide participation across all Energize Connecticut (CT) residential programs, not just HES and HES-IE. The profiling element was the first of its kind in the state.

This evaluation was performed by NMR Group and its subcontractors Cadeo and DNV. NMR Group and Cadeo, respectively, led the process and impact components of this evaluation, while DNV led the profiling effort.

This evaluation, which built on previous impact and process evaluations completed in 2019 and 2016, respectively produced:

- **Accurate gross and net measure-level energy savings and realization rates** for prospective application as part of Program Savings Documentation (PSD) updates.
- **Actionable, process-oriented insights** that will help Connecticut Natural Gas, Eversource, Southern Connecticut Gas, and United Illuminating (the Companies) continue to evolve these critical programs to better serve customers, improve program delivery, and meet statewide weatherization goals.

Key Finding #1: Air sealing and insulation savings in natural gas-heated homes are much lower than the previous evaluation and ex ante values, but generally in line with regional benchmarks.

Air sealing and insulation are the two most important measures delivered through HES and HES-IE, collectively representing more than 80% of the lifetime savings associated with both programs. The study found gross realization rates – the ratio of ex post savings (determined through this evaluation) and ex ante savings (reported in the program tracking data and determined using the Program Savings Document savings algorithm) – that ranged from 10% to 17% for air sealing and 46%-51% for insulation in natural gas heated homes.

These ex post savings differ greatly from the previous evaluation and ex ante savings but are much closer (air sealing) and very similar to (insulation) the evaluations of benchmarked programs offered in Massachusetts and Rhode Island. Lower ex post savings are also consistent a long-term trend of declining average air sealing and insulation savings across the region.

The drivers of this decline in savings – in both Connecticut and neighboring states – are numerous, interrelated, and include program maturation, increasing heating system efficiencies, lower pre-program consumption, and the program's completing air sealing during the participant's assessment.

Related Recommendations

1A. Refine the HES incentive structure to encourage more comprehensive weatherization.

1B. Increase targeting of homes with greater savings potential.

1C. Consider an air sealing field assessment to assess work quality and missed opportunities.

Key Finding #2: HES participants install insulation less often than participants in similar regional programs.

Overall, 14% of HES participants installed insulation following their assessment. This number compares to 32% and 36% of participants in similar programs in Massachusetts and Rhode Island. The drivers of the low insulation rates for HES include lower incentive level in CT, different program designs and eligibility requirements, and significant contractor Variance.

Related Recommendations

2A. Revisit HES' current existing conditions requirements to quality for insulation.

2B. Directly incentivize HES vendors based on their insulation conversion rate.

2C. Provide dedicated sales training.

2D. Simplify and sharpen customer-facing incentive messaging.

2E. Develop a program or offer elevated incentives targeting moderate-income households and/or rental properties.

Key Finding #3: The results of this evaluation reveal an implicit trade-off and central question inherent in Connecticut's current delivery model: What's better - less savings at more homes or more savings at fewer homes?

HES averages less air sealing and insulation savings per participant than the benchmarked programs. However, the program's different delivery model (conducting blower-door guided air sealing during the initial assessment instead of during a separate, subsequent visit) means that a much larger percentage of HES participants receive air sealing than the other programs. Accounting for the incidence and savings of air sealing and insulation in each program, the average savings per assessed HES home is still between two-thirds and three-quarters of comparable programs despite more participants getting air sealing. This leads to an important policy question: What program design is best achieves the Company and state's energy, weatherization, and equity goals – one that results in less savings at more homes or more savings at fewer homes? This study provides the information necessary for policy makers to make a design decision that best balances these critical factors. The study also includes recommendations for improving program performance, notably around increasing the percentage of participants that are recommended and install insulation.

Related Recommendation

3A: The Companies should carefully consider how to modify or whether to continue the current delivery model and seek to balance program savings goals, statewide weatherization targets, and equitable access. Supporting information is provided in the study.

Key Finding #4: Unlike air sealing and insulation, the study generally found high gross savings and NTG results for most other measures.

While air sealing and insulation constitute the majority of HES and HES-IE lifetime savings, both programs offer a range of other measures. Most of these measures, for both programs, generally

met gross and net savings expectations. In reviewing these measures, the study determined updated gross realization rates and identified refinements for the next PSD update.

Related Recommendation

4A. Apply the recommended PSD changes documented as part of the next PSD update.

Key Finding #5: Financial and logistical barriers impede the statewide weatherization goals.

7% of HES and 19% of HES-IE participants from 2017 to 2020 had a health and safety barrier that affected their assessment. The cost of remediating these barriers and landlord permission is preventing participants from installing more measures – and its likely demand for remediation assistance will exceed available funding. This was one of the reasons that program and community stakeholders expressed doubt that the state will meet its goal of weatherizing 80% of all residential units in 2030 without significant changes in program funding, incentives, and workforce development. This includes finding qualified technicians.

Related Recommendations

5A. Expand the Statewide Weatherization Barriers program to serve the needs of low- and moderate-income customers.

5B. Work with existing vendors and contractors to increase training opportunities, recruit new technicians, and conduct outreach to technical schools.

Key Finding #6: Certain customer segments face additional barriers to participation in HES and HES-IE.

Per stakeholders, underserved segments include low-income and moderate-income customers, renters, rural customers, customers with limited English proficiency, elderly customers, and immigrant customers. Barriers to participation in HES or HES-IE among equity-related demographic groups included difficulty affording health and safety remediation, installing additional measures, accessing program information, and scheduling assessments. Meanwhile, program participants are more highly educated and younger than households in the general population. To improve the programs' reach, community stakeholders suggested the Companies shift their outreach focus away from Company marketing efforts to community outreach efforts.

Related Recommendations

6A: Remove barriers to participation for customers with limited English proficiency by providing vendors with access to a language line and use of other language technologies.

6B: Expand eligibility for HES-IE or consider targeted offerings for moderate income customers.

6C: Offer assessments on evenings or weekends to accommodate customers are unable to take off work during the weekday.

6D: Divert resources from traditional marketing campaigns community outreach efforts. Work with local institutions and organizations to spread awareness about the program in communities.

Key Finding #7: Overall satisfaction among vendors and HES participants is high, with room to improve program communication and messaging, particularly for HES-IE participants.

Vendors expressed overall satisfaction with the program and their role promoting energy-efficiency and weatherization services to customers, while seeking improvements to certain program requirements and the quality inspection process. Specifically, the program can improve information sharing during and after the assessment and help some participants overcome their issue scheduling an assessment. In general, HES participants report higher overall satisfaction with the program (81%) than HES-IE participants (68%).

Related Recommendations

7A: Ensure technicians walk through the findings of the assessment and next steps with HES-IE participants and consistently follow-up with next steps.

7B: Improve customer service experiences for customers looking to schedule an assessment or receive additional information.

7C: Follow up with all participants to remind them about recommended measures and provide additional information.

Key Finding #8: Virtual audits offered during the pandemic had limited uptake, which resulted in 25% lower savings.

Few participants (12%) opted to receive virtual audits and those that did had averaged less savings (based on reported savings in the program tracking data). Vendors also did not favor virtual audits, citing frustration with the fact that there was still an in-person component to conduct air sealing and other core services. According to vendors, customers would often not schedule the in-person visit to complete the assessment, the program did not adequately compensate vendors for the added effort involved, and spotty internet service could complicate delivery of the virtual audit.

Related Recommendation

8A: Consider adopting stricter guidelines for virtual audits to enable greater savings and compensate vendors for the time needed to conduct the virtual pre-assessment.

Key Finding #9: Collectively, the residential single-family and multifamily income eligible programs are effectively reaching disadvantaged households.

The percent of total savings from the income-eligible programs is about the same as the percent of low-income households (single-family and multifamily). This pattern indicates that, at the broadest level of analysis, savings from the energy efficiency programs are distributed the same as population distributions. The residential portfolio, overall (not just HES & HES-IE), is also successfully reaching areas with high concentrations of equity-related demographics.

Key Finding #10: The residential portfolio is reaching disadvantaged areas through locations with unusually high savings and the income-eligible (IE) programs.

When unusually high-saving sites are removed from the portfolio, disadvantaged areas tend to have lesser savings from the portfolio. Approximately 30% of program savings occurred at sites with unusually high (top 1%) site-level savings. Satellite imagery confirmed that many of the unusually high-savings locations are large multifamily properties with over 100 units. Thus, it appears that a substantial portion of savings are coming from large multifamily properties.

Key Finding #11: Despite reaching disadvantaged areas generally, the portfolio underrepresents rural areas and single-family, low-income households.

Across the whole portfolio, electric and gas savings are concentrated in the urban areas. The study's analysis found that customers in urban areas disproportionately participated in residential programs relative to more rural portions of the state. The study found that residential portfolio-level savings rate (i.e., total first year program savings occurring in a census block group divided by the total consumption in that block group), is concentrated in urban areas. The analysis also found that low-income, single-family households are somewhat under-enrolled in the IE electricity programs. Gas savings showed a similar pattern as electric savings except low-income, single-family areas appeared to be receiving about the same amount savings as the number of households: 9% of households were in these areas and 10% of the gas savings occurred there.

Related Recommendations (for Key Findings #9-#11)

9A: Create program designs that dedicate more resources to renters and rural areas of the state.

9B: Devote additional income-eligible program resources to enrolling single-family homes.

Key Finding #12: Significant delays in data request fulfilment and data quality issues adversely impacted the timeliness of this study and its ability to inform the planning process.

The study submitted its initial data request to the Companies in August 2020. The study also submitted an updated data request in January 2021 following a data-focused call between the study and Companies. It took until February 2022 and more than 200 data request related communications for the Companies to provide the data necessary to complete the process, impact, and customer profiling tasks scoped for this study. The significant delay fulfilling the study's data requests had a commensurate impact on the study's timeline and budget. There is always a lag between evaluated participation cohorts and evaluation reports, especially when using a billing analysis that requires at least a full year of post-participation data, but the delays in data request fulfillment resulted in the difference between the evaluated HES & HES-IE cohort (2019) and the study completion (2023) being much greater than planned.

In addition to these delays, the study encountered issues with the data itself including, but not limited to multiple and inconsistent unique customer identifiers, masked account numbers, incomplete measure details, disparate data structures, and a lack of data dictionaries.

Related Recommendations

11A: Improve the rigor of data collection and management, as well as Data consistency between Eversource and UI. Specifically, both companies should:

- Use data validation to force a standard for recording key customer information such as account numbers and addresses.
- Regularly audit data to ensure that vendors are using data fields properly.
- Consider specific quality control and assurance procedures that include financial penalties and rewards related to data completeness and integrity.
- Establish a process for storing data queries related to evaluation studies that the Company can leverage and replicate such that they can reissue data request updates in the consistent format (UI specifically; not an issue for Eversource).
- Require distributors and contractors applying for instant rebates on behalf of their customers to record customer contact information to better track customer participation and uptake of energy efficient measures.
- Include the number of treated units in tracking data associated with multi-unit and/or multifamily buildings.

Executive Summary

This report, developed for the Connecticut Evaluation Administrator (EA) Team, summarizes the findings of Home Energy Solutions (HES) and Home Energy Solutions-Income Eligible (HES-IE) Single Family Impact and Process Evaluation (R1983). This report also includes the results of a Residential Customer Profiling effort that assessed statewide participation across all Energize Connecticut (CT) residential programs, not just HES and HES-IE.

This evaluation was performed by NMR Group and its subcontractors Cadeo and DNV. NMR Group and Cadeo, respectively, led the process and impact components of this evaluation, while DNV led the profiling effort.

Background

HES and HES-IE are Connecticut's two most significant residential programs in Connecticut. In 2019, the program year this evaluation focused on, the two programs collectively represented 74% of the state's residential annual energy savings (MMBTUs).[2] As such, the programs merited a comprehensive evaluation (i.e., impact and process) that produced:

- **Accurate gross and net measure-level energy savings and realization rates** for prospective application as part of Program Savings Documentation (PSD) updates.
- **Actionable, process-oriented insights** that will help Connecticut Natural Gas, Eversource, Southern Connecticut Gas, and United Illuminating (the Companies) continue to evolve these critical programs to better serve customers, improve program delivery, and meet statewide weatherization goals.

This evaluation report updates previous impact and process evaluations completed in 2019 and 2016, respectively, as well as interim results findings memo provided to the Companies in September 2022.[3,4] The residential customer profiling element of this study represents the first of its kind in the state.

Tasks & Objectives

Figure 1 lists the evaluation tasks completed as part of R1983 and maps each task to the study's objectives, which are associated with three overarching research topics:

1. Assessing Program Delivery
2. Determining Program Impacts
3. Understanding Program Reach

[2] https://energizect.com/sites/default/files/documents/Final-2019-Annual-Legislative-Report-WEB02262020_2_0.pdf
[3] https://www.energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf
[4] https://documentcloud.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3A6ad1a31e-b53f-43aa-81bc-d5646e8c7d45#pageNum=1

Figure 1: Research Topics and Evaluation Tasks

		Stakeholder Interviews	Participant Surveys	Program Material & Data Review	Billing & Realization Rate Analysis	Building Simulation & Engineering Algorithms	Customer Profiling	Bench-marking
Assessing Program Delivery	Program Delivery & Performance	✓	✓	✓				✓
	Data Quality & Management	✓		✓				
	Impact Result Drivers	✓	✓	✓	✓			✓
Determining Program Impacts	Retention & Persistence		✓					✓
	Gross Savings			✓	✓	✓		✓
	Net-to-Gross	✓	✓					✓
	Realization Rates Drivers	✓	✓	✓	✓	✓		✓
Understanding Program Reach	Customer Profiling			✓			✓	✓
	Targeting via Census Data			✓			✓	

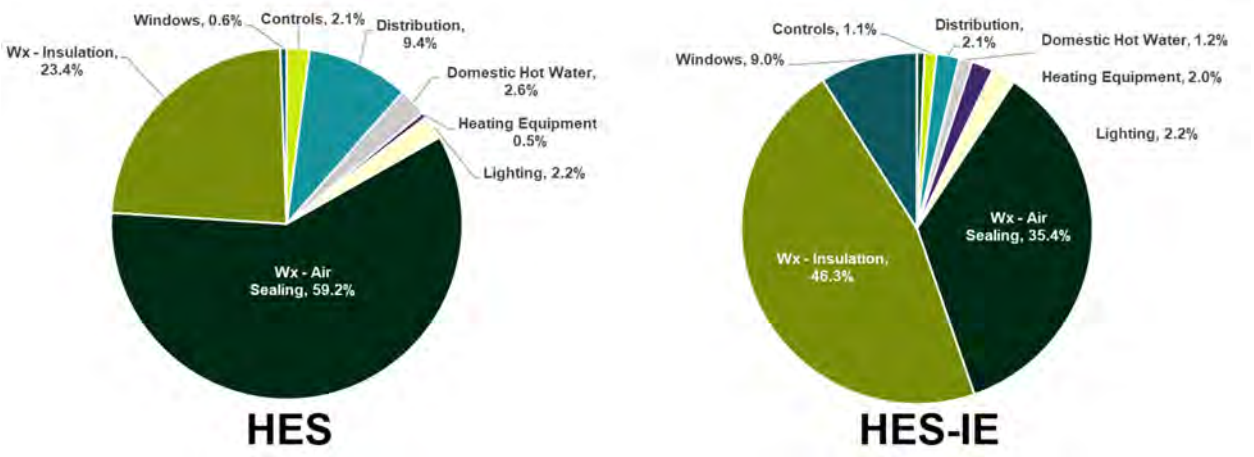
BACKGROUND

During home energy assessments, vendors provide customers core services, which can include directly installing measures, blower-door-guided air sealing, and/or duct sealing. Connecticut's approach to air and duct sealing, which happens during the assessment, differs from comparable residential assessment programs in neighboring states. Programs in Massachusetts and Rhode Island only conduct blower door-guided air sealing and duct sealing during a separate visit to the home, which is usually completed when program recommended insulation is installed although air sealing can occur during a return visit independent of insulation.

HES customers pay a nominal fee for these services, and a portion of the cost of add-on measures, whereas HES-IE customers receive the assessment, associated services, and add-on measures at no cost. Vendors also examine homes for hazardous materials and unsafe conditions, e.g., asbestos, mold, and gas leaks, the existence of which may prevent vendors from completing the assessment or performing any air or duct sealing.

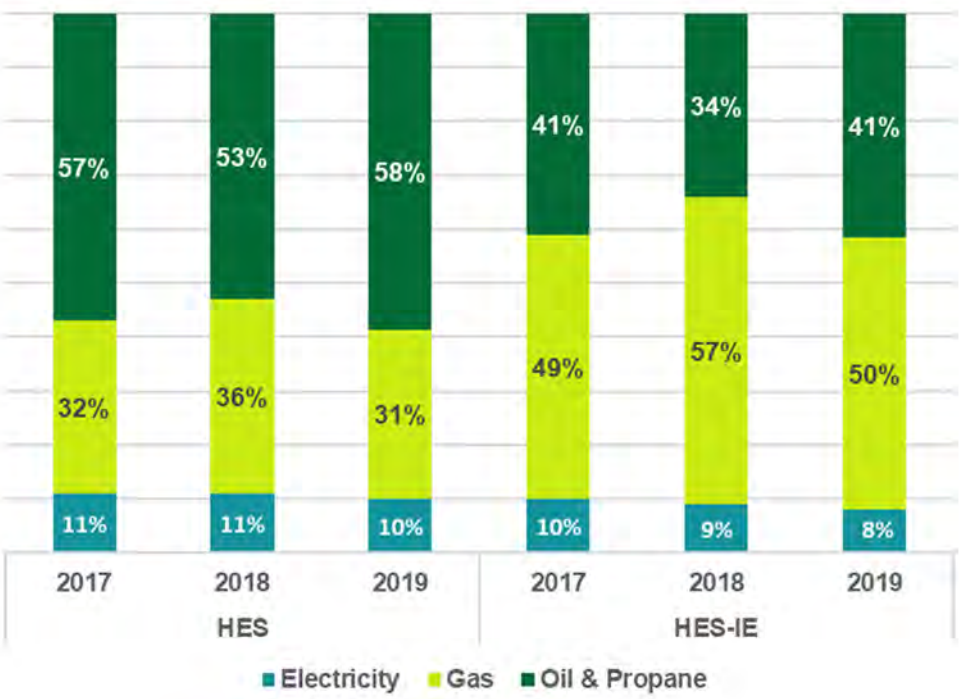
Most of the lifetime savings associated with both programs comes from air sealing (especially for HES) and insulation, collectively referred to as weatherization. Duct savings (HES) and windows (HES-IE) are also a meaningful contributor to program savings.

Figure 2. Percent of Lifetime Ex Ante Savings by Measure Type – MMBTUs across all fuels (2019)



Most HES ex ante lifetime savings come from delivered fuel measures (heating oil and propane), whereas most HES-IE savings are associated with natural gas measures. Electric measures played a lesser role in both programs between 2017 and 2019.

Figure 3: Percent of Program Lifetime Ex Ante Savings by Fuel Type – MMBTUs across all fuels (2017-2019)



KEY FINDINGS & RECOMMENDATIONS

Finding 1: Air sealing and insulation savings in natural gas-heated homes are much lower than the previous evaluation and ex ante values, but generally in line with regional benchmarks.

Air sealing and insulation are the two most important measures delivered through HES and HES-IE, Connecticut's flagship residential energy efficiency program offerings.

The study found low average ex post savings for air sealing and insulation in natural gas heated homes relative to the previous HES & HES-IE impact evaluation (R1603), as well as the reported ex ante savings. As shown in Table 1, the realization rate – the ratio of ex post savings (determined through this evaluation) and ex ante savings (reported in the program tracking data and determined using the Program Savings Document [PSD] savings algorithm) – ranged from 10% to 17% for air sealing and 46%-51% for insulation in natural gas heated homes. These results came from the study's billing analysis and were corroborated using multiple statistical models, as well as engineering-based approaches.

Table 1: Evaluated Air Sealing and Insulation Savings (CCF/Year) for 2019 Participants (Statewide, Natural Gas-Heated Customers)

	Air Sealing				Insulation			
Program	Previous Eval	Ex Ante*	Ex Post	Realization Rate	Previous Eval	Ex Ante*	Ex Post	Realization Rate
HES	64	102	17	17%	154	119	60	51%
HES-IE	59	106	11	10%	158	211	97	46%

*Reported in program tracking data.

However, the ex post air sealing and insulation from this study are much closer to benchmarked evaluations of similar programs[5] offered in Massachusetts and Rhode Island – particularly for insulation. The juxtaposition of this study's results, the previous HES & HES-IE impact evaluation, and these regional benchmarks – provided in Table 2 – suggests that the findings of the previous evaluation were potentially outlying results.

[5] While these three programs are similar home energy assessment-based retrofit programs, some differences in design and delivery exist. See Finding #2 for more details.

Table 2: Benchmarking: Air Sealing and Insulation Natural Gas Savings (CCF/Year)[6]

Program Type	Program	Reference	Air Sealing	Insulation
Market Rate	**HES (CT, 2019)**	**Current CT evaluation (R1983)**	**17**	**60**
	HES (CT, 2015-16)[7]	Previous CT evaluation (R1603)	64	154
	EWSF (RI, 2017-18)[8]	Regional Benchmark	33	60
	HES/RCD (MA, 2015-16)[9]	Regional Benchmark	31	98
Income Eligible	**HES-IE (CT, 2019)**	**Current CT evaluation (R1983)**	**11**	**97**
	HES-IE (CT, 2015-16)	Previous CT evaluation (R1603)	59	158
	IESF (RI, 2015-16)[10]	Regional Benchmark	N/A	87*

*The IESF evaluation in Rhode Island only reported combined savings for air sealing and insulation. To approximate the likely insulation-only savings, the team leveraged the air sealing-specific savings from the EWSF evaluation in Rhode Island (33 CCF/year) and subtracted that amount from the IESF savings of 120 CCF/year for both air sealing and insulation.

Zooming out, the results of this evaluation are consistent with a **long-term trend of declining average air sealing and insulation savings**. As shown in Figure 4, nearly every subsequent impact evaluation in Connecticut (HES), Massachusetts (HES/RCD), and Rhode Island (EWSF) resulted in lower evaluated savings for natural gas-heated participants that received air sealing and/or insulation.

[6] The benchmarked studies in Massachusetts and Rhode Island reported savings in therms, not CCF, which is the metric used in the PSD. To provide an apples-to-apples comparison, the team converted the reported savings in both states to CCF using a therms-to-CCF conversion factor of 0.964. Consequently, the savings shown in Table 2 differ slightly from the savings listed in each of the linked evaluation reports.

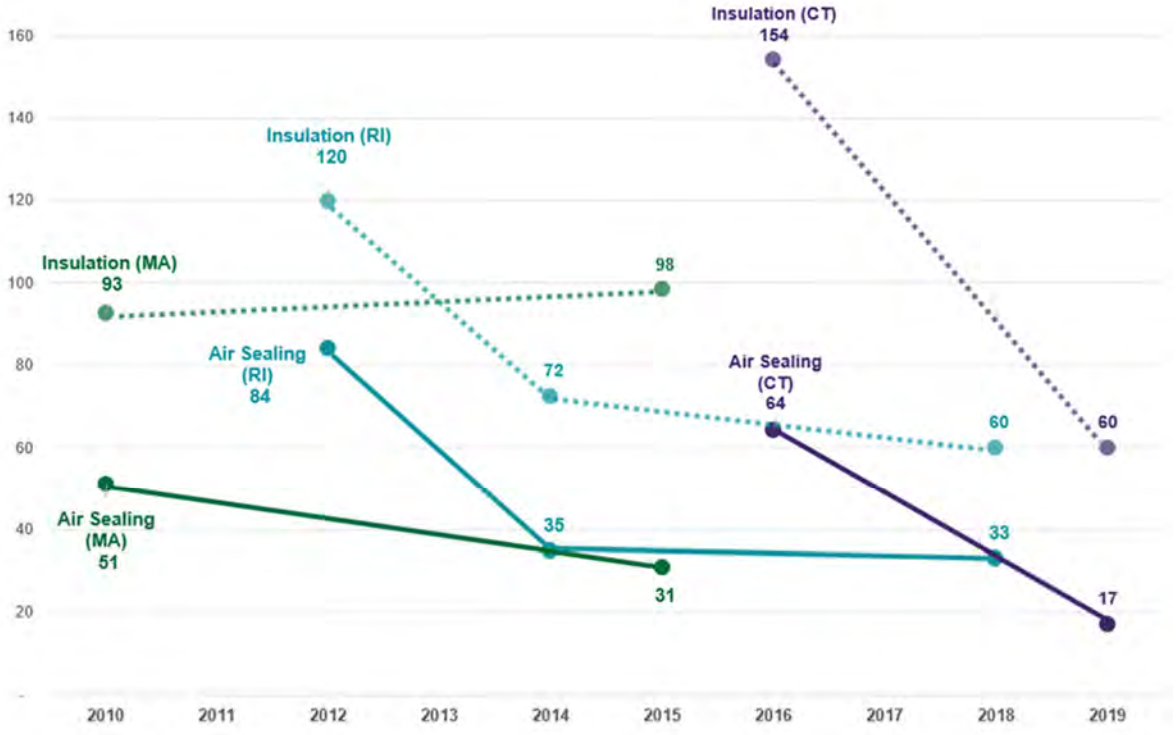
[7] https://acrobat.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3A6ad1a31e-b53f-43aa-81bc-d5646e8c7d45#pageNum=1

[8] EnergyWise Single Family (EWSF) Program (http://rieermc.ri.gov/wp-content/uploads/2020/10/ng-ri-ewsf-impact-and-process-comprehensive-report_final_04sept2020.pdf)

[9] Home Energy Services (formerly) or Residential Coordinated Delivery Initiative (https://ma-eeac.org/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf)

[10] Income Eligible Single Family Program (http://rieermc.ri.gov/wp-content/uploads/2019/04/ng-ri-ies-impact-evaluation-report_final_30aug2018.pdf)

Figure 4: Evaluated Savings Over Time by State – Average Air Sealing & Insulation Savings (CCF/Year) for Market Rate Natural Gas-Heated Customers[11]



The global drivers of this consistent decline in air sealing and insulation savings – in both Connecticut and neighboring states – are numerous and include:

- **Less "Low-Hanging Fruit."** Customers with least efficient homes (and highest energy bills) are most motivated to air seal and/or insulate their homes through programs like HES and HES-IE. As a result, there tends to be less savings opportunity per home as programs mature, achieve greater cumulative participation, and serve those customers in most need of program services. In addition, as program's mature they also tend to have more repeat participants, which also means less remaining savings potential.[12]
- **Increasing Heating System Efficiencies.** The savings opportunity for air sealing and insulation measure is also correlated with the efficiency of participants' heating system. Increases in the prevalence of higher efficiency condensing gas furnaces and boilers[13]

[11] In addition to the previous referenced Massachusetts and Rhode Island evaluations Figure 4 also includes data from https://ma-eeac.org/wp-content/uploads/Home-Energy-Services-Impact-Evaluation-Report_Part-of-the-Massachusetts-2011-Residential-Retrofit-and-Low-Income-Program-Area-Evaluation.pdf and http://rieermc.ri.gov/wp-content/uploads/2018/03/national-grid-rhode-island-energywise-single-family-impact-evaluation_final_31oct2012.pdf. Similar to Table 2, the evaluation converted savings reported in therms to CCF.

[12] This evaluation did not estimate repeat participation but a recent participation study of the EWSF and IESF programs in Rhode Island found repeat participation rates between 3-8%. The study also found that 15% and 7% of EWSF and IESF participants, respectively, also participated in different efficiency programs within the last ten years. (http://rieermc.ri.gov/wp-content/uploads/2022/06/participant-and-non-participant-study-summary.pdf)

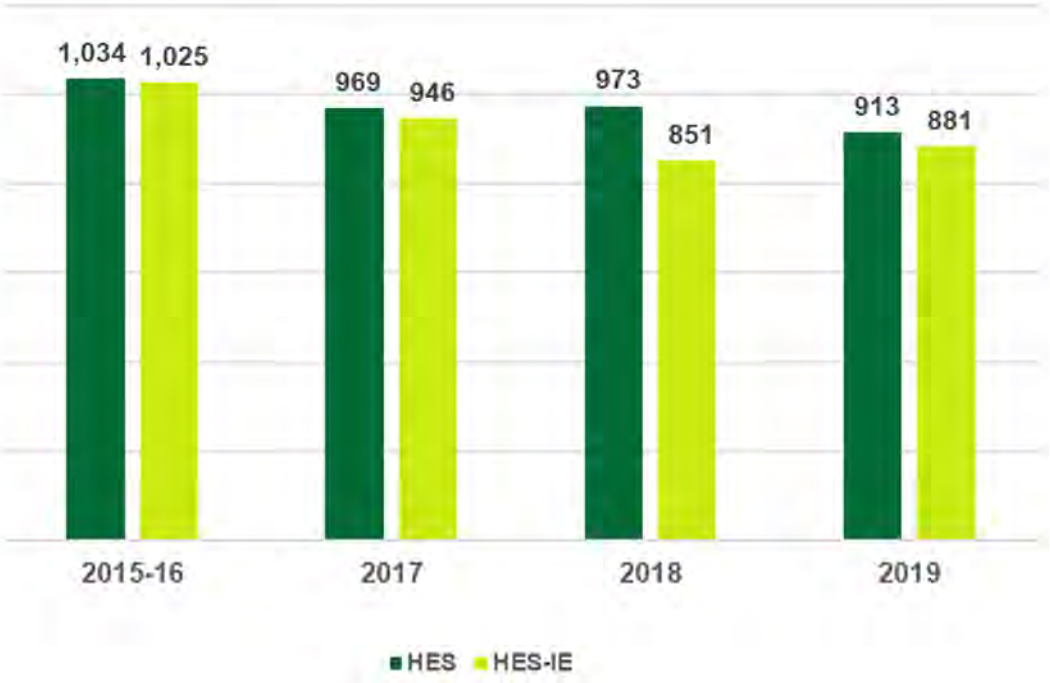
[13] Per the most recent study in a series of Residential Building Use and Equipment Characterization study in neighboring Massachusetts: "For newly installed gas furnaces and boilers, the distribution is heavily skewed toward

across the country due to declining costs and continued program intervention improves overall efficiency, but also means less savings potential for weatherization measures.

For HES & HES-IE specifically, the study also found the following drivers of lower air sealing and/or insulation savings:

- **Lower pre-program consumption.** In part due to the reasons listed above, the study observed a downward trend in annual pre-program heating-related natural gas consumption over participating HES cohorts over time. Specifically, the study found the average 2019 HES participant's pre-program heating usage (913 CCF/year) was 12% less than the average 2015-2016 HES participant (1,034 CCF/year), which were the focus of the previous HES impact evaluation (R1603). A similar comparison for HES-IE shows a decline of 14% over the same time period. Declining pre-program consumption alone does not fully explain the decrease in evaluated savings between R1983 and R1603. However, declining average pre-program natural gas energy consumption has a direct impact on both program savings and is a contributing factor to the lesser observed savings: lower pre-program consumption means less opportunity for heating-related energy savings.

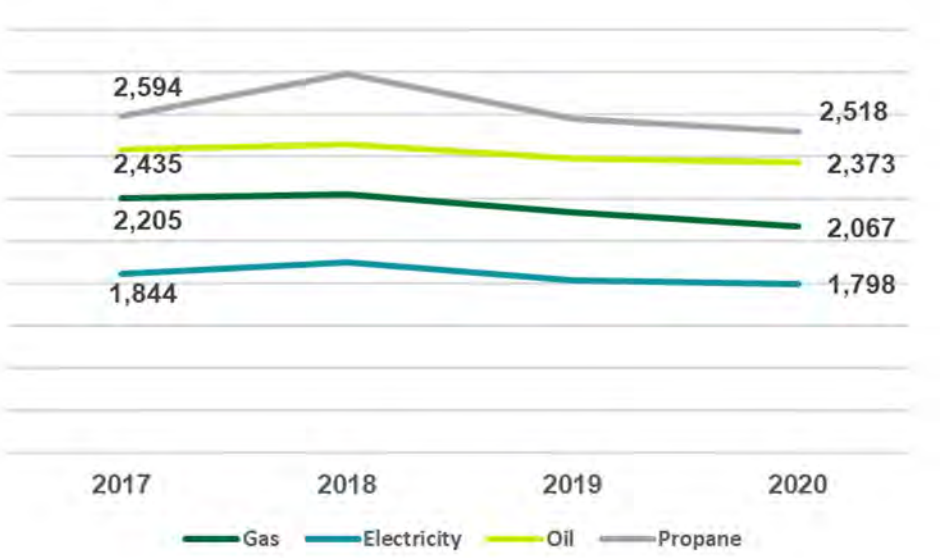
Figure 5: HES & HES-IE Pre-Program Normalized Annual Natural Gas Heating Consumption for Air Sealing and/or Insulation Participants (CCF/Year)



95+ Annual Fuel Utilization Efficiency (AFUE) furnaces, which aligns with a general trend of furnace manufacturers focusing their condensing furnace product offerings on 95+ AFUE furnaces." (https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf)

- **Smaller participating homes.** Relatedly, the study's analysis of 2017 – 2020 program data showed the size of the average participating home (i.e., square footage of heated space) declined modestly over time for natural gas heated homes that participated HES & HES-IE.[14] The study decline in home size over these four year is less than the observed decline in consumption, which suggests the observed decrease in consumption over time is only partially driven by home size.

Figure 6: HES Average Participant Heated Square Footage by Year and Fuel Type[15]



About Delivered Fuels

Since billing analysis is not possible for delivered fuels (due to lack of detailed usage data), the study team leveraged the natural gas billing analysis results to evaluate air sealing and insulation savings for participants that heat with oil and propane. To best reflect delivered fuel participants, the study applied engineering adjustments to the natural gas results to account for differences in fuel-specific heating system efficiencies and relative home size (as shown in Figure 6 *delivered fuel homes were, on average, larger). Because the study leans on the natural gas billing analysis, the findings in section – and the recommendations in the following section – are generally applicable to delivered fuel weatherization participants. However, the study found much gross realization rates for delivered fuels than natural gas – especially for insulation through HES-IE (see Table 4).*

[14] Eversource only; did not have comparable heated square footage for UI.

[15] It is important to note the difference in home size by heating fuel type. This is one of the engineering adjustments the study made when leveraging the results of the natural gas billing analysis to evaluate other fuel types – especially heating oil and propane, which cannot be analyzed via billing analysis.

- **Less time air sealing.** Unlike the programs in Massachusetts and Rhode Island where air sealing occurs during a separate, post-assessment visit, HES & HES-IE conduct air sealing during participant's initial energy assessment. The HES & HES-IE vendors interviewed indicated they typically spent two to four hours assessing each home. The average includes the myriad of non-air sealing responsibilities HES and HES-IE vendors have at each assessment: engaging with the participant, doing a complete energy audit of the home, installing direct install measures, sealing ductwork, the "kitchen table" wrap-up to share results and, for some customers, estimating the DOE Energy Score. As a result, the amount of time dedicated to air sealing is only a portion of the self-reported average of two to four hours per assessment and meaningfully less than the average number of hours (six) spent just air sealing as part of the MA HES/RCD program.[16]

Recommendations for Addressing Finding 1: Low Wx Savings

The study offers several recommendations to address these low evaluated savings and generate higher average air sealing and/or insulation savings prospectively:

RECOMMENDATION 1A. Refine the HES incentive structure to encourage more comprehensive weatherization. In 2019, 38% of the HES participants who installed insulation following their assessment only insulated their attic. Encouraging participants to weatherize their home more comprehensively – i.e., install multiple types of insulation – will drive higher average savings. We recommend that the Companies consider the following incentive refinement opportunities subject to the cost-effectiveness requirements of the program:

- Tiered or bundled customer incentives that increase as participants act on more insulation recommendations.
- Optimizing incentive levels for each type of insulation to encourage HES participants to go beyond only insulating their attic and encourage installing wall and/or basement insulation.
- Retaining the elevated incentive levels (initially increased in 2020 in response to the COVID-19 pandemic), to drive and provide financial support for more comprehensive weatherization (subject to cost-effectiveness considerations)
- Offering escalating incentives and/or financial bonuses to vendors when the participants that they assess act on multiple recommendations.

RECOMMENDATION 1B. Increase targeting of homes with greater savings potential. The study found higher air sealing and insulation savings for customers who lived in larger homes, leakier homes, and/or those with greater pre-program usage. These characteristics are all consistent with basic building science principles associated with greater savings opportunity; they suggest that increased targeting as part of prospective program cycles could increase the average savings determined through future evaluations. Specifically, we recommend that the Companies target customers with highest energy usage intensity (i.e., energy consumption per square foot) via direct marketing efforts.

[16] Based on HES/RCD tracking data

RECOMMENDATION 1C. Consider an air sealing field assessment to assess work quality and missed opportunities. A qualitative assessment of HES' air sealing, duct sealing, and insulation practices (R151) completed in 2016 identified opportunities for potential improvement.[17] While significant time has passed since that study, the low air sealing savings determined through this evaluation suggest a follow-up study may be warranted. Such a study, especially one with a more empirical focus than R151 could provide more definitive insights into lower air sealing savings.

Finding 2: HES participants install insulation less often than participants in similar regional programs

A key goal of assessment-based programs, like HES, is to identify efficiency opportunities and, through incentives and education, to get customers to act on those opportunities. Consequently, a key performance metric is an assessment program's ability to convert recommendations into installation. Since HES completes air sealing during the initial assessment, the program's primary recommendation is installing attic, wall, and/or floor insulation.

To assess HES' effectiveness of turning assessments into insulation jobs, the study benchmarked HES's performance against the same comparable market rate programs in Massachusetts[18] and Rhode Island[19] using three metrics:

- **Recommendation rate.** Insulation Recommendations/ Total Assessments
- **Conversion rate.** Insulation Installations/ Assessments with Insulation Recommendations
- **Installation rate.** Insulation Installations/ Total Assessments

Before comparing these metrics across programs, it is important to acknowledge that the three programs – HES in Connecticut, HES/RCD in Massachusetts, and EWSF in Rhode Island – are similar, but not identical. There are differences in the design and delivery of the programs that potentially affect one or more of these metrics. The most notable differences include:

- **Different Eligibility Thresholds.** For example, HES requires a pre-program existing R-value of less than R-19 in attics to qualify for an attic insulation incentive. By comparison, both RCD and EWSF provide attic insulation incentives when the pre-program existing R-value is less than R-49. As a result, it is possible that a participant in HES/RCD or EWSF with, for example, R-25 in their attic would receive and potentially act on an insulation recommendation while a HES participant with the same existing insulation levels would be ineligible.
- **Different Incentive Levels.** According to interviewed program staff, HES has historically set insulation levels with the goal of covering, on average, 50% of a participant's average upfront insulation costs. This incentive coverage rate is less than Massachusetts' historical approach of covering 75% of participant costs.[20]

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[17] https://energizect.com/sites/default/files/documents/R151%20-%20CT%20HES%20Air%20Sealing%2C%20Duct%20Sealing%2C%20and%20Insulation%20Practices%20-%20Final%20Report_3.24.16.pdf

[18] 2018 participants in Massachusetts' Home Energy Services program (now the Residential Coordinated Delivery program); specifically Portfolio J, KPI #7. https://ma-eeac.org/wp-content/uploads/MA-RES-35-HES-Process-Evaluation-Comprehensive-Report_FINAL_31MAR2018.pdf

[19] 2018 participants in Rhode Island EnergyWise Single Family program (Table 3). http://rieermc.ri.gov/wp-content/uploads/2020/10/ng-ri-ewsf-impact-and-process-comprehensive-report_final_04sept2020.pdf

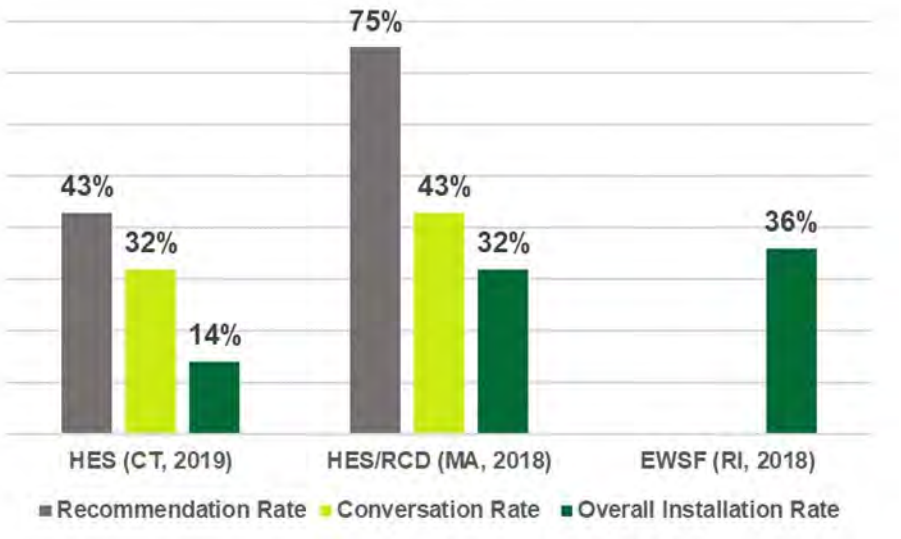
[20] As noted later in this section, HES (and HES/RCD and EWSF) modified their incentives in response to COVID-19.

These differences between HES and the programs in the neighboring states – stricter eligibility requirements and lower incentives – certainly impact the recommendation, conversion and installation rates and merit consideration when comparing metrics across states. However, despite these differences, it's informative to benchmark across states to assess HES' general performance encouraging insulation adoption and to understand the potential implications of these program design differences.

As shown in Figure 7, HES had lower rates for all three metrics relative to the regional benchmarks. Given the programmatic differences noted above, this result is unsurprising. However, it is interesting to note the magnitude of the differences and the overall takeaway that twice the percentage of participants in Massachusetts and Rhode Island install insulation than in HES.

Figure 7: Benchmarking: Insulation Recommendation, Conversion, and Installation Rates

(Market Rate Customers, All Fuel Types)



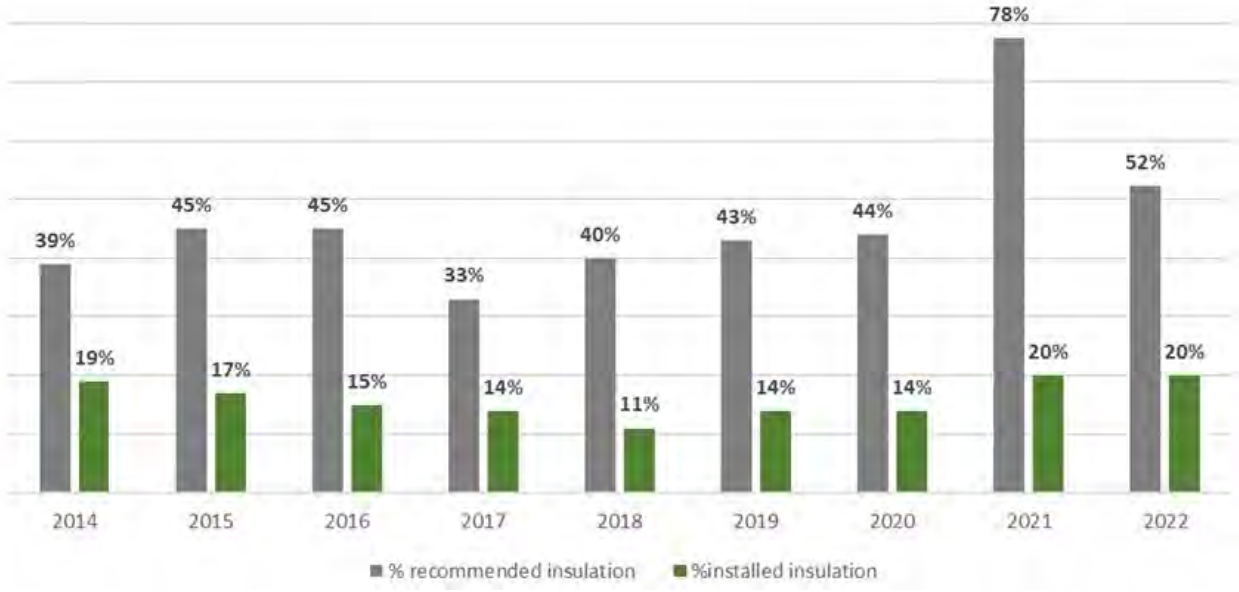
The study's independent assessment of the insulation installation rate (14%) for 2019 HES participants (using the provided program tracking data) matched the Companies reporting on the state's dashboard.[21] The longer-term perspective of insulation installation rates in Figure 8 shows that the 2019 rate of 14% is not a historical outlier.[22]

[21] https://www.ctenergydashboard.com/Public/PublicHESActivity.aspx

[22] The near doubling of the recommendation rate in 2021 is, however, an outlier. While this study did not focus on this time period, it's likely the modified and virtual assessment practices deployed in response to COVID-19 resulted in the significant spike in insulation recommendation rates.

Figure 8: Insulation Installation Rates Over Time

(2014 – 2022, Statewide Dashboard)



Additionally, the study also found that moderate-income HES participants installed insulation at a lower rate than other participants. HES participants with an income less than 80% of the area median income (AMI) were significantly less likely to have installed insulation (9%) than other HES participants (19%).

The drivers of the low insulation rates for HES include:

- **Lower Incentives.** In 2020, HES increased the insulation incentives to encourage participation in the wake of the pandemic. However, prior to these elevated incentives, as noted above, HES aimed to cover approximately 50% of participant's average upfront insulation costs, which is less than Massachusetts' historical 75% coverage. As evident in Figure 8, higher incentives in 2021 and 2022 have encouraged greater installation rates. With additional time for these more recently assessed participants to act on their insulation recommendation, it's possible the insulation installation gap with Massachusetts will narrow or even close.
- **Different Program Designs.** As noted previously, HES (and HES-IE) conduct blower-door assisted air sealing during customer's initial assessment, while the programs in Massachusetts and Rhode Island air seal during a subsequent visit to the home. It's important to note that the program design in Connecticut results in a larger percentage of overall customers receiving air sealing (i.e., all participants without a pre-weatherization barrier) than customers are receiving in the benchmarked states. This positive program design attribute could possibly have an unintended consequence: it's possible the more comprehensive initial assessment leads HES participants to think they are "done" after the assessment and that installing insulation is less important.

Contractor Variance. It is unsurprising that some vendors, in relative terms, were more successful encouraging HES participants to install the insulation they recommended than other vendors. Given these vendors are all delivering the same program, the wide variation in installation rates suggests certain vendors are better at targeting customers likely to act, convincing customers of the value of insulating their home, or are more focused on insulation (because they specialize in these ancillary residential services). The fact that some vendors are more successful at targeting or as selling indicates that training could increase performance for the vendors with lower rates The study offers several recommendations for encouraging a greater percentage of HES participants to act on their vendor's recommendations to insulate their home, including:

Recommendations for Addressing Finding 2: Low HES Insulation Installation Rates

RECOMMENDATION 2A. Revisit HES' current existing conditions requirements to quality for insulation. Given the comparison to Massachusetts and Rhode Island, it is likely that relaxing HES' current pre-program R-value eligibility requirements would result in more qualifying situations, insulation recommendations, and assessed participants installing insulation. However, allowing participants with higher existing R-values to participate is likely to also affect the program's average savings adversely, which, as discussed in Finding 1, is already lower than anticipated. The Companies will need to carefully consider the trade-off between enabling more participants to qualify for insulation and the potential effect on average savings and choose the option that maximizes the total impact of the program while meeting the program's cost-effectiveness requirements. One potential variation would be to relax the pre-program R-value requirements when a participant commits to installing more than one type of insulation. The total savings associated with more comprehensively insulating the home would offset the expected lesser savings per insulation type.

RECOMMENDATION 2B. Directly incentivize HES vendors based on their insulation conversion rate, not just air sealing completions. Right now, the current HES payment structure incentivizes vendors to provide high-level air sealing during the assessment and move on to the next customer. Because insulation is an add-on measure, installed later and often by a different vendor, the vendor doing the assessment is not always motivated to focus on convincing the customer to act on their insulation recommendation. To achieve program goals, it's vital to significantly increase the percentage of HES participants that install insulation. Air sealing alone is not enough. Explicitly tying vendor incentives to their customer's insulation installation and/or conversion rates will more directly align vendor's financial motivations with program goals.

RECOMMENDATION 2C. Provide dedicated sales training. Interviewed vendors said they could train anyone to perform a home energy assessment, but it is difficult to turn an energy technician into a salesperson. Program-supported, sales-focused training will provide vendors with additional skills necessary to communicate the value of insulation to participating HES participants. The training should:

- Identify and leverage best practices from HES vendors with highest install rates, as well as sales best practices used outside energy efficiency programs.
- Provide vendors with specific language they can use to articulate the program's value proposition, enumerate its benefits, and properly emphasize the non-energy benefits that often motivate action.
- Teach vendors to be clear with participants: "We air sealed today, but that is not enough; you also need to insulate your home."

RECOMMENDATION 2D. Simplify and sharpen customer-facing incentive messaging. When the study compared the MassSave.com and EnergizeCT.com websites, there was a clear difference in how each website framed insulation incentives. MassSave.com described the incentives offered in Massachusetts in terms ("75% off" versus "1.70 per square foot" for EnergizeCT.com) that are more likely to resonate with the average, non-technical customer. The websites also differed in their specificity. MassSave.com provides the costs for an example project, whereas EnergizeCT.com acknowledges the same uncertainty differently stating: "The average initial costs varies from home to home". While technically true, the ambiguity of this language does not enable customers to understand the value of the program and make decisions accordingly. Lastly, MassSave.com emphasizes non-energy benefits like comfort whereas these important motivators for action are not mentioned on EnergizeCT.com.

Figure 9: Excerpts from MassSave.com and EnergizeCT.com

Survey results support improving program communication. Nearly one in ten HES participants (8%) and 18% of HES-IE participants were dissatisfied with the information provided about additional energy-savings opportunities.

RECOMMENDATION 2E. Develop a program or offer elevated incentives targeting moderate-income households and/or rental properties. As noted above, the insulation installation rate was appreciably lower for HES participants that earn less than 80% of the area median income (AMI) but more than threshold to receive insulation at no cost through HES-IE (60% state median income). The study estimated that at least 13% of HES participants would be considered moderate income by this definition.[23] To close this gap, it's clear the Companies will have to modify their program design and/or incentive levels.

Potential models for such a program include:

- The Massachusetts HES program's moderate-income offering, available since 2016, which provides enhanced incentives for customers with incomes between 61% and 80% of SMI.
- New York's statewide low- and moderate-income (LMI) portfolio, which offers incentives that cover 50% of the project cost for moderate-income customers and 100% for low-income customers.[24]

Some moderate-income programs the study reviewed had limited uptake initially.

Finding 3: The results of this evaluation reveal an implicit trade-off and central question inherent in Connecticut's current delivery model: What's better - less savings at more homes or more savings at fewer homes?

As shown in Finding 1, when implemented, the Connecticut programs averaged less air sealing savings (17 and 11 CCF/year per participant) than comparable assessment-based programs in neighboring Massachusetts and Rhode Island (between 31 and 33 CCF/year per participant).

However, HES and HES-IE deliver air sealing differently than the programs in Massachusetts and Rhode Island. In Connecticut, blower-door guided air sealing is implemented in nearly every participating home during each customer's comprehensive energy assessment.[25] By contrast, the programs in Massachusetts and Rhode Island conduct comprehensive air sealing as part of a separate visit to the customer's home in preparation for installing insulation. As a result, those programs most commonly only conduct air sealing in the subset of assessed homes where the participating customer decided to install at least one type of program recommended insulation.

Comparing the average evaluated air sealing savings per participant for the two approaches shows that the Connecticut approach yields lower savings per air sealed home than do Massachusetts and Rhode Island. Qualitative details gathered by the evaluation team support this quantitative finding; chiefly that Connecticut contractors spend less time air sealing during the

[23] As one-fifth of HES survey respondents declined to answer the question about their household income, it is possible the share of moderate-income HES participants is higher than 13%.
[24] NYSERDA. "Statewide Low- to Moderate-Income Portfolio Implementation Plan, Version 2." April 29, 2022. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/LMI/2022-04-Statewide-LMI-Implementation-Plan.pdf
[25] The programs do not air seal homes when ventilation-related health and safety issues are identified.

assessments than contractors in Massachusetts as part of the dedicated air sealing visits in Massachusetts under the Residential Coordinated Delivery (RCD) program model (average of six hours). Since air sealing is only one of the contractor objectives during the Connecticut assessment visits, this likely limits the extent of their air sealing.

To fully assess the two delivery models, it is important to assess the average savings and incidence with which air sealing and insulation occur for each program. This perspective recognizes that, while Connecticut's delivery model produces a lower average savings per air sealed customer, it does result in a much larger percentage of participants receiving air sealing.

Table 3 compares the proportion of participants in each program that received each weatherization element, as well as the average savings for each. Because of HES' lower average insulation savings (discussed in Finding #1) and lower insulation installation rate (Finding #2) the average weatherization savings per assessed home in HES is approximately two-thirds that of RCD and three-quarters of EWSF.

Table 3: Comparison of Average Air Sealing & Insulation Saving per Participant (CCF/year)

	Connecticut (HES)		Massachusetts (HES/RCD)		Rhode Island (EWSF)	
	% of Participants	Average Savings	% of Participants	Average Savings	% of Participants	Average Savings
Received only air sealing	76%	17	0%	0	0%	0
Received air sealing & insulation	14%	77	32%	125	36%	93
Did not receive air sealing or insulation	10%	0	68%	0	68%	0
Overall	**100%**	**24**	**100%**	**40**	**100%**	**33**

The previous table reflects the realities of HES' current design relative to the approach used by in Massachusetts and Rhode Island: the Connecticut air-seal-during-assessment approach results in less average savings per customer but generates some savings – and therefore some value - for a larger percentage of participating customers. This leads to an important policy question: What program design is preferable – one that results in less savings at more homes or more savings at fewer homes? Or does a third option exist? What approach balances cost effectiveness, efficacy, and equity? The following section tackles this question.

Recommendations for Addressing Finding 3: The Companies should carefully consider how to modify or whether to continue the current delivery model.

As shown in the preceding pages, this evaluation yielded significant insight into the viability and appropriateness of the current delivery model used by HES and HES-IE. These insights include key evaluation outputs such as average savings per assessed home, average savings for the homes that received air sealing and those that also installed insulation, and the percentage of assessed homes that received one or both key program measures.

Specifically, the study found:

- The MA and RI model delivered more savings per assessed household than the CT model, which buoys cost-effectiveness given the relatively fixed cost of completing assessments.
- The MA and RI model encouraged a larger percentage of participants to act on their insulation recommendations, which generates greater overall savings and supports cost-effectiveness.
- The CT model, which enabled and incentivized contractors to deliver air sealing savings during the initial assessment, resulted in a larger proportion of assessed homes receiving air sealing relative to MA and RI albeit with lower average air sealing savings per home (again relative to MA and RI).

These points collectively suggest that the MA and RI program model delivers more savings at lower cost than the current CT model.

However, adopting some of the recommendations included in this study could lead to higher average air sealing and insulation savings in CT and, most importantly, more CT participants that would receive a recommendation for and install insulation. Making these improvements could fundamentally change the program delivery comparison across states.

Ultimately, while the evaluation metrics above offer essential information for assessing optimal program delivery, this study cannot offer a definitive recommendation regarding optimal program delivery. This is because the question is not purely an evaluation one. Such a decision requires balancing critical non-evaluation factors such as statewide policies, energy savings goals, and equity that lay outside the domain of this study summarized below:

- **CT has a policy goal to weatherize 80% of homes by 2030.** That is a policy argument for conducting air sealing in as many assessed homes as possible. However, the question that needs to be addressed is whether the air sealing-only savings levels achieved by the current program will meet the greenhouse gas goals and can then be considered as being “weatherized”. (Stakeholders are continuing to define “weatherized” as it relates to this goal.) Definitional issues aside, it is clear HES and HES-IE are essential vehicles for helping meet the 2030 goal. As such, it’s critical that the air sealing and/or insulation services delivered through the programs align with the yet-to-be-determined weatherization definition and, more broadly, help the state meet its greenhouse gas goals.
- **Equity is another policy element that plays into this decision**. The State has a goal to ensure equitable access to energy efficiency and solar energy for all households. Weatherizing more homes, even at a lower level, may be an important component contributing to this goal. This study’s customer profiling effort observed a positive correlation between energy program participation and income. This finding is consistent with industry-wide studies.[26]

[26] https://eta-publications.lbl.gov/sites/default/files/ee_program_participation.pdf

Finding 4: Unlike air sealing and insulation, the study generally found high gross savings and NTG results for most other measures.

Air sealing and insulation constitute more than three-quarters of HES and HES-IE lifetime savings and, as determined through this study, showed a substantial drop in savings. For these reasons, those key measures justified significant attention as part of this study. However, both programs offer a wide variety of other measures, which, unlike air sealing and insulation, generally met gross and net savings expectations.

Table 4 summarizes the study's ex post savings and resulting realization rates for all HES and HES-IE measures. For most measures, the provided data enabled the study to estimate program-specific savings and realization rates. For the other measures, none of which constitute more than 1% of either program's total savings, the team calculated a single gross saving value applicable for both programs.

Table 4: Ex Post Savings and Realization Rates by Program, Measure, and Fuel

Measure Group	Measure	% Total Savings HES/ HES-IE∞	Electric		Natural Gas		Oil		Propane	
			HES & HES-IE		HES & HES-IE		HES & HES-IE		HES & HES-IE	
			kWh	RR	CCF	RR	gal	RR	gal	RR
Appliances & Plug Load	Refrigerator*,©	<0.1 / 2.0	404	N/A						
	Freezer*,©	0.1 / 0.3	145	N/A						
	Dehumidifier*,©	0.1 / < 0.1	218	N/A						
	Clothes Washer*,©	0.2 / < 0.1	189	N/A	3.9	N/A	4.9	N/A	7.4	N/A
	Advanced Power Strips*	<0.1 / < 0.1	117	N/A						
Heating Equipment	Heat Pump – Ducted (heating)	<0.1 / < 0.1	1723	100%						
	Heat Pump – Ducted (cooling)	Included in heating	279	100%						
	Heat Pump – Ductless (heating)	0.5 / <0.1	918	100%						
	Heat Pump – Ductless (cooling)	Included in heating	260	100%						
	Furnace Replacement	<0.1 / < 0.1			109	96%	81	96%	123	96%
	Boiler Replacement	<0.1 / 3			87	98%	64	98%	98	98%
	ECM Circulator Pump*	0 / 0.5	68	100%						

Measure Group	Measure	% Total Savings	HES		HES-IE		HES		HES-IE		HES		HES-IE		HES		HES-IE	
			kWh	RR	kWh	RR	CCF	RR	CCF	RR	gal	RR	gal	RR	gal	RR	gal	RR
Domestic Hot Water	Faucet Aerators	0.6 / 0.5	38	100%	35	100%	1.6	100%	1.5	100%	1.2	100%	1.1	100%	1.8	100%	1.7	100%
	Showerhead	1.4 / 1.0	126	100%	149	100%	5.3	100%	6.2	100%	3.9	100%	4.6	100%	5.9	100%	7.0	100%
	Pipe Insulation	1.6 / 0.4	16	100%	15	100%	0.7	100%	0.7	100%	0.5	100%	0.5	100%	0.8	100%	0.7	100%
Lighting	Lighting**	18.4 / 19.2	18	44%	17	91%												
Controls	Wi-Fi Thermostat (Heating)*	2.3 / 1.3	386	N/A	372	N/A	30	N/A	38	N/A	22	N/A	28	N/A	34	N/A	43	N/A
	Wi-Fi Thermostat (Cooling)*	Included in heating	37	N/A	37	N/A												
Weatherization	Air Sealing Infiltration Reduction (Blower Door Test)	49.1 / 29.5	106	9%	69	4%	17	17%	11	10%	14	18%	9.5	11%	23	22%	15	16%
	Air Sealing Infiltration Reduction (Prescriptive)	1.7 / 1.9	101	9%	27	4%	6.2	17%	4.3	10%	5.2	18%	2.6	11%	6.4	22%	5.3	16%
	Insulation – All	15.9 / 32.4	480	27%	677	19%	60	50%	97	46%	65	67%	91	101%	105	69%	147	102%
Distribution	Duct Sealing	8.0 / 1.8	55	11%	54	5%	8.8	12%	8.6	8%	7.4	13%	7.2	12%	12.0	18%	11.7	24%
Windows	Windows	0.4 / 6.3	56	100%	71	100%	2.9	100%	5.5	100%	2.1	100%	4.0	100%	3.2	100%	6.0	100%

Key	*Billing Analysis*	*Engineering Algorithm*	*Engineering Adjusted Billing Analysis*	*Billing Analysis Informed Engineering Algorithm*

*Deemed measures; gross realization rates are not applicable.

** Unlike other savings in this table, the lighting savings are net as the results of billing analyses for residential lighting should be interpreted as net, not gross, savings.

© Per the PSD algorithm, the savings for these appliances combines lost opportunity and retirement savings.

∞ Reflects contribution toward to total ex ante annual savings generated in 2019 by the mix of measures delivered through the program that year.

Table 5 summarizes the measure-specific gross realization rates in the previous table by program and fuel-type. These program-level and fuel-specific gross realization rates are primarily driven by the lower-than-anticipated air sealing and insulation measures.

Table 5: Fuel-Specific and Overall program Gross Realization Rates

Program	Electricity		Natural Gas		Delivered Fuels		Overall	
	% of Lifetime Savings	GRR	% of Lifetime Savings	GRR	% of Lifetime Savings	GRR	% of Lifetime Savings	GRR
HES	10.3%	**39.5%**	31.3%	**29.0%**	58.3%	**34.0%**	100%	**33.0%**
HES-IE	8.3%	**82.3%**	50.3%	**33.5%**	41.3%	**66.2%**	100%	**51.1%**

With regard to net savings, the study found overall weighted NTG ratio of 84% for HES (Table 6); NTG is not applicable for HES-IE.[27] Overall, measure-specific NTG rates, detailed in Section 5, were generally high and free-ridership values were similar to other studies, particularly in Massachusetts, which used a similar NTG algorithm to this study.

Table 6: Overall HES Net-to-Gross (NTG) Ratio

Ratios and Ratio	HES
Weighted free-ridership rate	23%
Weighted spillover rate	7%
Net-to-gross ratio	84%

Recommendations for Addressing Finding 4: High realization rates and NTG estimates for most non-air sealing and insulation measures.

RECOMMENDATION 4A. Apply the recommended PSD changes documented in Appendix F as part of the next PSD update. The realization rates in Table 4 rely on the current PSD algorithms and inputs. Through this evaluation, the study identified a handful of instances where a PSD algorithm would benefit from a correction or where an input value could be improved. Making these recommendations in the PSD will result in more accurate ex ante savings as part of prospective program cycles and improve realization rates resulting from future evaluations.

Finding 5: Financial and logistical barriers impede the statewide weatherization goals.

At least 7% of HES and 19% of HES-IE participants from 2017 to 2020 had a health and safety barrier that affected their assessment. Survey respondents self-reported barriers at a higher rate than recorded in the program tracking data:12% of HES and 31% of HES-IE survey respondents reported a health and safety barrier. Moderate-income HES participants had higher rates of health and safety barriers than other HES participants with household incomes greater than 80% area median income (AMI). Ten percent of households with incomes falling within 60%

[27] The overall NTG ratio excludes LED lighting, which was no longer provided through the HES program in the 2022-2024 term; however, the Companies continue to provide LEDs to HES-IE participants. The overall NTG ratio with lighting included was 83%.

SMI to 80% AMI had asbestos or vermiculite insulation, compared with 6% of households with incomes greater than 80% AMI.

Cost is a significant barrier to both remediating health and safety barriers and installing additional measures following the assessment. Nearly one-quarter of HES-IE participants (23%) and 7% of HES participants reported having asbestos or vermiculite insulation. HES-IE respondents who did not remediate the asbestos or vermiculite insulation (69%) cited cost and landlord permission as the most common barriers.

Demand for remediation assistance likely exceeds available funding. The Statewide Weatherization Barrier Remediation Services Program launched by DEEP in 2022 is designed to serve 1,000 low-income customers in its first year.[28] However, survey results indicated that nearly 4,500 single-family HES-IE households that participated from 2017 to 2020 might be waiting for remediation services for asbestos or vermiculite insulation. This is a conservative estimate; it excludes households that have other health and safety barriers, including mold, all multifamily households, and households with barriers who received assessments in 2021 or 2022. Nearly 70% of HES-IE survey respondents with asbestos or vermiculite insulation found during their assessments (2017 – 2020) indicated they had not yet pursued remediation.

Cost was a leading deterrent for rebated measure installation and awareness of financing options was limited. One-fifth of respondents that did not install insulation, HVAC measures, or a water heater following the assessment said that the measure was too expensive. While participants utilized incentives and financing to afford installations of more expensive equipment installs, such as heat pumps, awareness of financing options was limited. Only one-half of HES respondents (51%) and 28% of HES-IE respondents indicated they were aware of financing options available through the program.

Vendors and community stakeholders doubted that the state of Connecticut will meet its goal of weatherizing 80% of all residential units in 2030 without significant changes in program funding, incentives, and workforce development. WAP also struggles to find qualified auditors and contractors to complete the work, leaving unspent program funds on the table.

Qualified technicians are in demand but scheduling on-the-job training can be difficult. Program stakeholders acknowledged challenges in managing a diverse group of program vendors, many of which were trying to grow their workforce while maintaining quality control. Vendors expressed concern about maintaining a fully staffed workforce while balancing program training requirements with keeping up with home energy assessments. Vendors requested additional assistance from the program in training new technicians. (See Training and Workforce Development for more details).

[28] Department of Energy and Environmental Protection (DEEP). June 23, 2022. “DEEP Launches ICAST Partnership to Deliver Weatherization Barrier Remediation Services to Connecticut Families.” https://portal.ct.gov/DEEP/News-Releases/News-Releases---2022/DEEP-Launches-ICAST-Partnership-to-Deliver-Weatherization-Barrier-Remediation-Services.

Recommendations for Addressing Finding 5: Financial and logistical barriers impede the statewide weatherization goals.

RECOMMENDATION 5A. Expand the Statewide Weatherization Barriers program to serve the needs of low- and moderate-income customers. The Residential Energy Preparation Services (REPS) program began in 2022 with a mandate to serve 1,000 low-income households with $12.3 million in federal funds, at an average cost per unit of $11,700.[29,30]If the program is successful, expand its mandate to other income-eligible households waiting for services and moderate-income households that may also face financial barriers to remediation. Homes with health and safety barriers only receive complementary air sealing and cannot benefit from additional savings through the program.

RECOMMENDATION 5B. Work with existing vendors and contractors to increase training opportunities, recruit new technicians, and conduct outreach to technical schools. Trained technicians and installation contractors are vital to the HES and HES-IE program. Provide compensation for program vendors to complete training through the program. Vendors identified a need for sales training to help technicians persuade participants on the benefits of installing additional measures through the program during the kitchen table wrap-up. Adequate staffing levels are also vital for program success. Consider a model utilized by the sponsors of Mass Save to partner with local community-based organizations to develop the workforce for energy-efficiency programs: Clean Energy Pathways and the Workforce Partnership Grant.[31]

Finding 6: Certain customer segments face additional barriers to participation in HES and HES-IE.

Stakeholders suggested some customer segments are underserved by the program, including low-income and moderate-income customers, renters, rural customers, customers with limited English proficiency, elderly customers, and immigrant customers. (See Participation and Awareness for additional details.)

Program participants are more highly educated and younger than households in the general population. Comparison of survey results to census data suggests that HES/HES-IE program participants were more likely to have a bachelor's degree or higher, suggesting that participants may also skew wealthier. Households with an occupant aged 65 or older were also underrepresented among survey respondents. However, the racial composition of survey respondents was similar to estimates from the census, suggesting the program is successfully reaching a diverse set of customers.

Barriers to participation in HES or HES-IE among equity-related demographic groups included difficulty affording health and safety remediation, installing additional measures, accessing program information, and scheduling assessments. As the participant survey

[29] DEEP. "DEEP Launches ICAST Partnership to Deliver Weatherization Barrier Remediation Services to Connecticut Families." June 23, 2022. https://portal.ct.gov/DEEP/News-Releases/News-Releases---2022/DEEP-Launches-ICAST-Partnership-to-Deliver-Weatherization-Barrier-Remediation-Services.
[30] DEEP. "Residential Energy Preparation Services." https://portal.ct.gov/DEEP/Energy/Conservation-and-Load-Management/Weatherization-Barrier-Mitigation. Accessed May 2023.
[31] Mass Save. "Communities." https://www.masssave.com/partners/community. Accessed March 2023.

focused on single-family households, these findings complement, rather than contradict, the customer profile finding (Finding 8) that large multifamily locations are driving participation in areas with populations of underserved customers.

Program marketing and word-of-mouth referrals are the primary sources of program awareness among current participants. Over one-half of respondents (59% of HES respondents and 54% of HES-IE respondents) learned about the program through program marketing, including the Energize Connecticut website, bill inserts, utility company websites, and/or utility advertisements. Approximately one-quarter of participants (25% of HES respondents and 23% of HES-IE respondents) learned about the programs from family or friends.

Community stakeholders suggested the Companies shift their outreach focus away from Company marketing efforts to community outreach efforts. Stakeholders representing communities with underserved populations identified gaps in program outreach, implying that some of the resources the Companies are spending on traditional marketing, such as bill inserts and advertisements, should be spent directly in communities to engage trusted messengers, including local institutions and community members. The program is currently succeeding in reaching customers that have higher trust in utilities and can be engaged by traditional marketing efforts. Some communities may not respond to messaging from utilities or government-affiliated agencies. The Community Action Agencies (CAAs) that administer HES-IE are responsible for community outreach, but stakeholders agreed that these efforts are absent or nonexistent in some communities. Stakeholders suggested empowering community organizations, including schools, local community groups, non-profits, and community events to spread awareness of HES and HES-IE. Word-of-mouth is an effective referral strategy for HES and HES-IE. Improving the program experience for HES-IE customers could improve the positive messaging around the program and result in more referrals to the program.

Recommendations for Addressing Finding 6: Barriers to Participation

RECOMMENDATION 6A: Remove barriers to participation for customers with limited English proficiency by providing vendors with access to a language line and use of other language technologies. HES-IE program materials are available in English and Spanish, while HES program materials are available only in English. In order to effectively engage participants of both programs, technicians need to clearly explain the assessment to customers and provide information about additional opportunities, rebates, and next steps.

RECOMMENDATION 6B: Expand eligibility for HES-IE or consider targeted program offerings for moderate income customers. Fewer HES customers with incomes less than 80% of AMI are installing rebated measures (15%) than other HES participants (29%) but are not eligible for free or more deeply discounted measures available to low-income participants.

RECOMMENDATION 6C: Offer assessments on evenings or weekends to accommodate customers who are unable to take off work during the weekday. Community stakeholders suggested this program change because some customers work multiple jobs or cannot afford an unpaid day off work. This study did not include a non-participant survey and could not quantify the number of potential customers excluded due to incompatible schedules.

RECOMMENDATION 6D: Divert resources from traditional marketing campaigns community outreach efforts. Work with local institutions and organizations to spread awareness about the program in communities. Company-branded marketing efforts have successfully engaged some participants, but utilities are not trusted messengers for other communities. To reach them, the program should utilize the principles of Community-Based Social Marketing to engage communities that do not respond to traditional marketing efforts, such as bill inserts, radio or television campaigns, or E-mail.[32] Community Action Agencies are likely well positioned to expand their outreach efforts to include these community sources. Schools, community organizations, and neighborhood associations, and community events could provide valuable opportunities to spread awareness of program offerings, answer questions, and address any concerns. Consider utilizing models similar to these offerings by the Sponsors of Mass Save, the Community First Partnership and the Community Education Grant.[33]

Finding 7: Overall satisfaction among vendors and HES participants is high, with room to improve program communication and messaging, particularly for HES-IE participants.

Vendors expressed overall satisfaction with the program and their role promoting energy-efficiency and weatherization services to customers, while seeking improvements to certain program requirements and the quality inspection process.

HES participants report higher overall satisfaction with the program (81%) than HES-IE participants (68%). Program satisfaction is similar to levels observed during the 2016 evaluation of the program, which found that 80% of HES participants and 72% of HES-IE participants were satisfied with their experience with the program. HES-IE participants reported higher levels of dissatisfaction with the professionalism and service provided by technicians (13%, compared to 4% of HES participants). One in five HES-IE participants expressed dissatisfaction with the energy savings from their assessment (20%), compared to 11% of HES participants.

The program can improve information sharing with participants during and after the assessment. Nearly one in ten HES respondents (8%) and one-fifth of HES-IE respondents (18%) expressed dissatisfaction with information provided to them about energy-savings opportunities during the assessment or the kitchen table wrap-up. The majority of these respondents said the technician and/or the assessment itself was not very informative.

In particular, HES-IE participants were frustrated that they did not receive recommendations or information directly from the technician. In the HES-IE model, technicians submit paperwork directly to the Companies to determine eligibility for add-on measures.

Some participants had issues scheduling an assessment. While satisfaction was high overall, five percent of survey respondents had issues with their assessments being canceled or rescheduled, waiting to schedule an appointment, or contacting customer service.

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[32] University of Pennsylvania. "Your Quick Guide to Community-Based Social Marketing." https://sustainability.upenn.edu/sites/default/files/legacy/Guide%20to%20Community-Based%20Social%20Marketing.pdf. Accessed March 2023.
[33] Mass Save. "Communities." https://www.masssave.com/partners/community. Accessed March 2023.

Home comfort is an important motivation for participating. Half of all respondents said they participated in HES or HES-IE to find ways to make their home more comfortable. While savings on a utility bill can be difficult to perceive when energy costs increase, improvement in home comfort is a tangible non-energy benefit that can increase satisfaction and be used to encourage customers to act on the recommendation to install insulation.

Recommendations for Addressing Finding 7: Improve participant experience by increasing engagement during and after assessments.

RECOMMENDATION 7A: Ensure technicians walk through the findings of the assessment and next steps with HES-IE participants and consistently follow-up with next steps. While HES participants need to apply for rebated measures following their assessment, HES-IE participants are eligible for additional services directly from the program. This program model may lead some vendors to sign up HES-IE participants for all the add-on measures they are eligible for without the benefit of a kitchen table wrap-up because there is no need to convince the HES-IE participant of the benefits before they receive the energy-saving measure. This may leave some HES-IE participants dissatisfied with their experience and unsure about the next steps.

RECOMMENDATION 7B: Improve customer service experiences for customers looking to schedule an assessment or receive additional information. Ensure prompt response times when a customer calls customer service or uses the WISE USE hotline to schedule an assessment.

RECOMMENDATION 7C: Follow up with all participants to remind them about recommended measures and provide additional information. Encourage vendors to follow up with customers after their assessment to answer any questions and make sure the customer is aware of how to proceed with accessing additional energy savings opportunities, including referrals for installation services if applicable. As in Recommendation 2A above, offer additional financial incentive for vendors to engage with customers beyond the assessment to increase installation of rebated measures. The Companies can also send reminders via mail and/or email to remind customers how to take action to increase the savings from their assessment.

Finding 8: Virtual audits offered during the pandemic had limited uptake, which resulted in 25% lower savings.

Few participants opted to receive virtual audits. Only 12% of HES participants who received an assessment after March 2020 indicated they had received a virtual audit, or pre-assessment, offered by the program following the onset of the COVID-19 pandemic. More than three-quarters of participants who self-reported receiving a virtual audit (n=23) were satisfied with the experience (82%) and did not report any issues following the technician's instructions during the audit. According to the Energize Connecticut website, virtual pre-assessments are still available for current participants.[34]

[34] Energize Connecticut. "Virtual Pre-assessment: Home Energy Solutions." https://energizect.com/energy-evaluations/home-energy-solutions-virtual-pre-assessment. Accessed March 2023.

Participants who self-reported receiving a virtual audit had lower average ex ante savings reported in the program tracking data (7.7 MMBtu) than those who did not report having part of their assessment conducted virtually (10.3 MMBtu), a 25% difference. The survey did not ask participants who had not received a virtual audit to explain why they had elected not to do so. The lower savings rate for recipients of a virtual audit could be due to differences in quality of services delivered in the virtual audit format, lower engagement with the program, or participant unwillingness to permit additional contractors in their home to install add-on measures during the pandemic.

Vendors also did not favor virtual audits, citing frustration with the fact that there was still an in-person component to conduct air sealing and other core services. According to vendors, customers would often not schedule the in-person visit to complete the assessment, the program did not adequately compensate vendors for the added effort involved, and spotty internet service could complicate delivery of the virtual audit.[35]

Recommendations for Addressing Finding 8: Increasing Value of Virtual Assessments

RECOMMENDATION 8A: Consider adopting stricter guidelines for virtual audits to ensure access to savings opportunities and compensating vendors for the additional time needed to conduct the virtual pre-assessment. Blower door-guided air sealing, duct sealing, and hot water-saving devices cannot be offered during a virtual pre-assessment. Any virtual pre-assessment that is not followed by an in-home follow-up visit will achieve lower savings than a traditional assessment. Offering the virtual pre-assessment separately than an in-home visit can nearly double the work for a vendor to serve a single site and should be compensated accordingly.

Finding 9: Collectively, the residential single-family and multifamily income eligible programs are effectively reaching disadvantaged households.

The percent of total savings from the income-eligible programs is about the same as the percent of low-income households (single-family and multifamily). The U.S. Census classifies approximately one-fourth (27%) of the households in Census block groups that receive electric service as low-income, and about 30% of households with gas service as low-income (Table 7). The proportion of total savings from the income-eligible programs (Table 8; includes multifamily) is approximately the same as the proportion of low-income households in both cases (33% for electric and 32% for gas). This pattern indicates that at the broadest level of analysis, savings from the energy efficiency programs are distributed the same as population distributions.

Due to data limitations, the study can only provide insight into electric and gas first year savings. Delivered fuel savings and lifetime savings could not be analyzed.

[35] There were too few participants who self-reported receiving a virtual audit after March 2020 to compare satisfaction (n=21) with other participants; however, 82% of the participants reported satisfaction with their experience with the virtual audit.

Table 7: Household Distributions by Income Level

Household income	Percent of Homes in Census Block Groups with Electric Service	Percent of Homes in Census Block Groups with Gas Service
Moderate or higher income	73%	70%
Low income	27%	30%

Table 8: Savings* Distributions by Program Type

Programs	Electric Savings (kWh)	Gas Savings (CCF)	Electric Savings (%)	Gas Savings (%)
Non-Income-Eligible	125,814,158	7,106,794	67%	68%
Income-Eligible	61,294,181	3,413,870	33%	32%
Total	187,108,339	10,520,664	100%	100%

*Single-family and multifamily savings both included

The residential portfolio, overall (not just HES & HES-IE), is successfully reaching areas with high concentrations of equity-related demographics. Table 9 shows that areas with high concentrations of limited English proficiency, low-income households, multifamily housing, renters, and that were on the state-wide distressed areas list in 2018, 2019, or 2020 all tended to have greater electric and gas savings from the portfolio as a whole, relative to the consumption in those areas. A positive correlation indicates that areas where there are a higher percentage of households with that characteristic tend to have higher savings rates. A negative correlation indicates that areas that have a higher percentage of the characteristic tend to have lower savings rates (and vice versa). For example, the 0.199 correlation for Low Income and Electric Savings rate indicates that areas with relatively higher percentages of low income households tended to have higher savings rates.

The savings rate variable is calculated by dividing total program savings in a Census block group by the total consumption in that block group. Due to data limitations, the study can only provide insight into electric and gas first year savings. Delivered fuel savings and lifetime savings could not be analyzed.

Table 9: Correlations Between Demographics and Savings Rates (Residential Portfolio Participation)

Demographic variable	Whole Portfolio Electric Savings rate	Whole Portfolio Gas Savings rate
Limited English	0.142 *	0.071 *
Low income	0.199 *	0.097 *
Moderate income	0.009	0.034
High income	-0.182 *	-0.007
Multifamily housing	0.337 *	0.193 *
Single-family housing	-0.236 *	-0.109 *
Renter-occupied housing	0.242 *	0.108 *
Construction year pre-1950	-0.009	-0.069 *
Distressed 2018, 2019, 2020	0.103 *	0.021

*Correlation is statistically different from 0 ($p<0.01$)

Finding 10: The residential program portfolio is reaching disadvantaged areas through locations with unusually high savings and the income-eligible (IE) programs.

When unusually high-saving sites are removed from the portfolio, disadvantaged areas tend to have lesser savings from the portfolio. Approximately 30% of program savings occurred at sites with unusually high (top 1%) site-level savings. Satellite imagery confirmed that many of the unusually high-savings locations are large multifamily properties with over 100 units. Thus, it appears that a substantial portion of savings are coming from large multifamily properties where a large number of individual units were treated, but the savings were recorded to a single unit in those properties. There was no way to disaggregate the number of units actually treated with the available data. When these sites are removed, disadvantaged areas tend to have lesser savings rates from the portfolio (Table 10). Not all multifamily locations exhibit this issue, so this finding does not apply to all multifamily locations.

Table 10: Pairwise Correlations – Unusually High-saving Sites Removed

	Electric Saving Rate	Gas Saving Rate
Limited English	-0.125 *	-0.099 *
Low income	-0.138 *	-0.101 *
Moderate income	0.035	0.010
High income	0.075 *	0.039
Multifamily housing	-0.312 *	-0.162 *
Single-family	0.244 *	0.168 *
Renter-occupied housing	-0.234 *	-0.184 *
Pre-1950 construction	-0.007	-0.048
Distressed last three years	0.050	0.013

* Correlation is statistically different from 0 (p<0.01)

Disadvantaged areas tend to have lower savings from the non-income-eligible (Non-IE) programs. Table 11 shows that areas with high concentrations of: limited English proficiency, low-income households, moderate-income households, renters, and that were on the statewide distressed areas list in 2018, 2019, or 2020 all tended to have lesser electric and gas savings from the Non-IE programs to the consumption in those areas.

Table 11: Pairwise Correlations – Non-IE Programs

	Electric Saving Rate	Gas Saving Rate
Limited English	-0.063 *	-0.116 *
Low income	-0.076 *	-0.166 *
Moderate income	-0.044 *	-0.049 *
High income	0.054 *	0.149 *
Multifamily housing	0.103 *	-0.013
Single-family	0.002	0.128 *
Renter-occupied housing	-0.005	-0.132 *
Pre-1950 construction	-0.085 *	-0.159 *
Distressed last three years	-0.094 *	-0.182 *

* Correlation is statistically different from 0 (p<0.01)

Finding 11: Despite reaching disadvantaged areas generally, the portfolio underrepresents rural areas and single-family, low-income households.

Across the whole portfolio, electric and gas savings are concentrated in the urban areas. Figure 10 and Figure 11 show the geographic concentrations of electric and gas savings, respectively. The figures show that customers in urban areas disproportionately participated in residential programs relative to more rural portions of the state. The study found that residential portfolio-level savings rate (i.e., total first year program savings occurring in a census block group divided by the total consumption in that block group), is concentrated in urban areas. This metric inherently controls for differences in population levels across block groups (via total energy consumption), so the observed concentrations are not simply a product of more customers living in urban areas. Undeveloped areas (e.g., lakes) and areas without utility service are whited out. Delivered fuels participation is not included in the map.

Figure 10: Electric Savings Rate 2017 – 2020

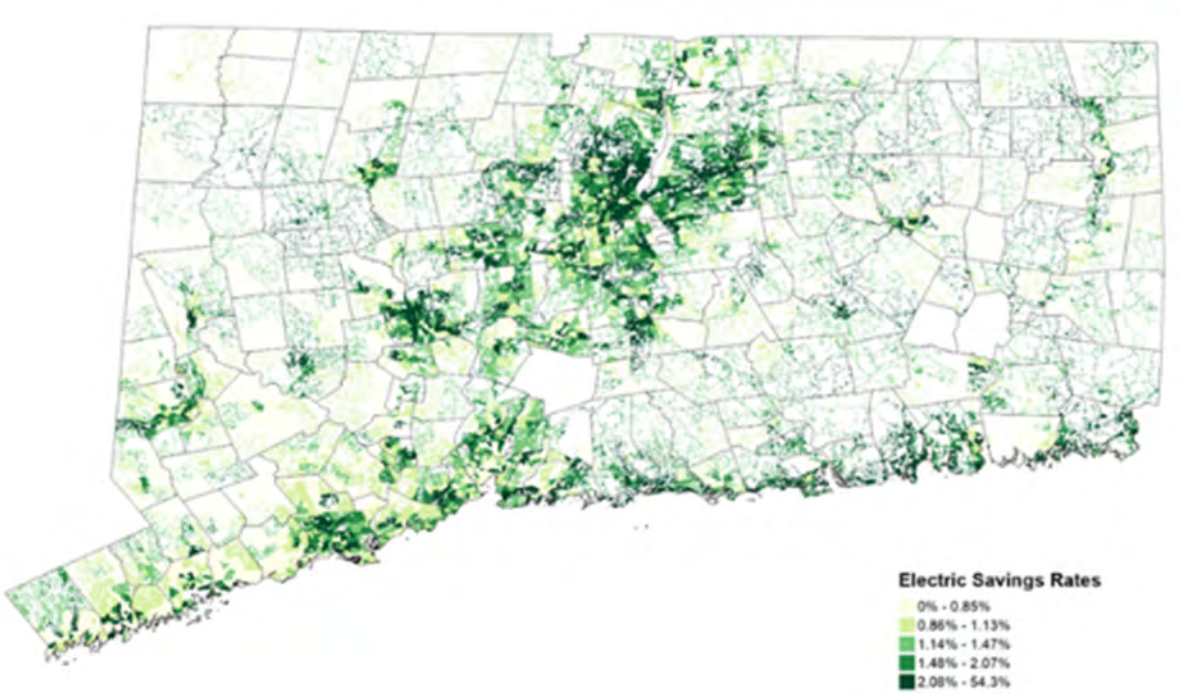
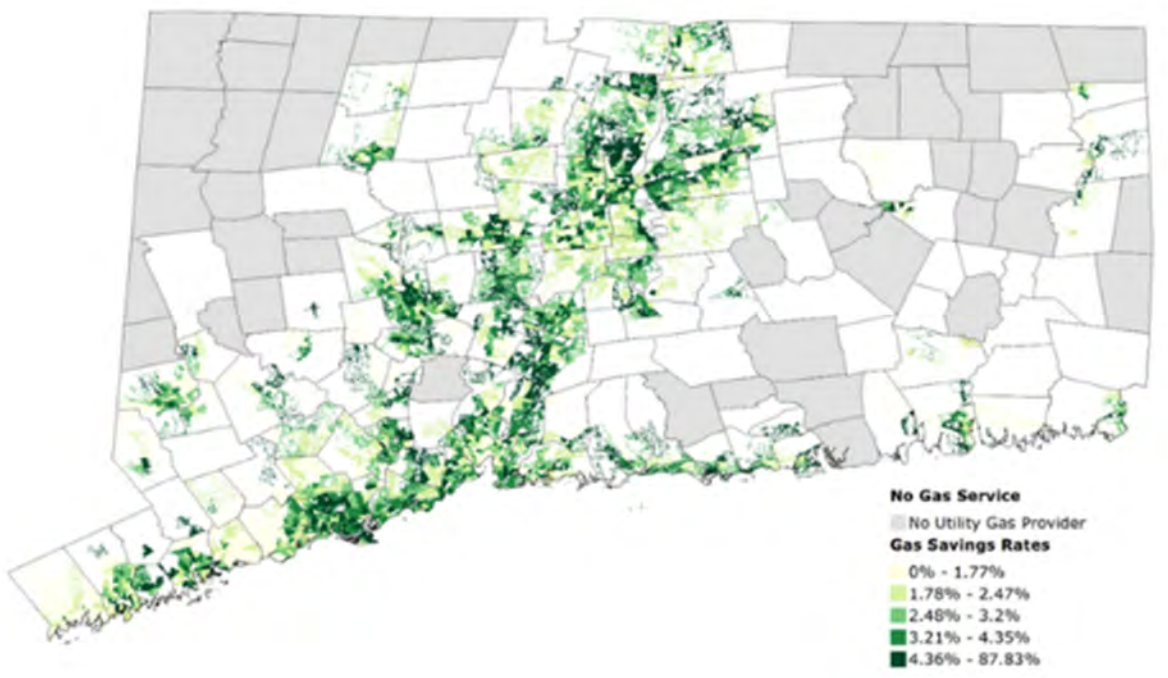


Figure 11: Gas Savings Rate 2017 – 2020



Low-income, single-family households are somewhat under-enrolled in the IE electricity programs. Table 12 shows the distributions of households and IE program electric savings across census block groups that are above and below the median proportions of low-income and single-family households. IE program electric savings were disproportionately concentrated in low-income, multifamily areas. Approximately 41% of households were in these areas, while 72% of IE program electric savings occurred in these areas. Low-income, single-family areas were somewhat underserved: 9% of households were in these areas while only 6% of the electric savings occurred there.

Gas savings showed a similar pattern as electric savings except low-income, single-family areas appeared to be receiving about the same amount savings as the number of households: 9% of households were in these areas and 10% of the gas savings occurred there.

Table 12: IE Electric Savings Distributions

Label	Concentration of Low-income homes	Concentration of Single-family homes	% of Households	% of IE electric savings	% of IE gas savings
High-income, multifamily	Low	Low	11%	7%	7%
High-income, single-family	Low	High	39%	14%	13%
Low-income, multifamily	High	Low	41%	72%	70%
Low-income, single-family	High	High	9%	6%	10%

Recommendations Related to Findings 9 - 11: Reaching Diverse Customer Segments

The study offers multiple recommendations for extending the Companies' reach and overcoming remaining barriers to more equitable participation:

RECOMMENDATION 9A: Create program designs that dedicate more resources to renters and rural areas of the state. Reaching renters is a continuous challenge for all programs due to issues with split incentives, permissions, and access. Rural areas are also challenging because of lower population densities and, often, fewer qualified contractors to complete energy-efficiency projects, which make the cost of enrollment higher in these areas. The Companies will have to take care to maintain program cost-effectiveness requirements while reaching these more-difficult-to-serve customer and location segments.

RECOMMENDATION 9B: Devote additional income-eligible program resources to enrolling single-family homes. There was generally a greater administrative cost to enrolling these homes per unit of savings, so care should be taken to maintain cost-effectiveness requirements.

Finding 12: Significant delays in data request fulfilment and data quality issues adversely impacted the timeliness of this study and its ability to inform the planning process.

The study submitted its initial data request to the Companies in August 2020. The study also submitted a updated data request in January 2021 following a data-focused call between the study and Companies. It took until February 2022 and more than 200 data request related communications for the Companies to provide the data necessary to complete the process, impact, and customer profiling tasks scoped for this study. The significant delay fulfilling the study's data requests had a commensurate impact on the study's timeline and budget. There is always a lag between evaluated participation cohorts and evaluation reports, especially when using a billing analysis that requires at least a full year of post-participation data, but the delays in data request fulfillment resulted in the difference between the evaluated HES & HES-IE cohort (2019) and the study completion (2023) being much greater than planned.

In addition to these delays, the study encountered issues with the data itself including, but not limited to multiple and inconsistent unique customer identifiers, masked account numbers, incomplete measure details, disparate data structures, and a lack of data dictionaries. In general, the study encountered more issues in the collection and processing of UI data relative to

Eversource. Collectively, these data issues across both companies limited the study's ability to provide greater visibility into some findings. The data issues encountered as part of this study are described in greater detail in Appendix G.

Recommendations Related to Finding 12: Improving data delivery that undermine timeliness of the evaluation work.

The study offers multiple recommendations for extending the Companies' reach and overcoming remaining barriers to more equitable participation:

RECOMMENDATION 12A: Improve the rigor of data collection and management, as well as Data consistency between Eversource and UI. Specifically, both companies should:

- Use data validation to force a standard for recording key customer information such as account numbers and addresses.
- Regularly audit data to ensure that vendors are using data fields properly.
- Consider specific quality control and assurance procedures that include financial penalties and rewards related to data completeness and integrity.
- Establish a process for storing data queries related to evaluation studies that the Company can leverage and replicate such that they can reissue data request updates in the consistent format (UI specifically; not an issue for Eversource).[36]
- Require distributors and contractors applying for instant rebates on behalf of their customers to record customer contact information to better track customer participation and uptake of energy efficient measures.
- Include the number of treated units in tracking data associated with multi-unit and/or multifamily buildings.

[36] In response to DEEP's Condition of Approval of the 2022-2024 CL&M Plan, UI has been working towards developing and updating a data dictionary for customer and program data. https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Attachment-A---Schedule-of-2022-2024-Conditions-of-Approval.pdf

Section 1 About HES and HES-IE

To make the greatest use of this study's findings, it's important that readers understand how HES and HES-IE are delivered, the measures promoted, and recent trends in participation.

1.1 Program Descriptions

Home Energy Solutions ("HES") and Home Energy Solutions – Income Eligible ("HES-IE") are Connecticut's flagship residential retrofit energy-efficiency programs within the Connecticut Energy Efficiency Fund ("CEEF") residential program portfolio. Both programs are amongst the state's largest residential efforts in terms of both program budgets and annual energy reduced (MMBtu).[37] The programs help homeowners and rental property owners conduct home energy assessments, learn about ways to make their homes more energy-efficient and comfortable, and carry out energy efficiency upgrades.

As a reminder, this evaluation focused on the single family element of HES and HES-IE. Both programs also serve multifamily buildings, which is not covered by the scope of this study.

During the home energy assessments, technicians provide core services, which could include directly installing LEDs, faucet aerators, showerheads, blower-door-guided air sealing, and/or duct sealing. HES customers pay a nominal fee for these services, ($75 to $174, depending on the program year) whereas HES-IE customers receive them at no cost. [38] Technicians also examine homes for hazardous materials and unsafe conditions, e.g., asbestos, mold, and gas leaks.

HES & HES-IE technicians conduct comprehensive air sealing as part of the initial assessment*. This is different from similar assessment-based programs in neighboring states where weatherization contractors only conduct air sealing during follow-up visits to the subset of participants that decide to install insulation. As a result, nearly all HES & HES-IE participants receive air sealing, while a minority of participants in similar programs do.*

After providing core services, technicians turn to a "kitchen table sales effort," in which they review completed work with customers, educate them on how to make their homes more efficient and comfortable, then provide them with information and/or professional referrals to install rebated (HES) or add-on (HES-IE) measures.

As indicated in Table 13, add-on measures include ENERGY STAR-certified appliances (refrigerators, freezers, dehumidifiers, clothes washers), building envelope upgrades (insulation and windows, double-pane or better), Wi-Fi thermostats, heat pumps (air-source, geothermal, or ductless mini-splits), and other HVAC equipment replacement (central air conditioners, natural gas furnaces and boilers). The idea driving both programs, that the assessments are an entry

[37] https://energizect.com/connecticut-energy-efficiency-board/about-energy-efficiency-board/annualreports. Accessed August 2022.
[38] Throughout the study period, the co-pay increased from $124 in 2017, to $149 in 2018 ($174 for oil and propane-heated homes), and eventually decreased to $75 for all fuels in 2020 (see HES Co-Pay in Appendix B).

point to pursue deeper savings, makes the kitchen table conversation integral. Participants who choose to install add-on measures are usually eligible for rebates, financing, or both. For HES-IE participants, vendors obtain multiple quotes and submit them for screening before the program approves them.

Some HES-IE participants receive services through the Weatherization Assistance Program (WAP). The program strives to provide participants with the most comprehensive services possible and engages in cost-sharing with WAP to provide additional services for eligible customers.

Both HES and HES-IE participants also receive a comprehensive HES Customer Report and a DOE Home Energy Score report.[39] The latter provides customers with a visual aid that explains how they could capture deeper energy savings from upgrades to their home.

1.2 PROGRAM MEASURES

At the outset of R1983, the study worked with the Companies to categorize the detailed measure data provided in the HES and HES-IE tracking data into 19 discrete measures associated with eight measure categories.

Table 13: HES & HES-IE Measures[40]

Measure Group	Measure
Domestic Hot Water	• Faucet Aerators • Showerhead • Pipe Insulation
Lighting	• Lighting
Controls	• Wi-Fi Thermostats*
Appliance & Plug Load	• Refrigerator* • Freezer* • Dehumidifier* • Clothes Washer* • Advanced Power Strips
Weatherization	• Air Sealing • Insulation*
Distribution	• Duct Sealing
Windows	• Windows*
Heating Equipment	• Heat Pump – Ducted* • Heat Pump – Ductless* • Furnace Replacement* • Boiler Replacement* • ECM Circulator Pump*

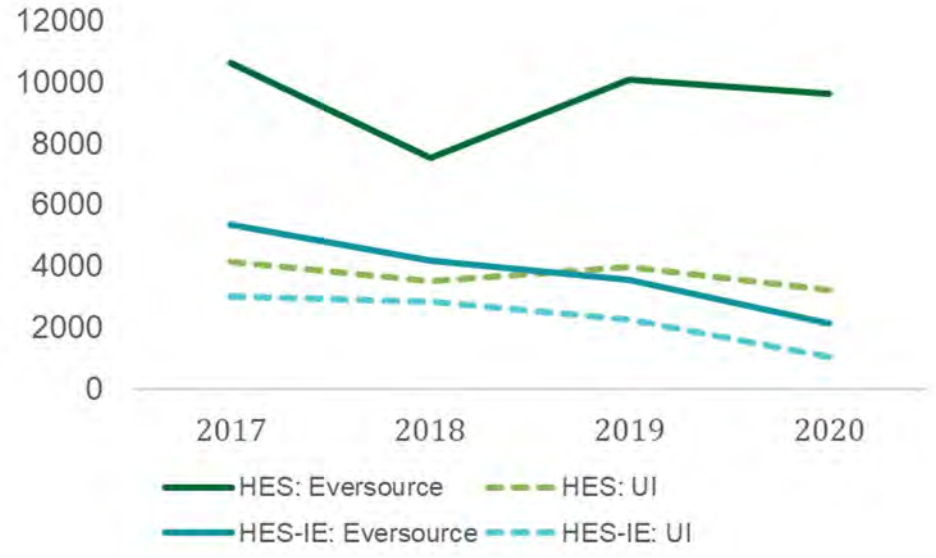
**Add-on/Rebated measure*

[39] According to the field implementation manual, HES-IE customers did not receive DOE Home Energy reports until 2019 or later.
[40] See https://energizect.com/rebates-and-incentives for the latest information regarding these measures

1.3 RECENT PARTICIPATION TRENDS

According to the program tracking data provided by Eversource and UI, total participation (i.e., unique customers that received an assessment) in HES-IE steadily declined between 2017 and 2020. Specifically, HES-IE experienced a 16% year-over-year drop in both 2018 and 2019, likely due to the legislative raid on program funds,[41] followed by a larger drop (45%) in 2020 – likely the result of the COVID-19 pandemic. Participation in HES was more stable over the same time frame (minus a dip in 2018) and experienced a less dramatic pandemic-related drop off in 2020 than HES-IE. The study's benchmarking efforts identified similar dips in participation due to the pandemic, with the size of the dip related to the state's pandemic policies and the programs' abilities to ramp up the programs in-person and/or virtually.

Figure 12: Total Participation (by Program, Company, and Year)



As noted above, HES and HES-IE customers may choose to act on one or more of the recommendations from their assessment and install a "rebated" (HES) or "add-on" (HES-IE) measure, such as insulation or a new heating system. It is important to note that not all participants receive a recommendation for a rebated or add-on measure.[42] This may be because the assessment did not identify the need for such a measure or because a technical or health and safety barrier prevents the recommendation.

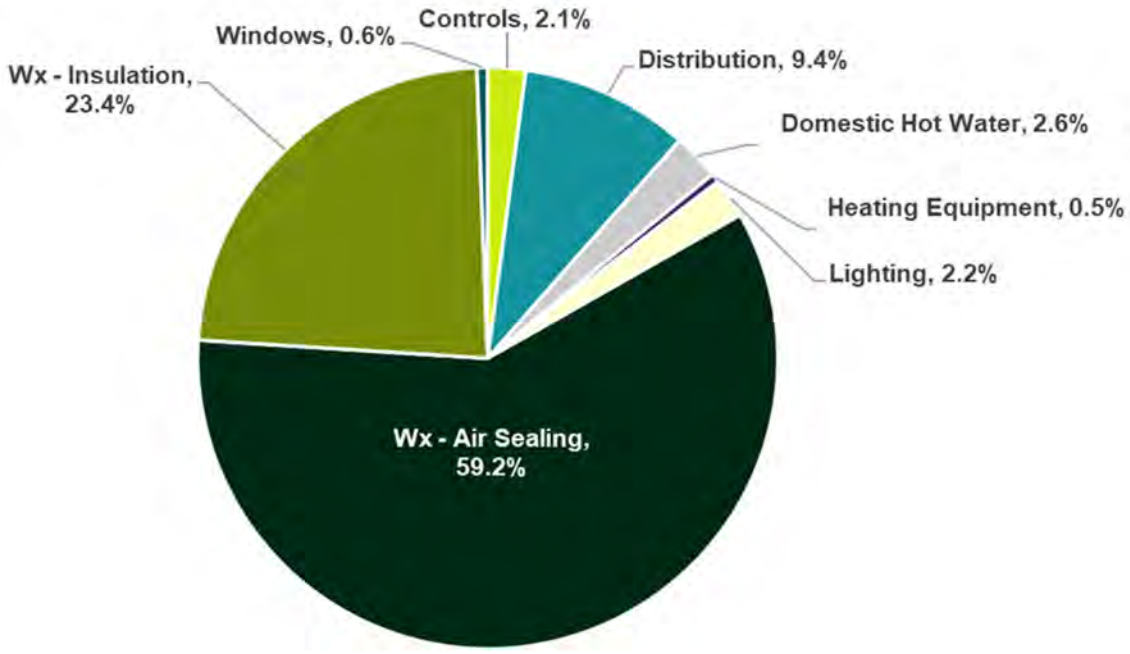
[41] The state legislature raided energy efficiency funding in early 2018, which resulted in cuts to the HES/HES-IE program in 2018 and 2019. The Office of Consumer Counsel estimated that 12,900 fewer homes would receive weatherization services following the funding cuts. (Consumer Counsel. January 16, 2018. "Impacts of the Energy Efficiency Fund Raid Being Felt Throughout Connecticut." https://portal.ct.gov/-/media/OCC/20180112FundraidimpactsTOpdf.pdf.)

[42] The program tracking data provided by Eversource and UI did not include data regarding add-on measures that were recommended by the technician but not installed. However, according to the statewide dashboard, technicians recommended the add-on measures to 2017-2020 HES participants at the following rates: appliances (61%), HVAC equipment (58%), insulation (40%), water heaters (40%) and windows (4%). https://energizect.com/eeb-statewide-energy-efficiency-dashboard.

1.4 Ex Ante Savings by Measure Group and Fuel Type

As show in Figure 13, across all fuel types (electric, natural gas, oil, and propane), more than half (59.2%) of HES ex ante lifetime savings in 2019, came from air sealing. This outcome is intuitive given HES and HES-IE delivery model, which provides air sealing to all eligible customers (i.e., those without barriers) during the initial assessment. Another 23.4% and 9.4% come from rebated insulation and distribution improvement (i.e., duct sealing), respectively. Even in 2019, direct install lighting constituted a small portion of the program's lifetime savings.[43]

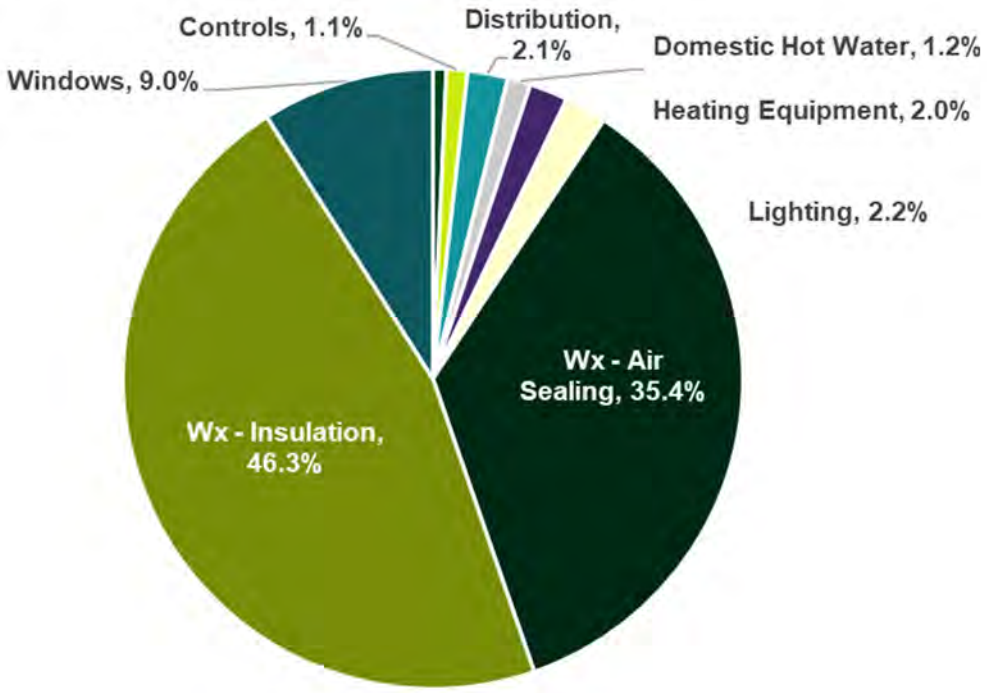
Figure 13: Percent of Lifetime Ex Ante Savings by Measure Type – MMBTUs across all fuels (HES, 2019)



The distribution of lifetime ex ante savings for HES-IE (Figure 14) is also heavily comprised of weatherization measure (i.e., air sealing and insulation). However, the HES-IE program in 2019 saw most of its savings from insulation, not air sealing. The difference is certainly the result of the HES-IE program offering insulation at no cost to participants, which eliminates the financial barriers that HES customers fact when deciding whether to act on insulation opportunities.[44] It is also notable that windows, for the same reason, are also a more impactful measure group for HES-IE.

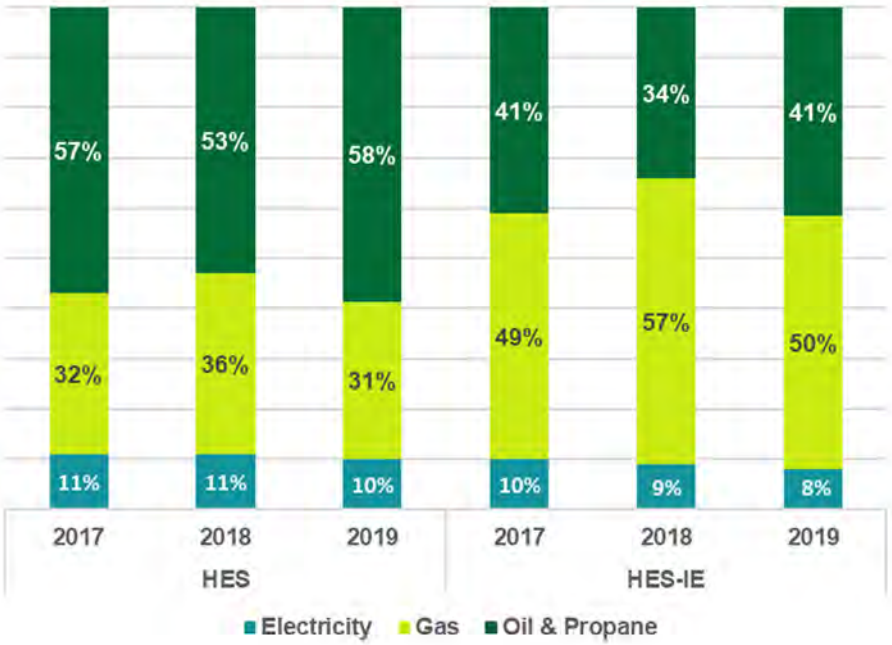
[43] Since 2019, the Companies have incrementally phased lighting out of HES (and soon HES-IE).
[44] As with HES, overcoming pre-weatherization barriers remains a potential obstacle to an HES-IE participant installing insulation.

Figure 14: Percent of Lifetime Ex Ante Savings by Measure Type – MMBTUs across all fuels (HES-IE, 2019)



This study also summarized how each fuel type (electricity, natural gas, and delivered fuels) contributes to the program's overall savings. Most HES ex ante lifetime savings come from delivered fuel measures (heating oil and propane), whereas most HES-IE savings are associated with natural gas measures. Electric measures played a lesser role in both programs between 2017 and 2019. The distribution of savings by fuel type differs significantly by company: nearly two-thirds of Eversource's HES lifetime savings (63%) come from delivered fuels, whereas most of UI's savings are associated with natural gas measures (61%).

Figure 15: Percent of Program Lifetime Ex Ante Savings by Fuel Type – MMBTUs across all fuels (2017-2019)



Section 2 About this Study

This report details findings from NMR, Cadeo, and DNV's impact and process evaluation of the Home Energy Solutions ("HES") and Home Energy Solutions—Income Eligible ("HES-IE") programs, which both fall under the Energize Connecticut initiative.

2.1 Study Background and Goals

In terms of annual energy savings (MMBtu) and program budgets, HES and HES-IE are two of the largest residential programs in Connecticut.[45] As such, the programs merited a comprehensive evaluation (i.e., impact and process) that produced:

- **Accurate gross and net measure-level energy savings and realization rates** for prospective application as part of Program Savings Documentation (PSD) updates.
- **Actionable, process-oriented insights** that will help Connecticut Natural Gas, Eversource, Southern Connecticut Gas, and United Illuminating (the Companies) continue to evolve these critical programs, particularly in response to changes stemming from the COVID-19 pandemic and the continued shift away from lighting.

This evaluation updates previous impact and process evaluations completed in 2019 (for program years 2015 to 2016) and 2016 (for program years 2013 to 2015), respectively.[46,47] The residential customer profiling element of this study represents the first of its kind in the state.

2.2 Study Tasks & Objectives

Figure 16 lists the evaluations tasks completed as part of R1983 and maps each task to the study's objectives, which are associated with three overarching research topics:

1. **Assessing Program Delivery**
2. **Determining Program Impacts**
3. **Understanding Program Reach**

[45] https://energizect.com/connecticut-energy-efficiency-board/about-energy-efficiency-board/annualreports. Accessed August 2022.
[46] https://www.energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf
[47] https://documentcloud.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3A6ad1a31e-b53f-43aa-81bc-d5646e8c7d45#pageNum=1

Figure 16: Research Topics and Evaluation Tasks

		Stakeholder Interviews	Participant Surveys	Program Material & Data Review	Billing & Realization Rate Analysis	Building Simulation & Engineering Algorithms	Customer Profiling	Bench-marking
Assessing Program Delivery	Program Delivery & Performance	✓	✓	✓				✓
	Data Quality & Management	✓		✓				
	Impact Result Drivers	✓	✓	✓	✓			✓
Determining Program Impacts	Retention & Persistence		✓					✓
	Gross Savings			✓	✓	✓		✓
	Net-to-Gross	✓	✓					✓
	Realization Rates Drivers	✓	✓	✓	✓	✓		✓
Understanding Program Reach	Customer Profiling			✓			✓	✓
	Targeting via Census Data			✓			✓	

2.3 KEY LIMITATIONS AND SOURCES OF UNCERTAINTY

The study sought every opportunity to minimize uncertainty and produce specific, actionable findings and recommendations. Nonetheless, it is important to acknowledge that it is not possible to eliminate all sources of uncertainty and/or bias. Specifically, the study is subject to the following inherent limitations and sources of uncertainty:

- **Delayed Data Request Fulfillment.** The study submitted its initial data request to the Companies in August 2020 and submitted a follow-up in data request in January 2021. It took until February 2022 and more than 200 data request related communications for the Companies to provide the data necessary to complete the process, impact, and customer profiling tasks scoped for this study. The significant delay fulfilling the study's data requests had a commensurate impact on the study's timeline and budget. There is always a lag between evaluated participation cohorts and evaluation reports, especially when using a billing analysis that requires at least a full year of post-participation data, but the delays in data request fulfillment resulted in the difference between the evaluated HES & HES-IE cohort (2019) and the study completion (2023) being much greater than planned.
- **Program Data Challenges.** As detailed in Appendix G of this report, the study experienced serious challenges obtaining, combining, standardizing, and analyzing HES & HES-IE program tracking data for the process and impact evaluation, as well as broader residential program data for the customer profiling effort. The study employed a series of quality assurance checks to mitigate these challenges (e.g., comparing summarized tracking data to existing program-level reported customer counts or savings value, having

Eversource and UI review measure mapping tables, rates using two data teams perform independent merges to compare). However, it is important to acknowledge that the data-centric challenges both limited what the study could report and added uncertainty to the findings.

- **Survey Recall Bias.** Several survey respondents used open-ended responses in the survey to explain that they could not recall the answer to certain survey questions due to the amount of time that had passed between their participant and the survey. As the study examined participants who received an assessment in 2017 to 2020 and the participant survey was fielded in late 2021, nearly all the respondents responded to the survey at least one year after receiving an assessment. As noted above, this lag was exacerbated by the delays fulfilling the study's data request.

2.4 Report Organization

This report is designed to prioritize summarizing the study's key findings while also providing detailed insight into HES & HES-IE delivery and impacts.

To achieve this, the body of the report includes four summary sections:

- Methodology
- Key Findings: Process
- Key Findings: Impact
- Key Findings: Customer Profile

To supplement these summary sections, the report includes a set of appendices that elaborate and expand upon the key findings, as well as offer a more detailed description of the evaluation methodologies used as part of R1983. These appendices include:

- Appendix A: Detailed Methodologies
- Appendix B: Process Evaluation - Detailed Results
- Appendix C: Additional Net-to-Gross and Installation Rate Findings
- Appendix D: Additional Impact Evaluation Findings
- Appendix E: Additional Customer Profile Findings

The appendix of this report also includes two sections that summarize the study's collective recommendations for updating the PSD in one easy-to-access and leverage place and that provides more insight into some of the data-centric challenges faced by the study team.

- Appendix F: Summary of PSD Updates
- Appendix G: Summary of Encountered Data Issues

To supplement the gross savings results provided in this report, the study team created and provided a separate **Impact Evaluation Supporting Documentation** workbook.

The workbook includes a tab for each HES & HES-IE measure that was evaluated using an engineering approach (i.e., algorithms or building simulation). For these measures, the workbook details the PSD energy savings calculation used to evaluate that measure and all the values (and

sources) for algorithm inputs and assumptions. Each tab links to common sets of participants, housing stock, and engineering assumptions, ensuring consistency across measures. The study determined, early in the evaluation process, that such a workbook (versus similar details provided in a static report appendix) was a more functional format for conveying these details.

Section 3 Methodology

This section provides a high-level summary the methodology the study used to complete each of R1983's seven complementary tasks:

- **Stakeholder Interviews**
- **Participant Surveys**
- **Program Material & Data Review**
- **Billing & Realization Rate Analysis**
- **Engineering Algorithms & Building Simulation**
- **Customer Profiling**
- **Benchmarking**

For a more detailed description of the study's task-specific methodologies, see Appendix A.

Stakeholder Interviews

- Completed 30 interviews with:
  - Program Staff (n=2)
  - DEEP Weatherization Assistance Program (WAP) Coordinator (n=1)
  - Program Vendors (n=16)
  - Community Action Agency (n=1)
  - Community Stakeholders (n=10)

Focused interview topics on program delivery, drivers and barriers to participation, health and safety barriers, training and workforce development, and the needs of underserved populations.

Participant Surveys

- Surveyed 1,208 randomly sampled 2017-2020 participants in single-family households; 932 HES participants and 276 HES-IE participants stratified by HUD Metro Fair Market Rent (FMR) Area (HMFA) and participation type.
- Oversampled participants who installed low-incidence measures in order to calculate NTG (see Participant Survey Methodology).
- Invited customers to participate in the web survey with a letter and follow-up postcard and/or email reminder, with the option to complete the survey over the phone. The outreach materials and survey were offered in both English and Spanish.
- Provided all participants who completed the survey with a $10 incentive.
- Focused survey topics on customer experience, drivers and barriers to participation, health and safety barriers, program marketing, and awareness and attitudes towards additional savings opportunities, including the availability of rebates and financing.
- Calculated measure-specific persistence rates.
- Estimated net-to-gross ratios for all program measures, including direct-install and add-on measures, for the HES program.[48]
- Weighted NTG ratio results by program savings (see Saving Weights).

[48] HES-IE measures are assumed to have a NTG of 100%.

Weighted non-NTG (process) survey results to account for the higher response rate of Eversource customers and the oversampling of low-incidence rebated or add-on measures relative to the population of HES/HES-IE participants (see Survey Weights).

Program Materials & Data Review

- Program materials review focused on assessing their quality, clarity, comprehensiveness, consistency, and accuracy.

Materials included field implementation manuals; kitchen table wrap-up/leave-behind packets; vendor training materials and QA/QC protocols; vendor scorecards and inspection reports, and DOE Home Energy Score reports.

Billing and Realization Rate Analysis

- Used to evaluate savings when measure-specific billing analysis results met pre-determined threshold of better than ±20% precision at the 90% confidence level, which was primarily true (at the statewide level) for air sealing and insulation in natural gas heated homes and lighting.
- Combined customer-specific billing records with weather data and measure installation data to get a complete perspective of each customer's energy consumption drivers.
- Specified and refined a monthly post-program regression (PPR) model.
- Matched each treatment group customer to a control group (consisting of future HES and HES-IE participants) customer with a similar, monthly, pre-program energy consumption pattern.
- Used a consistent screening process to ensure the model only included customers with sufficient billing data and without spurious billing records
- Estimated separate participant-specific "difference of differences" savings (using matched control) to corroborate pooled PPR model results, as well as provide greater insight into differences in savings by vendor.
- Weather-normalized (where applicable) using 30-year historical weather data from sixteen National Oceanic and Atmospheric Administration (NOAA) weather stations; mapped each participant to the closest NOAA weather station.
- Disaggregated billing data into specific end uses (heating, water heating, and baseload) to inform engineering algorithms and building simulation activities.

Engineering Algorithms & Building Simulation

- Relied primarily on the algorithms documented in the 19th Edition, 2022 Connecticut Program Savings Document (PSD)[49] to calculate savings.
- Leveraged detailed HES and HES-IE data from both Companies when available to calculate baseline and efficient cases as required to complete PSD-prescribed algorithms.
- Used recent studies or sources cited in other regional TRMs (including Massachusetts, New York, and Rhode Island) when we identified a PSD algorithm or parameter that warranted updating.
- Made engineering adjustments to leveraged billing analysis results to inform savings estimates for delivered fuel measures

[49] https://energizect.com/sites/default/files/2021-11/Final%202022%20PSD%20FILED%20%2811-1-2021%29.pdf

- Modeled using EnergyPlus, DOE's open-source whole-building energy modeling simulation engine.
- Constructed four baseline home geometries using inputs like square footage, number of floors, and foundation types from Eversource and UI program data.
- Simulated two different scenarios for each baseline model type and program type (total of 16 models) reflecting pre-program and post-program air sealing and insulation (such as walls, floors, and ceiling) measure values.
- Leveraged the difference between pre- and post-program results to estimate the average heating and cooling savings proportions attributed to each measure by model type.
- Weighted the average savings proportions of the air sealing and insulation measures to the number of customers represented by each model type.

Customer Profiling

- Consolidated 2017 to 2020 program tracking and customer billing data from the Companies into a single dataset.
- Geocoded all entries in the evaluation datasets. Addresses representing 90% of electric savings and 88% of gas savings were geocoded to Census block groups. The study excluded data from Census block groups[50] with less than 25 utility customer accounts or where reported savings were greater than total energy consumption for the block.[51] The excluded values represented 1% of electric savings and 3% of gas savings. The final evaluation datasets thus contained 88% of the electric savings and 85% of the gas savings of the original evaluation datasets.
- Consolidated the evaluation data set to Census block group level
- Added American Community Survey data at block group level
- Computed participation metrics of location participation and population savings rates
- Ran zero-order correlations on all pairs of variables
- Conducted multiple regression analysis to isolate effects of intercorrelated variables on savings rate.

Program Benchmarking

- The study benchmarked NTG estimates against findings from similar programs in the Northeast and Mid-Atlantic.
- The study benchmarked process and impact findings against studies of similar programs and previous Connecticut HES/HES-IE evaluations, where applicable.

[50] Census block groups typically include 600 to 3,000 people.
[51] Site-level savings will rarely exceed 10% of consumption. However, the evaluation used this more lenient threshold to include as much of the tracked savings as possible.

Table 14 summarizes the targets and achieved completes for each outreach data collection task. See Appendix A for additional details on the methodology for these research tasks.

Table 14: Primary Data Collection Targets and Completes by Data Collection Task

Data Collection Task	Target	Completes
Program Staff Interviews	2	2
DEEP Weatherization Assistance Program (WAP) Coordinator	1	1
Qualified Vendor Interviews	Up to 40 (20 per program)	17 (10 both programs; 6 HES only; 1 HES-IE only)[52]
Community Stakeholder interviews	Up to 12	10
Participant Survey	1,200	1,208 (932 HES; 276 HES-IE)

[52] The study contacted all active vendors (29) and invited them to participate in an interview.

Section 4 Key Findings: Process Evaluation

This section contains key findings related to the study's assessment of the delivery of HES & HES-IE including program participation and awareness, participant experience with the program, vendor and participant satisfaction, vendor performance, and suggestions for improvements to program processes.

As noted in the "Report Organization" section, readers can find additional process related findings in Appendix B.

4.1 Participation and Awareness

Vendors and stakeholders identified **customer types that they believe are underserved by the HES/HES-IE program** and suggested solutions to serve these groups more effectively:

- *Low-income customers* may be underserved due to difficulty in verifying income or inability to take off work for the assessment.
- *Moderate-income* customers do not qualify for HES-IE but have difficulty affording the recommended upgrades and the remediation costs of health and safety barriers. The study operationalized these households as having incomes that fell between 60% and 80% of the area median income (AMI).
- *Renters* require approval to participate from their landlords. Vendors and stakeholders suggested directly engaging with landlords to educate them on the benefits of the program.
- *Rural customers* may be located outside vendors' service areas and have fewer options for service.
- *Customers with limited English proficiency* may not have access to program materials or advertisements printed in their language or be able to communicate effectively with program vendors; one vendor suggested providing technicians access to a language line.
- *Elderly customers* have fixed incomes and may have difficulty accessing program materials online.
- *Immigrant customers* may be wary of engaging with programs that involve house visits and personal data collection.

The customer profiling effort found that the HES-IE program was adequately serving low-income customers, achieving savings at an expected rate relative to the population of low-income customers in the state. Stakeholder insight on this population illuminates reasons why individuals may be unable to participate, even if low-income customers as a demographic group are being effectively served by the program.

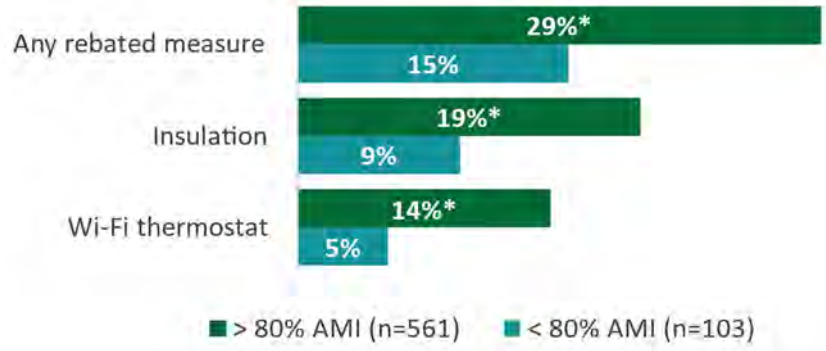
Customer profiling results corroborated vendor and stakeholder insights on moderate-income and rural customers. Rural areas have lower program participation than urban areas and areas with high concentrations of moderate-income households are being served at below-average rates by non-income-eligible programs. See Section 6 for additional details.

Moderate-income households install fewer rebated measures following their assessment than other HES participants. Households with incomes less than 80% of the area median

income (AMI) were significantly less likely to have installed a rebated measure (15%) than other HES participants (29%). As shown in Figure 17, these moderate-income households installed insulation (9%) and Wi-Fi thermostats (5%) less frequently than HES participants with incomes greater than 80% AMI (19% and 14%, respectively).

Figure 17: Rebated Measures Installation by Income (HES)

(Source: Measure installation rate from program tracking data and income level from participant survey)



*Significantly different than participants with incomes less than 80% AMI at the 90% confidence level.

The Massachusetts PAs launched a targeted moderate-income offer through the Home Energy Services (HES) program in 2016. This offer provides enhanced incentives to HES customers with incomes between 61% and 80% SMI.[53] Participation was initially limited due to challenges identifying qualifying households. Program administrators attempt to determine eligibility for the moderate-income offering when a customer signs up for the assessment. Energy specialists were also trained to promote the moderate income offering while on site for an assessment.

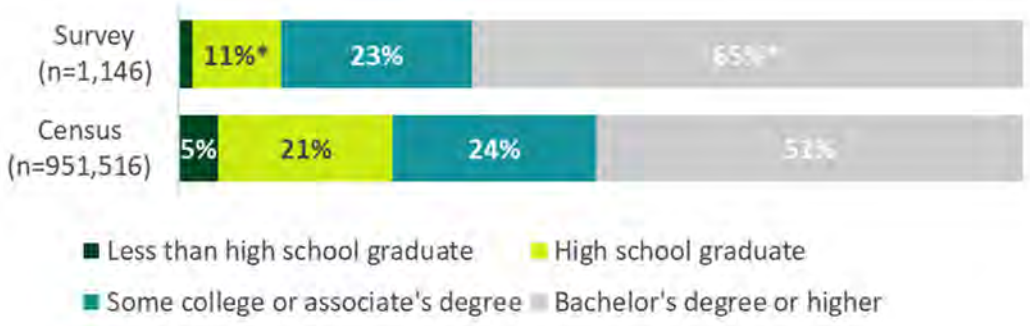
Demographics of survey respondents suggest HES/HES-IE participants skew more highly educated and younger. Program participants are more highly educated than the general population (Figure 18). HES and HES-IE survey respondents were statistically significantly more likely to have a bachelor's degree or higher (65%) compared to census estimates (51%). As educational attainment is correlated with higher earnings,[54] this finding suggests that program participants may also be wealthier or have higher earning potential, on average.[55]

[53] MA EEAC. "Home Energy Services Process Evaluation (Res 35)." March 2018. https://ma-eeac.org/wp-content/uploads/MA-RES-35-HES-Process-Evaluation-Comprehensive-Report_FINAL_31MAR2018.pdf

[54] U.S. Bureau of Labor Statistics. September 8, 2022. "Education Pays." https://www.bls.gov/emp/chart-unemployment-earnings-education.htm.

[55] Figure 18 combines both HES and HES-IE participants when comparing survey respondent demographics to the census, as census results cannot be broken out by program. Furthermore, the survey asked respondents to categorize their household income as over or under a threshold (AMI). Considering HES-IE participants qualify for the program by meeting income requirements, this finding likely suggests that HES participants could be wealthier, on average, than non-participants.

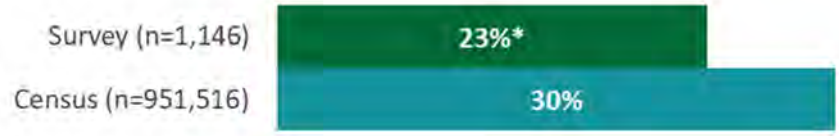
Figure 18: Highest Educational Attainment of Owner-Occupied Households



*Significantly different from census estimates at the 90% confidence level.

Comparison to census data also suggests that households with people 65 and older are underrepresented among program participants (Figure 19).

Figure 19: Owner-Occupied Households with Occupant Aged 65+



*Significantly different from census estimates at the 90% confidence level.

Renters face barriers to participation that disproportionately affect HES-IE customers. Four of six community stakeholders who commented on program barriers brought up issues between landlords and tenants as an important barrier to program participation (see Barriers to Renters).

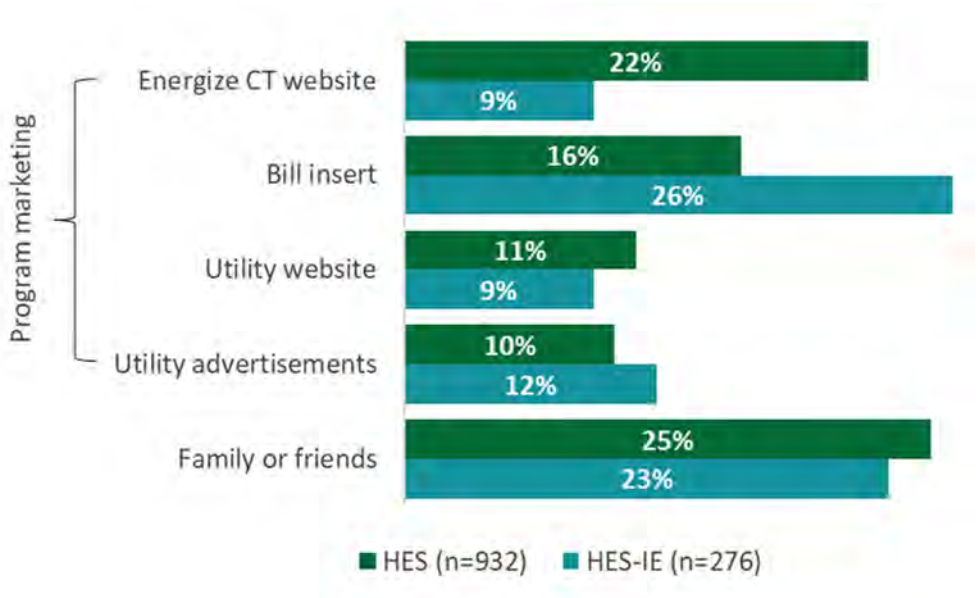
The perspectives of these customers are not likely to be reflected in the participant survey, as the renters in the study likely already secured landlord approval to engage the program. However, renters who participate may face challenges accessing deeper savings through the program. Nearly two-thirds of HES-IE renters (62%, n=47) and one of nine HES renters surveyed cited lack of permission from their landlord as barriers to air sealing and/or installation of insulation, HVAC equipment or water heaters following the assessment.

Program marketing and word-of-mouth referrals are the primary sources of program awareness among current participants. Over one-half of respondents (59% of HES respondents and 54% of HES-IE respondents) learned about the program through program marketing, including the Energize Connecticut website, bill inserts, utility company websites, and/or utility advertisements (Figure 20). Approximately one-quarter of participants (25% of HES

respondents and 23% of HES-IE respondents) learned about the programs from family or friends.[56,57]

Figure 20: Top Sources of Program Awareness

(Source: Participant survey)



Customers can schedule assessments by contacting their utilities, calling the WISE USE hotline, or contacting program vendors directly. Only four of the 17 vendors interviewed considered leads generated through the WISE USE hotline their primary source of customer leads. Vendors reported receiving customer referrals through partnerships with solar contractors, referrals from previous customers, and marketing efforts.

Community stakeholders suggested the Companies shift their outreach focus away from Company marketing efforts to community outreach efforts. They suggested empowering local institutions, including schools, local community groups, non-profits, and community events to spread awareness of HES and HES-IE. These stakeholders agreed that friends, family, and community members were trusted messengers (see Program Marketing).

Home comfort and energy savings are important motivators for participation in HES and HES-IE. HES and HES-IE respondents shared the same top three motivations for deciding to have their home energy assessment done: 1) to identify opportunities to save the most money, 2) to learn about energy-saving opportunities, and 3) to make their homes more comfortable (see Motivations for Participation).

[56] This finding is slightly lower than in Massachusetts, where a 2018 evaluation of the Massachusetts HES program found that 31% of participants heard about the program from friends, family, or neighbors. "Home Energy Services Process Evaluation (R35)." March 2018. https://ma-eeac.org/wp-content/uploads/MA-RES-35-HES-Process-Evaluation-Comprehensive-Report_FINAL_31MAR2018.pdf.

[57] The R4 study found that 32% of HES participants and 23% of HES-IE participants heard about the program from family or friends. https://energizect.com/sites/default/files/R4_HES-HESIE%20Process%20Evaluation,%20Final%20Report_4.13.16.pdf

HES respondents with moderate incomes (below 80% area median income (AMI), but above the threshold for HES-IE eligibility) were more likely than other HES respondents to say they decided to have the home assessment done to find ways to make their home more comfortable.

4.2 Participant Experience and Satisfaction

Overall, participants are satisfied with the program. HES respondents were more satisfied with their program experience overall than HES-IE respondents (81% compared to 68%). Satisfaction is similar to the 2016 HES and HES-IE evaluation, which found that 80% of HES participants and 72% of HES-IE participants were satisfied with the program overall.

HES-IE participants reported higher levels of dissatisfaction with the professionalism and service provided by technicians (13%, compared to 4% of HES participants). One in five HES-IE participants expressed dissatisfaction with the energy savings from their assessment (20%), compared to 11% of HES participants. See satisfaction scores for HES and HES-IE participants for more details.

Among participants with a health and safety barrier, those respondents who reported accessing remediation were more satisfied with the program. HES-IE participants who remediated their health and safety barrier were more satisfied with the energy savings from the program (an average rating of 4.4 on a scale from 1 to 5) and their experience with the program overall (4.7), compared with HES-IE participants that did not access remediation (rating their satisfaction a 3.7 and 4.0, respectively).

Some participants had issues scheduling an assessment. While satisfaction was high overall, five percent of survey respondents had issues with their assessments being canceled or rescheduled, waiting to schedule an appointment, or contacting customer service.

Satisfaction about the energy savings that resulted from the assessment was the lowest-rated program element for both HES and HES-IE respondents (61% and 65% of respondents satisfied, respectively). When asked what their utility could do to address barriers to installing insulation, HVAC equipment, water heaters, and/or air sealing, HES-IE respondents most often requested to be provided with more information about energy savings from these measures.

4.3 Vendor Performance and Program Experience

Vendors expressed overall satisfaction with the program and their role promoting energy-efficiency and weatherization services to customers, while seeking improvements to certain program requirements and the inspection process. On a scale from 0 to 10, where 0 was “not at all satisfied” and 10 was “very satisfied,” vendors rated their satisfaction with the program an 8.2, on average. Vendors attributed satisfaction, in part, to customer satisfaction with the program, positive relationships with program staff, clear program guidelines, and the program’s response to challenges posed by the COVID-19 pandemic.

The HES/HES-IE program is a critical revenue source for program vendors. Several vendors noted that the CL&M funds diversion in 2017 and 2018 led to cutbacks, which resulted in staffing shortages when the funding was restored.

Vendors suggested improvements to several program elements**:**

- **Communication with program staff**. While some vendors were satisfied, other vendors cited issues with payment of invoices, difficulty of obtaining program materials (e.g., customer handouts), and a lack of coordination in handling customer complaints.
- **Mobile data entry tool**. Approximately half of the vendors had issues or suggested improvements, cited issues with syncing, losing data, manual data entry, and no ability to input custom recommendations.
- **Inspection and quality control.** Vendors cited issues with the inspector trailing too close to them while they worked, lengthening the time spent at a customer's home, or confusing the customer. Some vendors felt that the inspection reports were useful training tools for their technicians but found the reports difficult to access.

While participants reported some issues with program vendors, they were generally satisfied; 84% of HES respondents and 75% of HES-IE respondents expressed satisfaction with the professionalism and service provided by the technicians. There was no statistically significant difference in participant satisfaction ratings across vendors.

Qualified technicians are in demand but scheduling on-the-job training can be difficult. Program stakeholders acknowledged challenges in managing a diverse group of program vendors, many of which were trying to grow their workforce while maintaining quality control. Vendors expressed concern about maintaining a fully staffed workforce while balancing program training requirements with keeping up with home energy assessments. Vendors requested additional assistance from the program in training new technicians; however, program stakeholders noted that there are barriers to spending federal funding on workers not employed by a participating agency.

Vendors generally expressed negative reactions about the DOE Home Energy Score. Fewer than one-fifth of HES participants opted to receive the DOE Home Energy Score. Several vendors felt that it had limited usefulness to customers, many of whom were wary about making the score part of the Multiple Listing Service (MLS). Moreover, vendors expressed concern that the requirement was an additional burden on a technician's time at the customer's home.

4.4 Participant and Vendor Experience with Virtual Pre-Assessments

Few participants opted to receive virtual audits, offered in 2020 following the onset of the COVID-19 pandemic. Among HES and HES-IE respondents who had an energy assessment after March 2020, one-tenth or fewer said they completed a virtual audit (see Virtual Preassessment).

Participants who reported receiving a virtual audit had lower average savings, 7.7 MMBtu, compared to 10.3 MMBtu for participants who received an assessment after March 2020 but did not report having part of their assessment conducted virtually. The lower savings rate for recipients of a virtual audit could be due to differences in quality of services delivered in the virtual audit format, lower engagement with the program, or participant unwillingness to permit additional contractors in their home to install add-on measures during the pandemic.

Vendors also did not favor this approach. Of the nine vendors who discussed their experience with virtual audits, eight expressed a negative view. Several vendors mentioned there was still an in-person component to the virtual audits and that they would always need to go to the home to gather data properly, and others expressed frustration that several customers who had received a virtual audit had not called back to schedule the in-person visit to complete the assessment, spotty internet service had complicated the delivery of the virtual audit, or the program did not adequately compensate vendors for the effort involved with completing a virtual audit.

4.5 Coordination Between HES-IE and WAP

Some HES-IE participants receive services through the Weatherization Assistance Program (WAP). The program strives to provide participants with the most comprehensive services possible and engages in cost-sharing with WAP in order to provide additional services for eligible customers.

WAP has a much smaller budget than HES-IE. At an average cost of $7,000 per home, WAP serves 200 to 250 homes per year, compared with thousands of units through HES-IE. The ability to cost-share with HES-IE keeps the average cost per unit down and allows WAP to serve more Connecticut residents. One Community Action Agency (CAA) estimated that 25 to 30 percent of their HES-IE participants also participate in WAP.

WAP program coordinators would like to see more data sharing between the Companies and WAP in order to better identify customers that are eligible for both programs. A single application that qualifies someone for multiple services would improve coordination across programs and enhance services for income-eligible customers. WAP has been operating under a surplus of funds since 2017 and could serve more homes through the program.

4.6 Barriers to Additional Savings

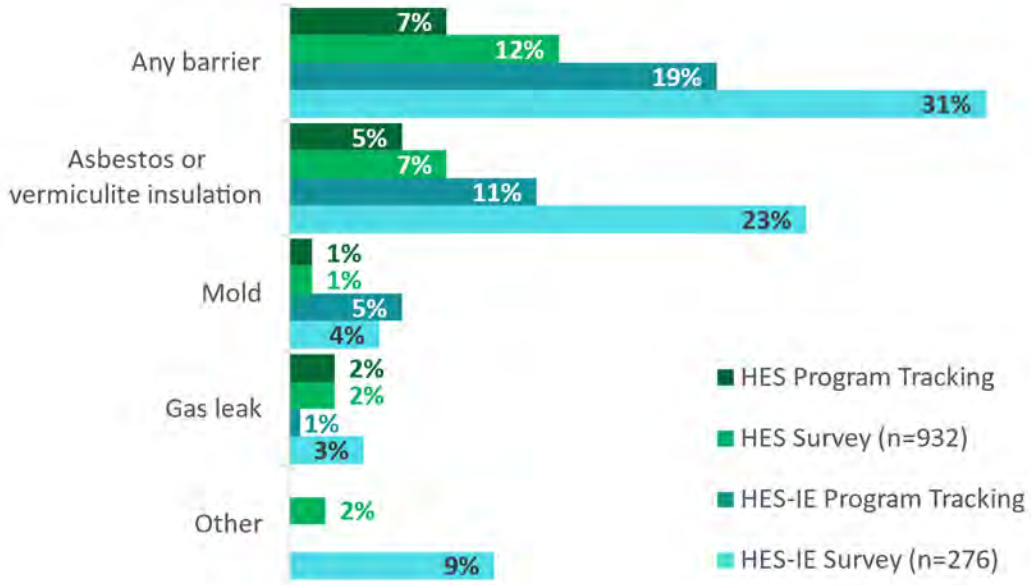
Health and safety barriers prevent technicians from performing services, including air sealing, at the participant's home. Financial barriers can prevent customers from remediating health and safety barriers as well as affording rebated measures recommended by the technician.

4.6.1 Health and Safety Barriers

At least 7% of HES and 19% of HES-IE participants from 2017 to 2020 had a health and safety barrier that affected their assessment. Survey respondents self-reported barriers at a higher rate than recorded in the program tracking data (Figure 21).

Figure 21: Incidence of Health and Safety Barriers in HES/HES-IE

(Source: Program tracking data and participant survey)



Moderate income HES participants had higher rates of health and safety barriers than other HES participants. Ten percent of households with incomes falling within 60% to 80% AMI had asbestos or vermiculite insulation, compared with 6% of households with incomes greater than 80% AMI.

Health and safety barriers continue to limit participation and threaten the statewide goal of weatherizing 80% of all residential units by 2030. Asbestos and/or vermiculite insulation was the top barrier to air sealing cited by respondents who did not receive blower door-guided air sealing.

Ten of the 13 vendors interviewed do not believe the state is on track to meet its goal of weatherizing 80% of all residential units in 2030 without significant changes in funding and incentives.[58] Vendors and community stakeholders noted a myriad of challenges, including the age of housing stock, weatherization barriers, workforce shortages, and competing concerns for the customer's limited resources.

Participants experience financial barriers to remediating health and safety concerns. Four in 10 HES-IE respondents with asbestos (41%) and one in four HES respondents with asbestos or vermiculite insulation (22%) cite cost as the reason they did not remediate after being notified about the issue by the technician (see Health and Safety).

Vendors note the cost of remediation was a high barrier for their customers, who often left health and safety issues unaddressed. Community stakeholders describe remediation options for health and safety barriers being scarce, unaffordable, and/or opaque to people in the communities they serve, leading to negative experiences with HES and HES-IE.

[58] Four additional vendors did not speak to this question.

The program does not offer adequate support for participants with health and safety barriers. Only half of HES participants (50%) and 40% of HES-IE participants who reported having a health and safety barrier recalled receiving information about remediation options from the vendor. Community stakeholders echoed this concern, noting that some participants were unsure as to why technicians made no upgrades during the assessment or what options they had for remediation.

The Weatherization Assistance Program (WAP) defers work for participants with large health and safety issues. Some HES-IE participants also receive services through WAP, which has limited funding ($1,500 to $2,000 per unit) to address small health and safety barriers (e.g., roof repair to fix a source of mold). DOE limits health and safety remediation to 15% of total budget (25% with a waiver). WAP coordinators note that some states "braid" LIHEAP funds with WAP funds to expand energy efficiency offerings, but Connecticut does not. There are limited options for most income-eligible customers that require barrier remediation before proceeding with energy-efficiency services.

Health and safety issues prevent technicians from providing services but can be difficult to identify prior to the assessment. Leaving a participant's home without conducting an assessment strains vendor resources and can be disappointing for customers. However, only two of the 10 vendors who discussed their experience with the pre-screening process thought it was helpful in identifying health and safety barriers before arriving at a customer's home for the assessment. One vendor reported that despite routinely sending customers an email with examples of health and safety barriers, they still encountered barriers that prevented them from completing an assessment at approximately one in ten homes. Customers may have difficulty correctly identifying barriers that a technician is trained to recognize.

Two vendors suggested pre-screening through guided video calls with a technician could help identify health and safety barriers before a home visit, but that customer willingness and vendor staff availability might limit that approach. While it may not be possible to improve the rate at which health and safety barriers are identified prior to an on-site inspection by the field technicians, improved program support for participants with barriers may improve customer satisfaction and uptake of remediation efforts.

4.6.2 Quality Control and Inspection

The inspection process is an important feature designed to ensure the participants receive a quality program experience and technicians are following program guidelines when conducting an assessment.

Approximately ten percent of a vendor's projects are inspected by a third-party program inspector. Vendors are evaluated using a Quality Inspections form which covers safety, customer service, and measures. After each inspection, they receive the Program Inspection Report and the score is updated on the Vendor Scorecard. While program staff report satisfaction with the inspection process, most of the vendors interviewed for this study suggested improvements to make the inspection process run more efficiently and generate more useful feedback for the technicians (see LINK TO B.2.8).

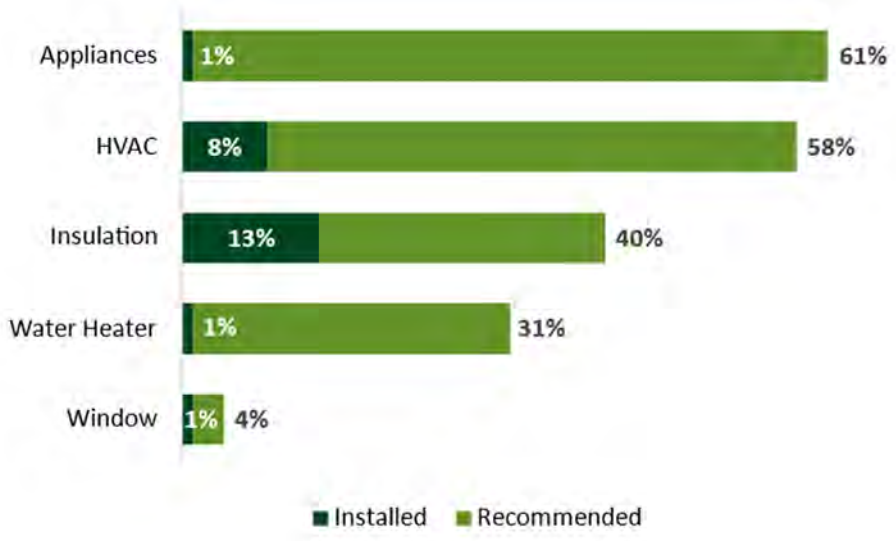
The study did not include interviews with inspectors or an evaluation of inspection protocols. A review of inspection reports and the field implementation manual suggests that the inspection process is more focused on adherence to program guidelines than improving energy savings outcomes. Given the low realization rate of air sealing, the inspection process could play a larger role in ensuring that the air sealing provided by HES will produce long-term savings for the customer.

4.6.3 Installation of Additional Measures

Insulation and HVAC are the most common rebated measures, but most participants that receive a recommendation do not follow through with the installation. As shown in Figure 22, insulation was the most commonly installed add-on measure (13%), followed by HVAC (8%).[59]

Figure 22: Recommendation and Installation Rates of Rebated Measures, HES (2017-2020)

(Source: Statewide Energy Efficiency Dashboard)



In the survey, an additional 22% of HES respondents self-reported installing insulation, presumably outside the program because the study was unable to match their household to an insulation rebate. This suggests that some participants may be taking steps to weatherize their home outside of the program. However, as the study was not provided with data on what measures were recommended for each household, it is not possible to say whether the self-reported insulation installs were completed at the recommendation of a HES technician.

The program is not successfully communicating the benefits and savings opportunities associated with add-on or rebated measures. Nearly one in ten HES participants (8%) and 18% of HES-IE participants were dissatisfied with the information provided about additional energy-savings opportunities. Program technicians review the assessment and walk the

[59] Energize CT Statewide Energy Efficiency Dashboard. https://www.ctenergydashboard.com/Public/PublicHESActivity.aspx

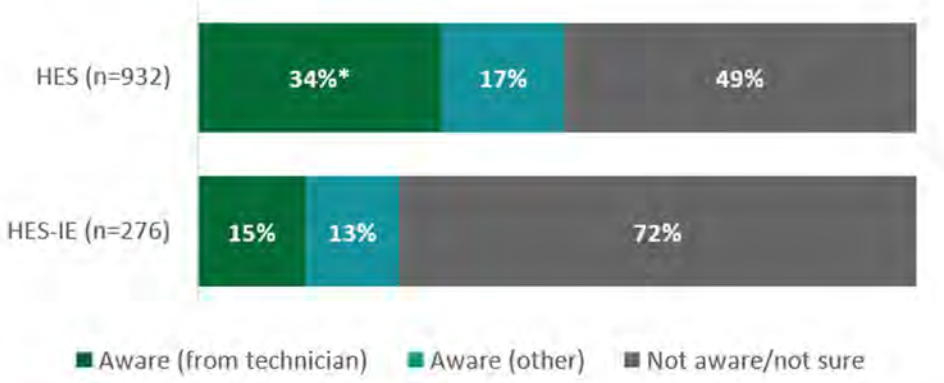
participant through recommended measures and rebate opportunities at the kitchen table wrap-up. However, only two-thirds of HES participants (65%) recalled this conversation with the technician. Vendors identified an opportunity to improve this program service by offering sales training to technicians.

Cost is a significant barrier to installing additional measures following the assessment. Cost was a common reason cited by participants for not installing insulation, HVAC equipment, or a water heater following their assessment (see Barriers and Solutions to Additional Measure Installation). These participants suggested that the program offer additional rebates or financing options in order to overcome this barrier.

Participants utilize available financing options to afford installations of more expensive equipment installs, such as heat pumps. A higher percentage of respondents who installed geothermal or ground source heat pumps or ductless mini splits reported applying for financing compared to other measures eligible for financing (see Application for Financing). However, **awareness of financing options was somewhat limited**; only one-half of HES respondents and one-quarter of HES-IE respondents indicated they were aware of the financing options through the program (see Awareness of Financing). HES respondents were more likely than HES-IE respondents to recall the technician discussing financing options (Figure 23).

Figure 23: Awareness of Financing Options

(Source: Participant survey)



*Significantly different from HES-IE at the 90% confidence level.

Vendors suggest that the program improve processing times, increase marketing efforts, and increase the number of measures eligible for 0% financing to help customers take advantage of financing options.

Some vendors are expanding their services to offer heat pump installations. HES respondents reported installing heat pumps at lower rates than other HVAC equipment following their assessment (see Additional Measure Installation). However, several vendors indicate that they install heat pumps as well as conduct assessments, or plan to in the future, and express optimism over the growing interest in heat pumps.

Participants that accessed rebates through the program requested improvements to customer service and application processes. HES respondents who applied for rebates were

asked to rate their satisfaction with the application process (74% satisfied), the amount of the rebate (70% satisfied), and the time it took to receive the rebate (77% satisfied). Dissatisfied respondents cite a complicated, lengthy application process, customer service issues, long waits for the rebate, and rebate amounts that were too low to be worth the hassle.

Section 5 Key Findings: Impact Evaluation

This section highlights key findings related to the study's assessment of the impact of HES & HES-IE. As noted in the "Report Organization" section, readers can find additional details regarding the impact evaluation methodologies in Appendix A, as well as more impact related findings in Appendix D and in the separate Impact Evaluation Supporting Documentation workbook.

5.1 Program Impact Metrics

In Connecticut, the energy savings of a given measure are determined using the following savings metrics and evaluation impact factors:

- **Gross Savings.** The savings attributable to a program, participant, or measure, estimated using billing analysis, engineering algorithms, building simulation or some combination of impact evaluation methodologies.
- **Realization Rates (RR).** The ratio of evaluated savings determined through an independent evaluation, such as R1983, to gross savings claimed by the Company/program.
- **Free-ridership (FR)[60].** The fraction of gross program savings that would have occurred in the absence of a Conservation and Load Management (C&LM) program.
- **Spillover (SO).** The savings attributable to a C&LM program in addition to gross savings. Spillover savings may result from participants who install additional energy-efficient measures due to their previous involvement with the program, and non-participants that the program nonetheless influences to install energy-efficient measures.
- **Installation Rate (ISR).** The fraction of recorded measures (i.e., in program tracking data) that were verified as installed.
- **Net Savings**. The final savings value attributable to a program or measure after accounting for all relevant impact factors.

As shown below in the basic net savings calculation below, the difference between gross and net savings is entirely due to applying the four listed impact factors. While this example focuses on electric savings, the same net savings calculation is relevant for natural gas, heating oil, or propane savings.

$$kWh_{net} = kWh_{gross} \times RR_{kWh} \times ISR \times (1 + SO - FR)$$

Given the central role of this calculation in assessing the impact of programs in Connecticut, this study has organized the program impact section of this report accordingly.[61]

[60] In Connecticut, as is true in many states, free-ridership is assumed to be 1.0 (or 100%) for income-eligible programs such as HES-IE.
[61] Please see Appendix F for a summary table of all impact evaluation metrics and factors.

5.2 GROSS SAVINGS & REALIZATION RATES

As noted previously, this study used one (or a combination) of three complementary impact methodologies (billing analysis, engineering algorithms, and building simulation) to evaluate the gross savings – and consequently the gross savings realization rate – associated with every HES & HES-IE measure across all four fuel types. Table 15 summarizes the study's gross savings and gross savings realization rate for every program measure on both programs. The table also indicates the methodology the study used to estimate gross savings for that measure and fuel combination, as well as each measure's relative savings contribution toward total HES and HES-IE program savings.[62]

As evident in the table, the study used engineering algorithms to evaluate most measures. This is common given the large number of low savings or infrequently installed measures that are best estimated using the algorithms from the Connecticut PSD.

However, the study relied on the billing analysis to evaluate the four measures responsible for the most savings in both programs (air sealing, insulation, duct sealing in natural gas-heated homes and lighting). This was possible as these four measures yielded billing analysis results at better than 20% precision at the required 90% confidence interval.

ARE BILLING ANALYSIS RESULTS GROSS OR NET?

Billing analysis produce a result that lies on a spectrum between net and gross savings. The exact location on that spectrum depends on the customers in the control group and the measure in question. Since this study used future participants as the control group, the billing analysis-based weatherization savings—per the guidance of the Uniform Methods Project—should be considered **gross.** This is because these future participants installed insulation through the program later, implying they had not previously done so outside of the program. Conversely, the billing analysis results for lighting measures, should be interpreted as **net** as participants are known to install widely available, lower-cost measures such as LEDs prior to participation.

[62] Across all relevant fuel types in MMBTUs using ex post gross savings for program year 2019.

Table 15: Ex Post Gross Savings and Gross Savings Realization Rates

Measure Group	Measure	% Total Savings HES/ HES-IE∞	Electric		Natural Gas		Oil		Propane	
			HES & HES-IE		HES & HES-IE		HES & HES-IE		HES & HES-IE	
			kWh	RR	CCF	RR	gal	RR	gal	RR
Appliances & Plug Load	Refrigerator*,©	<0.1 / 2.0	404	N/A						
	Freezer*,©	0.1 / 0.3	145	N/A						
	Dehumidifier*,©	0.1 / < 0.1	218	N/A						
	Clothes Washer*,©	0.2 / < 0.1	189	N/A	3.9	N/A	4.9	N/A	7.4	N/A
	Advanced Power Strips*	<0.1 / < 0.1	117	N/A						
Heating Equipment	Heat Pump – Ducted (heating)	<0.1 / < 0.1	1723	100%						
	Heat Pump – Ducted (cooling)	Included in heating	279	100%						
	Heat Pump – Ductless (heating)	0.5 / <0.1	918	100%						
	Heat Pump – Ductless (cooling)	Included in heating	260	100%						
	Furnace Replacement	<0.1 / < 0.1			109	96%	81	96%	123	96%
	Boiler Replacement	<0.1 / 3			87	98%	64	98%	98	98%
	ECM Circulator Pump*	0 / 0.5	68	100%						

Measure Group	Measure	% Total Savings	HES		HES-IE		HES		HES-IE		HES		HES-IE		HES		HES-IE	
			kWh	RR	kWh	RR	CCF	RR	CCF	RR	gal	RR	gal	RR	gal	RR	gal	RR
Domestic Hot Water	Faucet Aerators	0.6 / 0.5	38	100%	35	100%	1.6	100%	1.5	100%	1.2	100%	1.1	100%	1.8	100%	1.7	100%
	Showerhead	1.4 / 1.0	126	100%	149	100%	5.3	100%	6.2	100%	3.9	100%	4.6	100%	5.9	100%	7.0	100%
	Pipe Insulation	1.6 / 0.4	16	100%	15	100%	0.7	100%	0.7	100%	0.5	100%	0.5	100%	0.8	100%	0.7	100%
Lighting	Lighting**	18.4 / 19.2	18	44%	17	91%												
Controls	Wi-Fi Thermostat (Heating)*	2.3 / 1.3	386	N/A	372	N/A	30	N/A	38	N/A	22	N/A	28	N/A	34	N/A	43	N/A
	Wi-Fi Thermostat (Cooling)*	Included in heating	37	N/A	37	N/A												
Weatherization	Air Sealing Infiltration Reduction (Blower Door Test)	49.1 / 29.5	106	9%	69	4%	17	17%	11	10%	14	18%	9.5	11%	23	22%	15	16%
	Air Sealing Infiltration Reduction (Prescriptive)	1.7 / 1.9	101	9%	27	4%	6.2	17%	4.3	10%	5.2	18%	2.6	11%	6.4	22%	5.3	16%
	Insulation – All	15.9 / 32.4	480	27%	677	19%	60	50%	97	46%	65	67%	91	101%	105	69%	147	102%
Distribution	Duct Sealing	8.0 / 1.8	55	11%	54	5%	8.8	12%	8.6	8%	7.4	13%	7.2	12%	12.0	18%	11.7	24%
Windows	Windows	0.4 / 6.3	56	100%	71	100%	2.9	100%	5.5	100%	2.1	100%	4.0	100%	3.2	100%	6.0	100%

Key	*Billing Analysis*	*Engineering Algorithm*	*Engineering Adjusted Billing Analysis*	*Billing Analysis Informed Engineering Algorithm*

*Deemed measures; gross realization rates are not applicable.

** Unlike other savings in this table, the lighting savings are net as the results of billing analyses for residential lighting should be interpreted as net, not gross, savings.

© Per the PSD algorithm, the savings for these appliances combines lost opportunity and retirement savings.

∞ Reflects contribution toward to total ex ante annual savings generated in 2019 by the mix of measures delivered through the program that year.

5.2.1 Notable Gross Savings Findings

Below are notable gross findings for several of the key HES and HES-IE measures. For additional gross savings findings, please see Appendix D and/or the Impact Evaluation Supporting Documentation workbook.

Low Natural Gas Air Sealing & Insulation Savings

Air sealing and insulation are the two most important measures delivered through HES and HES-IE, Connecticut's flagship residential energy efficiency program offerings. In 2019, the two measures collectively constituted more than 80% of both HES and HES-IE's total ex ante lifetime energy savings across all measures and fuel types (including delivered fuels). As such, these two critical measures were a focus of this study's impact evaluation.

This study reports all billing analysis results at the statewide level (i.e., without segmenting by company). This is because the study found statewide results to be more robust and stable estimates of savings across multiple model variation and specifications. Although company-specific estimates for some model variations were statistically significant, the company-specific results varied too greatly across small changes in specifications whereas the statewide estimates were stable and robust across model variations.

The study found low average ex post savings for air sealing and insulation in natural gas heated homes relative to the previous HES & HES-IE impact evaluation (R1603), as well as the reported ex ante savings. As shown in Table 16, the realization rate – the ratio of ex post savings (determined through this evaluation) and ex ante savings (reported in the program tracking data and determined using the Program Savings Document [PSD] savings algorithm) – ranged from 10% to 17% for air sealing and 46%-51% for insulation in natural gas heated homes. These results came from the study's billing analysis and were corroborated using multiple statistical models, as well as engineering-based approaches.

Table 16: Evaluated Air Sealing and Insulation Savings (CCF/Year) for 2019 Participants (Statewide, Natural Gas-Heated Customers)

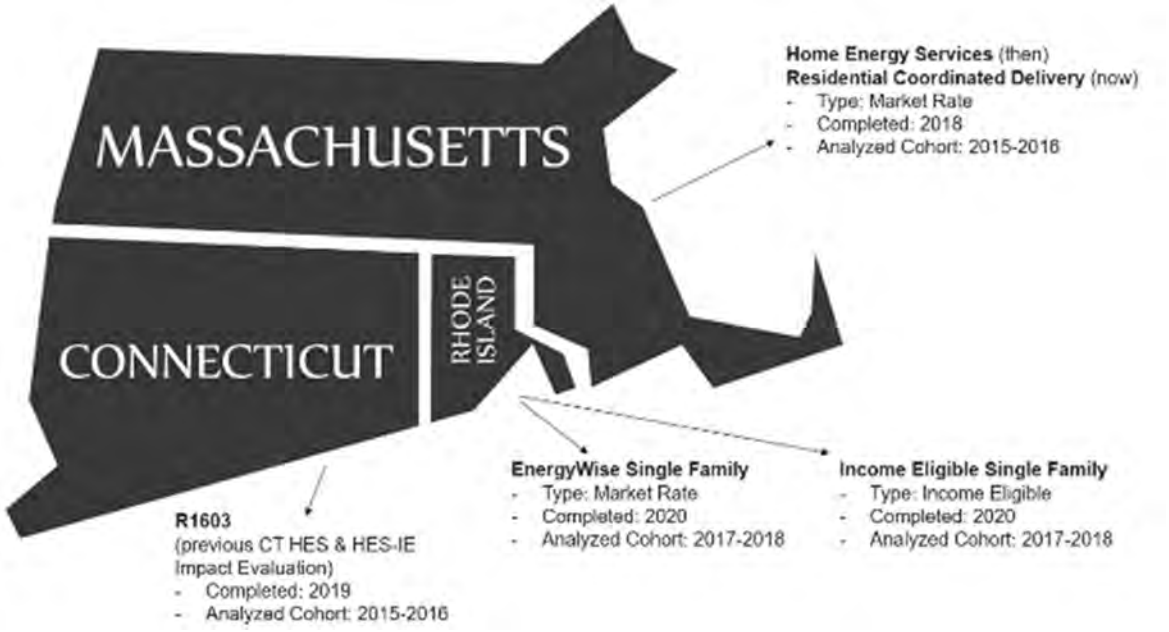
Program	Air Sealing				Insulation			
	Previous Eval	Ex Ante*	Ex Post	Realization Rate	Previous Eval	Ex Ante*	Ex Post	Realization Rate
HES	64	102	17	17%	154	119	60	51%
HES-IE	59	106	11	10%	158	211	97	46%

*Reported in program tracking data

Benchmarking

To provide context for these gross savings results, the study compared them to the results of the most recent evaluations of similar programs offered in neighboring Massachusetts and Rhode Island, as well as the previous impact evaluation of HES & HES-IE.

Figure 24: Summary of Relevant Regional Impact Benchmarks



The ex post air sealing and insulation from this study are much closer to benchmarked evaluations of similar programs[63] offered in Massachusetts and Rhode Island – particularly for insulation. The juxtaposition of this study's results, the previous HES & HES-IE impact evaluation, and these regional benchmarks – provided in Table 17 – suggests that the findings of the previous evaluation were potentially outlying results.

The ex-post air sealing and insulation savings determined for HES and HES-IE were also lower than the evaluated savings for the same measures in similar programs offered in Massachusetts and Rhode Island. However, a comparison against these regional benchmarks – provided in Table 17 – also reveals that the results of this study are much closer to results of evaluations in neighboring states than the previous HES & HES-IE impact evaluation in Connecticut.

[63] While these three programs are similar home energy assessment-based retrofit programs, some differences in design and delivery exist. See Finding #2 for more details.

Table 17: Benchmarking: Air Sealing and Insulation Natural Gas Savings (CCF/Year) [64]

Program Type	Program	Reference	Air Sealing	Insulation
Market Rate	**HES (CT, 2019)**	**Current CT evaluation (R1983)**	**17**	**60**
	HES (CT, 2015-16)[65]	Previous CT evaluation (R1603)	64	154
	EWSF (RI, 2017-18)[66]	Regional Benchmark	33	60
	HES/RCD (MA, 2015-16)[67]	Regional Benchmark	31	98
Income Eligible	**HES-IE (CT, 2019)**	**Current CT evaluation (R1983)**	**11**	**97**
	HES-IE (CT, 2015-16)	Previous CT evaluation (R1603)	59	158
	IESF (RI, 2015-16)[68]	Regional Benchmark	N/A	87*

*The IESF evaluation in Rhode Island only reported combined savings for air sealing and insulation. To approximate the likely insulation-only savings, the team leveraged the air sealing-specific savings from the EWSF evaluation in Rhode Island (33 CCF/year) and subtracted that amount from the IESF savings of 120 CCF/year for both air sealing and insulation.

The results of this evaluation were consistent with a long-term trend of declining average air sealing and insulation savings. As shown in Figure 25, every subsequent impact evaluation in Connecticut (HES), Massachusetts (HES/RCD), and Rhode Island (EWSF) resulted in lower evaluated savings for natural gas-heated participants that received air sealing and/or insulation.

[64] The benchmarked studies in Massachusetts and Rhode Island reported savings in therms, not CCF, which is the metric used in the PSD. To provide an apples-to-apples comparison, the team converted the reported savings in both states to CCF using a therms-to-CCF conversion factor of 0.964. Consequently, the savings shown in Table 2 differ slightly from the savings listed in each of the linked evaluation reports.

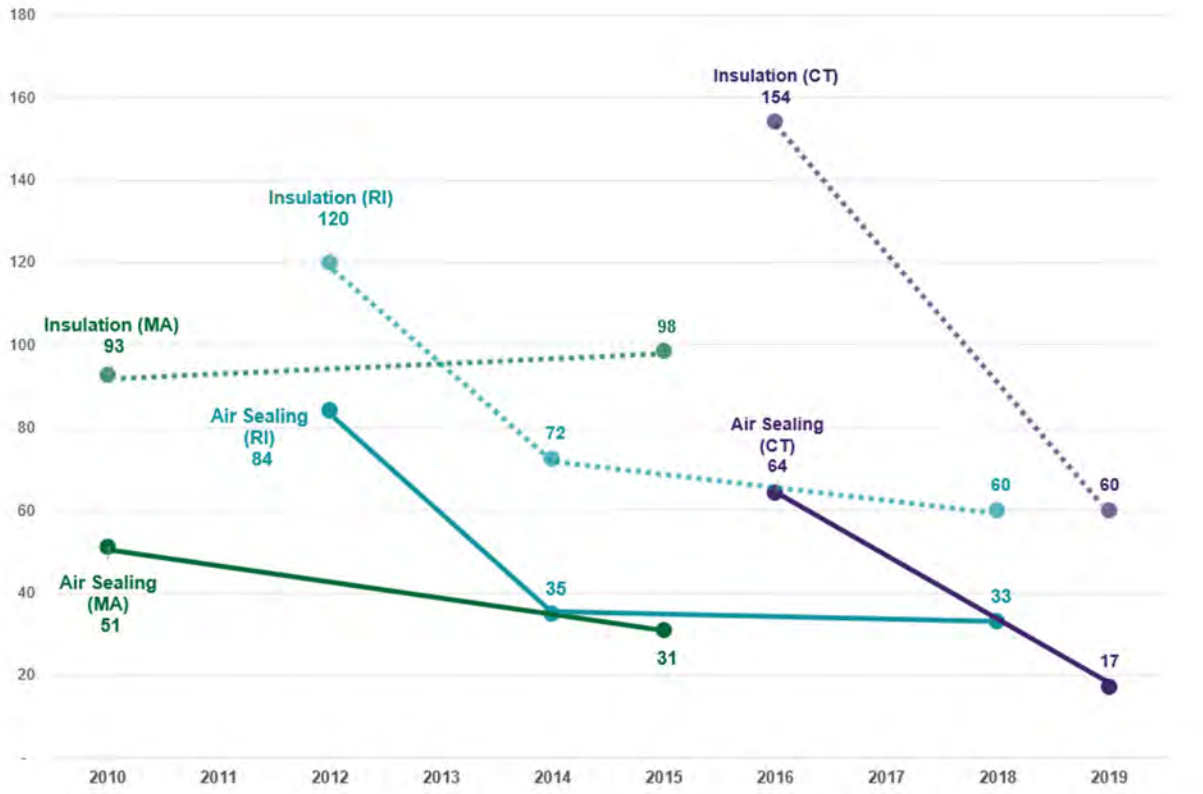
[65] https://acrobat.adobe.com/link/review?uri=urn%3Aaaid%3Ascds%3AUS%3A6ad1a31e-b53f-43aa-81bc-d5646e8c7d45#pageNum=1

[66] EnergyWise Single Family (EWSF) Program (http://rieermc.ri.gov/wp-content/uploads/2020/10/ng-ri-ewsf-impact-and-process-comprehensive-report_final_04sept2020.pdf)

[67] Home Energy Services (formerly) or Residential Coordinated Delivery Initiative (https://ma-eeac.org/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf)

[68] Income Eligible Single Family Program (http://rieermc.ri.gov/wp-content/uploads/2019/04/ng-ri-ies-impact-evaluation-report_final_30aug2018.pdf)

Figure 25: Evaluated Savings Over Time by State – Average Air Sealing & Insulation Savings (CCF/Year) for Market Rate Natural Gas-Heated Customers[69]



Key Drivers

The global drivers of this consistent decline in air sealing and insulation savings – in both Connecticut and neighboring states – are numerous and include:

- **Less "Low-Hanging Fruit."** Customers with the least efficient homes (and highest energy bills) are most motivated to air seal and/or insulated their homes through programs like HES and HES-IE. As a result, there tends to be less savings opportunity per home over time as programs mature, achieve greater cumulative participation, and serve those customers in most need of program services.[70]
- **Increasing Heating System Efficiencies.** The savings opportunity for air sealing and insulation measure is also correlated with the efficiency of participants' heating system.

[69] In addition to the previous referenced Massachusetts and Rhode Island evaluations Figure 4 also includes data from https://ma-eeac.org/wp-content/uploads/Home-Energy-Services-Impact-Evaluation-Report_Part-of-the-Massachusetts-2011-Residential-Retrofit-and-Low-Income-Program-Area-Evaluation.pdf and http://rieermc.ri.gov/wp-content/uploads/2018/03/national-grid-rhode-island-energywise-single-family-impact-evaluation_final_31oct2012.pdf. Similar to Table 2, the evaluation converted savings reported in therms to CCF.

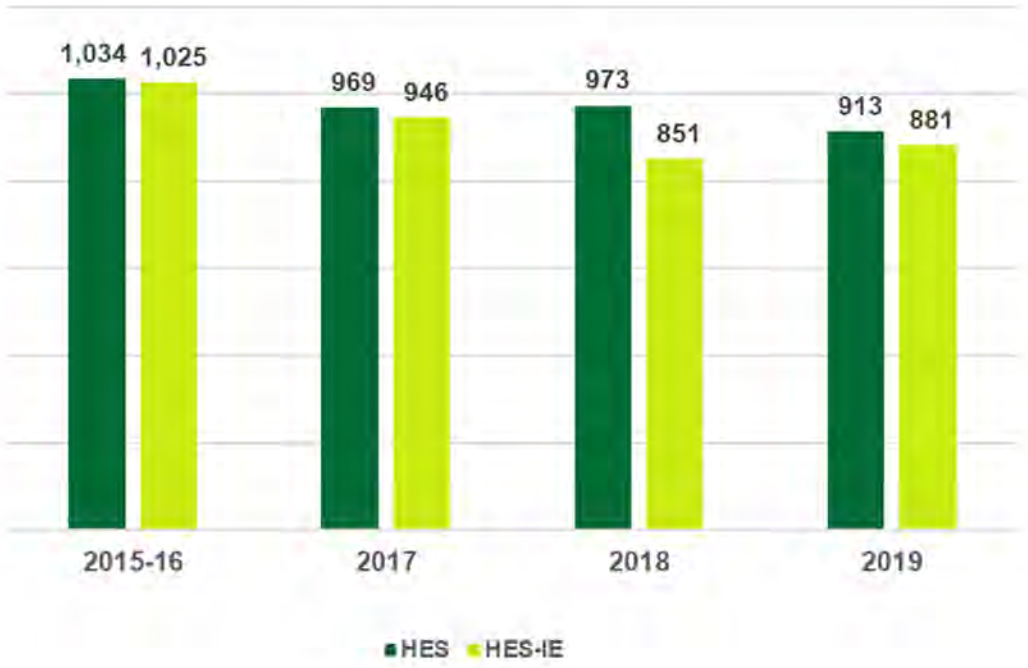
[70] This evaluation did not estimate repeat participation but a recent participation study of the EWSF and IESF programs in Rhode Island found repeat participation rates between 3-8%. The study also found that 15% and 7% of EWSF and IESF participants, respectively, also participated in different efficiency programs within the last ten years. (http://rieermc.ri.gov/wp-content/uploads/2022/06/participant-and-non-participant-study-summary.pdf)

Increases in the prevalence of higher efficiency condensing gas furnaces and boilers[71] across the country due to declining costs and continued program intervention improves overall efficiency, but also means less savings potential for weatherization measures.

For HES & HES-IE specifically, the study also found the following drivers of lower air sealing and/or insulation savings:

- **Lower pre-program consumption.** In part due to the reasons listed above, the study observed a downward trend in annual pre-program heating-related natural gas consumption over participating HES cohorts over time. Specifically, the study found the average 2019 HES participant's pre-program heating usage (913 CCF/year) was 12% less than the average 2015-2016 HES participant (1,034 CCF/year), which were the focus of the previous HES impact evaluation (R1603). A similar comparison for HES-IE shows a decline of 14% over the same time period. Declining pre-program consumption alone does not fully explain the decrease in evaluated savings between R1983 and R1603. However, declining average pre-program natural gas energy consumption has a direct impact on both program savings and is a contributing factor to the lesser observed savings: lower pre-program consumption means less opportunity for heating-related energy savings.

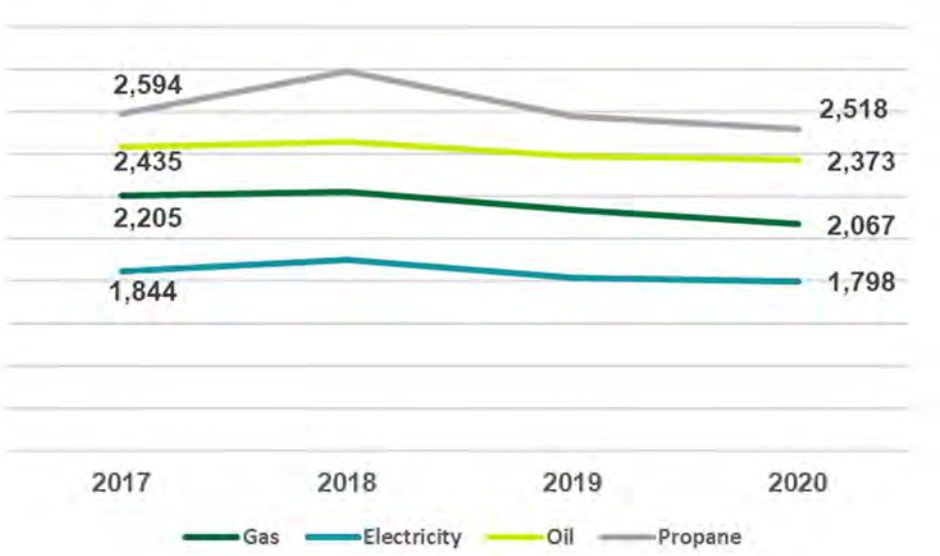
Figure 26: HES & HES-IE Pre-Program Normalized Annual Natural Gas Heating Consumption for Air Sealing and/or Insulation Participants (CCF/Year)



[71] Per the most recent study in a series of Residential Building Use and Equipment Characterization study in neighboring Massachusetts: "For newly installed gas furnaces and boilers, the distribution is heavily skewed toward 95+ Annual Fuel Utilization Efficiency (AFUE) furnaces, which aligns with a general trend of furnace manufacturers focusing their condensing furnace product offerings on 95+ AFUE furnaces." (https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf)

- **Smaller participating homes.** Relatedly, the study's analysis of 2017 – 2020 program data showed the size of the average participating home (i.e., square footage of heated space) declined modestly over time for natural gas heated homes that participated in both HES & HES-IE and across all heating fuel types.[72] The study decline in home size over these four year is less than the observed decline in consumption, which suggests the observed decrease in consumption over time is only partially driven by home size.

Figure 27: HES & HES-IE Average Participant Heated Square Footage by Year and Fuel Type[73]



- **Less time air sealing.** Unlike the programs in Massachusetts and Rhode Island where air sealing occurs during a separate, post-assessment visit, HES & HES-IE conduct air sealing during participant's initial energy assessment. The HES & HES-IE vendors interviewed indicated they typically spent two to four hours assessing each home. The average includes the myriad of non-air sealing responsibilities HES and HES-IE vendors

ABOUT DELIVERED FUELS

Since billing analysis is not possible for delivered fuels (due to lack of detailed usage data), the study team leveraged the natural gas billing analysis results to evaluate air sealing and insulation savings for participants that heat with oil and propane. To best reflect delivered fuel participants, the study applied engineering adjustments to the natural gas results to account for differences in fuel-specific heating system efficiencies and relative home size (as shown above, delivered fuel homes were, on average, larger). **Because the study leans on the natural gas billing analysis, the findings in section are generally applicable to delivered fuel weatherization participants.** However, the study found much gross realization rates for delivered fuels than natural gas – especially for insulation through HES-IE.

[72] Eversource only; did not have comparable heated square footage for UI.
[73] It is important to note the difference in home size by heating fuel type. This is one of the engineering adjustments the study made when leveraging the results of the natural gas billing analysis to evaluate other fuel types – especially heating oil and propane, which cannot be analyzed via billing analysis.

have at each assessment: engaging with the participant, doing a complete energy audit of the home, installing direct install measures, sealing ductwork, the "kitchen table" wrap-up to share results and, for some customers, estimating the DOE Energy Score. As a result, the amount of time dedicated to air sealing is only a portion of the self-reported average of two to four hours per assessment and meaningfully less than the average number of hours (six) spent just air sealing as part of the HES/RCD program.[74]

Results Validation

The study undertook several steps to ensure the validity of these lower-than-anticipated gross savings results for air sealing and insulation. These included:

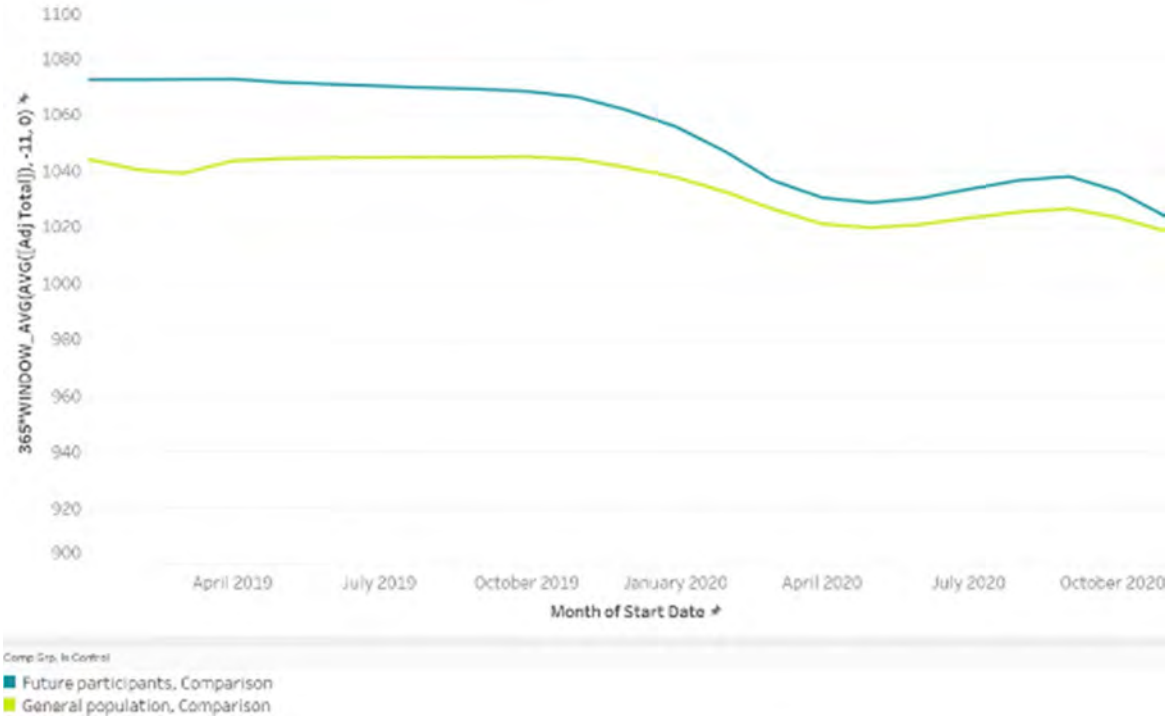
- **Multiple Estimation Methods.** The study estimated air sealing and insulation savings using three different methodologies: the billing analysis model used to report the ex post savings in Table 16 (PPR with matched control), a billing data comparison (an unmodeled weather-normalized comparison of annualized consumption in the pre- and post-period for treatment and control groups), and building Simulation (using pre- and post-participation tracking data and billing data calibrated). All three approaches produced results lower than the program's ex ante savings.
- **Alternative Control Groups.** The study observed a decrease in consumption from "pre" to "post" (as defined by their match) in our control group, which was made up of customers that participated in HES and HES-IE in 2020. Since decreases in control group consumption effectively serves to reduce the savings associated with the treatment group (because that change in consumption is associated with non-programmatic factors), it was important to look closely at the reduction. The study specifically wanted to confirm the trend was not specific to the "future" HES and HES-IE participants and was not, potentially, associated with these future participants taking early efficiency actions which would bias the evaluation's ex post results. To test for this, the study repeated the billing analysis using a sample of general population customer with matched on their similarity to treatment group participant's pre-program consumption. The alternative group also showed a decline in savings over time (shown in Figure 28) and did not produce a statistically significant difference in the billing analysis results. This counterintuitive that heating usage would decrease in 2020 when customers are, due to COVID-19, spending more time at home, the results is consistent with the Residential Building Use and Equipment Characterization study in neighboring Massachusetts.[75]

[74] Based on HES/RCD tracking data

[75] "The peak day demand for cooling end uses increased, while the demand for heating end uses (boilers, furnaces, and hardwired electric heat) decreased. These shifts can be explained by the increases in homes' internal heat loads. People being home, cooking, working, and using office equipment more during the pandemic likely increased the average heat gain of the home, which added to the cooling load and decreased the resulting heating load." (https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf)

Figure 28: Average Normalized Annual Natural Gas Consumption of "Future" Participant and General Population Control Groups Customers

(Rolling average of the previous 12 months – CCF/year, HES)



- **Consistency with Building Science Principles.** The study confirmed the air sealing and insulation savings for HES and HES were consistent with key building science principles and positively correlated with participant exhibiting certain characteristics. For example, the study confirmed that participants with higher total savings were associated with higher pre-program consumption and that those with greater air sealing savings were associated with greater post-air sealing CFM reductions. While expected, these intuitive outcomes confirm the validity of our billing analysis model results and show greater pre-participant savings when greater savings opportunities exist.

Low rates of HES insulation installation

A key goal of assessment-based programs, like HES, is to identify efficiency opportunities and, through incentives and education, to get customers to act on those opportunities. Consequently, a key performance metric is an assessment program's ability to convert recommendations into installation. Since HES completes air sealing during the initial assessment, the program's primary recommendation is installing attic, wall, and/or floor insulation.

To assess HES' effectiveness of turning assessments into insulation jobs, the study benchmarked HES's performance against the same comparable market rate programs in Massachusetts[76] and Rhode Island[77] using three metrics:

- **Recommendation rate.** Insulation Recommendations/ Total Assessments
- **Conversion rate.** Insulation Installations/ Assessments with Insulation Recommendations
- **Installation rate.** Insulation Installations/ Total Assessments

Before comparing these metrics across programs, it is important to acknowledge that the three programs – HES in Connecticut, HES/RCD in Massachusetts, and EWSF in Rhode Island – are similar, but not identical. There are differences in the design and delivery of the programs that potentially affect one or more of these metrics. The most notable differences include:

- **Different Eligibility Thresholds.** For example, HES requires a pre-program existing R-value of less than R-19 in attics to qualify for an attic insulation incentive. By comparison, both RCD and EWSF provide attic insulation incentives when the pre-program existing R-value is less than R-49. As a result, it is possible that a participant in HES/RCD or EWSF with, for example, R-25 in their attic would receive and potentially act on an insulation recommendation while a HES participant with the same existing insulation levels would be ineligible.
- **Different Incentive Levels.** According to interviewed program staff, HES has historically set insulation levels with the goal of covering, on average, 50% of a participant's average upfront insulation costs. This incentive coverage rate is less than Massachusetts' historical approach of covering 75% of participant costs.[78]

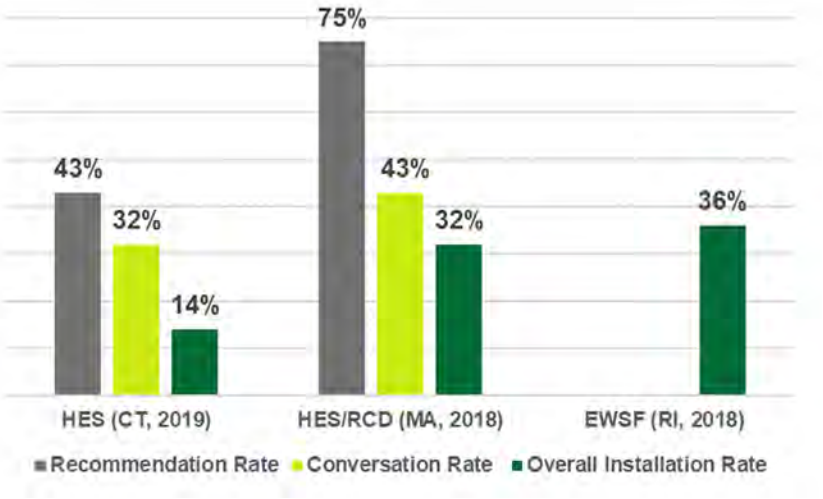
These differences between HES and the programs in the neighboring states – stricter eligibility requirements and lower incentives – certainly impact the recommendation, conversion and installation rates and merit consideration when comparing metrics across states. However, despite these differences, it's informative to benchmark across states to assess HES' general performance encouraging insulation adoption and to understand the potential implications of these program design differences.

As shown in Figure 29, HES had lower rates for all three metrics relative to the regional benchmarks. Given the programmatic differences noted above, this result is unsurprising. However, it is interesting to note the magnitude of the differences and the overall takeaway that twice the percentage of participants in Massachusetts and Rhode Island install insulation than in HES.

[76] 2018 participants in Massachusetts' Home Energy Services program (now the Residential Coordinated Delivery program); specifically Portfolio J, KPI #7.
https://ma-eeac.org/wp-content/uploads/MA-RES-35-HES-Process-Evaluation-Comprehensive-Report_FINAL_31MAR2018.pdf
[77] 2018 participants in Rhode Island EnergyWise Single Family program (Table 3). http://rieermc.ri.gov/wp-content/uploads/2020/10/ng-ri-ewsf-impact-and-process-comprehensive-report_final_04sept2020.pdf
[78] As noted later in this section, HES (and HES/RCD and EWSF) modified their incentives in response to COVID-19.

Figure 29: Benchmarking: Insulation Recommendation, Conversion, and Installation Rates

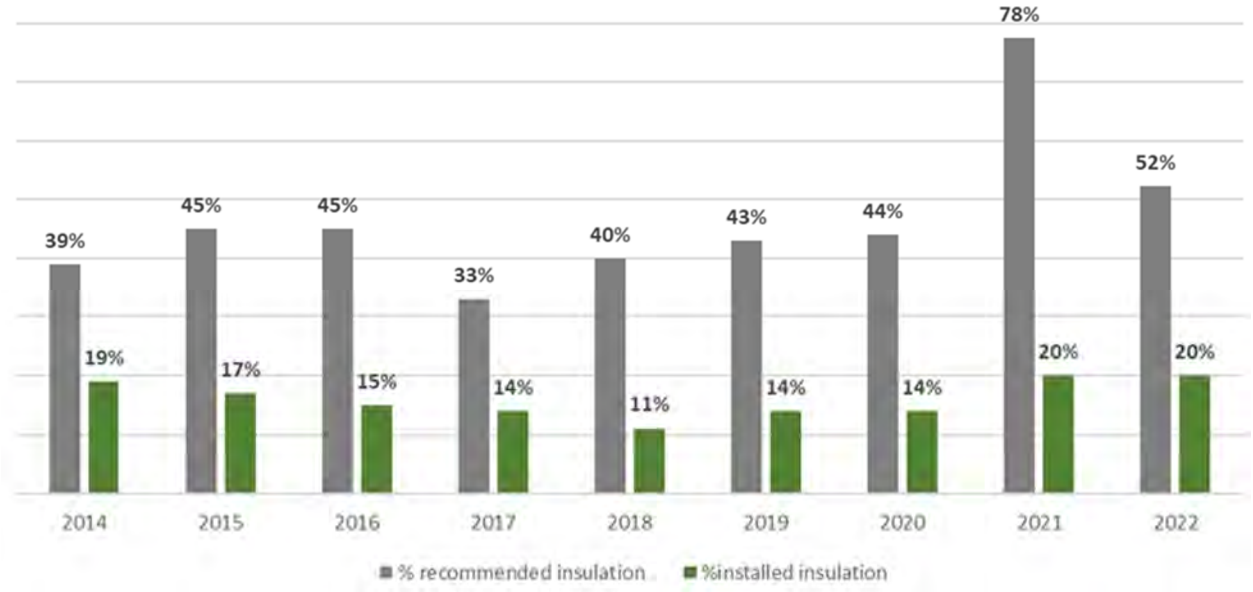
(Market Rate Customers, All Fuel Types)



The study's independent assessment of the insulation installation rate (14%) for 2019 HES participants (using the provided program tracking data) matched the Companies reporting on the state's dashboard.[79] The longer-term perspective of insulation installation rates in Figure 30 shows that the 2019 rate of 14% is not a historical outlier.[80]

Figure 30: Insulation Installation Rates Over Time

(2014 – 2022, Statewide Dashboard)



[79] https://www.ctenergydashboard.com/Public/PublicHESActivity.aspx

[80] The near doubling of the recommendation rate in 2021 is, however, an outlier. While this study did not focus on this time period, it's likely the modified and virtual assessment practices deployed in response to COVID-19 resulted in the significant spike in insulation recommendation rates.

Additionally, the study found that moderate-income HES participants installed insulation at a lower rate than other participants. HES participants with an income less than 80% of the area median income (AMI) were significantly less likely to have installed insulation (9%) than other HES participants (19%).

The drivers of the low insulation rates for HES include:

- **Lower Incentives.** In 2020, HES increased the insulation incentives to encourage participation in the wake of the pandemic. However, prior to these elevated incentives, as noted above, HES aimed to cover approximately 50% of participant's average upfront insulation costs, which is less than Massachusetts' historical 75% coverage. As shown above, higher incentives in 2021 and 2022 have encouraged greater installation rates. With additional time for these more recently assessed participants to act on their insulation recommendation, it's possible the insulation installation gap with Massachusetts will narrow or even close.
- **Different Program Designs.** As noted previously, HES (and HES-IE) conduct blower-door assisted air sealing during customer's initial assessment, while the programs in Massachusetts and Rhode Island air seal during a subsequent visit to the home. It's important to note that the program design in Connecticut results in a larger percentage of overall customers receiving air sealing (i.e., all participants without a pre-weatherization barrier) than in the benchmarked states. This positive program design attribute could possibly have an unintended consequence: it's possible the more comprehensive initial assessment leads HES participants to think they are "done" after the assessment and that installing insulation is less important.
- **Contractor Variance.** It is unsurprising that some vendors, in relative terms, were more successful encouraging HES participants to install the insulation they recommended than other vendors. Given these vendors are all delivering the same program, the wide variation in installation rates suggests certain vendors are better at targeting customers likely to act and/ or convincing customers of the value of insulating their home. The fact that some vendors are more successful at targeting or as salespeople indicates that training could increase performance for the vendors with lower rates.

Implicit trade-off and central question inherent in Connecticut's current delivery model: What's better - less savings at more homes or more savings at fewer homes?

When implemented, the Connecticut programs averaged less air sealing savings (17 and 11 CCF/year per participant) than comparable assessment-based programs in neighboring Massachusetts and Rhode Island (between 31 and 33 CCF/year per participant).

However, HES and HES-IE deliver air sealing differently than the programs in Massachusetts and Rhode Island. In Connecticut, blower-door guided air sealing is implemented in nearly every participating home during each customer's comprehensive energy assessment.[81] By contrast, the programs in Massachusetts and Rhode Island conduct comprehensive air sealing as part of a separate visit to the customer's home in preparation for installing insulation. As a result, those programs most commonly only conduct air sealing in the subset of assessed homes where the participating customer decided to install at least one type of program recommended insulation.

Comparing the average evaluated air sealing savings per participant for the two approaches shows that the Connecticut approach yields lower savings per air sealed home than do Massachusetts and Rhode Island. Qualitative details gathered by the evaluation team support this quantitative finding; chiefly that Connecticut contractors spend less time air sealing during the assessments than contractors in Massachusetts as part of the dedicated air sealing visits in Massachusetts under the Residential Coordinated Delivery (RCD) program model (average of six hours). Since air sealing is only one of the contractor objectives during the Connecticut assessment visits, this likely limits the extent of their air sealing.

But to fully assess the two delivery models, it is important to assess the average savings and incidence with which air sealing and insulation occur for each program. This perspective recognizes that while Connecticut's delivery model produces a lower average savings per air sealed customer, it does result in a much larger percentage of participants receiving air sealing.

Table 18 compares the proportion of participants in each program that received each weatherization element, as well as the average savings for each. Because of HES' lower average insulation savings (discussed in Finding #1) and lower insulation installation rate (Finding #2) the average weatherization savings per assessed home in HES is approximately two-thirds that of RCD and three-quarters of EWSF.

Table 18: Comparison of Average Air Sealing & Insulation Saving per Participant (CCF/year)

	Connecticut (HES)		Massachusetts (HES/RCD)		Rhode Island (EWSF)	
	% of Participants	Average Savings	% of Participants	Average Savings	% of Participants	Average Savings
Received only air sealing	**76%**	**17**	**0%**	**0**	**0%**	**0**
Received air sealing & insulation	**14%**	**77**	**32%**	**125**	**36%**	**93**
Did not receive air sealing or insulation	**10%**	**0**	**68%**	**0**	**68%**	**0**
Overall	**100%**	**24**	**100%**	**40**	**100%**	**33**

The previous table reflects the realities of HES' current design relative to the approach used by in Massachusetts and Rhode Island: the Connecticut air-seal-during-assessment approach results in less average savings per customer but generates some savings – and therefore some

[81] The programs do not air seal homes when ventilation-related health and safety issues are identified.

value - for a larger percentage of participating customers. This relative leads to an important policy question: What program design is preferable – one that results in less savings at more homes or more savings at fewer homes? Or does a third option exist?

Lighting savings remain steady

After air sealing and insulation, lighting – specifically screw-in LEDs – were the next largest contributor to program savings in 2019. Similar to the weatherization measures, the study generated statistically significant and stable billing analysis results for lighting (i.e., whole-home lighting) at the statewide level. The per-bulb results – calculated by dividing the average household lighting savings by the average number of LEDs installed, which was 20 for HES and 21 for HES-IE – are summarized in Table 19.

The savings determined from this study (R1983) are nearly identical to the previous evaluation (R1603), which was completed four years prior. This consistency indicates that the program's lighting savings are stable over time. The results are also consistent with a recent market rate (EnergyWise) and income eligible (Income Eligible Single Family) program evaluations in Rhode Island, which ranged from 15-18 kWh/year.

Table 19: Evaluated Lighting Savings (kWh/bulb) Over Time (by Program)

Program (Statewide)	Savings (kWh/bulb)	
	R1603	R1983
HES	18	18
HES-IE	19	17

Other notable non-weatherization or lighting results

While air sealing and insulation in homes heated with natural gas, heating oil, and propane, as well as lighting, represent the majority of HES and HES-IE's claimed savings, both programs directly install and recommend a variety of other efficiency measures. Regarding non-weatherization measures, this study found:

- **Duct sealing.** Natural gas billing analysis found 9 CCF/participant (i.e., for those participants that received the measure, which was 38% of HES participants). This value is significantly less than the ex ante savings, as well as the deemed value assumed by the 2023 Massachusetts Technical Reference Manual (3.9 MMBtu/home or approximately 38 CCF). The disparity between the ex post savings and the ex ante savings and regional benchmark suggests that duct sealing may suffer from the same there's-a-lot-to-do-during-the-assessment issue discussed above regarding air sealing. At present, duct sealing represents a larger portion of HES ex ante lifetime savings (9.4%) than HES (2.1%) although the difference is largely attributable to a larger percentage of HES-IE customers installing insulation, which has significant lifetime savings and diminishes the contribution of other measures.
- **Wi-Fi Thermostats.** This study identified a better source for heating-related thermostat savings (a 2021 Guidehouse report versus the current source from 2012) for prospective use in the next PSD. The study also evaluated savings for HES homes separately from HES-IE homes, as the savings varied meaningfully by program.

- **Heat Pumps.** The study team suggests changing the cooling efficiency metric used in the PSD from EER to SEER2 as the latter metric is a more complete representation of cooling efficiency and thus energy savings over a range of operating conditions. This suggestion is consistent with 2014 Central Air Conditioning Impact and Process Evaluation recommendations, which was to switch to SEER but continue using EER for demand savings estimates.
- **Other.** Many other measures had gross realization rate of 100% or close, indicating no identified change to the PSD algorithm or input parameters.

For a complete set of study recommended updates to PSD algorithm and/or input parameters, please see in Appendix F.

5.3 FREE-RIDERSHIP, SPILLOVER, AND INSTALLATION RATES

The study estimated an **overall weighted NTG ratio of 84% for HES**, which is comprised of a 24% free-ridership estimate and 7% spillover estimate.[82] (The study did not assess NTG for HES-IE, which is assumed to be 100%.)

Table 20: Overall Net-to-Gross (NTG) Rates and Ratios
(source: Participant survey; n=925)

Ratios and Ratio	HES
Weighted free-ridership rate	23%
Weighted spillover rate	7%
Net-to-gross ratio	84%

The study estimated weighted NTG ratios for core measures between 79% (door and window weatherization and water heater pipe wrap) and 96% (blower-door air sealing). The highest NTG ratios, 96% and 93%, were for two core building envelope measures (blower-door air sealing and duct sealing, respectively). These two measures were the only two with 100% installation rates as well. LED light bulbs were estimated to have a NTG of 71%; however, as lighting is no longer offered through the program, it was excluded from the overall NTG ratio of 84%.

Table 21 shows the savings-weighted free-ridership, net-to-gross, and installation rates of core measures. Three core measures – LED light bulbs, door/ window weatherization, and pipe wrap/ tank insulation – had lower NTG ratios (71%, 79%, and 79%, respectively) and higher installation rates (98%, 92%, and 97%, respectively). Water-saving measures (aerators and showerheads) had higher NTG ratios (87%) and the lowest installation rates (85% and 82%, respectively) of all core measures.

[82] The overall NTG ratio of 84% excludes lighting, which was no longer provided through the HES program in the 2022-2024 term; however, the Companies continue to provide LEDs to HES-IE participants. With lighting included, the overall NTG ratio would have been 83% (see Appendix C for more information).

Table 21: Core Measures Net-to-Gross and Installation Rates
(source: Participant survey)

Measure	n	FR	SO	NTG (1 + SO – FR)	Installation Rate
Door and Window Weatherization	224	28%	7%	79%	92%
Duct Sealing	204	14%	7%	93%	100%
Water-Saving Faucet Aerators	39	20%	7%	87%	85%
Water-Saving Showerheads	31	20%	7%	87%	82%
Blower-Door-Guided Air Sealing	107	11%	7%	96%	100%
Water Heater Pipe Wrap or Tank Insulation	82	28%	7%	79%	97%
Energy-Efficient LED Light Bulbs	80	36%	7%	71%	98%

The study estimated weighted NTG ratios for add-on measures (Table 22). Limiting the analysis to measures with sample sizes greater than five, insulation had the highest NTG ratio (84%), and refrigerators and freezers had the lowest NTG ratio (60%). Ductless heat pumps had a NTG ratio of 69%. The remaining add-on measures with sample sizes greater than five all had NTG ratios between 64% (dehumidifier) and 74% (energy-efficient windows).

Only two study respondents installed air-source heat pumps and one a ground source heat pump. Combined, the FR value for heat pumps is 38%. Given the small sample sizes for individual heat pump types, the study recommends using an overall heat pump NTG ratio of value of 69%.

Five of the ten add-on measures had 100% installation rates, albeit with sample sizes ranging from one to 201. Excluding windows, the remaining installation rates were 96% or higher. As the installation rate for windows in the 2022 PSD was 100%, and the study estimate (93%) is skewed by a small sample size, we recommend averaging the two installation rates (100% and 93%) for a window installation rate of 97.5% (98%).

Table 22: Rebated Measures Net-to-Gross and Installation Rates
(source: Participant survey)

Measure	N	FR	SO	NTG (1 + SO – FR)	Installation Rate
Insulation	201	23%	7%	84%	100%
Smart Thermostat	153	34%	7%	73%	96%
Refrigerator / Freezer	39	47%	7%	60%	97%
Ductless Heat Pump	31	37%	7%	69%	98%
Clothes Washer	27	42%	7%	65%	96%
Energy-Efficient Windows[1]	25	33%	7%	74%	93%
Dehumidifier	13	43%	7%	64%	100%
Central Air Conditioning System	8	38%	7%	69%	100%
Geothermal Heat Pump	2	40%	7%	69%	100%
Air-Source Heat Pump	1	47%	7%	69%	100%

[1] One respondent reported that the windows associated with their address in the program tracking data were "never installed;" this was a high-savings project and as such the weighted installation rate for windows is reduced accordingly. The study recommends averaging this installation rate with the installation rate in the 2022 PSD for an installation rate of 98%.

See NTG Benchmarking for a comparison of free-ridership findings from this study to other studies. For the purposes of comparison to past Connecticut HES studies, we note that the R4 study had a different NTG approach than the R1983 study, which used the Massachusetts NTG algorithm with a Labeled Affective Magnitude (LAM)-adjusted scale.[83] Measure-specific free-ridership values estimated for the HES program are similar to values from the most recent NTG study in Massachusetts.

[83] The methodology for converting the linearly scored elements of the Massachusetts Residential Self-Report NTG Method to a Labeled Affective Magnitude scale was outlined in a memo to the EA team on April 28, 2021, and was based off the D'Souza and Skumatz (SERA) draft paper for ECEEE.

Section 6 Key Findings: Customer Profile

This section describes the key findings from the analyses used to examine the types of customers that participated and the extent of their participation in all of Connecticut's residential energy efficiency programs (downstream programs only) from 2017 through 2020. The evaluation first analyzed the portfolio as a whole, including single-family and multifamily participants, to assess the extent to which all programs are reaching disadvantaged areas. More specific analyses of the IE and non-IE programs independently explored additional nuances in program delivery, including examining single-family and multifamily results separately.

The profiling process consisted of four major steps:

1. Data preparation (described in Appendix A)
2. Calculation of participation metrics (described in Appendix A)
3. Examining distribution of savings relative to distribution of the population
4. Single characteristic analyses using correlational analysis
5. Multiple characteristic analyses using multiple regression methods
6. Outlier sensitivity analysis that repeated the single characteristic analyses to assess how certain types of participants influenced overall findings

The key outcome variable used in this section is savings rate. Savings rate represents depth of savings achieved by the programs. It is the percentage of total annual consumption represented by first year gross savings for the measures installed. It is calculated at the block group level by summing first-year savings for all participating locations within that block group and dividing by the sum of the consumption of all locations (including nonparticipants) in the block group for a single year. Because of data availability, the study could only analyze first year electric and gas savings rates.

Equation 1: Savings Rate

$$savings\ rate = \frac{\sum\ first\ year\ savings_{participants}}{\sum\ annual\ consumption_{all\ households}}$$

6.1 Savings by Program

Table 23 lists the savings by program in the analysis data set. It is subdivided by company and program name and lists whether the program is considered an income-eligible program. Approximately one-third of total analyzed savings were in income-eligible programs. This table reflects the level of detail and information provided to the evaluation team.

Table 23: Savings by Program (2017-2020)

Company	Program Name	Income Eligible	Electric savings (MWh)	Gas savings (CCF)
Eversource	Appliance Retirement		45,528	0
	Estar Homes (Res. New Construction)		2,316,589	238,576
	HES HVAC		2,304,356	0
	HES MF		4,114,317	148,083
	HES Rebates		2,840,764	197,714
	HES SF		0	572,393
	HES Wi-Fi Thermostat		70,773	0
	Home Energy Solution - HVAC, Water Heater		33,362,770	1,311,395
	Home Energy Solutions - Core Services		3,212,450	5,324
	Home Energy Solutions Home Performance		18,923,181	0
	Home Energy Solutions - HVAC, Water Heaters		0	632
	Home Energy Solutions Tier 1		37,984,124	0
	Insulation Rebate		2,461,228	0
	Natural Gas Boiler Water Reset Rebate		0	45
	Natural Gas Water Heater		0	91,724
	Residential New Construction		954,462	225
	RNC HERS Rating		16,800	0
	Smart Living Catalog		13,662	0
	Top Ten USA Appliance Rebate		870,254	125
	Window Rebate		57,202	0
	Appliance Replacement HES-IE	Yes	64,521	0
	HES Income Eligible	Yes	4,813,284	119,225
	HESIE 1	Yes	258,487	0
	HESIE 2	Yes	12,657,464	0
	HESIE 3	Yes	21,243,691	0
	HES-IE Mobile Sub 1	Yes	92,444	0
	HES-IE Mobile Sub 2	Yes	6,812,234	0
	Income Eligible (HES-IE)	Yes	4,111,164	1,042,259
UI	CWH		0	128,817
	ENERGY STAR HOMES		1,291,706	162,235
	HOME ENERGY SOLUTIONS		11,285,959	1,613,515
	HVC		3,688,034	2,635,990
	LOW INCOME (RES.)	Yes	11,240,893	2,252,385
Overall	Non-Income-Eligible		125,814,158	7,106,794
	Income-Eligible	Yes	61,294,181	3,413,870

6.2 KEY FINDINGS

Electrical and gas savings are concentrated in urban areas of the state. Figure 31 shows the concentration of electricity savings. Figure 32 shows the concentration of gas savings.

Figure 31: Electrical Savings Rate 2017-2020

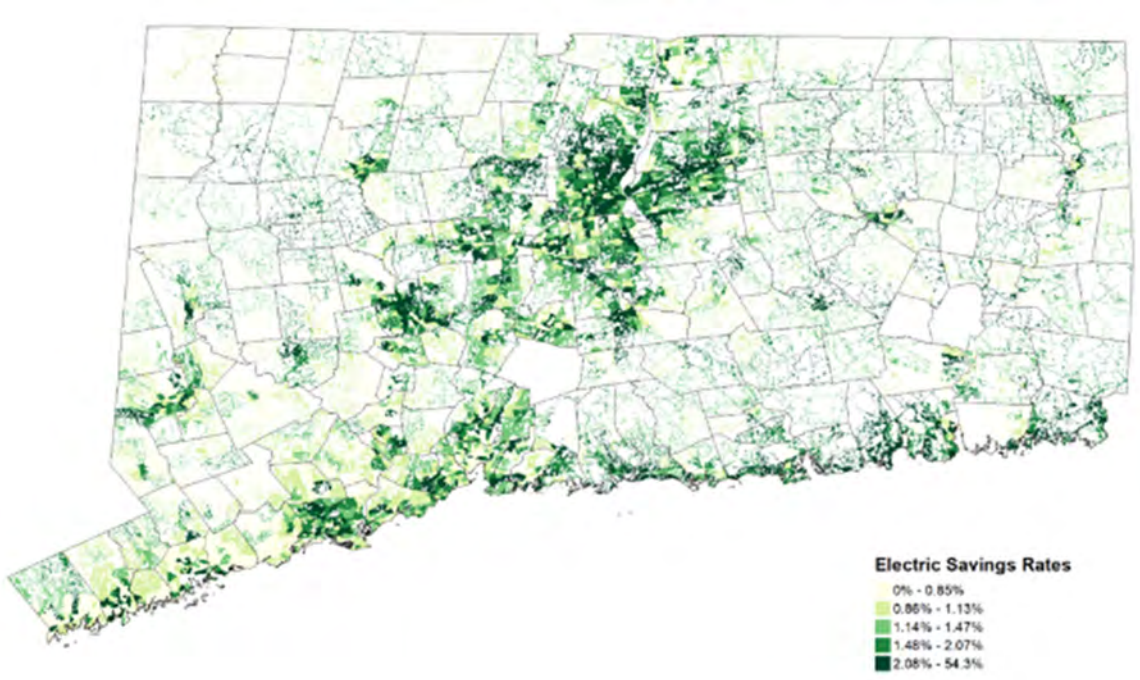
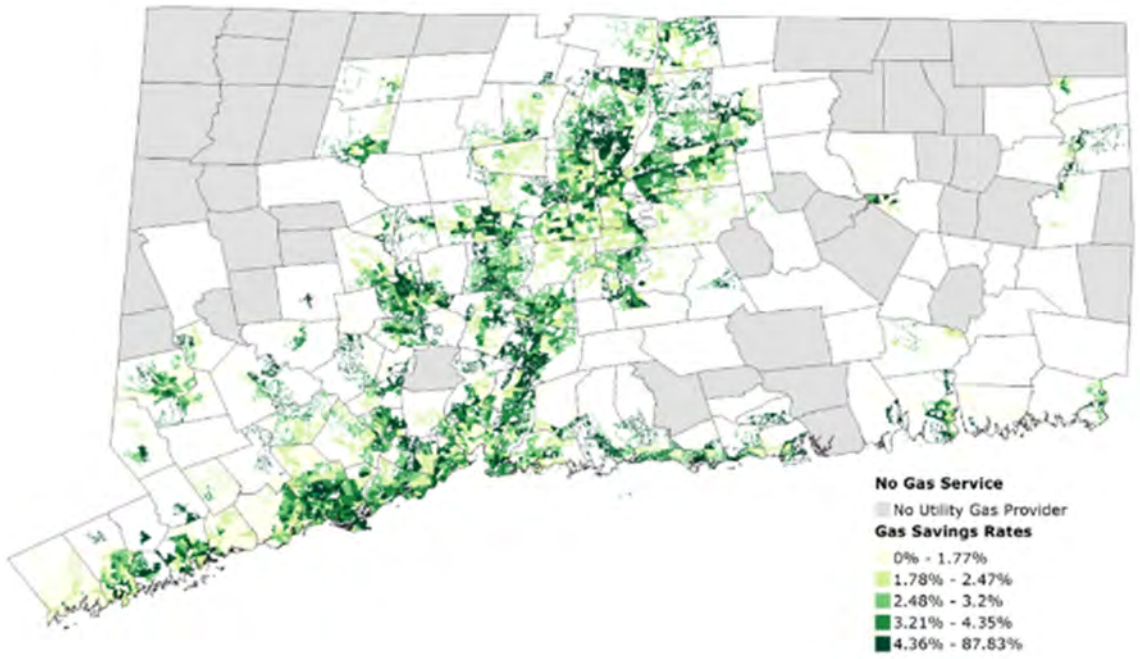


Figure 32: Gas Savings Rate 2017-2020



The percent of total savings from the income-eligible programs is about the same as the percent of low-income households (single-family and multifamily). The U.S. Census classifies approximately one-fourth (27%) of the households in Census block groups that receive electric service as low-income, and about 30% of households with gas service as low-income (Table 24). The proportion of total savings from the income-eligible programs (Table 25; includes multifamily) is approximately the same as the proportion of low-income households in both cases (33% for electric and 32% for gas). This pattern indicates that at the broadest level of analysis, savings from the energy efficiency programs are distributed the same as population distributions.

Table 24: Household Distributions by Income Level

Household income	Percent of Homes in Census Block Groups with Electric Service	Percent of Homes in Census Block Groups with Gas Service
Moderate or higher income	73%	70%
Low income	27%	30%

Table 25: Savings* Distributions by Program Type

Programs	Electric Savings (kWh)	Gas Savings (CCF)	Electric Savings (%)	Gas Savings (%)
Non-Income-Eligible	125,814,158	7,106,794	67%	68%
Income-Eligible	61,294,181	3,413,870	33%	32%
Total	187,108,339	10,520,664	100%	100%

*Single-family and multifamily savings both included

Income-eligible programs are reaching customers in areas with high concentrations of equity-related demographics.

IE program electric and gas savings rates are positively correlated with all the examined variables. This means that areas with higher concentrations of English isolation, low incomes, moderate incomes, multifamily housing[84], renter-occupied housing, pre-1950 construction, or that were on the state distressed list sometime over the past three years tend to have higher levels of savings (relative to consumption) than areas with lower concentrations of those variables.

In contrast, areas with greater concentrations of high incomes or single-family housing tend to have lower savings from the IE programs than areas with lower concentrations of those variables.

[84] Although statistically greater than zero, the correlation between moderate income and electric savings rate is low.

Table 26: Pairwise Correlations – IE Programs and Census Variables

	Electric Saving Rate	Gas Savings Rate
Limited English	0.268	0.169
Low income	0.363	0.236
Moderate income	0.056	0.077
Multifamily housing	0.384	0.242
Renter-occupied housing	0.355	0.224
Pre-1950 construction	0.072	0.029
Distressed last three years	0.242	0.155
High income	-0.317	-0.231
Single-family	-0.343	-0.223

All correlations are statistically different from 0 ($p<0.01$), except gas savings with pre-1950 construction, which is not statistically significantly different from zero.

The IE electric programs are somewhat underserving areas with high concentrations of low income and single-family housing.

Table 27 shows the distributions of households and IE program electric savings across Census block groups that are above and below the median proportions of low-income and single-family households. These results show that IE program electric savings are disproportionately concentrated in low-income, multifamily areas. Approximately 41% of households are in these areas, while 72% of IE program electric savings occur in these areas. The other three combinations have lesser proportions of savings than households. The high-income, single-family areas are especially disproportionately low on savings, but this is not a major issue for an income-eligible program. It does appear that low-income, single-family areas are somewhat underserved: 9% of households are in these areas while only 6% of the electric savings occur there.

Gas savings show a similar pattern as electric savings. IE program gas savings are also disproportionately concentrated in low-income, multifamily areas. Approximately 41% of households are in these areas, while 70% of IE program gas savings occur in these areas. For gas savings, low-income, single-family areas appear to be receiving savings commensurate with their proportion of the household population: 9% of households are in these areas and 10% of the gas savings occur there.

Table 27: IE Electric Savings Distributions

Label	Concentration of Low-income homes	Concentration of Single-family homes	% of Households	% of IE electric savings	% of IE gas savings
High-income, multifamily	Low	Low	11%	7%	7%
High-income, single-family	Low	High	39%	14%	13%
Low-income, multifamily	High	Low	41%	72%	70%
Low-income, single-family	High	High	9%	6%	10%

The non-IE programs tend to achieve savings in areas with high concentrations of high-income or single-family homes and not in areas with high concentrations of equity-related demographics.

Non-IE program savings are negatively correlated with most of the examined equity-related variables. Negative correlations indicate that areas with high concentrations of these variables tend to have lower savings rates in the non-IE programs.

It should be noted that the non-IE programs are not designed to serve the equity-related populations. That is what the IE programs are designed to do and appear to be doing. While most of the correlations for the non-IE programs are negative, they are weak and do not indicate particularly strong relationships. Thus, the non-IE programs are only slightly underserving these areas, despite program goals and design that does not focus on serving these areas.

Table 28: Pairwise Correlations – Non-IE Programs, Electricity

	Electric Saving Rate	Gas Savings Rate
Limited English	-0.063	-0.116
Low income	-0.076	-0.166
Moderate income	-0.044	-0.049
Multifamily housing	0.103	-0.013
Renter-occupied housing	-0.005	-0.132
Pre-1950 construction	-0.085	-0.159
Distressed last three years	-0.094	-0.182
High income	0.054	0.149
Single-family	0.002	0.128

All correlations are statistically different from 0 ($p<0.01$), except the cells with grey font, which are not statistically significantly different from zero.

To the extent that the non-IE programs are achieving savings in areas with high concentrations of equity-related demographics, it appears to be occurring through the participation of large, multifamily locations.

Savings outliers were defined as any record above the 99th-percentile of site-level savings. These sites accounted for approximately 30% of all program savings. An analysis using Google satellite images revealed that most of these outliers were large, multifamily locations with hundreds of

units. The amount of savings for these records were reasonable for the overall number of units in the buildings, and the tracking data condensed all those savings onto one or two specific units.

These outliers have a substantial effect on the patterns of savings for the Non-IE programs. Table 29 shows the correlations for electric and gas savings rates and the demographics variables when the outliers are removed from the analysis. The savings are all in the same direction as when the outliers are included (Table 28) but are much stronger. Negative correlations are more negative, and the positive correlations are more positive. This indicates that to the extent the Non-IE programs are reaching areas with high concentrations of equity-related demographics, they are doing so via the outliers. The outliers are predominantly large multifamily properties, so when the Non-IE programs tended to reach the equity-related areas via multifamily installations.

Table 29: Non-IE Program Correlations – Outliers Removed

	Non-IE Electric	Non-IE Gas
Limited English	-0.315	-0.229
Low income	-0.403	-0.303
Moderate income	-0.122	-0.087
Multifamily housing	-0.284	-0.209
Renter-occupied housing	-0.407	-0.325
Pre-1950 construction	-0.256	-0.202
Distressed last three years	-0.296	-0.21
High income	0.704	0.503
Single-family	0.757	0.575

All correlations are statistically different from 0 ($p<0.01$)

Appendix A Detailed Methodologies

This section provides more detail into the methods used to carry out each evaluation task.

A.1 Stakeholder Interviews

A.1.1 Program Staff and DEEP Interviews

The evaluation included interviews with HES and HES-IE program staff from both Companies and the Weatherization Assistance Program (WAP) coordinators at the Connecticut Department of Energy and Environmental Protection (DEEP) (Table 30).[85] Interview questions sought to confirm that program delivery is consistent with its description in the C&LM plan:

- To learn program staff's perspectives on program delivery and future goals
- To discuss any recent or planned program changes, including revised eligibility criteria
- To understand any lessons learned from remote home energy assessments, plus their views on how remote assessments may figure into the program's future.

In addition, DEEP stakeholders spoke about coordination between WAP and HES/HES-IE, areas for improvement, and strategies for improving services to underserved populations.

Table 30: Stakeholder Interviews

Stakeholder	Number of Interviews
Program staff	2
DEEP staff	1

A.1.2 Vendor Interviews

The evaluation included interviews with seventeen qualified HES and/or HES-IE vendors in total, including one Community Action Agency (CAA), an agency responsible for administering certain state programs, including energy assistance (Table 31).[86] Interview questions sought to learn vendors' perspectives on program delivery and customer experience, program tracking data collection, drivers and barriers (health and safety, physical and non-physical), financing and incentives, rebated or add-on measure penetration and quality assurance, DOE Home Energy Scores, and remote home energy assessments. Vendor interviews included questions to assess non-participant spillover (NPSO). Interviews were conducted via telephone or web conferencing software from June 2021 to January 2022.[87]

[85] Two DEEP staff members attended a single interview.
[86] Only two CAAs currently provide weatherization services, but the HES-IE program began providing compensation to non-weatherization CAAs for their referral of energy assistance-approved customers to the HES-IE program in 2017.
[87] Several vendors contacted in the summer of 2021 requested to delay the interview until later in the year due to an exceptionally busy schedule caused by high customer demand for assessments and insulation installs.

Table 31: Vendor Interviews

Role	Number of Interviews
Program vendors	16
Community Action Agency (CAA)	1
Total	17

A.1.3 Community Stakeholder Interviews

The evaluation included in-depth interviews with 10 community stakeholders to understand how the program could better serve communities across Connecticut more equitably and effectively. Interviews were conducted with a variety of community representatives (Table 32), including two housing and energy non-profits, an academic researching public health in Connecticut communities, a community activist helping neighbors sign up for HES audits, a city official overseeing a local weatherization initiative, and five Neighborhood Revitalization Zone (NRZ) representatives (three from Hartford and two from Bridgeport). According to a Connecticut law enacted in 1995, NRZ neighborhood committees provide a mechanism for local stakeholders and municipal officials to develop a strategic plan to revitalize their neighborhood.[88]

Interview topics included awareness of the HES and HES-IE programs, challenges affecting the community, gaps in coverage by the program and other assistance services, effective marketing and outreach strategies, health and safety issues, and the impacts of a high energy burden. Interviews were conducted via telephone or web conferencing software from December 2021 to May 2022.

Table 32: Community Stakeholder Interviews

Stakeholder Role	Number of Interviews
NRZ representative (Hartford)	3
NRZ representative (Bridgeport)	2
Housing/energy non-profit	2
Public health researcher	1
Community organizer	1
Municipal official	1
Total	10

A.2 PARTICIPANT SURVEY

The study included a participant survey with HES and HES-IE participants. Blackstone Group, a CATI firm, printed and mailed the outreach materials, programmed and implemented the survey, and issued $10 gift cards to participants who completed the survey.

[88] https://portal.ct.gov/OPM/NRZ/NRZ-Program

A.2.1 Sample Plan and Survey Completes

The study targeted 1,200 completes for the participant survey and achieved 1,208 (Table 33). Given the more-stringent statistical needs of NTG calculations by individual measure, the sample allocation prioritized HES respondents. Among HES respondents, it prioritized those who installed add-on measures, which were less prevalent than core measures in the Program population.

Table 33: Participant Survey Completes

Program	Target Completes	Completes Achieved
HES	900	932
HES-IE	300	276
Total	1,200	1,208

The study weighted process findings by measure and service territory (A.2.5.1) so they better represent the program population, rather than the sample allocation and survey completes, which disproportionately had installed add-on measures.

A.2.2 Outreach

The study was fielded from November 2021 through February 2022. Advance letters, as well as subsequent postcard and email reminders, invited participants to take the survey in either English or Spanish. Subsequent waves of outreach were tailored to meet target survey completes by program and/or individual measures.

Table 34: Participant Survey Outreach

Survey Wave (Date)	Outreach Method	Contacted
Soft Launch (11/5/2021)	Email	500
First Wave (11/18/2021)	Letters	11,059
1st Reminder -- Soft Launch Sample (11/22/2021)	Email	475
2nd Reminder – Soft Launch Sample (12/10/2021)	Email	469
First Wave (12/14/2021)[a]	Letter	2,777
Reminder (1/4/2022)	Postcard	3,214[b]
HES-IE Only Wave (1/28/2022)	Letter	950
Reminders to HES-IE wave (2/14/2022)	Email	100

[a] Some letters in the first wave sample were held back due to miscommunication from the CATI firm.
[b] After screen-outs removed; also sent to 102 soft launch participants who had previously only received an email invitation.

A.2.3 Response Rate

Outreach to 13,009 HES and HES-IE participants resulted in 1,208 total completes, comprised of 932 HES respondents and 276 HES-IE respondents. The response rate for the outreach was 9.3%, as determined using a calculator developed by the American Association of Public Opinion Research (AAPOR).[89] According to the calculator, the response rate would be 17% under the

[89] American Association for Public Opinion Research (2020). "Response Rate Calculator, Version 4.1" spreadsheet available at https://www.aapor.org/AAPOR_Main/media/MainSiteFiles/Response-Rate-Calculator-4-1-Clean.xlsx. Accessed March 2022.

conservative estimating that half of the cases of unknown respondent eligibility would be eligible to complete the survey.

Both rates are based on the number of unopened, returned outreach letters recorded from November 2021 to early January 2022. Returned outreach letters were not recorded from early January 2022 through February 2022 due to an oversight by the CATI firm. The calculation, therefore, assumes the rate observed during the first half of the survey fielding period remained consistent throughout the remainder of the study.

A.2.4 Area Median Income (AMI)

One of the eligibility criteria for HES-IE respondents is having a household income less than 60% of the state median income by household size. To investigate whether respondents with moderate income of 80% or less of area median income (AMI), the study asked respondents to identify whether their household income was more or less than 80% AMI for their area and household size (Table 35).[90,91]

Table 35: 2021 Area Median Income by HMFA

HUD Metro FMR Area (HMFA)	Household Occupancy							
	1	2	3	4	5	6	7	8
Bridgeport	$56,336	$64,384	$72,432	$80,480	$86,918	$93,357	$99,795	$106,234
Colchester-Lebanon	$64,512	$73,728	$82,944	$92,160	$99,533	$106,906	$114,278	$121,651
Danbury	$64,848	$74,112	$83,376	$92,640	$100,051	$107,462	$114,874	$122,285
Hartford-West Hartford-East Hartford	$58,408	$66,752	$75,096	$83,440	$90,115	$96,790	$103,466	$110,141
Milford-Ansonia-Seymour	$55,552	$63,488	$71,424	$79,360	$85,709	$92,058	$98,406	$104,755
New Haven-Meriden	$52,080	$59,520	$66,960	$74,400	$80,352	$86,304	$92,256	$98,208
Norwich-New London	$49,616	$56,704	$63,792	$70,880	$76,550	$82,221	$87,891	$93,562
Southern Middlesex County	$64,176	$73,344	$82,512	$91,680	$99,014	$106,349	$113,683	$121,018
Stamford-Norwalk	$80,304	$91,776	$103,248	$114,720	$123,898	$133,075	$142,253	$151,430
Waterbury	$45,248	$51,712	$58,176	$64,640	$69,811	$74,982	$80,154	$85,325
Litchfield County	$57,624	$65,856	$74,088	$82,320	$88,906	$95,491	$102,077	$108,662
Windham County	$46,592	$53,248	$59,904	$66,560	$71,885	$77,210	$82,534	$87,859

[90] UniteCT, "HUD Area Median Income Levels," *Connecticut Department of Housing*, last modified July 2022, https://portal.ct.gov/DOH/DOH/Programs/UniteCT.
[91] Office of Policy Development & Research, "Income Limits,", *U.S. Department of Housing and Urban Development*, last modified April 2022, https://www.huduser.gov/portal/datasets/il.html.

A.2.5 Weighting

A.2.5.1 Survey Weights

The study weighted respondents' answers to process questions on the participant survey based on Company territory and their installed measures. Specifically, the latter accounted for whether a respondent installed only core measures, one add-on measure, or multiple add-on measures. Weighting the process results in this way mitigated the oversampling for add-on measures that the study required to statistically significant net-to-gross (NTG) results by measure, as well as differences in response rate by Company territory among completed survey responses.

Table 36: Process Evaluation Survey Weights

Weight	Measure Mix	HES	HES-IE
Eversource	Core only	1.14	1.71
	One add-on	0.16	0.25
	Multiple add-ons	0.83	0.68
United Illuminating	Core only	1.64	4.80
	One add-on	0.96	4.40
	Multiple add-ons	0.88	4.40

A.2.5.2 Savings Weight (NTG and ISR)

In estimating the net savings associated with HES, the study weighted survey respondents' net-to-gross (NTG) responses by their program savings, derived from the program tracking database and converted into MMBtu (for electric measures only). The study weighted NTG responses for each individual measure by the savings recorded in the tracking database for that measure.

In estimating installation rates for each measure, the study weighted responses by respondents' measure-specific savings. For example, the weighted installation rate for pipe wrap represents. the percentage of all respondents' pipe wrap savings associated with those who reported installing it. Savings associated with respondents who never installed the pipe wrap count against the installation rate, but not those who answered, "I'm not sure."

A.2.6 Calculating Net-to-Gross Ratios and Installation Rates

To calculate NTG ratios, the study relied on free-ridership (FR) and spillover (SO) algorithms that reflect industry best practices and specific knowledge of Connecticut's Energy Efficiency Fund programs. It built upon the Massachusetts Residential Self Report Net-to-Gross Method (MA NTG) algorithm [92] by developing scoring schemes that incorporated the Labeled Affective Magnitude (LAM) scale in place of linearly scored elements.[93] The algorithms use findings from the participant survey.

[92] NMR Group, Inc. and Tetra Tech, Inc. May 28, 2020. "Consistent Methodology for Self-Reported Residential Net-to-Gross Measurement (MA19X03-B-RSRNTG). https://ma-eeac.org/wp-content/uploads/MA19X03-B-RSRNTG_Residential-SR-NTG-Report_FINAL_2020.5.28.pdf.

[93] The methodology for converting the linearly scored elements of the Massachusetts Residential Self-Report NTG Method to a Labeled Affective Magnitude scale was outlined in a memo to the EA team on April 28, 2021, and was based off the D'Souza and Skumatz (SERA) draft paper for ECEEE.

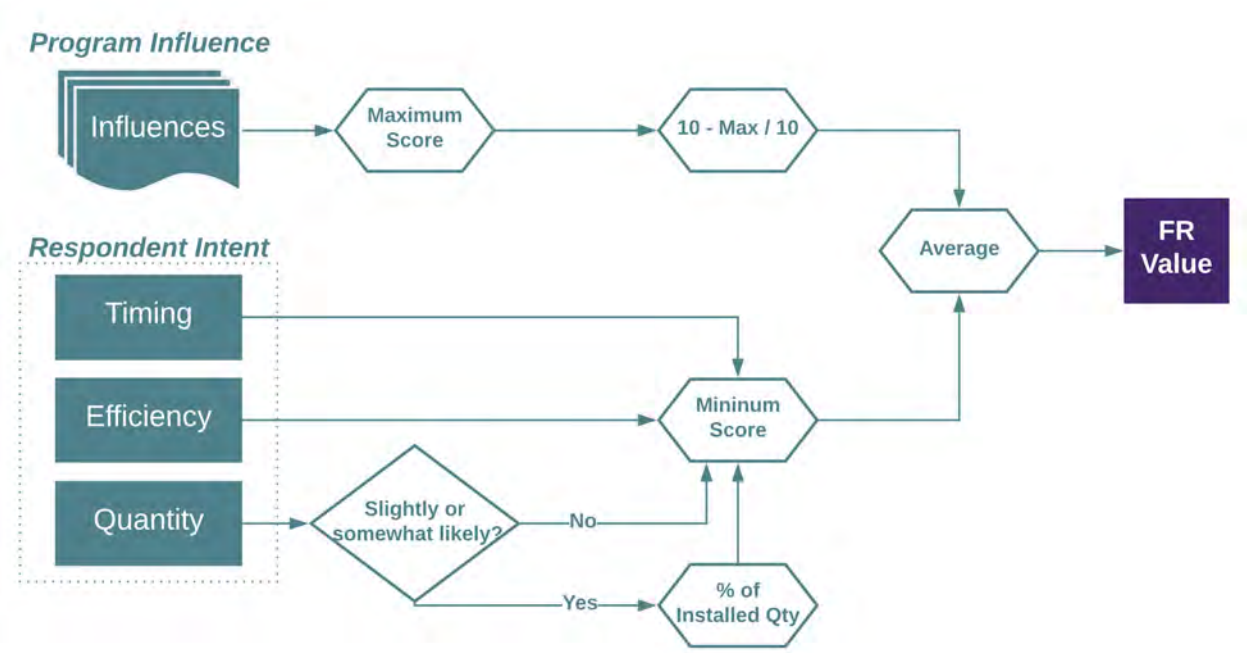
Free-ridership consists of two elements:

- **Influence.** The survey asked respondents to consider how influential various program elements were on their decision to install the program measure: the program rebate available from the utility; financing options available to help pay for the upgrade; information provided by the technician during the home energy assessment; information provided by the respondent's utility or Energize Connecticut[SM]; and marketing materials provided by the contractor.[94] The free-ridership algorithm used the maximum influence score from all program elements rated by each respondent.
- **Intent**, which itself contains three scores:
  1. **Timing**. The survey asked respondents about the likelihood of installing the measure when they did if the rebate, financing, and/or program support had not been available. If the measure was mechanical equipment or an appliance, respondents also indicated whether it was new or installed to replace an existing piece of equipment.
  2. **Quantity**. The survey asked respondents to indicate the likelihood of their installing the same number of units (in the case of mechanical equipment, appliances, lighting, thermostats, or windows) or amount/percentage of the measure (in the case of air sealing, duct sealing, weatherization, and insulation).
  3. **Efficiency.** The survey asked respondents to indicate the likelihood that they would have installed a measure with the same level of efficiency as the program-supported measure. This question was asked about all add-on measures. For core measures, the survey only asked about lighting because efficiency levels for services such as air sealing, duct sealing, door and window weatherization, and water-saving measures do not have meaningful variations in efficiency.

After determining influence and intent scores for each relevant respondent, the FR algorithm takes the average of these two scores to determine their overall FR score.

[94] The survey only asked respondents to rate the influence of program rebates or financing if they previously indicated they were aware of or applied for them. Likewise, the survey only asked respondents who installed an add-on measure about the influence of the contractor that installed it.

Figure 33: Free-Ridership Algorithm Flowchart



Participant spillover (PSO) contains the following elements:

- **Non-rebated measures.** HES participants were asked in the survey whether they had made any energy-efficiency purchases or changes for which they had not received a rebate or financing from their utility since participating in the program. The survey also asked whether their participation in the HES program influenced their decision to take these actions. Respondents then indicated which non-rebated measure(s) or upgrade(s) they installed. For each measure identified, respondents indicated how they knew the measure was energy-efficient, the energy-efficiency rating, if applicable (e.g., ENERGY STAR status, SEER, HPSF, AFUE, and/or EF values), and how many of each measure they installed.
- **Program influence level.** After describing the energy-efficiency and quantity of the non-rebated measure(s) installed after participating in the HES program, respondents rated the importance of their experience of the HES program on each measure and their likelihood of installing the measure if they had not participated in the HES program. Scores from these two influence questions were combined to calculate the participant spillover score for each measure.
- **Weighting by savings.** The analysis weighted for savings by dividing the total spillover savings by the total savings for each respondent (including those who did not claim any spillover.) Spillover savings for each measure were calculated from the average savings in the program database or the 2021 Connecticut Program Savings Document (PSD).[95]

[95] Connecticut's 2022 Program Savings Document. Filed on March 1, 2022. Connecticut's 2022 Program Savings Document (energizect.com). Accessed June 14, 2022.

To assess non-participant spillover (NPSO), the study included interview questions for HES and HES-IE program vendors about the number of assessments and types of equipment they install outside of the program, compared to the amount of work that does go through the program. The Massachusetts Residential NTG Measurement algorithm specifies that trade ally surveys should assess the following elements to quantify NPSO: the number of program-qualified measures sold or installed, the percentage of measures that received rebates, and the influence of the program on the sales of program-qualified but not rebated measures. However, the R1983 interview guide was unable to collect this granular information on NPSO for the reasons outlined below (see Non-Participant Spillover). Therefore, the study offers a qualitative assessment of non-participant spillover which supports the findings from the participant spillover calculation.

To calculate installation rates, the study included survey questions where respondents could confirm, for each of the measures associated with their household in the program tracking data, how many were still installed in their homes, installed then removed, or never installed.[96]

A.3 Program Material and Data Review

The study included a review of various program materials, assessing them for quality, clarity, comprehensiveness, consistency, and accuracy. The types of materials included:

- Field implementation manuals from 2017 and 2019.
- Print on Demand (POD) booklets provided to the customer after the kitchen table sales effort.
- Vendor training materials and QA/QC reports.
- DOE Home Energy Score reports.

The study sampled inspection reports from 2017 through 2019 for closer review of scoring and inspector notes. The inspection scoring process is used to track performance of services by vendor technicians and was created to maintain a high level of quality in program delivery. An independent quality control inspector rates the technician on metrics across three areas: safety, customer service, and measures.

Inspection reports for individual vendors were considered alongside customer satisfaction scores for vendor performance throughout the course of the analysis. However, the inspection reports and vendor scorecards were not significantly correlated with other findings from the study. They are useful as tools for the program staff to track vendor performance and provide short-term feedback and suggestions for improvement.

A.4 Billing and Realization Rate Analysis

This subsection provides additional detail regarding the study's billing analysis methodology and is organized around the following topics:

[96] The study did not ask whether blower-door guided air sealing and/or duct sealing measures were still installed in the household, as these measures would be nearly impossible to uninstall and may have created unnecessary confusion for the survey respondent.

- Applicable Measures
- Treatment Group and Control Group Selection
- Creation of Pre- and Post-Periods
- Weather Normalization
- Data Screening and Attrition
- Model Specification
- Controlling for Cross Participation
- COVID-19 Pandemic Considerations
- Model Performance Metrics

A.4.1 Applicable Measures

The study used billing analysis to estimate savings for following electric and natural gas measures, which were installed in sufficient quantities and/or impact total energy consumption to identify statistically significant changes in household energy consumption.

- **Electric**. Lighting (at the household-level).[97]
- **Natural Gas**. Weatherization (air sealing, wall insulation, floor insulation, attic insulation), and duct sealing.

A.4.2 Treatment Group and Control Group Selection

The treatment group are HES and HES-IE participants who installed at least one applicable billing analysis measure in 2019.

The study used a control group of "future" participants from HES and HES-IE 2020 program year. Using a control group accounts for the impact of various macroeconomic factors and other influences on pre- and post-program energy consumption that are unrelated to the programs and avoid conflating the impact of those factors with program-generated energy savings. Such factors and influences include weather, economic effects, the movement of people in and out of dwelling units, and fluctuations in per-unit energy costs. The inclusion of a control group was particularly critical given the impacts of the pandemic.

To identify the most relevant future participants for the control group, the study used the quasi-experimental matched control group (MCG) method. The MCG method goes beyond random sampling of treatment and comparison groups and instead uses a nearest-neighbor algorithm to match each participant (treatment group) customer with a specific customer from a pool of future participants (control group) based on pre-program energy consumption. This approach identifies the future participant whose energy consumption pattern over the most recent 12 pre-participation months was most like that of the participant.

[97] The study also attempted a billing analysis of weatherization in electrically heated homes, but the results did not meet the study's statistical significance requirements.

As shown in Table 37, the matching approach described above yield treatment and control groups – for both programs and participation types – with very similar total pre-program normalized annual natural gas consumption.

Table 37: Total Average Pre-Program Normalized Annual Natural Gas Consumption (CCF/year)[98]

	Core (Air Sealing Only)		Rebated (Air Sealing & Insulation)	
Program	**Treatment**	**Control**	**Treatment**	**Control**
HES	1,057	1,051	1,110	1,093
HES-IE	1,060	1,046	1,071	1,063

A.4.3 Creation of Pre- and Post-Periods

For each participant, the day before the earliest program installation date (usually the date of their home energy assessment when they had measures such as lighting and aerators directly installed) is the last day of pre-period. Conversely, the day after each participant's last installation date marks the first day of the post-period.

However, billing cycles do not perfectly align with these specific pre- and post-period demarcations, so the study created a "blackout" period that ensures clearly defined pre and post periods. The blackout period includes the billing cycle that includes the last day of the pre-period, the first day of the post-period, and every billing cycle in-between. The study used the blackout period to ensure the analysis did not consider a participant's energy consumption during those billing cycles when estimating programmatic impacts.

A.4.4 Weather Normalization

The study followed the two-stage process for calculating the normalized consumption as outlined in the DOE's UMP for Whole-building Retrofit with Consumption Data Analysis Evaluation Protocol. The UMP method involves fitting parameters describing baseload and HDD components to describe actual usage of each participant based on actual HDD. Normalized consumption is calculated by using TMY3-based HDD values which are multiplied by the heating coefficient and added to the baseload described by the models for each participant.

A.4.5 Data Screening & Attrition

The team used billing analysis to separately evaluate HES & HES-IE weatherization savings in natural gas-heated Eversource and UI homes. As noted previously, weatherization refers to one or more of the following measures: air sealing, attic insulation, wall insulation, and floor/basement insulation.

To begin, the study identified the relevant HES & HES-IE treatment (2019) and control (2020) participants for both Companies. A screening process when narrowed the treatment and controls groups to only those participants who met the necessary criteria for inclusion in the billing analysis. As shown in Table 38 and Table 39, the screening process removed natural gas participants that

[98] Total natural gas consumption – not just heating related natural gas consumption as reported elsewhere in the report.

we could not confidently map to billing data, that lacked sufficient billing records, or whose exhibited extreme usage. In total, the screening process removed 53% of HES and more than two-thirds (67%) of HES-IE participants. The largest loss of data resulted from the process of matching program tracking data to billing data. The HES-IE had a greater loss of data at this stage due to account numbers provided by Eversource were partially masked (i.e., obscured to protect private information). The study team worked closely with Eversource to access unmasked account numbers, but unmasked values were no longer available for many of these HES-IE participants. Subsequently, the study was able to match 65% of the masked account numbers to the full account number.

Despite the high-level of attrition, there were enough accounts available to generate statistically significant estimates at the statewide level for both programs. However, there were not sufficient accounts to generate results at the company level. This is because the company-specific savings estimates failed the study's model stability test, which entailed iteratively estimating savings using subtly different specifications and variable coding schemes. All statewide estimates fell within the 90% confidence level of the standard model, an indication of stable and reliable results. However, more than a third of the company-specific model savings fell outside the confidence level of the standard estimate, an indication of instability and unreliable results at that more granular level. The previous HES & HES-IE impact evaluation (R1603) also presented program-specific results at the statewide level because more granular results (i.e., by Company) were also not statistically significant.

Table 38: Billing Analysis Sample Attrition – Natural Gas Weatherization (HES – Eversource and UI)

HES	Statewide		
	# of Effected Accounts	% of Effected Accounts	Remaining Accounts
Total weatherized accounts	-	-	3,293
Non-gas heat	34	1%	3,259
Multi-family dwelling	21	1%	3,238
Unable to map to billing data	1,139	35%	2,099
Insufficient pre or post data (<12 months)	448	14%	1,651
Extreme monthly consumption (>35 therms in single month)	1	0%	1,650
Extreme annual consumption (<1st and >99th Percentile)	33	1%	1,617
Extreme savings change (±40%)	96	3%	1,521
Attic hatch only (no other insulation)	404	12%	1,117
Overall	**2,176**	**66%**	**1,117**

Table 39: Billing Analysis Sample Attrition – Natural Gas Weatherization (HES-IE – Eversource and UI)

HES-IE	Statewide		
	# of Effected Accounts	% of Effected Accounts	Remaining Accounts
Total weatherized accounts	-	-	1,564
Non-gas heat	10	1%	1,554
Multi-family Dwelling	21		1,533
Unable to map to billing data	771	49%	762
Insufficient pre or post data (<12 months)	159	10%	603
Extreme monthly consumption (>35 therms in single month)	1	0%	602
Extreme annual consumption (<1st and >99th Percentile)	12	1%	590
Extreme savings change (±40%)	64	4%	526
Attic hatch only (no other insulation)	149	10%	377
Overall	**1,187**	**76%**	**377**

Given the extent of the data attrition shown above, the study compared the building and consumption characteristics of the participants included in the billing analysis and that that were not to check for similarity and potential bias. The study found:

- **Similar sized homes**. The participants excluded from the HES treatment group have a mean square footage only 3% higher than the treatment group. The difference for HES-IE were slightly higher: the participants excluded from the HES-IE treatment group have a mean square footage 7% higher than the treatment group.
- **Older homes**. The participants in excluded from the HES treatment group lived, on average, in older homes (68 years old) than those included in the treatment group (57 years old) although neither value was statistically significantly different from the average for all participants with home ages.
- **Similar consumption**. The HES and HES-IE treatment groups both had very similar consumption levels (1% and 2% different, respectively) compared to the population of participants in both programs.

Model Specification

The study uses a monthly Post Program Regression (PPR) billing analysis model to estimate energy savings attributed to the HES and HES-IE programs. The model uses the “post-program” period – that is, the period after the start of the program – energy usage only as the dependent variable in the model, as shown in Equation 2:

Equation 2: Post Program Regression

$$ADC_{ct} = \sum_{measure\ group\ m} b_{1m} Treatment_{mc} + b_2 LagADC_{ct} + \sum_{month\ i} b_{3i} Month_{it} + \sum_{month\ i} b_{4i} Month_{it} * LagADC_{ci} + b_5 CrossProg_c + e_{ct}$$

Where

- ADC_{ct} = average, weather-normalized daily energy consumption for customer *c* at calendar month *t*
- $Treatment_{mc}$ = 1 if customer *c* is in treatment for measure group *m*, 0 if customer *c* is in control group
- $LagADC_{ct}$ = average weather-normalized daily consumption from customer *c* during calendar month *t* of the pre-program period
- $Month_{it}$ = 1 when index *i* = calendar month *t*, 0 otherwise. We include this series of 12 terms to capture month-specific effects in our analysis
- $CrossProg_c$ = 1 if customer *c* received an energy-efficiency or health and safety-related improvement from outside of the HES or HES-IE programs
- e_{ct} is a cluster-robust error term from the regression model

For this model, the study used billed, pre-program period weather-normalized energy consumption as an explanatory variable which helps to condition expected, billed energy consumption in the post-program period. The model also includes monthly fixed effects and uses the model to interact these monthly fixed effects with the pre-program energy use variable, which allows pre-program usage to have a different effect on post-program usage in each calendar month. The coefficients of the treatment groups (b_{1m}) are estimates of average daily energy savings during the post-program period.

The study represented model groups as dummy variables representing the installation of air sealing only, air sealing & insulation, duct sealing, and domestic hot water measures. Other measure installations were not in the treatment group. The study did not observe DHW measures yielding significant savings but kept the measure category in to avoid specification bias.

A.4.6 Controlling for Cross-Participation

The study team recognizes the necessity of identifying, and controlling for, measures installed outside of the HES and HES-IE programs; not doing so would conflate the programs and overstate the billing analysis results. For example, some HES participants may also receive measures through other utility programs. To avoid conflating savings across programs in instances such as this, the model requested and leveraged data for other residential programs, which was collected as part of the Customer Profiling task. The study used these data to control for cross-program participation, specifically by including a program or measure-specific dummy variable reflecting cross-participation in our model specification.

A.4.7 COVID-19 Pandemic Considerations

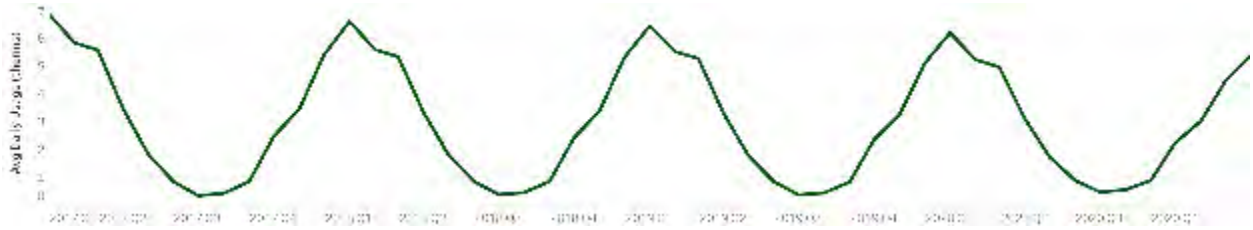
The post-program period for 2019 HES & HES-IE participants in the treatment group includes the start of the COVID-19 pandemic, including months when stay-at-home orders were in place and/or many customers began working from home.

From a modeling perspective, the study's use of a control group, which also experienced the pandemic-related impacts and lifestyle changes, accounts for the potential impact of the pandemic on the study's modeled savings. In fact, accounting for these types of non-programmatic factors is exactly the reason that control groups are considered industry best practice for billing analysis-based evaluation efforts.

To further test for the potential impact of the COVID-19 pandemic on evaluation, the study team also investigated for 1) **changes in energy consumption** and 2) **differences in participant characteristics** before and after the start of the pandemic.

- **Changes in Energy Consumption.** The study did not identify any drastic deviations in We will discuss best delivery options with the EA Team. This finding, while somewhat counter-intuitive given many people spent more time at home because of the COVID-19 pandemic, is consistent with residential studies of the same time in Massachusetts.[99]

Figure 34: Average Participant Daily Usage (CCF) Over Time



- **Difference in Participant Characteristics.** It is also possible that the pandemic changed the composition of participants that enrolled in HES and HES-IE in 2020 (relative to previous years). Since the study used 2020 participants as the control group, the study proactively looked for any significant differences between the 2019 and 2020 participants that would violate the assumption the groups are similar (in ways beyond their pre-program consumption, which was the basis for the matching algorithm). The team looked at home age, home size, and consumption and did not find any differences in the available program data. However, it's important to note that the study could only assess

[99] "The peak day demand for cooling end uses increased, while the demand for heating end uses (boilers, furnaces, and hardwired electric heat) decreased. These shifts can be explained by the increases in homes' internal heat loads. People being home, cooking, working, and using office equipment more during the pandemic likely increased the average heat gain of the home, which added to the cooling load and decreased the resulting heating load." (https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2022-03-01.pdf)

characteristics in the available data, which does not contain every customer characteristic, so it is not possible to completely rule out a violation of model assumptions.

A.4.8 Model Performance Metrics

Billing analysis estimates for measures are provided for at the 90% confidence all level. Estimates for savings attributed to HES-IE lighting program were the only program/measure savings with greater than the desired 20% precision. Although it has less precision, the estimate agreed with the HES estimate and serves as a reasonable estimate of savings. Coefficients represent daily savings; the study multiplied by 365 to yield annual savings.

Table 40. Billing Analysis Model Details (Sample Size and Confidence & Precision Values)

Program	HES				HES-IE			
	N	Coeff	Precision	P value	N	Coeff	Precision	P value
Air Sealing Only (Core Participants)	969	0.047	±6%	<0.01	259	0.031	±20%	0.03
Air Sealing & Insulation (Rebated/Add-on Participants)	148	0.172	±11%	<0.01	118	0.500	±19%	<0.01
Duct Sealing	194	0.015	±7%	0.06	18	0.005	±7%	<0.01
DHW	762	0.011	±107%	0.41	295	0.030	±96%	0.39
Lighting*	795	0.049	±19%	<0.01	963	0.047	±31%	<0.01

*Separate electric billing analysis model

A.5 Engineering Analysis and Building Simulation

As noted previously, the study created an Impact Evaluation Supporting Documentation workbook to supplement this report as a stand-alone, comprehensive repository of all engineering related details. The workbook includes a tab for each HES & HES-IE measure that was evaluated using an engineering approach (i.e., algorithms or building simulation). Therefore, any readers interested in methodologies, assumptions, and calculations associated with the engineering analysis should request access from the EA Team and refer to it for more information.

A.6 Customer Profiling

This section describes the steps taken to prepare the data for the customer profiling, metrics, and the analyses used by the evaluation team. Detailed findings are described in Appendix E.

A.6.1 Data Preparation

As a first step, the study requested program tracking and customer billing data from the Companies, then consolidated those data into a single dataset for the analysis. Table 41 provides a summary of the annual electric and gas consumption and claimed gross savings in the final evaluation dataset. The values are aggregates of annual energy consumption and gross energy savings from 2017 to 2020. The table provides the values by Company and the total across the

two Companies. The bulk of the electricity consumption and gross savings are from Eversource, while the bulk of the gas consumption and gross savings are from UI.

Table 41: Total Consumption and Savings Used in the Evaluation

Fuel	Company	Consumption (all customers)	Savings (downstream only)
Electricity (MWh)	Eversource	32,532,779	389,966
	UI	8,237,636	123,897
	Total	40,770,415	513,864
Gas (CCF)	Eversource	548,246,207	4,433,566
	UI	1,305,122,495	8,015,395
	Total	1,853,368,702	12,448,961

All entries were then geocoded in the evaluation datasets. Addresses representing 90% of electric savings and 88% of gas savings were geocoded to census block groups. The study excluded data from census block groups[100] with less than 25 accounts or where reported savings were greater than total energy consumption for the block.[101] The excluded values represented 1% of electric savings and 3% of gas savings. The final evaluation datasets thus contained 88% of the electric savings and 85% of the gas savings of the original evaluation datasets.

A.6.2 Savings by Program

Table 42 lists the savings by program in the analysis data set. It is subdivided by company and program name and lists whether the program is considered an income-eligible program. Approximately one-third of total analyzed savings were in income-eligible programs.

Table 42: Savings by Program (2017-2020)

Company	Program Name	Income Eligible	Electric savings (MWh)	Gas savings (CCF)
Eversource	Appliance Retirement		45,528	0
	Estar Homes (Res. New Construction)		2,316,589	238,576
	HES HVAC		2,304,356	0
	HES MF		4,114,317	148,083
	HES Rebates		2,840,764	197,714
	HES SF		0	572,393
	HES Wi-Fi Thermostat		70,773	0
	Home Energy Solution - HVAC, Water Heater		33,362,770	1,311,395
	Home Energy Solutions - Core Services		3,212,450	5,324
	Home Energy Solutions Home Performance		18,923,181	0

[100] Census block groups typically include 600 to 3,000 people.
[101] Site-level savings will rarely exceed 10% of consumption. However, the evaluation used this more lenient threshold to include as much of the tracked savings as possible.

Company	Program Name	Income Eligible	Electric savings (MWh)	Gas savings (CCF)
	Home Energy Solutions - HVAC, Water Heaters		0	632
	Home Energy Solutions Tier 1		37,984,124	0
	Insulation Rebate		2,461,228	0
	Natural Gas Boiler Water Reset Rebate		0	45
	Natural Gas Water Heater		0	91,724
	Residential New Construction		954,462	225
	RNC HERS Rating		16,800	0
	Smart Living Catalog		13,662	0
	Top Ten USA Appliance Rebate		870,254	125
	Window Rebate		57,202	0
	Appliance Replacement HES-IE	Yes	64,521	0
	HES Income Eligible	Yes	4,813,284	119,225
	HESIE 1	Yes	258,487	0
	HESIE 2	Yes	12,657,464	0
	HESIE 3	Yes	21,243,691	0
	HES-IE Mobile Sub 1	Yes	92,444	0
	HES-IE Mobile Sub 2	Yes	6,812,234	0
	Income Eligible (HES-IE)	Yes	4,111,164	1,042,259
UI	CWH		0	128,817
	ENERGY STAR HOMES		1,291,706	162,235
	HOME ENERGY SOLUTIONS		11,285,959	1,613,515
	HVC		3,688,034	2,635,990
	LOW INCOME (RES.)	Yes	11,240,893	2,252,385
Overall	Non-Income-Eligible		125,814,158	7,106,794
	Income-Eligible	Yes	61,294,181	3,413,870

A.6.3 Large Multifamily Locations

During the data preparation step, the study observed a substantial number of records that were associated with a single address but had savings in the 99th percentile of all site-level savings. Electric savings for these sites ranged from 13,200 to 3.7 million kWh. Gas savings for these sites ranged from 916 CCF to 78,908 CCF.

Examination of these sites revealed that many of them are large multifamily properties with dozens of units, and often multiple buildings. The examination determined that the amount of site-level savings for these records was reasonable for large multifamily properties with high numbers of individual units, so the core analyses included these records.

A.6.4 Combination With American Community Survey Data

The next step in preparing the data was to aggregate the utility tracking and billing data to the Census block group level. The data preparation appended a block group identifier to all records, so this step simply consisted of summing savings and consumption by block group.

The study then appended several American Community Survey (ACS) variables to the block group-level data. These variables included:

- **Household limited English proficiency (ACS Table ID: C16002)** – The number of households where no one over the age of 14 in the home speaks English "very well" relative to total households in the block group.
- **Household income[102] –** The number of low-income households whose income is up to 50% of the Area Median Income (AMI), the number of moderate-income households whose income is between 50% to 80% of the AMI, and the number of high-income households whose income is above 150% of the AMI, each relative to total households in the block group.
- **Building type (ACS Table ID: B25024)** – The number of attached and detached single family housing units and the number of multifamily housing units (buildings with 5+ units), each relative to total housing units in the block group.
- **Tenure (ACS Table ID: B25003)** – The number of renter- and owner-occupied housing units, each relative to total housing units in the block group.
- **Construction year (ACS Table ID: B25034)** – The number of housing units built before 1950 and the number of housing units built from 1950 onwards, each relative to total housing units in the block group.
- **Maximum educational attainment in household (ACS Table ID: B15003)** - The number of households with less than high school, high school, less than bachelors, bachelors, and advanced degrees, each relative to total households in the block group.
- **Age of household occupants (ACS Table ID: B25007)** – The number of households where the median age of occupants is above 65 years relative to total households in the block group.
- **Internet access (ACS Table ID: B28011)** – The number of households with internet (Broadband, Dial-up, Satellite) subscription relative to total households in the block group.
- **Heating fuel (ACS Table ID: B25040)** – The number of households with electric, utility gas, fuel oil and kerosene, and solar heating, each relative to total households in the block group.
- **Location (urban/rural)** – Block groups geocoded as rural or urban.

Connecticut maintains and annually updates a distressed communities list based on income and environmental justice metrics. The evaluation identified all communities that were on the distressed communities list in any of the three years analyzed (2018 to 2020) and flagged all block groups in those communities as "distressed in 2018, 2019, or 2020."[103]

[102] Source: Low Moderate Income Summary Data - Based on 2011-2015 ACS (LMISD - All Block Groups, Based on 2011-2015 ACS - HUD Exchange)

[103] There were 29 distressed communities identified using this approach, 23 of which were on the distressed list for all three years, 4 were on the list for two of the years, and 2 were on the list for one year (2020).

A.6.5 Participation Metrics

The study considered two metrics for participation: location participation rate and savings rate. Both metrics are calculated at the census block group level (200 to 1000 households) rather than individual household level.

Location participation rate is the percentage of households receiving service that participate in energy-efficiency programs, calculated by dividing the number of participating households by the number of billed households.

Equation 3: Location Participation Rate

$$location\ participation\ rate = \frac{\#participating\ households}{\#billed\ households}$$

Location participation rate is useful for assessing the breadth of participation within an area. All participating households are considered equally, regardless of the size or number of energy efficiency measures they install. The large, multifamily participant records described in the previous section distort the location participation rate calculations. These records contribute only a single count to the numerator, but many counts to the denominator. Thus, in block groups where these participants are located, location participation rates look lower than they really are.

Savings rate represents depth of savings achieved by the programs. It is the percentage of total annual consumption represented by first year gross savings for the measures installed. It is calculated at the block group level by summing first-year savings for all participating locations within that block group and dividing by the sum of the consumption of all locations (including nonparticipants) in the block group for a single year.

Equation 4: Savings Rate

$$savings\ rate = \frac{\sum^{f} irst\ \ year\ savings_{participants}}{\sum^{a} nnual\ \ consumption_{all\ households}}$$

Location participation rate and savings rate often correlate positively with each other – as the number of participating households in a block group increases, the savings rate numerator increases. However, large, multifamily participant records created a negative relationship between location participation rate and savings rate because of their distortion on location participation rate. In other words, these large multifamily records make it appear as though the percentage of consumption represented by program savings decreased as the number of participating locations increased.

The study decided to use only the savings rate metric for the profile analyses. The anomaly with large, multifamily participants suggests that location participation rates are less valid in this dataset than savings rates. While theoretically possible, an inverse relationship between participation metrics results in confusing and contradictory conclusions depending on which metric one uses in analyses.

A. Analysis

The evaluation analyzed the IE and non-IE programs independently because they are administered separately and have different demographic targets and objectives.

The study used a combination of correlation analysis and regression modeling to understand participations patterns relative to geographic-level demographic variables. The correlation analysis was the primary analysis, which answers the question of what are the dominant demographic variables in areas with high (or low) levels of participation? Because many demographic variables occur simultaneously (e.g., low-income households also tend to rent), the regression analyses answered the question of which demographic variables have a stronger relationship to participation, when the demographics occur together?

B. Correlation analysis

In the geospatial context of this study, correlation analyses identify variables that occur at similar levels within the geospatial units of interest (Census block groups). A high correlation between variables A and B indicates that areas with a high concentration of A also tend to have a high concentration of B (and vice versa). A negative correlation between variables C and D indicates that areas that tend to have a high concentration of C tend to have a *low* concentration of D (and vice versa). Thus, the correlational analyses allowed the evaluation team to identify what demographic characteristics were common in areas that had higher or lower levels of participation (as measured by savings rate).

Correlation coefficients (Pearson's r) can range from -1 to +1. Correlation coefficients around 0.3 (or -0.3) are common in social science research and represent moderately strong relationships between variables. Correlations closer to 0 indicate weaker relationships, and correlations closer to 1 (or -1) indicate stronger relationships. A variable always has a correlation of 1.0 with itself.

C. Regression analysis

When two demographic variables correlate with participation and with each other, multiple interpretations are possible. For example, in Connecticut, concentration of multifamily housing is positively correlated with participation. Concentration of renters is also positively correlated with participation. And concentration of multifamily housing is positively correlated with the concentration of renters. This pattern raises the question of which is the more directly relevant characteristic when it comes to predicting participation: concentration of multifamily or concentration of renters? Or are both independent predictors of participation?

The study used a method called statistical mediation analysis to assess which variables were more directly associated with participation rates.[104] This analysis uses a series of regression models to illuminate the effects of each demographic variable on participation rates while controlling for the effects of the other demographic variable.

An example of where mediation happens in other research is the relationship between a child's age, weight, and height. As children get older, they also tend to get taller and heavier. And as children get taller, they also tend to get heavier. Age, per se, does not result in higher weight. Age tends to result in greater height, and greater height results in greater weight. As children age, they

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[104] [1] Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51,* 1173-1182. Summarized at: http://davidakenny.net/cm/mediate.htm

get taller, and as children get taller, they tend to gain weight. Thus, we would say that height mediates the relationship between age and weight.

Generalizing, when there are three variables, X, Y, and M, correlated with each other, this method uses five criteria to determine statistical mediation as listed in Table 54. When all five criteria are met, it indicates that the effect of variable X on Y is mediated by variable M.

Table 54: Statistical Mediation Analysis Criteria

Criterion	Analytic evidence
1. Variable X predicts variable Y	X-Y correlation significant
2. Variable X predicts variable M	X-M correlation significant
3. Variable M predicts variable Y	M-Y correlation significant
4. Variable X no longer predicts Y when controlling for M	Model predicting Y with X and M; coefficient for X is not significant
5. Variable M predicts Y when controlling for X	Model predicting Y with X and M; coefficient for M is significant

Applied to energy efficiency program participation, the pattern this analysis attempts to identify is that one variable (e.g., renter concentration) is significantly correlated with participation rates because it is related to another variable (e.g., multifamily concentration) that is also correlated with participation rates. In this example, the analysis attempts to identify a pattern that indicates that renter concentration is associated with participation rates because renters tend to live in multifamily housing, or the effect of renting is mediated through the effect of multifamily housing.

D. Sensitivity Analysis

To assess the effects of the large savings outlier records on the analyses, the evaluation repeated the correlation and regression analyses on a data set that excluded the outliers.

A.6.5.1 Data limitations

Because of data availability, the study could only analyze first year electric and gas savings rates. Delivered fuel savings rates could not be analyzed because total consumption for delivered fuels is unknown. Likewise, lifetime total consumption is also unknown. Savings has to be normalized to total consumption to control for the size of individual locations (large buildings can save more because they consume more) and differences in population within block groups (similarly, a block group with many households could save more than one with fewer households.)

Account participation rates were not a viable metric for this study because approximately 30% of the savings were associated with only 1% of the accounts. Upon review of these accounts, the evaluation team verified that many of them are large multifamily properties with hundreds of individual units, but the savings were recorded in the database as associated with a single unit. This causes account participation rates to be unreliable.

Electric savings rates cannot be used as a proxy for delivered fuel savings rates because electric energy use only accounts for a fraction of the total energy used by a home heated with delivered fuels. Gas savings rates also cannot be used because the analyses in this report are geographically based and gas and delivered fuel geographies have minimum overlap.

Appendix B Process Evaluation - Detailed Results

This section presents detailed results from the process evaluation, which included a survey of HES and HES-IE participants and in-depth interviews with vendors, program stakeholders, and community stakeholders.

Detailed findings are organized into the following sections:

- **Participant engagement**, including participant satisfaction, sources of program awareness, program marketing and outreach, and underserved customer segments.
- **Program delivery and processes**, including participant and vendor satisfaction, program processes and communication, and quality control.
- **Drivers and barriers to participation**, including the kitchen table wrap-up, participant uptake of rebated or add-on measures, and solutions to barriers identified as preventing the installation of additional measures.
- **Health and safety barriers**, which describes the prevalence of issues that prevent weatherization and/or pose a health risk to customers, program implications, and barriers to remediation.
- **Rebates and financing**, including awareness of rebate and financing options, participant satisfaction with rebate amounts and processing time, and experience with the application process.
- **DOE Home Energy Scores**, including awareness and perceived usefulness of the score and vendors' experience providing the score as part of the assessment.
- **Training and workforce development**, including vendor experiences with training and retaining qualified technicians, program training requirements, and progress toward the statewide goal of weatherizing 80% of residential units by 2030.
- **Demographics and firmographics**, including number and age of occupants, income, race, ethnicity, and educational attainment of participants and tenure of program vendor interviewees.

B.1 Participant Engagement

The participant survey asked participants about their satisfaction and engagement with the program, both overall and regarding particular elements of the program, such as energy savings, rebate amount, and the professionalism of program contractors. Vendors and community stakeholders answered questions about program marketing, effective program outreach, and customer segments that could be underrepresented among program participants.

B.1.1 Key Findings

- HES and HES-IE respondents shared the same top three motivations for deciding to have the home energy assessment done: to identify opportunities to save the most money, to learn about energy-saving opportunities, and to make their homes more comfortable.

- HES respondents with moderate incomes (below 80% area median income (AMI), but above the threshold for HES-IE eligibility) were more likely than HES respondents with incomes above 80% AMI to say they decided to have the home assessment to find ways to make their home more comfortable.
- Over one-half of respondents (59% of HES respondents and 54% of HES-IE respondents) learned about the program through program marketing, including the Energize Connecticut website, bill inserts, utility company websites, and/or utility advertisements.
- Approximately one-quarter of participants (25% of HES respondents and 23% of HES-IE respondents) learned about the programs from family or friends.
- Vendors and stakeholders identified customer types that they believe are underserved by the program and suggested solutions to serve these groups more effectively:
    - *Low-income customers* may be underserved due to difficulty in verifying income or inability to take off work for the assessment.
    - *Moderate-income* customers do not qualify for HES-IE but have difficulty affording the recommended upgrades and the remediation costs of health and safety barriers. The study operationalized these households as having incomes that fell between 60% and 80% of the area median income (AMI).
    - *Renters* require approval to participate from their landlords. Vendors and stakeholders suggested directly engaging with landlords to educate them on the benefits of the program.
    - *Rural customers* may be located outside vendors' service areas and have fewer options for service.
    - *Non-English-speaking customers* may not have access to program materials or advertisements printed in their language or be able to communicate effectively with program vendors; one vendor suggested providing technicians access to a language line.
    - *Elderly customers* have fixed incomes and may have difficulty accessing program materials online.
    - *Immigrant customers* may be wary of engaging with programs that involve house visits and personal data collection.

B.1.2 Motivations for Participation

When asked why they decided to have the home energy assessment, respondents most frequently said they wanted to identify improvements to save money, learn about energy-saving opportunities, and to find ways to make their home more comfortable (Figure 36).

Figure 35: Reasons for Participating in HES or HES-IE

(Source: Participant survey; multiple responses allowed)

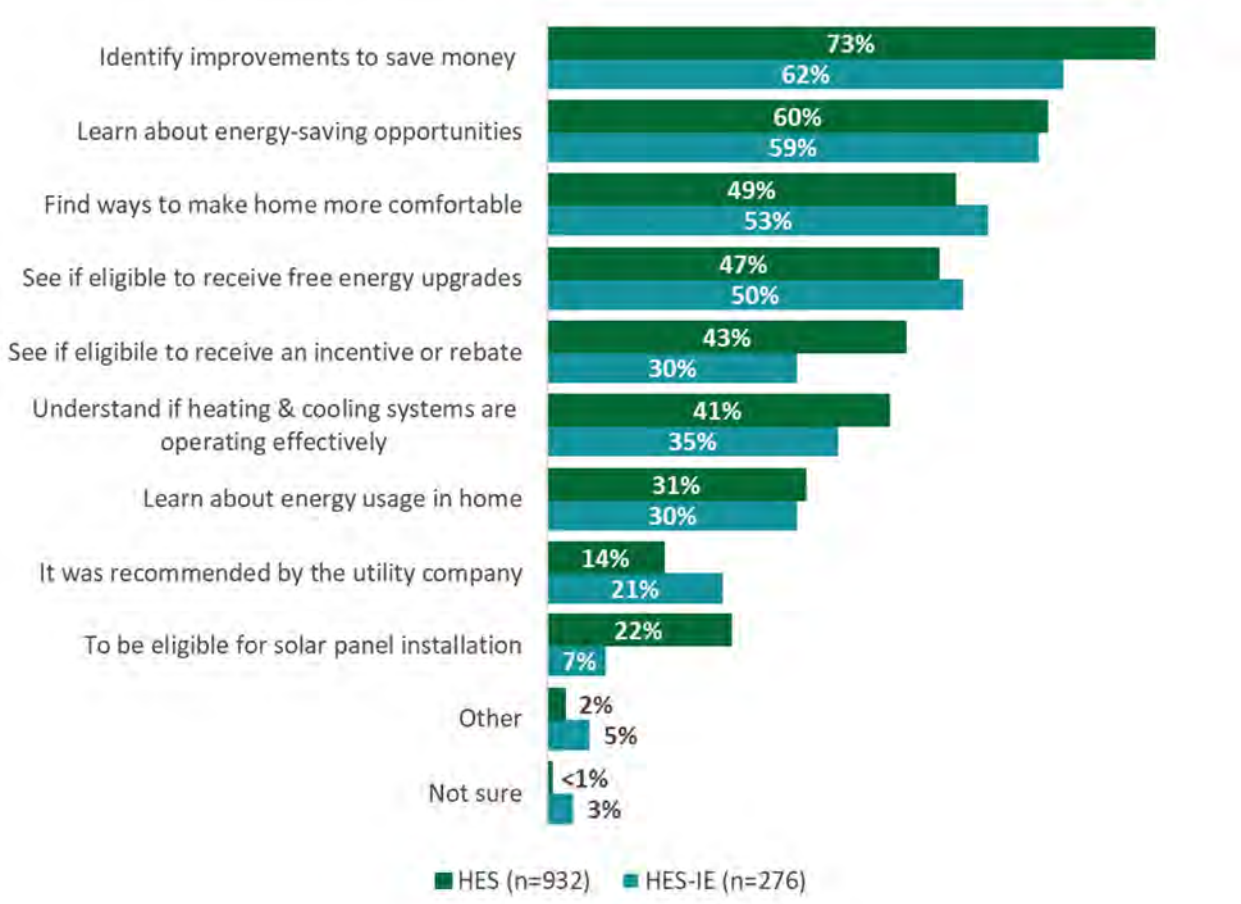
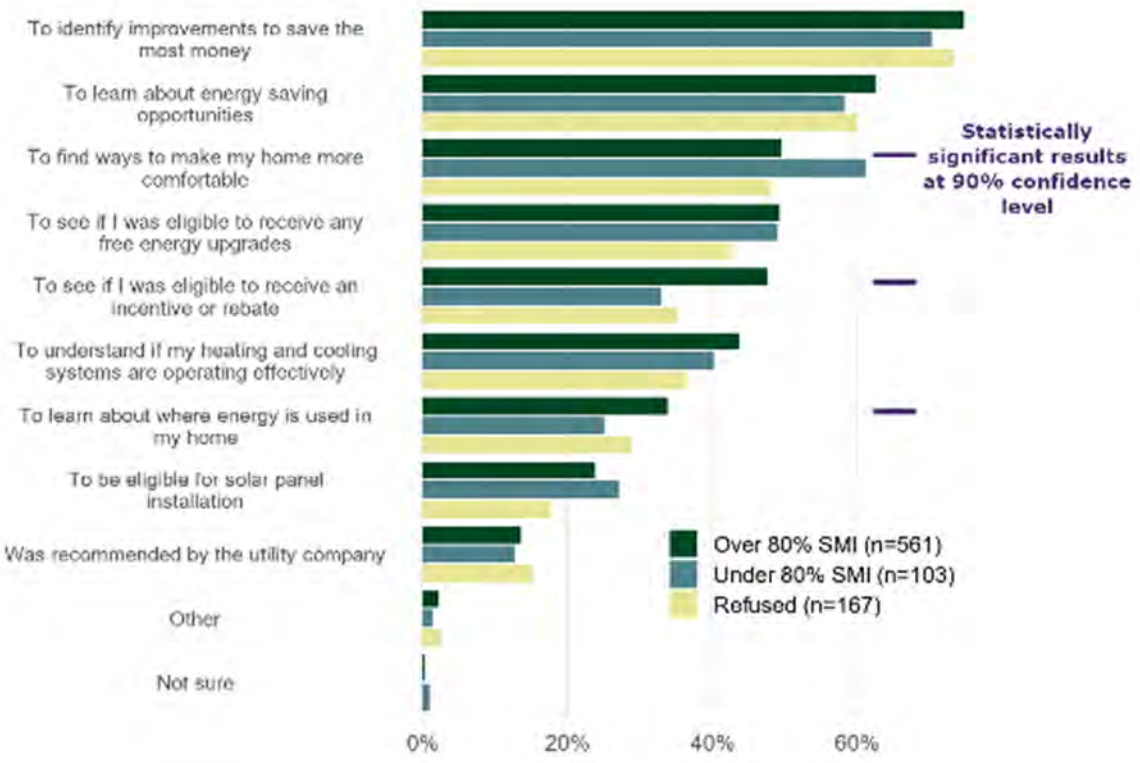


Figure 36 compares survey responses to this question across HES participants with self-reported incomes over and under 80% AMI, highlighting items with a statistically significant difference at the 90% confidence level. NMR categorized HES respondents below the 80% income threshold as moderate income. These households are not eligible for HES-IE. Moderate income respondents were statistically significantly more likely to have the assessment to find ways to make their home more comfortable (65% of respondents) compared to respondents with a self-reported income over 80% of AMI (50%). Respondents over that income threshold were significantly more likely to have the assessment to check their eligibility for an incentive or rebate (48%) and to learn about where energy is used in their homes (34%) compared to moderate income respondents (33% and 25%, respectively).

Figure 36: HES Participants' Motivations for Having the Home Energy Assessment Done by Income Level
(Source: Participant survey; n=932; multiple responses allowed)

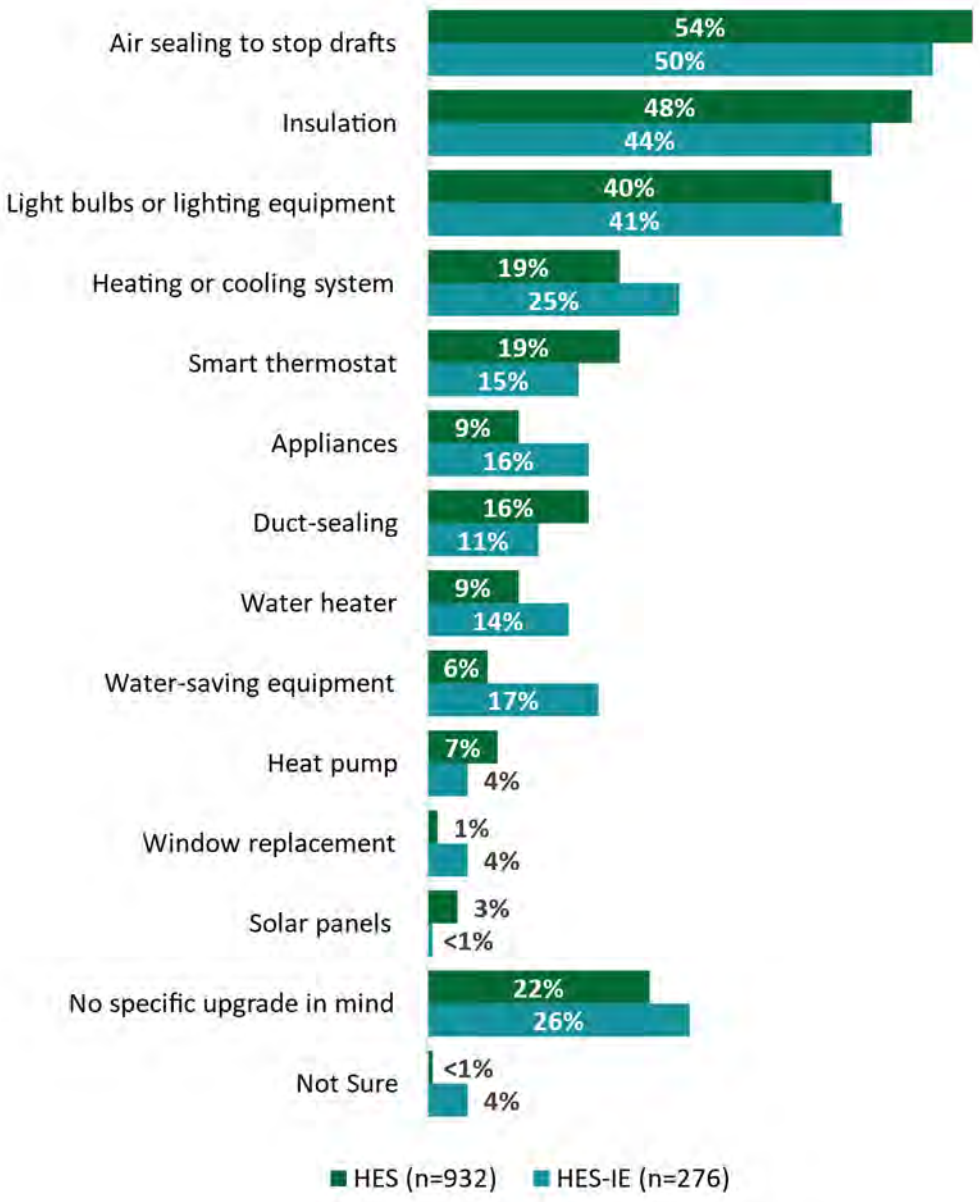


B.1.2.1 Measures of Interest

Respondents were most likely to say they were interested in air sealing, insulation, and light bulbs or lighting equipment when they first signed up for the assessment (Figure 37).

Figure 37: Measures of Interest When Signing Up for Assessment

(Source: Participant survey)



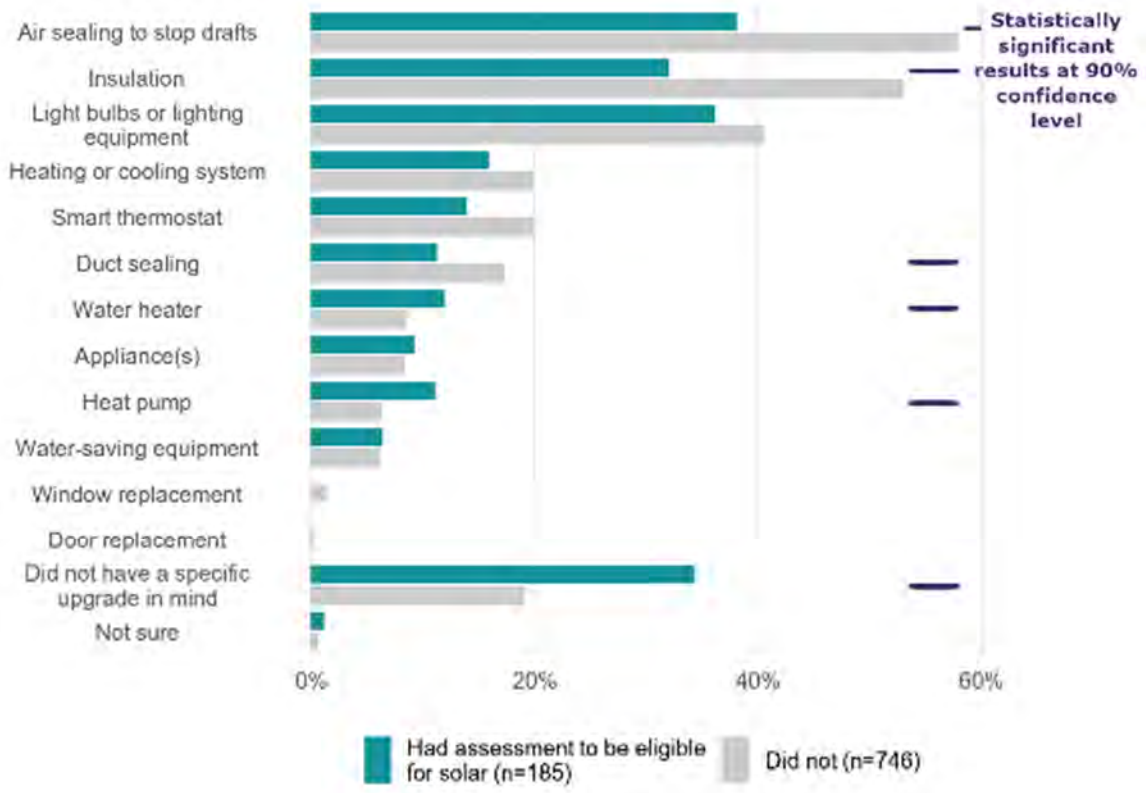
B.1.2.2 Solar Eligibility

Nearly one-quarter of HES respondents (22%) said they completed the assessment to be eligible for solar panel installation (Figure 35). Those respondents who reported receiving an assessment to become eligible for solar were statistically significantly more likely to say they did not have a specific energy-efficiency upgrade in mind when signing up for the assessment (Figure 38). They were also significantly more likely to express interest in water heaters and heat pumps, typical measures that would complement a PV solar installation. However, this same group of respondents was significantly less likely than other respondents to say they were interested in air sealing, insulation, and duct sealing. The program requires solar customers to have a home

energy assessment. These results suggest that solar customers may be simply "checking a box" to fulfill the requirement and not interested in achieving deeper savings.

Figure 38: Measures of Interest when Signing up for Assessment by Solar Eligibility, HES

(Source: Participant survey; n=932; multiple responses allowed)



B.1.3 Program Awareness and Marketing

Survey questions then asked participants how they had first learned about the home energy assessments on offer by utility companies. Community stakeholder interviewees also described their awareness of the HES program and the income-eligible offering (HES-IE).

B.1.3.1 Sources of Program Awareness

As shown in Figure 39, program marketing (the Energize Connecticut website, a bill insert, their utility company's website, or a utility advertisement).[105]

One-quarter of HES respondents (25%) and HES-IE respondents (23%) learned about the program from family or friends. Three vendors interviewed for the study noted that they give customers additional incentives for referring other households to them.[106]

[105] Multiple responses allowed; some respondents listed more than one program marketing initiative as a source of awareness.

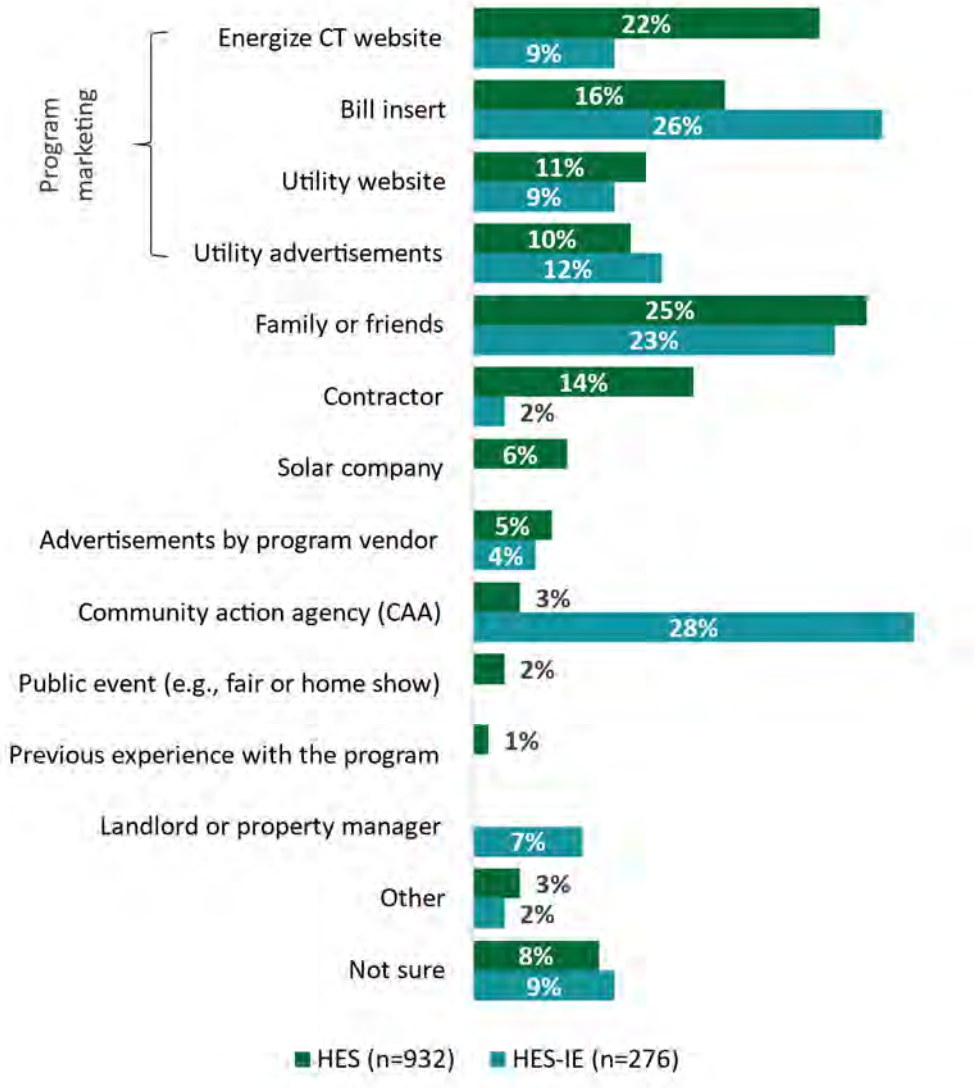
[106] The 2017 field implementation manual specifies

Participants also learned about the program through a program vendor (5% of HES respondents and 4% of HES-IE respondents) or a community action agency (3% of HES respondents and 28% of HES-IE respondents):

- Seven vendors reported conducting direct marketing through community events, online marketing, and mailings.
- Four vendors mentioned they promote the program when doing other work, such as roofing, in customers' homes and two worked with local sustainability or "green" groups to generate leads.
- One vendor noted that they worked with a local real estate agent to market to people who had just purchased a home.

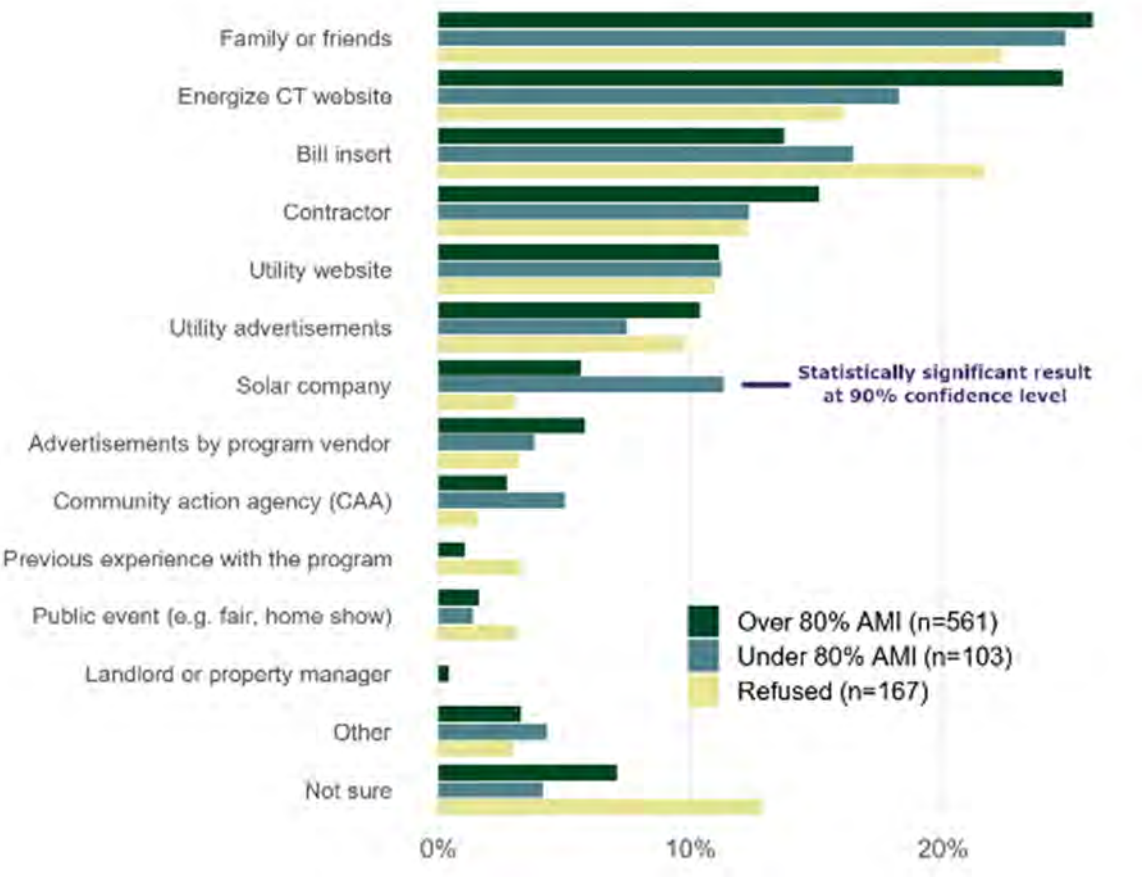
Figure 39: Sources of Program Awareness

(Source: Participant survey; multiple responses allowed)



Comparing HES respondents over and under 80% AMI, those under that income threshold (n=35) were statistically significantly more likely to have first learned about the program from a solar company (Figure 40). While only 6% of respondents overall first heard about the program from a solar company, these findings suggest solar installers may be effectively targeting moderate-income customers (i.e., for leased systems).

Figure 40:Sources of HES Program Awareness by Income
(Source: Participant survey; multiple responses allowed)



B.1.3.2 Community Awareness of Programs

Nine of the ten community stakeholder interviewees had heard of the HES program. Of these, six were themselves HES participants, one of whom had had two HES audits since living in their home. Another interviewee had experience helping six different homes go through HES or HES-IE before they began working with a non-profit. Five of these nine interviewees were aware the program had an income eligible offering.

Four of seven community stakeholder interviewees who commented on the awareness of the HES program in their community said knowledge of the program was not widespread.

One interviewee who worked for an organization that develops affordable housing and conducted homeowner education described widespread awareness in the communities they serve, though impressions of the program were not all positive:

> *"[Awareness of the program is] surprisingly more widespread than I would have thought. I used to think that if people only knew about this, especially income-eligible customers would really embrace it, because it's no cost. But I got quite a bit of pushback from residents who had tried to use the program years ago. I've come to understand they probably had a health and safety barrier but didn't really understand it."*

Two interviewees who served as presidents and/or members of their neighborhood revitalization zones (NRZ) described relatively little awareness of the program in their communities:

> *"In my neighborhood, the majority [of households] are renters. I don't think that landlords are participating in the program. [Among] the homeowners, I don't hear a lot of people talking about it."*

> *"Most people don't know about these programs. We need to do a better job of advertising that it's available. People assume our residents know about things, but they don't. Bill inserts might work, [as long as they are not too long]."*

B.1.3.3 Program Marketing

Several community stakeholders made suggestions on how to improve program marketing and outreach to better reach customers in their neighborhoods. Of the nine interviewees who discussed the effectiveness of program marketing, six said Company marketing was particularly ineffective, compared to two who said they would trust Company mailers and/or other marketing materials that have Company logos.

An interviewee who had served on their town's energy task force commented on Company ads as particularly ineffective when the programs were understaffed (B.7.4) and unable to serve customers. Another who had served on their town's energy commission elaborated on the impersonal feel of Company marketing:

> *"First-person accounts are more helpful than actors speaking in videos on the EnergizeCT website, which are not convincing. [The outreach] needs to be more personal, less packaged and slick. [The program] needs to deputize [local community groups] in better ways to do the work and compensate them."*

Interviewees also offered solutions to improving program marketing. Many were variations on the theme of empowering local community leaders and organizations to engage community members in word-of-mouth recommendations. One NRZ chair saw their organization as a useful vehicle for program marketing:

> *"Community events are a good [solution, and] NRZs making it an agenda item, posting [about the program] on social media, or have workshop sessions available."*

Two other NRZ members, as well as a private contractor and town energy commission member, agreed that local organizations and institutions (e.g., social services, schools, and non-profits) were the most effective messengers for HES and HES-IE. One felt that recommendations from friends and family were effective because they are seen as trusted messengers:

"[These measures] tend to be best received by friends and family, someone you know saying, 'I've done this. It worked. Here's someone who can help.' There are lots of things people don't trust, like people knocking on their door selling solar. They don't trust that the [Companies] are looking out for the best interest of the customer, or that the contractor who is most incentivized to sell a new piece of equipment is going to give them trusted and independent advice."

Others added:

"If we want the right kind of people getting the message, it would be best to have really high-quality process control so that people do not wait 6, 9, 12 months to get insulation installed. If people are not willing to tell their friends about [their experience], something has already failed about the program."

"[Outreach from] a local Energy Committee or Town Hall works better than if one of the Companies is the messenger."

B.1.4 Opportunities for Expanding Customer Engagement

Vendor and community stakeholder interviewees spoke about the challenges of participating in the program and how the program could better serve the diverse needs of customers in different communities.

B.1.4.1 Underserved Customers

Several vendors and community stakeholders noted customer segments they believed were underserved by the program, including HES-IE or low-income customers, renters, moderate-income customers, Hispanic customers, Asian customers, the elderly, rural customers, and multifamily households.[107]

B.1.4.2 Renters

When describing specific reasons **renters** were underserved by the program, vendors and community stakeholders mentioned the following issues:

- The landlord needs to sign off before they visit the property or do any work in a rental property.
- Tenants must also agree before they can go into a unit.
- Tenants and landlord may be unclear about the program requirements.

The survey asked renters whether they had any issues getting permission from landlords to participate in the program; none of the HES (n=9) or HES-IE (n=36) respondents reported any such issues. The survey results do not necessarily support the conclusion that renters do not have issues with their landlords, given the selection bias in surveying those who successfully participated in the program.

[107] Three vendors agreed that some customers could be underserved by the program but were unable to point to specific examples. One vendor did not believe that any customer segments were being underserved by the program.

B.1.4.3 Multifamily Households

When describing specific reasons **multifamily households** were underserved by the program, vendors noted the following issues:

- Program budget caps for each apartment in larger multifamily buildings.
- The process for multifamily buildings often involves visiting a percentage of the units, conducting blower door tests, and submitting a plan to the utilities for approval.

One vendor noted:

> *"Single family [assessments are] straightforward. We just get their utility accounts and make sure they haven't participated in the last three years. For multifamily assessments, we have to put in an application and get that approved, then sample some units and do testing. [We] also look into larger measures for the overall building. Then get quotes for the owner of the building and get those approved by the utilities to make sure the savings merit the incentive. Then go back to the customer and see if they want to move forward. It's a long and tenuous process, with lots of different parties involved."*

Another vendor, who installs a variety of energy efficiency measures as well as audits, thought the program should return to the previous policy of allowing the vendors to determine which apartments should be air sealed and to provide a budget for the building based on averaging the amount to be spent on each apartment, rather than having budget caps on individual apartments:

> *"When you go into a multifamily building, the problem now is [the program specifies] how much air sealing you can do in each apartment. So, the apartment that has an opening to the outside of the house very rarely gets fixed. So, we go in there, we put in new windows, we put in mini splits, and the people will save energy. But in some apartments, it's still going right outside, because we weren't allowed to do the work we should have been doing."*

B.1.4.4 Low- and Moderate-Income Customers

Vendors mentioned the following issues with customers with low- or moderate incomes:

- Difficulty in verifying **income** levels for HES-IE participation.
- **Moderate-income customers** do not qualify for HES-IE but still cannot afford most of the rebated measures recommended; as noted in Section 1.1.2, these customers also cannot afford health and safety barrier remediation.

Due to strict income thresholds for qualifying for HES-IE, moderate-income customers on the margins may have difficulty accessing the HES program. A program stakeholder identified the importance of assisting these customers with weatherization and energy efficiency before their high energy costs propel them into a lower income bracket.

Three community stakeholders said people who live paycheck-to-paycheck or work multiple jobs may have difficulty in finding time to schedule weatherization upgrades:

[Many people] can't take time off from their job to stay home and wait for an audit. What is the program's flexibility [for meeting the needs of these customers]? Could you have a night shift? [A] two-part visit if needed?"

One NRZ member suggested flexibility to schedule services during the weekend and/or on weeknights could help improve program uptake:

"Weekend or weeknight service would be great; that's when people are home. That's when I do door-knocking [to reach neighbors about other community initiatives]. If [the Companies] take the time to do door-knocking and hear what people are feeling, that would be a great justice, for the [HES program] to figure out 'What do the people need?'"

A similar proportion of HES and HES-IE respondents (3% each) indicated they had difficulty finding the time in their schedule for the assessment. However, as customers who had difficulty scheduling the assessment would likely have been unable to participate, this finding could be artificially low due to selection bias.

B.1.4.5 Other Underserved Customer Segments

When describing specific reasons other customer segments were underserved by the program, vendors mentioned:

- **Elderly customers** were less likely to find out about the program and apply on-line.
- **Immigrants** may be wary of programs such as HES and HES-IE, possibly due to house visits and data collection.
- Fewer vendors willing to travel the necessary distance to **rural customers'** homes.
- Language barriers for customers with **limited English proficiency.**

According to a program document review, there were no Company marketing or application materials for non-English speakers looking to participate in HES. Where Spanish-language materials were available, they were limited to HES-IE customers. One vendor requested access to a language line to better serve their customers that do not speak English.

B.2 Program Delivery and Processes

Survey questions asked participants to rate their satisfaction of program elements. Vendors and program stakeholders discussed program processes and procedures, communication with program staff, assessment scheduling, and the inspection quality control process.

B.2.1 Key Findings

- Overall, HES respondents were more satisfied with their program experience overall than HES-IE respondents (81% of respondents satisfied compared to 68% satisfied). For both HES and HES-IE participants, satisfaction about the energy savings that resulted from the assessment was the lowest-rated program element (61% and 65%, respectively).
- On a scale from 0 to 10, where 0 was "not at all satisfied" and 10 was "very satisfied," vendors rated their satisfaction with the program an 8.2, on average. Vendors attributed

their own satisfaction to customer satisfaction with the program, positive relationships with program staff, clear program guidelines, and the program's response to challenges posed by the COVID-19 pandemic.

- Only four of the seventeen vendors interviewed considered leads generated through the WISE USE hotline their primary source of customer leads. Vendors reported receiving customer referrals through partnerships with solar contractors, referrals from previous customers, and their company's marketing efforts.
- Customer uptake of virtual audits were limited; among HES and HES-IE respondents who had an energy assessment after March 2020, one-tenth or fewer said they completed a virtual audit.
- Of the nine vendors who discussed their experience with virtual audits, eight expressed a negative view.
- HES respondents who reported receiving a virtual audit had lower average program savings than other participants.
- Program stakeholders acknowledged challenges in managing a diverse group of program vendors, many of which were trying to grow their workforce while maintaining quality control. While participants reported some issues with program vendors, they were generally satisfied; 84% of HES respondents and 75% of HES-IE respondents expressed satisfaction with the professionalism and service provided by the technicians. There was no statistically significant difference in participant satisfaction ratings across vendors.

B.2.2 Satisfaction

Survey questions asked respondents how satisfied they were with various elements of their HES participation, using a 1 to 5 scale where 1 indicated "not at all satisfied" and 5 indicated "very satisfied." Some elements only appeared to respondents for whom they were applicable. For example, the survey only asked about satisfaction with the "time it took to schedule the installation of recommended equipment or upgrades" if a respondent had verified (in a previous survey question) that they installed a rebated measure.

B.2.2.1 HES Participants

HES respondents' overall satisfaction with their program experience was 4.3 out of 5 (Figure 41). Contractors' and technicians' professionalism and service scored 4.4, as did the process of scheduling a home assessment. The lowest-scoring elements were related to assistance with health and safety barriers (4.0), the application process to receive rebates or incentives (4.0), the rebate or incentive amount (3.9), and energy savings from the home energy assessment (3.8).

Figure 41: Customer Satisfaction, HES
(Source: Participant survey; n=932 unless otherwise shown)

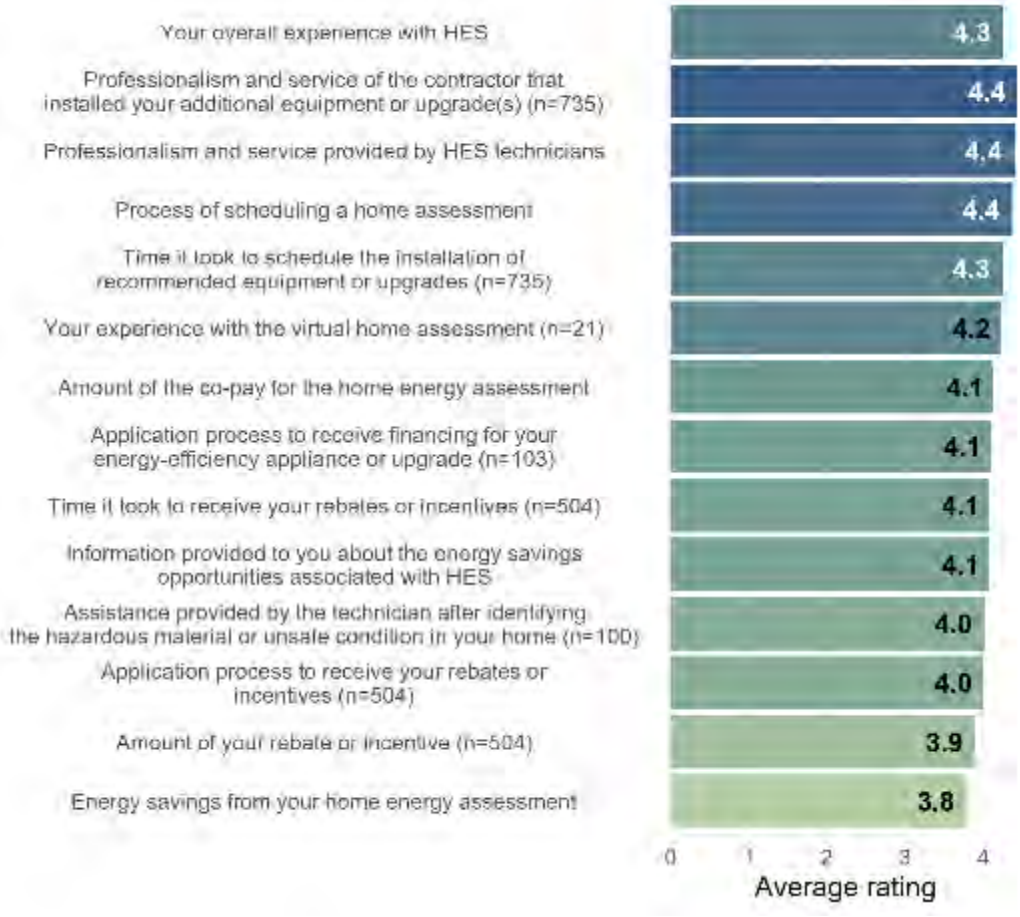


Table 43 shows the percentage of HES respondents who gave satisfaction ratings for each program feature.

Table 43: Customer Satisfaction, HES

(Source: Participant survey)

Features	n[1]	1 Not at all satisfied[2]	2	3	4	5 Very satisfied	Average Rating
Your overall experience with the HES program	928	2%	4%	13%	30%	51%	4.3
Professionalism & service of the contractor that installed your additional upgrade/equipment	659	2%	2%	9%	22%	65%	4.5
Professionalism & service provided by HES technicians	925	2%	2%	12%	20%	64%	4.4
Process of scheduling a home assessment	923	2%	3%	11%	26%	58%	4.4
Time it took to schedule installation of additional upgrade/equipment	655	2%	5%	13%	28%	52%	4.3
Experience with the virtual audit	21	0%	11%	8%	28%	54%	4.2
Amount of the co-pay	789	4%	5%	16%	25%	50%	4.1
Application for financing	97	3%	4%	8%	49%	36%	4.1
Time it took to receive rebates	468	5%	3%	16%	31%	46%	4.1
Information provided about energy-saving opportunities	919	2%	6%	18%	30%	44%	4.1
Assistance from technician after identifying hazardous material	92	5%	4%	23%	22%	46%	4.0
Application process for rebates	477	7%	4%	15%	30%	44%	4.0
Amount of rebate	486	6%	7%	18%	31%	39%	3.9
Energy savings from the assessment	907	3%	8%	27%	28%	33%	3.8

[1] Sample sizes exclude those who said, “Not applicable.”
[2] Some percentages do not sum to 100% due to rounding.

HES participants rated their satisfaction of the energy savings from their home energy assessment an average of 3.8. Respondents who rated their satisfaction a 1 or 2 (11%) were asked to explain.[108] One-half of respondents reported seeing no savings (31%) or no significant change (19%) in their utility bills; 3% of respondents reported that their bills increased after the assessment. Fewer than one in ten respondents (9%) did not see as much savings as they had hoped. Some respondents measured energy savings in terms of comfort; 7% of respondents experienced no change in comfort and 9% complained of poor quality weatherstripping or faulty air sealing.

[108] n=94; Excludes five participants who said, “I’m not sure.” Percentages sum to greater than 100%; multiple responses are allowed.

B.2.2.2 HES-IE Participants

HES-IE respondents' overall satisfaction with their program experience was 3.9 out of 5 (Figure 42). The rebate and/or incentive amount scored highest (4.4), followed by the application process and the time it took to schedule add-on measure installation (4.3 each). Contractors' and technicians' professionalism and service scored between 4.1 and 4.3 depending on whether the survey asked about core or add-on measures. The three lowest-scoring elements all scored below the average. In decreasing order, they were the information technicians provided about energy savings (3.8), the assistance they provided after identifying hazardous material or unsafe conditions in respondents' homes (3.7), and the energy savings from the home energy assessment (3.7).

Figure 42: Customer Satisfaction, HES-IE
(Source: Participant survey; n=276 unless otherwise shown)

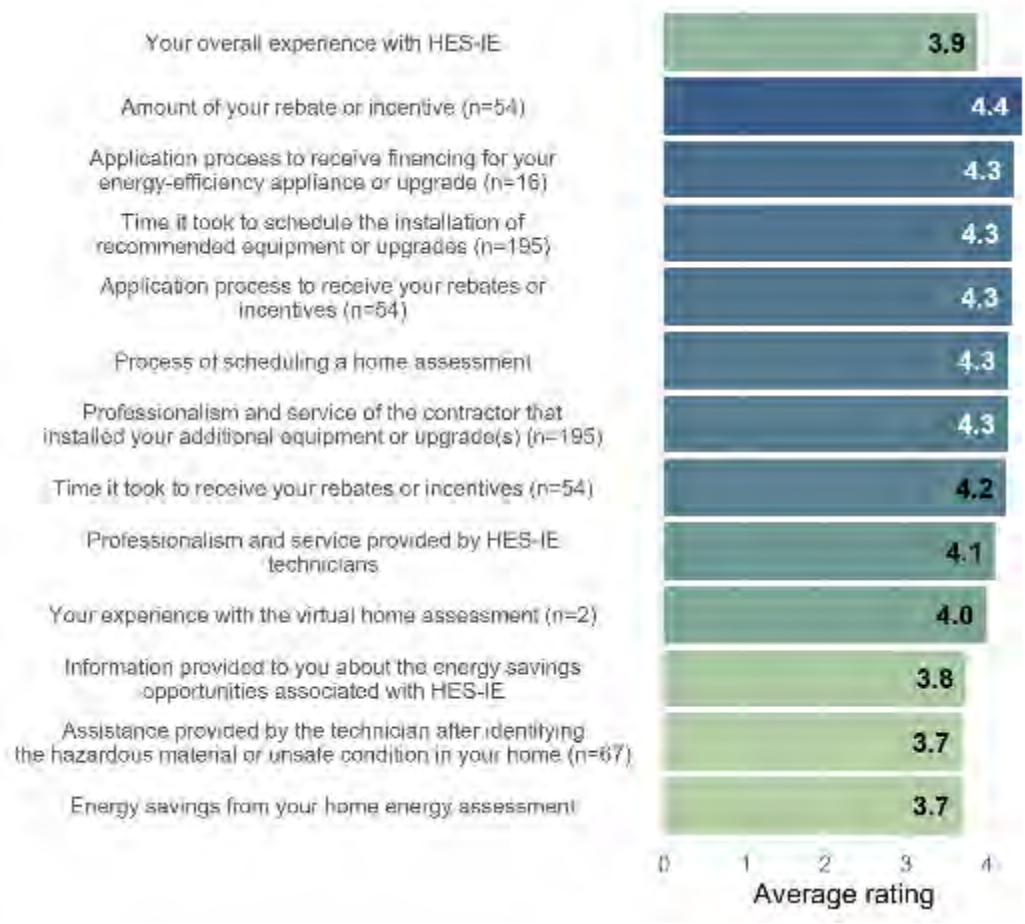


Table 44 shows the percentage of HES respondents who gave satisfaction ratings for each program feature.

Table 44: Customer Satisfaction, HES-IE

(Source: Participant survey)

Features	n[1]	1 Not at all satisfied[2]	2	3	4	5 Very satisfied	Average Rating
Your overall experience with the HES program	267	11%	5%	15%	21%	47%	3.9
Amount of rebate	45	0%	1%	9%	36%	54%	4.4
Application for financing	16	0	1	2	3	10	4.3
Time it took to schedule installation of additional upgrade/equipment	183	1%	2%	17%	23%	56%	4.3
Application process for add-ons	48	0%	<1%	18%	32%	49%	4.3
Process of scheduling a home assessment	264	3%	2%	13%	27%	54%	4.3
Professionalism & service of the contractor that installed your additional upgrade/equipment	179	6%	5%	7%	22%	61%	4.3
Time it took to receive rebates	45	0%	4%	15%	34%	47%	4.2
Professionalism & service provided by HES technicians	266	8%	5%	12%	19%	56%	4.1
Experience with the virtual audit	2	0	0	0	2	0	4.0
Information provided about energy-saving opportunities	262	11%	7%	18%	26%	39%	3.8
Assistance from technician after identifying hazardous material	64	15%	10%	13%	16%	47%	3.7
Energy savings from the assessment	255	15%	5%	14%	24%	41%	3.7

[1] Sample sizes exclude those who said, "Not applicable."
[2] Some percentages do not sum to 100% due to rounding; counts shown where n <20.

HES-IE respondents rated their satisfaction with the energy savings from their home energy assessment an average of 3.7. Respondents who rated their satisfaction a 1 or 2 (20%) were asked why.[109] Nearly one-half of respondents saw no bill savings (38%) or no significant change in their utility bills (9%), and six percent of respondents reported an increase in their bills. Fifteen percent of respondents did not experience any improvement in their home's comfort.

B.2.2.3 Vendor Satisfaction

On average, vendors rated their satisfaction working with the HES/HES-IE program an 8.2 out of 10, where 0 was "not at all satisfied" and 10 was "very satisfied."[110] Vendors who gave a rating above 8 most often cited program staff responding promptly to any requests, program information being clearly laid out, program staff being open to feedback from the vendors, and the program pivoting quickly to deal with the COVID-19 pandemic as reasons that led to their high

[109] n=33; Excludes seven respondents who said, "I'm not sure."
[110] Some respondents provided a range of numbers for the rating; in these cases, the overall average uses the midpoint of the range.

satisfaction rating. One respondent experienced a high level of job satisfaction from using the program to help their customers:

> *"Pretty much everything is laid out in the field implementation manual - and you can usually just type up something and search in the implementation manual. The people who are in charge are all very nice and easy to work with. And then I think it's a good program because customers really like it; you're helping them to save money and pointing out anything in their home that needs to be upgraded. So usually, 90% of the time you get really good feedback from people."*

Another vendor said:

> *"[From my company's experience working in other states], I think the HES programs are probably some of the best programs in the country. They have the right staff there. They are receptive. So, if we have an issue, if something isn't working, it's generally fixed pretty quickly. They are open to feedback."*

One of the respondents who gave a rating below eight cited long wait times for program staff to respond to phone calls or emails.

B.2.3 Assessment Scheduling

While most HES vendors accept leads on new customers from the program, new participants were primarily referred through word-of-mouth or from solar companies. Program participants can schedule a home energy assessment by calling the WISE USE hotline, contacting their utility, or scheduling with a vendor directly. Twelve of the 17 vendors interviewed mentioned receiving customer leads through the program, though only four vendors considered that a primary source of leads. Other common sources of leads were referrals by previous customers (nine respondents) and partnerships with solar vendors (seven respondents). One respondent offered previous customers an incentive for referring new leads to them.

Nine vendors said they would occasionally turn down leads due to a lack of staff availability. Two vendors said they turned down leads if the home was too far away from their headquarters, and one vendor said they did so if the customer had participated in other programs and thus would have less energy savings potential.[111]

Overall, 84% of HES participants were satisfied with the process of scheduling an assessment.[112] Respondents who gave a rating of 1 or 2 (5%) were asked why in a follow-up question:[113]

[111] In 2017, program vendor report cards take into consideration energy savings (in MMBtu) of all homes that received core services and the percentage of customers who install rebated measures following the assessment (2017 Field Implementation Manual). According to the 2019 Field Implementation Manual, vendors were only scored on the energy savings of homes receiving blower-door-guided air sealing; the percentage of homes that installed rebated measures were no longer taken into account (2019 Field Implementation Manual).
[112] 84% of participants rated their satisfaction with the program feature a 4 or 5 on a scale from 1 to 5, where 1 is *not at all satisfied* and 5 is *very satisfied.*
[113] n=41

- More than one-quarter of these respondents (27%) were dissatisfied that the vendor canceled or rescheduled.
- One-fifth of respondents (20%) were dissatisfied with lengthy wait times to schedule an appointment.
- 15% of respondents mentioned poor customer service.
- Two respondents (7%) had issues with getting an appointment through the WISE USE hotline. One of them said they eventually gave up and contacted vendors directly to schedule an appointment – a time-intensive process that most customers likely would not pursue.
- The time and effort involved in scheduling as well as scheduling difficulties due to participant schedules, vendor availability, and delays caused by the COVID-19 pandemic were mentioned by two respondents each.

Overall, most HES-IE participants (81%) were satisfied about the process of scheduling an assessment (see Satisfaction).[114] Respondents who gave a rating of 1 or 2 (5%) were asked why in a follow-up question:[115]

- Two respondents each were dissatisfied with lengthy wait times to receive an appointment or that the vendor rescheduled or canceled their appointment.
- One respondent cited poor customer service and said they had to make repeated calls to receive an appointment.
- Another respondent was disappointed they had to take the day off from work to accommodate the vendor's schedule.

B.2.4 Virtual Pre-Assessments

After the COVID-19 pandemic paused on-site visits beginning in March 2020, the Companies offered a virtual pre-assessment (*virtual audit*) option when the program resumed offering home energy assessments in the summer of 2020. While participants were generally satisfied (see Satisfaction), participation was limited; only 12% of the 178 HES respondents and two of the 27 HES-IE respondents who had a home energy assessment after March 2020 reported having a virtual pre-assessment.

HES participants who self-reported receiving a virtual audit appear to have achieved lower savings than other participants, with average savings of 7.7 MMBtu associated with their program participation, compared to 10.3 MMBtu for participants who received an assessment after March 2020 but did not report having part of their assessment conducted virtually.

Of the nine vendors that indicated they had experience with virtual audits, only one respondent had a positive experience, while the other eight provided negative feedback.[116] Several vendors

[114] 81% of participants rated their satisfaction with the program feature a 4 or 5 on a scale from 1 to 5, where 1 is *not at all satisfied* and 5 is *very satisfied.*
[115] n=6; Four respondents who said "don't know" are excluded.
[116] In addition, two vendors had heard of virtual audits but had not conducted any, and the remaining six vendors did not respond to this question due to time constraints during the interview.

mentioned there was still an in-person component to the virtual audits and that they would always need to go to the home to gather data properly. According to one vendor:

> *"At the end of the day, you have to go [to the home] anyway to finish the audit. The [customer simply does not have the building science expertise] that my guys are trained for. So even if you're holding a phone or an iPad up, [you will miss a lot of things]. They might not know to look for mold. And the customer cannot check for a gas leak."*

One vendor expressed frustration that several customers who had received a virtual audit had not called back to schedule the in-person visit to complete the assessment. One vendor experienced spotty internet service that complicated the delivery of the virtual audit and another thought that the program did not adequately compensate vendors for the effort involved with completing a virtual audit.

However, one vendor was in favor of virtual pre-assessments:

> *"Maybe 15% of people going through the program opt for the virtual pre-assessment. It's great. Especially when there's a relatively long wait for the in-person services, they can [still] learn more about their home. It's educational. We send them a few energy saving measures, right then and there. And again, probably the most beneficial [part] is that you know what [health and safety issues] are in that house that maybe they can get a head start on before we get out there. But like I said, we're probably talking about 15% of houses."*

Ten percent of HES respondents and less than 1% of HES-IE respondents who received an assessment after March 2020 said they were concerned about exposure to COVID-19.

B.2.5 HES Co-Pay

Throughout the study period, the co-pay increased from $124 in 2017, to $149 in 2018 ($174 for oil and propane-heated homes), and eventually decreased to $75 for all fuels in 2020.[117]

Three-quarters of HES participants (75%) were satisfied with the amount of the co-pay (see Satisfaction).[118] Respondents who rated their satisfaction a 1 or 2 (9%) were asked why:[119]

- More than one-third of respondents (36%) reported they were so dissatisfied by their experience with the assessment that the co-pay felt like a waste of money.
- A similar number of respondents (37%) said the co-pay was too high; two of these respondents indicated they had previously received an assessment through the program when the co-pay was lower.[120]

[117] Conservation, Load, and Management (CL&M) Plans, 2016-2018 and 2019-2021.
[118] 75% of participants rated their satisfaction a 4 or 5 on a scale from 1 to 5, where 1 is *not at all satisfied* and 5 is *very satisfied.*
[119] n=49; Excludes 11 respondents who said, "I don't know."
[120] Customers can qualify to receive an HES assessment every two years. Customers with records of multiple assessments in our sample were asked about their experience with the more recent assessment.

- Nearly one-fifth of respondents (18%) thought the assessment should be free; one of these respondents specified that the co-pay should be waived for senior citizens. One of these respondents mentioned a similar program in Massachusetts that has no co-pay.[121]
- One respondent felt it was unfair to have to pay more for the assessment because they had oil heating (an additional $25 surcharge).
- Another respondent indicated that they had received a co-pay waiver due to financial difficulties, but miscommunication with the vendor caused confusion at the assessment and they were asked to pay.[122]

Although the amount of the co-pay changed over the study period (2017 – 2020), satisfaction with the amount of the co-pay did not vary significantly across Conservation, Load, and Management (CL&M) plan years. HES customers who were unable or unwilling to pay the co-pay face a barrier to participation and are not reflected in the findings of the participant survey.

B.2.6 Assessment Length

Vendor estimates for how long it took them to do an on-site assessment ranged from one to six hours,[123] with an overall average of 3.6 hours. Three vendors noted that the audit time had increased due to safety precautions necessitated by the COVID-19 pandemic, with one estimating the new protocols added one to 1.5 hours to their audits. While one vendor wanted to increase the time spent on-site by having a more detailed discussion of the findings with the customers, most vendors offered suggestions on shortening audit times:

- Vendors cited the initial visit orientation, combustion appliance testing, separating sales pitches from the audits, and the DOE Home Energy Score as areas that could be modified to shorten the audit times. Regarding appliance combustion testing, one vendor said:

"[Some houses in New England have up to 15 appliances eligible for] the combustion and safety test. And if you have to do a combustion and safety test on all 15 of them, the day is over by the time you're done."

- Similarly, three vendors suggested audits could be improved by simplifying duct blaster tests. One respondent elaborated on the need to test duct leakage to the outdoors:

"One of the things that we would like to see changed is when we do the duct blaster test on any ductwork, we are not checking for leakage to the outside, just the total duct leakage in the house. Even if the system has ductwork that is in conditioned space, it's not operating efficiently if the air is not flowing where it needs to go."

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[121] Mass Save advertises a "no-cost home energy assessment." Unlike the Energize Connecticut HES/HES-IE program, the Mass Save assessment does not include air sealing or the installation of light bulbs. Mass Save, "What is a Home Energy Assessment?" https://www.masssave.com/residential/programs-and-services/energy-assessments/what-is-a-home-energy-assessment. Accessed December 2022.

[122] One respondent attributed the low rating to not giving out perfect scores and another realized the co-pay amount, while high, likely could have been higher.

[123] It is likely that the respondents with the shorter times excluded any "kitchen table wrap-up" sessions from their estimates.

- Another vendor shared that they spend time at the start of their visit explaining the program, what they would be doing in the home, and getting the customer to sign off. They suggested the utilities send customers a video with this information in advance to reduce the length of the audit.

While participants were not directly asked to rate their satisfaction with the length of the assessment, three HES respondents volunteered their opinions in another open-ended question. Three HES respondents said that the assessment was not thorough enough, while two thought the assessment took too long.[124]

B.2.7 Program Communication and Data Sharing

Program stakeholders and vendors described how program staff support vendors and communicate program updates. Program stakeholders described twice-annual meetings with program vendors, where the gathered group can give feedback and program staff can provide information about incentives, assessment procedures, supported measures, and other program updates. Vendors also provided feedback on program staff responsiveness to questions or concerns and their experience with the mobile data tool used during the assessment.

B.2.7.1 Program Communication

When asked about their interactions with the Companies, some vendors noted that they were generally satisfied and that communications with the program had improved recently.[125] The general feedback from respondents was positive, with one vendor noting:

> *"Everybody is willing to assist. So, it's not a problem. You know, if [my program contact] can't help me, they refer me to somebody else, but it's never like you're on your own."*

However, other vendors believed the Companies were understaffed, and one noted that there had been a considerable amount of staff turnover resulting in the need to communicate with many different people. Vendors also reported the following specific program communications issues:

- Invoices not paid promptly
- Inadequate communication when the program is running out of funds
- Difficulty obtaining customer materials such as handouts
- Lack of coordination in handling customer complaints

Vendors suggested communication could be improved by providing more training for program staff or by holding regular meetings to discuss program changes and other issues. They expressed concern that program changes communicated via email may not be read promptly during busy periods.

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[124] Survey questions asked participants to rate their satisfaction with elements of the program. Respondents who expressed dissatisfaction (a rating of 1 or 2 on a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied") were asked to explain why. Some respondents used this opportunity to identify specific issues outside of the prompt.

[125] For context around the timing of improvements, consider that vendor interviews were conducted June 2021 to January 2022.

B.2.7.2 Mobile Tool

Vendor interviewees had mixed reactions to the mobile tool used for on-site data entry. Five respondents believed it generally worked well; in particular, one respondent noted that the mobile tool made it easy to review data and keep track of what their technicians did in the field.

Six vendors had more negative feedback about the mobile tool:

- Five respondents found the manual data entry process burdensome.
- One respondent noted that they had lost the data they entered.
- One respondent thought they had to wait too long for the tool to sync.

In suggesting improvements for the mobile tool, one respondent recommended the tool provide an option to enter custom recommendations, such as properly venting the bathroom fan and installing a new condensate pump for the air conditioning system.

B.2.8 Inspection and Quality Control

The study included a review of inspection protocols and interviews with program staff and vendors about the process. Approximately ten percent of a vendor's projects are inspected by a third-party program inspector. Vendors are evaluated using a Quality Inspections form which covers safety, customer service, and measures. After each inspection, they receive the Program Inspection Report and the score is updated on the Vendor Scorecard. While program staff report satisfaction with the inspection process, only two of fifteen vendors

reported they were generally happy with the field inspection process and the feedback it provided for technicians. However, most vendors offered suggestions for improvement:

- The most common issue, mentioned by eight vendors, was concern with the inspector trailing the technician too close for comfort in the home and trying to find mistakes. One noted:

"I think it would be better [if the vendors and inspectors] communicate better... it would definitely help the program if the inspector and the contractor work as a team as opposed to against each other."

- Three vendors brought up the issue of inspections disrupting their schedules by lengthening the assessment time and, in some cases, delaying audits due to conflicts with the inspector's schedule.
- Two vendors believed inspectors knew less about the program than the technicians.
- One vendor wanted to keep inspectors from talking while customers were present.
- Another vendor noted the inspection could cause confusion for some customers:

"Sometimes the customers don't get [that] there's two guys coming into their house. I just tell my guys to make it clear that [the inspector] is a separate company because we don't want them to think that they're with us and get blamed [when] there's something the customer doesn't like. It's difficult for our guys; one of my customers was confused

because the inspector was making suggestions that totally conflicted with what my crew chief was saying."

- One vendor noted that the inspections would be most useful to them if they were done on a sample of homes for each crew in the field, rather than a sample of homes for each vendor.

Five vendors felt that inspection reports were a useful training tool for technicians. However, four vendors felt it was inconvenient to obtain the inspection reports, which required logging into the tracking system to see the reports. These vendors would prefer to either receive the reports by email or be notified when the reports are available to view.

Nine of thirteen vendors who commented on the program's process for resolving any issues identified by an inspection were satisfied. Three vendors believed dispute resolution took too long; one noted that it was challenging to reach program staff by email. Another vendor believed the inspection company was getting back at them for filing a dispute by increasing the number of inspections on their projects.

B.2.9 Technician Performance

HES respondents rated their satisfaction with the professionalism and service provided by the technicians an average of 4.4 on a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied;" this was one of the highest-rated program features (see Satisfaction.). Respondents who gave a rating of 1 or 2 (4%) were asked to elaborate.[126] They most commonly cited a lack of professionalism (26% of respondents), sloppy work and/or poor-quality workmanship (24%), and damage to their home (24%).[127] Another 17% of respondents were disappointed with the amount or quality of information they received from the technician, with some reporting that the technician rushed through the kitchen table wrap-up or did not provide any documentation about the assessment. Other issues included poor customer service (three respondents), technicians arriving late or unprepared (two respondents), and poor communication (one respondent).

HES-IE respondents rated their satisfaction with the professionalism and service provided by the technicians an average of 4.1 (see Satisfaction). Respondents who gave a rating of 1 or 2 (13%) were asked to elaborate. [128] These respondents reported technicians who behaved unprofessionally (16%), arrived late or unprepared (16%), did not provide adequate information about the assessment (12%), performed poor quality work (12%), and/or caused damage to their home (12%).

Customer satisfaction did not vary meaningfully by vendor.

B.3 Health and Safety Barriers

Survey questions asked respondents whether technicians had notified them of any hazardous material or unsafe conditions during their home energy assessments. Based on program tracking

[126] n=38; Excludes four respondents that gave non-applicable answers or said, "I'm not sure."
[127] Multiple responses permitted.
[128] n=25; Excludes four respondents that gave non-applicable answers.

data and their responses to these questions, some survey respondents saw follow-up questions about specific health and safety barriers and asking whether they had remediated any hazardous material or unsafe conditions or had made plans to do so. Respondents who reported no remediation saw additional questions about what may have prevented them from doing so.

Vendor and community stakeholder interviewees also weighed in about health and safety barriers. Vendors described how often they encountered barriers that prevented them from conducting energy efficiency services, whether that varied between HES and HES-IE participants, and whether they provided customers with resources about next steps and/or remediation. They also described whether they thought the program did an adequate job of supporting customers and vendors when they identified these barriers. Community stakeholders described people's concerns about remedying health and safety barriers in their homes, and what options they knew of for customers to do so. Program stakeholders also weighed in on the extent to which health and safety barriers prevent measure installations.

Following public planning workshops and input sessions in 2020 and 2021, DEEP announced an upcoming Statewide Weatherization Barrier Remediation Program to be operated by the International Center for Appropriate and Sustainable Technology (ICAST). The program is meant to address mold, asbestos, and other health and safety barriers—issues which participant survey respondents, vendors, and community stakeholder interviewees all touched upon. Due to the timing of this study, interview questions did not address vendor and stakeholder opinions on the new program.

B.3.1 Key Findings

- Thirteen of the seventeen vendors interviewed provided estimates of how often health and safety barriers prevent them from providing services, ranging widely from 2% to 40% of all jobs. According to the program tracking data, 7% of HES and 19% of HES-IE participants had a health and safety barrier. Vendor experience with barriers could vary depending on customer segment served or their pre-screening process for identifying barriers.
- Moderate income HES participants had higher rates of health and safety barriers than other HES participants. Ten percent of households with incomes falling within 60% to 80% AMI had asbestos or vermiculite insulation, compared with 6% of households with incomes greater than 80% AMI.
- Only two of the ten vendors who discussed their experience with the pre-screening process thought it was helpful in identifying health and safety barriers before arriving at a customer's home for the assessment.
- Four in ten HES-IE respondents with asbestos (41%) and three of ten HES-IE respondents with mold who did not pursue remediation said they could not afford to do so. One in four HES respondents with asbestos or vermiculite insulation (22%) or mold (one of four respondents) cited cost as the reason they did not remediate after being notified about the issue by the technician. Vendors noted the cost of remediation was a high barrier for their customers, who often left health and safety issues unaddressed.

- Community stakeholders echoed program participants and vendors in describing remediation options for health and safety barriers being scarce, unaffordable, and/or opaque to people in the communities they serve, leading to negative experiences with HES and HES-IE. They described speaking to program participants left confused as to why technicians made no upgrades, or what options they had for remediation.

B.3.2 Prevalence of Health and Safety Barriers

According to the program tracking data, asbestos and mold were the most frequently cited health and safety barriers among the population of program participants in 2017-2020 (Figure 43). Income-eligible households had a higher incidence of health and safety barriers than HES households.

Figure 43: Prevalence of Health and Safety Barriers, Population (2017-2020)
(Source: Program tracking data)

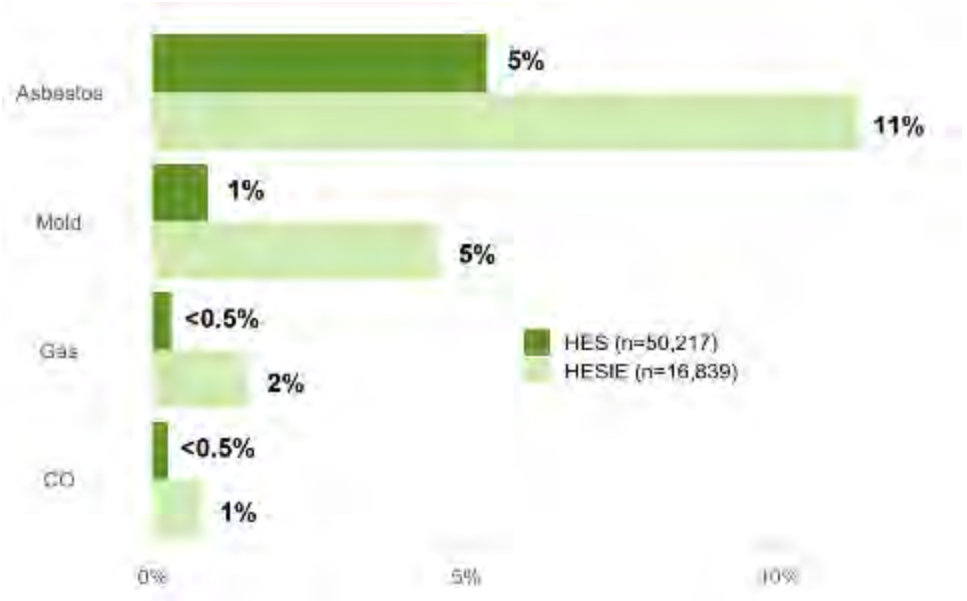
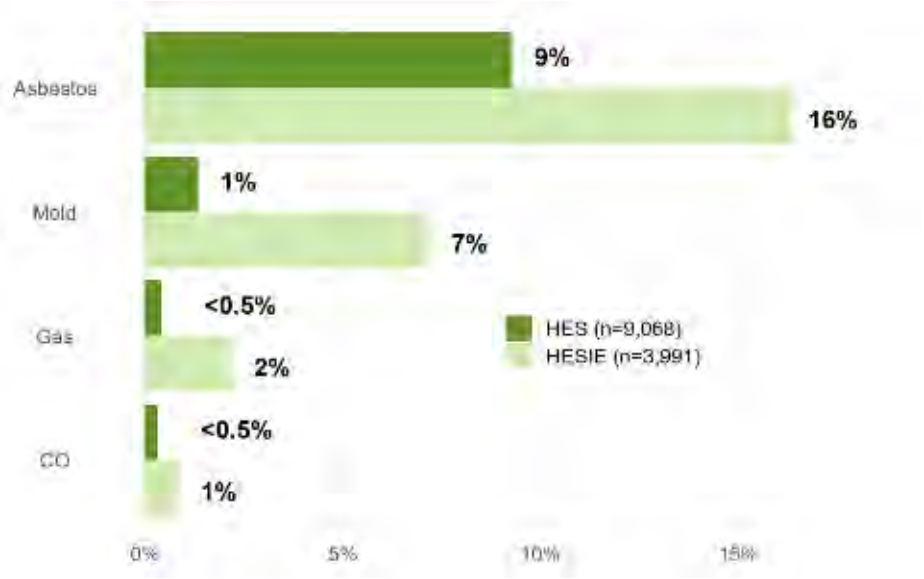


Figure 44 shows the incidence of health and safety barriers in program tracking data among participants sampled for participant survey outreach. Among sampled HES participants, asbestos was more prevalent (9%) than mold (1%). The prevalence of asbestos among sampled HES-IE participants (16%) was higher than the population (11%), as was mold prevalence (7% compared to 5%). See A.2.1 for additional details about the sample plan, which primarily oversampled for low-incidence measures to reach a sample size adequate for 10% relative precision at the 90% confidence level. The sampling plan secondarily oversampled for customers with health and safety barrier flags; however, this sampling was conducted without a strict statistical precision target.

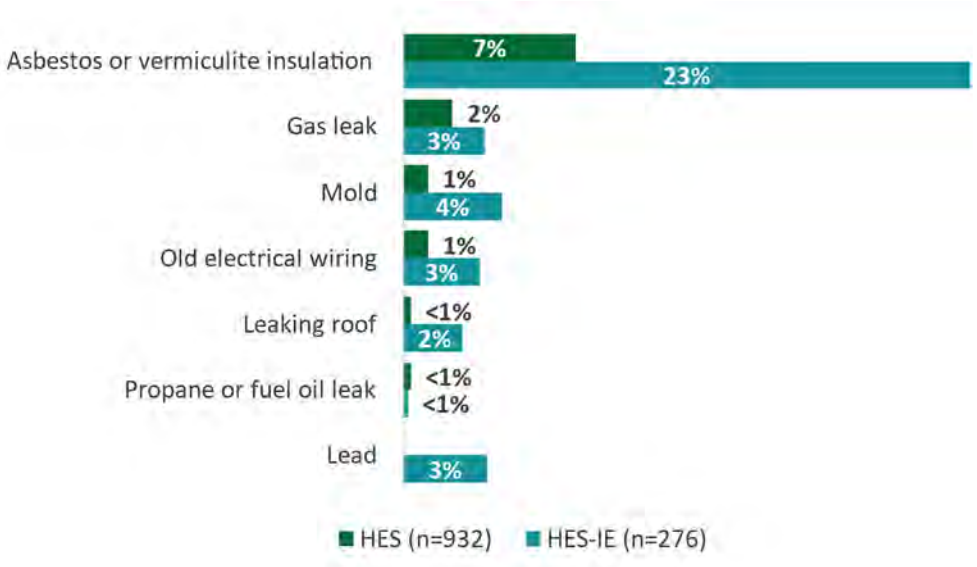
Figure 44: Reported Prevalence of Health and Safety Factors, Sampled Participants
(Source: Program tracking data)



Overall, 12% of HES survey respondents and 31% of HES-IE respondents reported having a health and safety barrier in their household. Figure 45 shows the health and safety barriers reported by survey respondents. Percentages differ from those in Figure 44 due to the nature of self-reported data collected up to several years after a respondent may have received the assessment. Some respondents could not recall hearing about the issue recorded in the tracking data, while some respondents reported an additional or unrecorded health and safety barrier. Health and safety barriers disproportionately affect low-income customers; nearly one-quarter of HES-IE respondents (23%) reported having asbestos and/or vermiculite insulation in their homes, compared to 7% of HES respondents.

Figure 45: Reported Prevalence of Health and Safety Barriers

(Source: Participant survey)



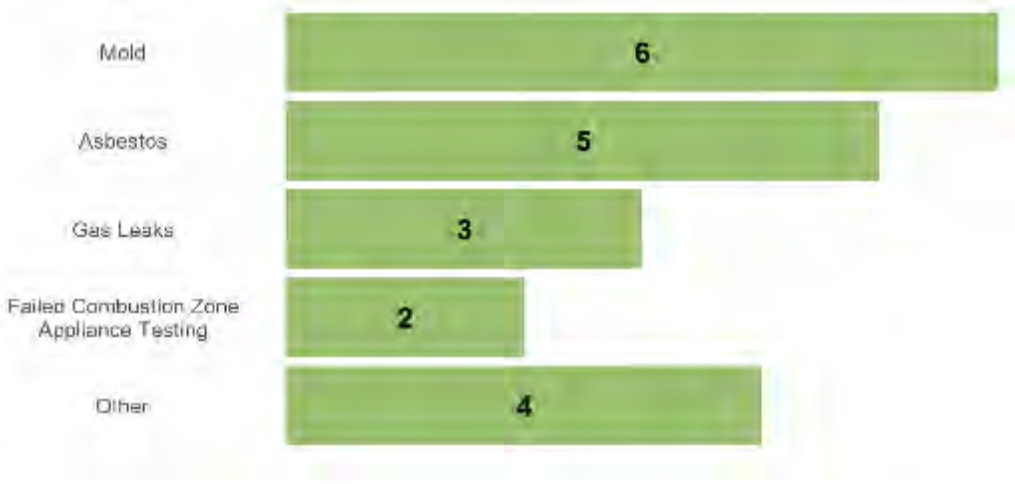
Moderate income HES participants had higher rates of health and safety barriers than other HES participants. Ten percent of households with incomes falling within 60% to 80% AMI had asbestos or vermiculite insulation, compared with 6% of households with incomes greater than 80% AMI.

Thirteen of the seventeen vendors interviewed provided estimates of how often health and safety barriers prevented them from providing services. The estimates ranged from 2% to 40% of all assessments[129]. Four respondents noted that health and safety barriers were more common among HES-IE than HES customers and one respondent thought the incidence was about the same for both groups. Program tracking data bears out vendors' experiences with higher health and safety barrier prevalence among HES-IE customers.

Interviewees anecdotally mentioned some of the barriers they tended to encounter mold and asbestos most often, followed by gas leaks, and failed combustion zone appliance testing. Interviewees also mentioned open wall construction, knob and tube wiring, hoarding, and high levels of CO^2.

[129] Two vendors estimated health and safety barriers prevented services 40% of the time; one worked only with HES and the other worked with both HES and HES-IE customers. This estimate is much higher than the health and safety barrier incidence rate recorded in program data.

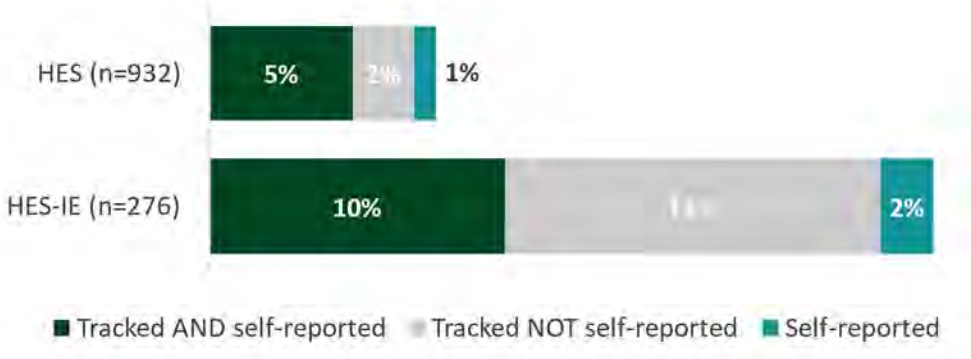
Figure 46: Hazardous Material and/or Unsafe Conditions Vendors Reported
(Source: Vendor interviews; n=10; multiple responses allowed)



B.3.2.1 Asbestos or Vermiculite Insulation

HES respondents were more likely than HES-IE respondents to recall the technician telling them about asbestos or vermiculite insulation found during the assessment. Fewer than half of the HES-IE respondents with asbestos or vermiculite insulation recorded in the program tracking data recalled hearing about it from the technician (*Tracked NOT self-reported*, Figure 47). One percent of HES respondents and two percent of HES-IE respondents self-reported the presence of asbestos or vermiculite insulation.

Figure 47: Participant Recollection of Asbestos or Vermiculite Insulation Found During Assessment
(Source: Participant survey and program tracking data)

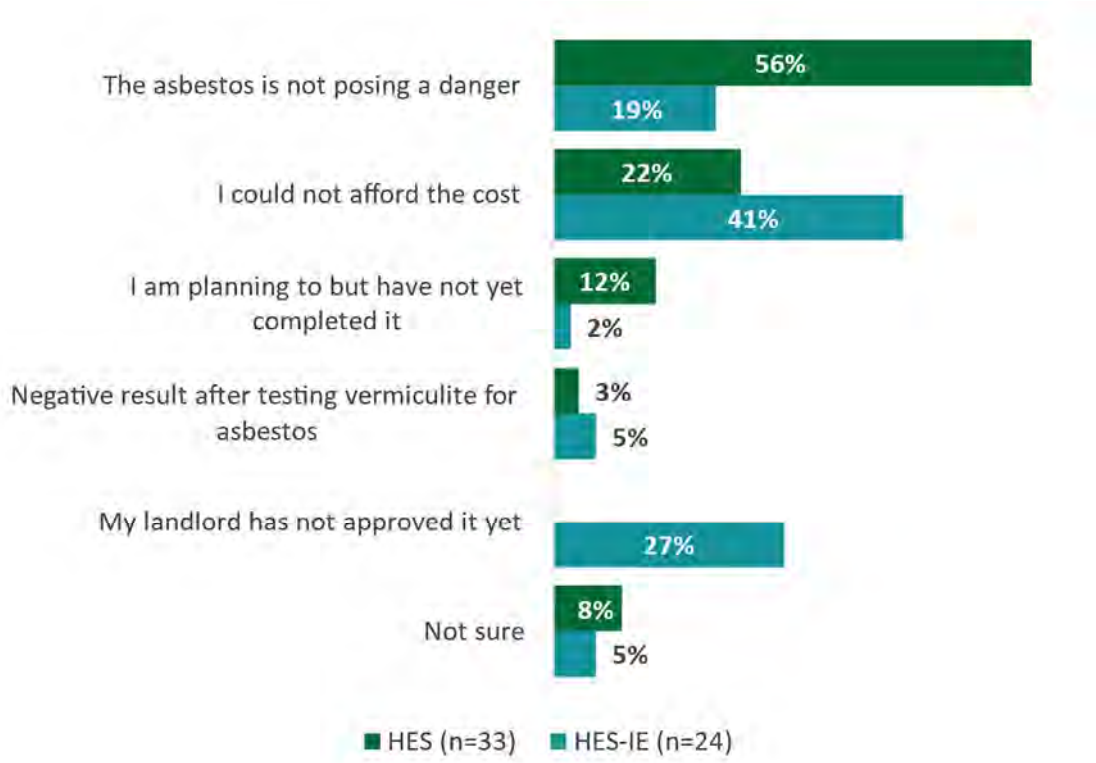


Among respondents who recalled the technician discussing the asbestos or vermiculite insulation found during the assessment (*Tracked AND self-reported* and *self-reported*, Figure 47), nearly one-third of HES and HES-IE respondents (31%, respectively) pursued remediation. Of the remaining respondents who did not remediate, more than one-half of HES respondents (56%) chose not to do so because the asbestos or vermiculite insulation was contained in an area of the

house that was not harmful to the occupants (Figure 48). Nearly one-quarter of HES respondents (22%) and 41% of HES-IE respondents did not pursue remediation because they could not afford it, while nearly one-third of HES-IE respondents (27%) said their landlord had not approved the remediation.

Figure 48: Reasons for Not Remediating Asbestos/Vermiculite Insulation

(Source: Participant Survey)



B.3.2.2 Mold

Overall, 1% of HES respondents and 4% of HES-IE respondents reported that mold was found in their homes during the assessment. However, recall of the issue varied; nearly half of HES-IE respondents (45%) with mold in the program data did not recall the technician informing them about it during the assessment (Figure 49).

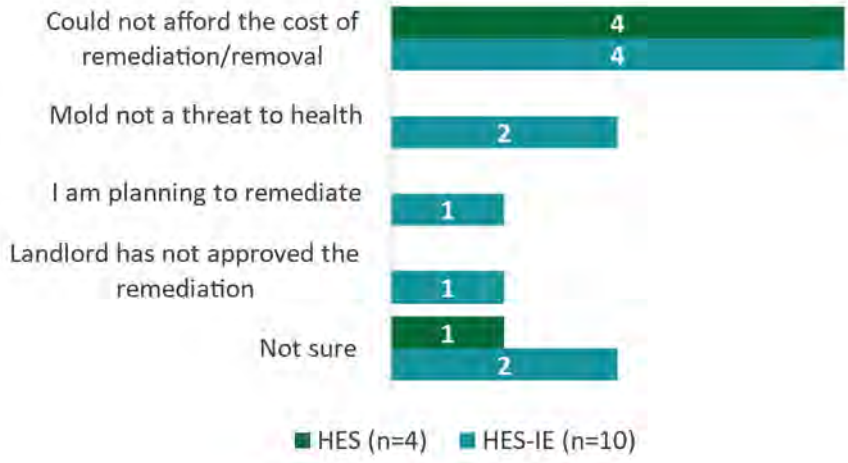
Figure 49: Recall of Mold Found During Assessment

(Source: Participant survey and program tracking data)

Twelve of nineteen HES respondents and 30% of 25 HES-IE respondents either removed or removed and remediated the source of the mold. Among respondents who did not remediate, the most common barrier was affordability (Figure 50).

Figure 50: Reasons for Not Remediating Mold

(Source: Participant survey)



B.3.3 Pre-Screening Process

Ten vendors weighed in on the pre-screening process for identifying health and safety barriers. Two respondents thought it was quite helpful, identifying issues such as mold which customers could easily see in their homes. One respondent noted that they would explain in detail what was allowable to the customer, getting as technical as possible during the pre-screening to reduce cancellations.

However, five respondents thought the pre-screening process was only helpful some of the time and three thought it was never helpful. One respondent noted that they routinely send customers an email with examples of mold, asbestos, open-wall construction, and other health and safety

barriers as part of the pre-screening and scheduling process, yet they still encountered barriers that prevented an assessment from moving forward at an estimated 10 to 15% of appointments.

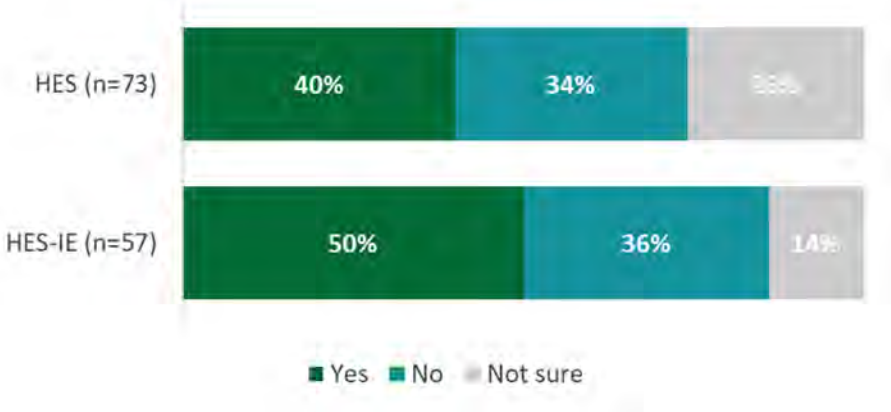
Two respondents noted that expanding virtual pre-screening (guided video calls with a technician) could help identify health and safety barriers before a home visit, but that customer willingness and vendor staff availability might limit that approach.

B.3.4 Remediation

Nearly half of HES respondents (40%) and half of HES-IE respondents (50%) with a health and safety barrier recalled technicians providing them with remediation options and/or a list of qualified third-party remediation contractors.

Figure 51: Respondents that Recall Receiving Remediation Information

(Source: Participant survey)



After identifying a health and safety barrier, twelve vendors noted that they refer customers to other vendors or programs that can help them with remediation, while one vendor offered remediation services themselves. However, vendors said that many customers could not afford to deal with health and safety barriers, and they were often not addressed.[130] One vendor noted:

> *"[The] only thing we can do is educate the customer on the problem and do the limited amount of work we're allowed to do. We refer them to companies that can do it, but it's very expensive and the program doesn't offer anything to support that. Not just IE, but HES customers can't afford that either most of the time."*

Similarly, another vendor noted that asbestos removal could cost as much as $15,000 and most of their customers could not afford that. Vendors emphasized the need to provide assistance to these customers by offering program support or aiding them in accessing federal or state funding, if available.

[130] Fourteen of the vendors addressed health and safety barrier remediation; one vendor did not specify how they informed customers of remediation options.

Five of the ten community stakeholder interviewees commented on their communities' concerns about their ability to remedy health and safety issues in their homes. One community stakeholder who served on their town's energy commission tied these concerns back to their community members' already-high energy burdens:

> *"Vendors that I know run across this all the time. One vendor said with 30% of the leads they get, when they get to the house, they find a health and safety barrier and that's the end of the story. The options people have to get that remediated are extremely low. You can take out a loan [that has interest rates comparable to credit cards] and have your asbestos removed. But who can afford that if you're struggling already?"*

Another community stakeholder interviewee who served on their town's energy commission noted that the issue is widespread:

> *"It's not just our community. The barriers we've identified are statewide. That's why we've lobbied as much as we have. Progress towards the goals of energy efficiency in that sector is not being met. And this is one of the key issues: health and safety. These people drop off a cliff [after their barrier is identified by the program]. They don't get help."*

B.3.4.1 Satisfaction with Information about Remediation

HES respondents with a health and safety barrier rated their satisfaction with the assistance provided by the technician after identifying the unsafe material or hazardous condition in their home a 4, on average (see Satisfaction). Nine percent of respondents who had a health and safety barrier respondents rated their satisfaction a 1 or 2: [131]

- Three respondents cited a lack of clear information or follow-up about the issue.
- Two respondents reported misunderstandings between the technician and respondent about why the health and safety issue affected the services offered by the HES program.
- One respondent did not recall receiving a list of qualified remediation contractors.
- Another respondent said they would have liked the technician to provide information about financial assistance for remediation.

HES-IE respondents with a health and safety barrier rated their satisfaction a with the assistance provided by the technician a 3.7, on average (see Satisfaction). One-quarter of respondents (25%) who had a barrier respondents rated their satisfaction a 1 or 2: [132]

- Five respondents said that they did not receive information about remediation options or qualified contractors from the technician.
- Two of the respondents were disappointed to learn their barrier could not be easily remediated.
- One respondent with a leaky roof said they pointed out the issue to the technician during the assessment.

[131] n=9; Two of the respondents said, "I'm not sure."
[132] n=12; One respondent expressed general disappointment with their technician and the other two respondents said, "I'm not sure."

- One respondent said the technician found carbon dioxide in an unused fireplace, but the fire department could not find the source of the leak.

B.3.4.2 Remediation for HES-IE Customers

One program stakeholder noted that Connecticut was unique in its lack of flexibility to combine Low-Income Energy Assistance Program (LIHEAP) funds with WAP funds to expand energy efficiency measures and services on offer to eligible customers. They described a process similar to vendors' and community stakeholders' experiences when vendors identify a health and safety barrier in customers' homes. Vendors can refer customers to state or local programs that may help with remediation, along with a notice of deferral that the energy efficiency work can continue pending prompt remediation (60 days); however, remediation options are scarce.

One interviewee who worked for an organization that develops affordable housing and conducts homeowner education explained how they had seen health and safety barriers lead to overall negative experiences with the program:

> *"People made it clear they didn't value what happened [during their site visit] and thought it wasn't enough. I've come to understand they probably had a health and safety barrier but didn't really understand it. I think a lot of the residents that were denigrating the program didn't understand why so little happened. The problem was that there weren't a lot of options for getting the barriers remediated. I can't really speak for the vendors, but I don't know how thorough they were in explaining the barriers. People may have misinterpreted this as 'These guys just don't want to do anything'. Or it is possible the vendors did not want to frighten the customer. I don't know what happened, but [to the community I serve], the program was often undervalued, and still is."*

Where health and safety barriers were not top of mind, one interviewee who serves as a NRZ chair mentioned it was because other concerns superseded them, including access to basic needs such as affording rent, utilities, and food for their families.

The Statewide Weatherization Barrier Remediation Services Program launched by DEEP in 2022 is designed to serve 1,000 low-income customers in its first year.[133] Nearly 70% of HES-IE survey respondents with asbestos or vermiculite insulation found during their assessments (2017 to 2020) indicated they had not yet pursued remediation. This finding indicates there are nearly 4,500 single-family HES-IE households that may be waiting for remediation services for a single weatherization barrier (asbestos or vermiculite insulation), not counting any multifamily households or households with barriers who received assessments in 2021 or 2022.

[133] Department of Energy and Environmental Protection (DEEP). June 23, 2022. "DEEP Launches ICAST Partnership to Deliver Weatherization Barrier Remediation Services to Connecticut Families." https://portal.ct.gov/DEEP/News-Releases/News-Releases---2022/DEEP-Launches-ICAST-Partnership-to-Deliver-Weatherization-Barrier-Remediation-Services.

B.4 Drivers and Barriers to Additional Savings

Beyond the core measures conducted during the assessment, participants can opt to install rebated (HES) or add-on (HES-IE) measures to achieve additional savings. Technicians introduce these opportunities to customers during the kitchen table wrap-up at the end of the assessment. The survey asked participants who did not receive air sealing during the assessment or install HVAC, insulation, or water heaters following the assessment to elaborate on their decision and suggest solutions to overcome these barriers.

B.4.1 Key Findings

- HES respondents reported installing heat pumps at lower rates than other HVAC equipment following their assessment. Self-reported rates of heat pump installation ranged from 1% to 5%, compared to 8% to 15% for boilers, furnaces, and central air conditioners.[134] However, several vendors indicated that they install heat pumps as well as conduct assessments, or plan to in the future, and expressed optimism over the growing interest in heat pumps.
- Nearly two-thirds of HES-IE renters (62%, n=47) and one of nine HES renters cited lack of permission from their landlord as barriers to air sealing and/or installation of insulation, HVAC equipment or water heaters following the assessment.
- Four out of six community stakeholders who commented on program barriers brought up issues between landlords and tenants as an important barrier to program participation. The perspectives of these customers are not likely to be reflected in the participant survey.
- Asbestos and/or vermiculite insulation was the top barrier to air sealing cited by respondents who did not receive blower door-guided air sealing.
- When asked what their utility could do to address barriers to installing insulation, HVAC equipment, water heaters, and/or air sealing, HES-IE respondents most often requested to be provided with more information about energy savings from these measures.
- **Insulation** is the most commonly installed rebated or add-on measure, according to program tracking data and as reported by survey respondents (25% of HES respondents and 26% of HES-IE respondents). More than one-quarter of HES respondents (28%) who did not install insulation said it was too expensive; respondents suggested increasing the rebate amount (23%) and offering additional financing options (17%).

B.4.2 Kitchen Table Wrap-Up

The field implementation manual instructs technicians that the kitchen table wrap-up is an important tool for customer education about energy efficiency, a critical component of both programs. The lead technician summarizes the work completed during the assessment, provides a customer report, and reviews the Print on Demand ("POD") booklet that describes rebates, financing options, and recommendations to install deeper energy-savings measure.[135]

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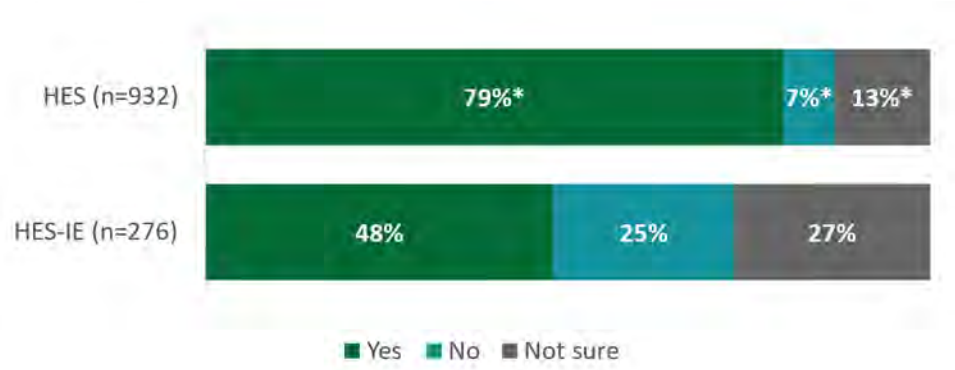
[134] Program tracking data was not available for these measures, so the efficiency of these self-reported measures is unknown.

[135] The 2019 HES/HES-IE Field Implementation Manual indicates that a comprehensive HES Customer Report was coming soon for HES-IE customers; in the meantime, HES-IE respondents received a hard copy report. If HES-IE customers are eligible for rebates, the program mails them rebate forms within two weeks of their assessment.

HES respondents were significantly more likely than HES-IE respondents to recall receiving the POD booklet from their technician during the kitchen table wrap-up (Figure 52).

Figure 52: Participants Receiving Booklet Outlining Services

(Source: Participant Survey)[1]



*Significantly different HES-IE at the 90% confidence level.

[1] Percentages do not sum to 100% due to rounding.

HES respondents rated their satisfaction with the information provided to them about the energy savings opportunities associated with the program a 4.1 (see Satisfaction). The 8% of respondents who rated their satisfaction a 1 or 2 were asked why:[136]

- Respondents expressed concerns that the technician was not informative (23%), did not provide any information (18%) or recommend any energy-saving opportunities (7%), or did not address their concerns (5%).
- One respondent received an outdated booklet with rebate forms that had expired the year prior.
- Nearly one-fifth said the assessment in general was not very informative (18%).

HES-IE respondents rated their satisfaction with the information provided to them about the energy savings opportunities associated with the program a 3.8 (see Satisfaction). The 18% of respondents who rated their satisfaction a 1 or 2 were asked why:[137]

- Most of these respondents said they did not receive any information about additional energy savings (50%) or were not provided with any recommendations by the technician (12%).
- One-fifth of respondents (21%) said the assessment was not very informative.
- Two respondents said they could not afford to make any additional upgrades.
- One respondent said they received incorrect information.
- Some respondents explained that they did not receive any follow-up from the vendor or from their utility after contacting program staff for assistance.

[136] n=57; Excludes ten respondents who said "I'm not sure" or gave non-applicable responses.
[137] n=34; Excludes two respondents who said "I'm not sure" or gave non-applicable responses.

One HES-IE vendor expressed concern that that HES-IE customers were less engaged in the kitchen table wrap-up because they did not have a co-pay associated with program participation. While the Community Action Agency (CAA) is responsible for signing up HES-IE participants, they subcontract to vendors who complete the assessments. This can lead to some confusion on the part of HES-IE customers about which contractor is responsible for providing information or follow-up services.

B.4.3 Additional Measure Installation

Survey questions asked respondents whether technicians had discussed any recommended rebated or add-on energy upgrades after completing the home energy assessment and checked whether respondents had installed any rebated or add-on measures they might have been eligible for which were not present in program tracking data.[138] For any such installed measures, follow-up questions asked respondents why they had made the upgrades.

B.4.3.1 HES Participants

Nearly two-thirds of HES respondents (65%) said technicians discussed recommended rebated energy upgrades after completing the home energy assessment (Figure 53).

Figure 53: Technicians Discussed Additional Recommended Upgrades, HES
(Source: Participant survey; n=932)

According to the Connecticut Statewide Energy Efficiency Dashboard,[139] technicians most commonly recommended appliances (61%) to HES participants, followed by HVAC (58%), insulation (40%), water heaters (31%), and windows (4%) from 2017 to 2020 (Figure 54). HES participants most commonly installed installation (13%), followed by HVAC equipment (8%). Recommendation rates for HES participants who responded to the survey were not available in the program tracking database; however, they are likely higher than the program average because the study oversampled participants with rebated measures (see section Satisfaction). The data in Figure 54 is reproduced from the Statewide Energy Efficiency Dashboard; the study did not receive data on recommendations made to individual participants.

[138] The number of respondents who saw each measure option varies because the survey only showed measures not present in each respondent's program tracking data.
[139] Energize CT. "Statewide Energy Efficiency Dashboard." https://energizect.com/eeb-statewide-energy-efficiency-dashboard. Accessed November 2022.

Figure 54: Recommendation and Installation Rates of Rebated Measures, HES (2017-2020)

(Source: Statewide Energy Efficiency Dashboard)

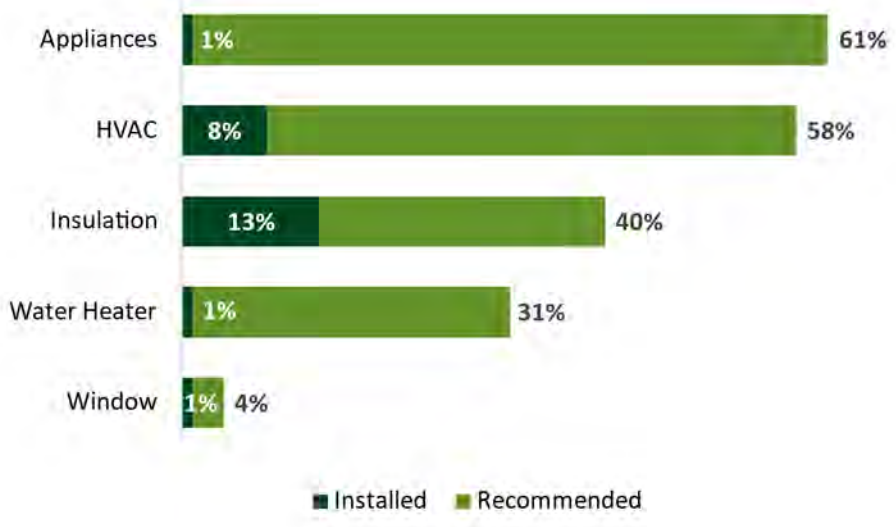


Figure 55 shows which measures HES respondents most commonly installed as rebated measures. *Tracked AND self-reported* indicates that the measure was reflected in the tracking data and the respondent confirmed it had been installed, while *tracked NOT self-reported* indicates the measure was in the tracking data, but the respondent did not recall the installation. As some measures in the tracking data were not associated with customer addresses,[140] the survey asked respondents to self-report whether they had installed any of the rebated measures following the assessment.

Similar to the figures in the Statewide Dashboard (Figure 54), insulation was the most commonly installed measure, with 15% of respondents verifying that they had received the insulation installation recorded in the program tracking data and an additional 22% self-reporting that they had installed insulation following the assessment. Wi-Fi-enabled thermostats were the second most common rebated measure installed, followed by refrigerators and clothes washers.

It is unlikely that all of the self-reported measures are energy-efficient or would have qualified for rebates. While the study oversampled respondents with rebated measures to estimate NTG, it is unlikely respondents exceeded the installation rates in Figure 54 to the extent seen in Figure 55.

[140] In some cases, the installation contractor's contact information was associated with the measure, or the customer received an instant discount for the measure (e.g., water heaters).

Figure 55: Upgrades Completed After Home Energy Assessment, HES
(Source: Participant survey; n's exclude respondents who said the measure was *not applicable*)

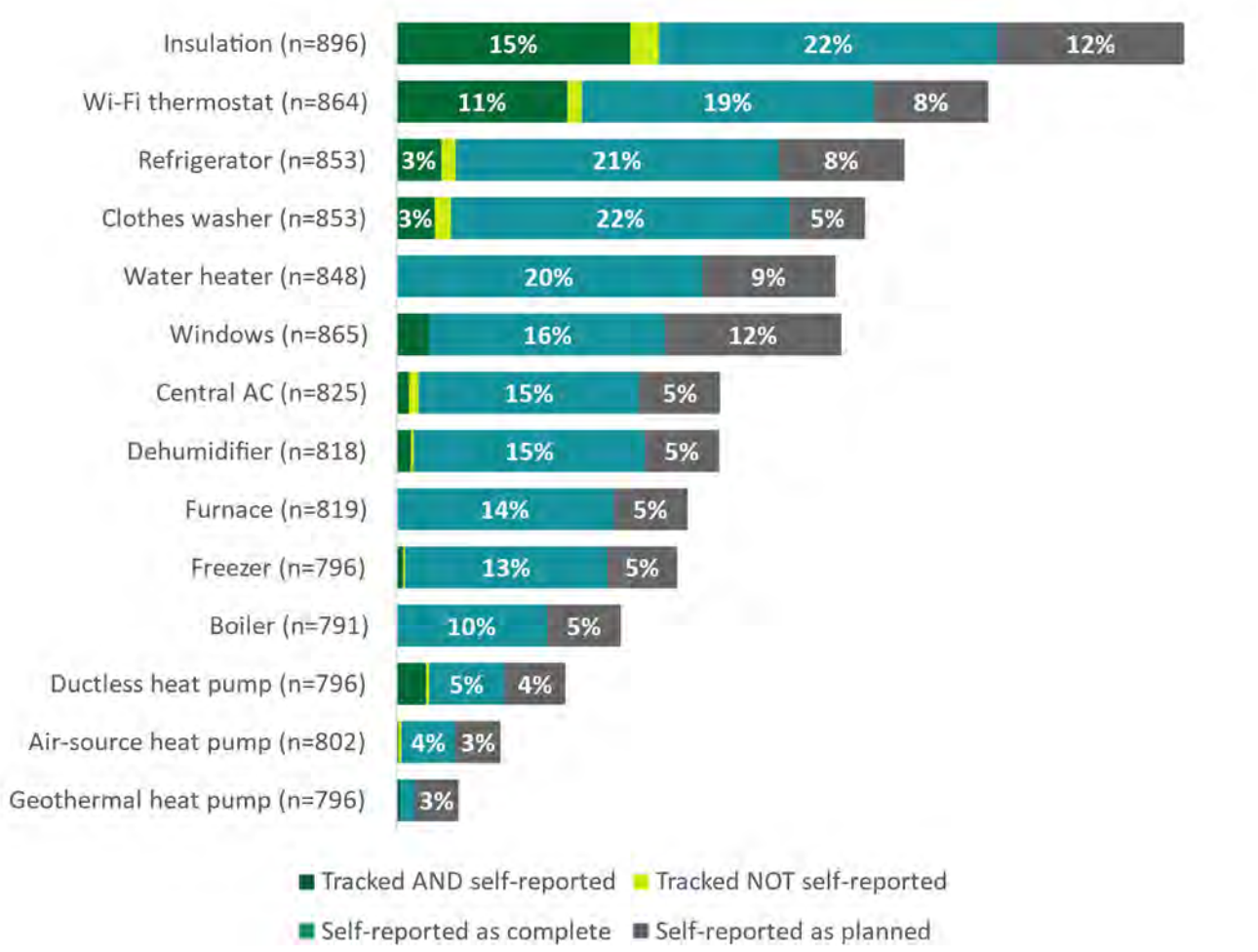


Table 45 shows detailed percentages for all measures in Figure 55.

Table 45: Rebated Upgrades Completed After Home Energy Assessment, HES

(Source: Participant survey)

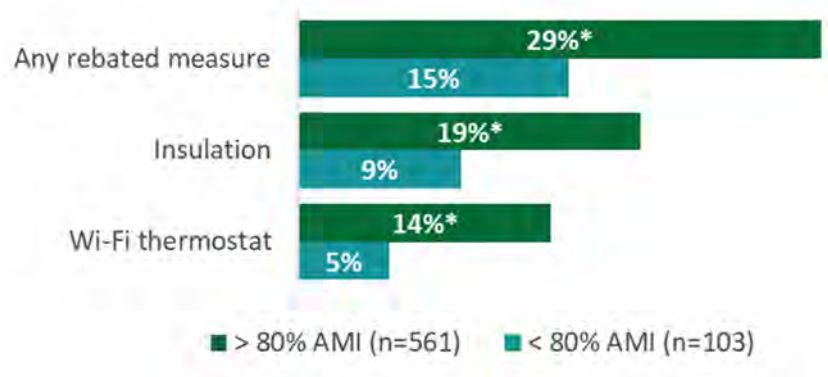
Features	n[1]	Tracked AND self-reported	Tracked NOT self-reported	Self-reported complete	Plan to install (self-reported)	No	Not sure
Insulation	896	15%	2%	22%	12%	46%	2%
Wi-Fi thermostat	864	11%	1%	19%	8%	58%	3%
Refrigerator	853	3%	1%	21%	8%	63%	3%
Clothes washer	853	3%	1%	22%	5%	66%	3%
Water heater	848	0%	0%	20%	9%	66%	5%
Windows	865	2%	0%	16%	12%	67%	4%
Central AC	825	1%	1%	15%	5%	74%	5%
Dehumidifier	818	1%	0%	15%	5%	75%	4%
Furnace	819	0%	0%	14%	5%	76%	5%
Freezer	796	0%	0%	13%	5%	78%	4%
Boiler	791	2%	0%	8%	1%	75%	13%
Ductless heat pump	796	2%	0%	5%	4%	83%	6%
Air source heat pump	802	<0%	<0%	4%	3%	87%	7%
Geothermal heat pump	796	0%	0%	1%	3%	95%	5%

[1] n's differ as some respondents answered "not applicable" or did not recall the technician discussing rebated measures after the assessment.

B.4.3.2 Moderate-Income Participants

Moderate-income households install fewer rebated measures following their assessment than other HES participants. As shown in Figure 56, Households with incomes less than 80% of the area median income (AMI) were significantly less likely to have installed a rebated measure (15%) than other HES participants (29%). Significantly fewer moderate-income HES participants installed insulation (9%) and Wi-Fi thermostats (5%) than other HES participants (19% and 14%, respectively).

Figure 56: Rebated Measure Installation by Income, HES



*Significantly different than participants with incomes less than 80% AMI at the 90% confidence level.

Table 46 shows detailed percentages for each measure. For each measure, the top row shows participants with incomes over 80% of the area median income (AMI) and the bottom row shows participants with less than 80% AMI.

Tracked AND self-reported indicates that the measure was reflected in the tracking data and the respondent confirmed it had been installed, while *tracked NOT self-reported* indicates the measure was in the tracking data, but the respondent did not recall the installation. As some measures in the tracking data were not associated with customer addresses,[141] the survey asked respondents to self-report whether they had installed any of the rebated measures following the assessment.

Table 46: Rebated Measures Completed After Assessment, by Income Level

(Source: Program data and participant survey)

Features	80% AMI	n[1]	Tracked AND self-reported	Tracked NOT self-reported	Self-reported complete	Plan to install (self-reported)	No	Not sure
Insulation	>	539	17%*	1%	21%	14%	44%	2%
	<	98	7%	2%	30%	9%	50%	1%
Wi-Fi thermostat	>	532	13%*	1%	22%	9%	53%	2%
	<	90	4%	1%	12%	9%	69%	4%
Refrigerator	>	515	3%	1%	22%	9%	63%	3%
	<	94	1%	2%	21%	7%	65%	4%
Clothes washer	>	512	3%	2%	22%	6%	65%	3%
	<	96	1%	0%	24%	4%	68%	3%
Water heater	>	516	0%	0%	22%	11%	64%	3%
	<	92	0%	0%	18%	5%	69%	8%
Windows	>	526	2%	0%	16%	14%	64%	3%
	<	96	<1%	0%	23%	7%	68%	2%
Central AC	>	511	1%	1%	17%	6%	70%	5%
	<	85	0%	0%	6%	4%	84%	6%
Dehumidifier	>	499	1%	0%	17%	5%	74%	3%
	<	85	0%	<1%	13%	2%	79%	6%
Furnace	>	497	0%	0%	16%	5%	74%	4%
	<	88	0%	0%	16%	3%	76%	5%
Freezer	>	482	1%	<1%	13%	6%	77%	3%
	<	83	0%	0%	15%	1%	79%	5%
Boiler	>	472	0%	0%	11%	5%	80%	4%
	<	89	0%	0%	10%	3%	80%	7%
Ductless heat pump	>	492	2%	<1%	6%	5%	81%	6%
	<	82	4%	0%	4%	3%	82%	6%

[141] In some cases, the installation contractor's contact information was associated with the measure, or the customer received an instant discount for the measure (e.g., water heaters).

Features	80% AMI	n[1]	Tracked AND self-reported	Tracked NOT self-reported	Self-reported complete	Plan to install (self-reported)	No	Not sure
Air source heat	>	495	<1%	<1%	5%	4%	84%	7%
pump	<	82	0%	0%	<1%	2%	91%	7%
Geothermal heat	>	491	<1%	0%	1%	3%	90%	5%
pump	<	81	0%	0%	2%	2%	92%	5%

[1] n's differ as some respondents answered "not applicable" or did not recall the technician discussing rebated measures after the assessment.

B.4.3.3 HES-IE Participants

One-fourth of HES-IE respondents (27%) said technicians discussed recommended add-on energy upgrades after completing the home energy assessment (Figure 57). However, it is possible that some HES-IE participants are unclear which add-on measures were recommended because technicians send the recommendations for some measures to the program directly to determine the participant's eligibility for no-cost or discounted installations through the program. HES participants are responsible for acting on the recommendations themselves by contacting program contractors and applying for rebates.

Figure 57: Technicians Discussed Additional Recommended Upgrades, HES-IE
(Source: participant survey; n=276)

Figure 58 shows which measures HES-IE respondents most commonly installed as add-on measures. *Tracked AND self-reported* indicates that the measure was reflected in the tracking data and the respondent confirmed it had been installed, while *tracked NOT self-reported* indicates the measure was in the tracking data, but the respondent did not recall the installation. As some measures in the tracking data were not associated with customer addresses,[142] the survey asked respondents to self-report whether they had installed any of the add-on measures following the assessment.

Similar to HES, insulation was the most commonly installed measure, with 25% of respondents verifying that they had received the insulation installation recorded in the program tracking data and an additional 19% self-reporting that they had installed insulation following the assessment. Wi-Fi-enabled thermostats were the second most common rebated measure installed, followed

[142] In some cases, the installation contractor's contact information was associated with the measure, or the customer received an instant discount for the measure (e.g., water heaters).

by windows; eligible HES-IE participants could receive no-cost window replacements through the program.

Figure 58: Add-on Upgrades Completed After the Home Energy Assessment, HES-IE

(Source: Participant survey; n excludes respondents who said the measure was *not applicable*)

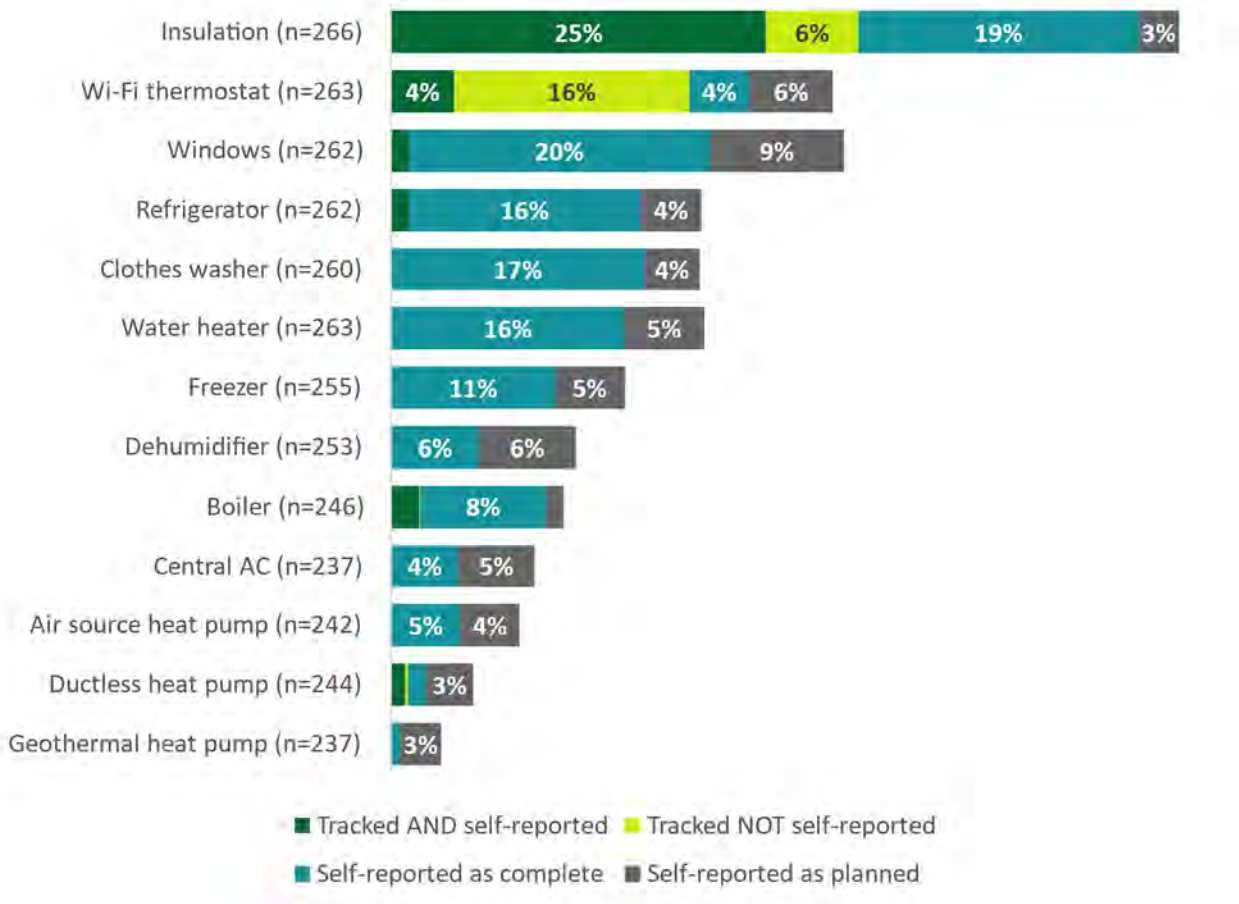


Table 47 shows detailed percentages for add-on measures in Figure 58.

Table 47: Rebated Upgrades Completed After Home Energy Assessment, HES-IE

(Source: Participant survey)

Features	n[1]	Tracked AND self-reported	Tracked NOT self-reported	Self-reported complete	Plan to install (self-reported)	No	Not sure
Insulation	266	25%	6%	19%	3%	36%	11%
Wi-Fi-enabled thermostat	263	4%	16%	4%	6%	63%	7%
Windows	262	1%	0%	20%	9%	59%	11%
Refrigerator	262	1%	0%	16%	4%	69%	10%
Clothes Washer	260	0%	0%	17%	4%	69%	10%
Water Heater	263	0%	0%	16%	5%	66%	13%
Freezer	255	0%	0%	11%	5%	72%	12%
Dehumidifier	253	0%	0%	6%	6%	77%	10%
Boiler	246	2%	0%	8%	1%	75%	13%
Central AC	237	1%	1%	15%	5%	74%	5%
Air Source heat pump	242	0%	0%	4%	3%	87%	7%
Ductless heat pump	244	2%	0%	5%	4%	83%	6%
Geothermal heat pump	237	0%	0%	1%	3%	91%	5%

[1] n's differ as some respondents answered "not applicable" or did not recall the technician discussing rebated measures after the assessment.

B.4.4 Experience with Installation Contractors

B.4.4.1 Scheduling the Installation

HES respondents who received at least one rebated measure rated their satisfaction with the time it took to schedule the installation a 4.3 (see section Satisfaction). Respondents who rated their satisfaction a 1 or 2 (7%) were asked why.[143] The most common issues were delays and/or a long wait time for installation (seven respondents) and poor customer service (four respondents). Other participants noted they had difficulty scheduling the installation (two respondents), taking time off work to accommodate the installation (two respondents), or finding a contractor (one respondent). One respondent indicated that their rebates expired while waiting for a contractor and another said the delays caused them to miss out on a season's worth of savings on their utility bill.

HES-IE respondents rated their satisfaction with the time it took to schedule the installation of recommended equipment or upgrades a 4.3 (see section Satisfaction). Respondents who rated their satisfaction a 1 or 2 (3%) were asked why.[144] Two respondents each had issues with poor

[143] n=15; Excludes respondents who said, "not applicable," "I'm not sure," or spoke about the services provided by the contractor during the installation and not about the process of scheduling the installation. Count sum to greater than 15 due to multiple responses.
[144] n=8; Excludes one respondent who responded, "not applicable."

customer service while scheduling or long wait times to receive an appointment for installation. The other respondents cited issues with the performance of the contractor.

B.4.4.2 Satisfaction with the Contractor

HES respondents who received at least one rebated measure rated their satisfaction with the professionalism and service of the contractor that installed it a 4.4, one of the highest-rated program elements (see section Satisfaction). Respondents who rated their satisfaction a 1 or 2 (n=11) were asked why:[145]

- Six respondents had improperly installed HVAC systems that required frequent repairs. Two of these respondents failed to receive their rebate because of incorrect information provided by the contractor.
- One respondent said their contractor was unprofessional and another reported having communication issues.
- One respondent who received insulation said their contractor did not install it to the proper R value.
- One respondent who received mold remediation said the contractor damaged their house and then did a poor job repairing and painting the damaged walls; another respondent who received insulation said the installer damaged their heating system in the process.

HES-IE respondents who received at least one add-on measure rated their satisfaction with the professionalism and service of the contractor that installed it a 4.3, on average (see section Satisfaction). Respondents who rated their satisfaction a 1 or 2 (11%) were asked why:[146]

- Five respondents reported sloppy work.
- Three respondents experienced a lengthy installation and/or unprofessional contractors.
- Two respondents experienced damage to their home; in particular, one respondent who received new windows said the contractor did not follow lead protocols.
- Another respondent who had their windows replaced said the contractor left without explaining how to use the new windows.

B.4.5 Barriers and Solutions to Additional Measure Installation

Survey questions asked respondents what barriers prevented them from installing additional measures available through the program. The survey asked about four measures: insulation, HVAC systems, water heaters, and air sealing. Community stakeholder interviewees also weighed in on barriers that they see people face in installing measures through the program, such as split incentives. This section expands on the participation barriers identified in Health and Safety Barriers.

[145] Count excludes respondents who said, “not applicable,” “I’m not sure,” or made reference to the technicians who performed the assessment. Count also includes three respondents whose explanations regarding their dissatisfaction with the process of scheduling the contractor included relevant information about the service provided by the installation contractor. Counts sum to greater than 11 due to multiple responses.
[146] n=11; Excludes respondents who said, “not applicable,” “I’m not sure,” or referenced their dissatisfaction with the assessment technician, not the contractor who installed the additional measure.

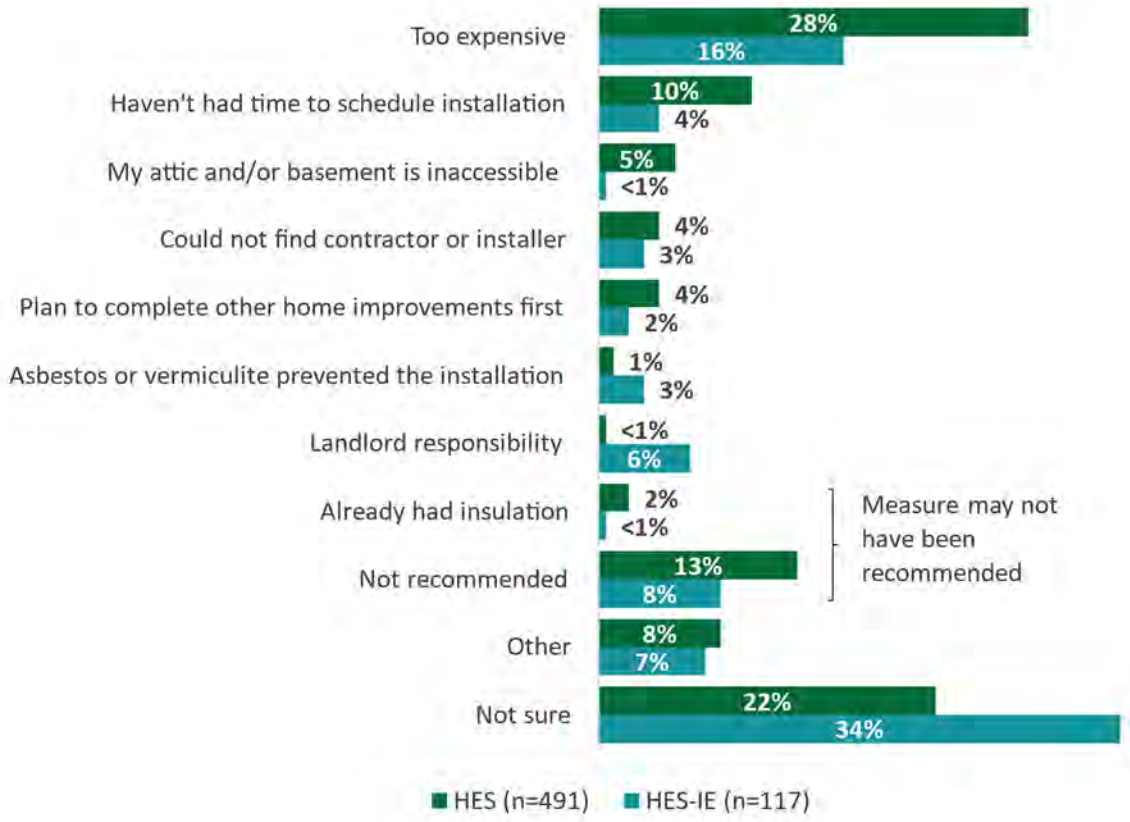
Respondents who did not install at least one of the following add-on measures (insulation, HVAC, water heating) or receive blower-door-guided air sealing during the assessment were randomly selected to elaborate on their decision regarding up to two of those measures. In the absence of household-level recommendation data from the Companies, the participant survey was unable to target these questions to participants who received a recommendation for, but did not ultimately install, these measures. According to the Statewide Dashboard, technicians recommended upgrading HVAC to 58% of HES participants, insulation to 40% of HES participants, and new water heaters to 31% of participants. Technicians perform blower-door-guided air sealing unless there is a health and safety barrier or the participant refuses.

B.4.5.1 Insulation

Cost was the most frequently cited barrier by respondents who did not install rebated or add-on insulation following the assessment (Figure 59). According to the Statewide Dashboard, technicians recommended insulation to 40% of HES customers (Figure 54); some respondents who said “not sure” may not have received a recommendation.

Figure 59: Barriers to Installation of Insulation

(Source: Participant survey, multiple responses allowed)

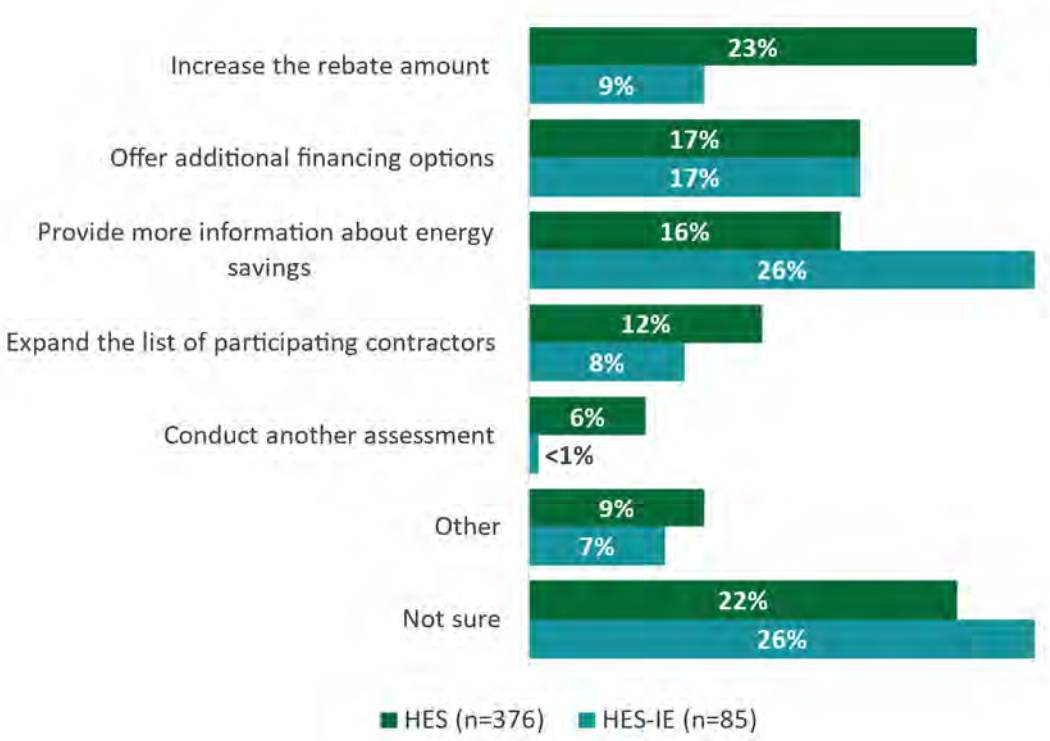


Among HES respondents who identified a barrier to installing insulation, the most frequently suggested solution was to increase the rebate amount (23%) and offer additional financing

options (17%). More than one-quarter of HES-IE respondents would like to receive more information about the energy savings from insulation (Figure 60).

Figure 60: Solutions to Insulation Barriers

(Source: Participant survey)

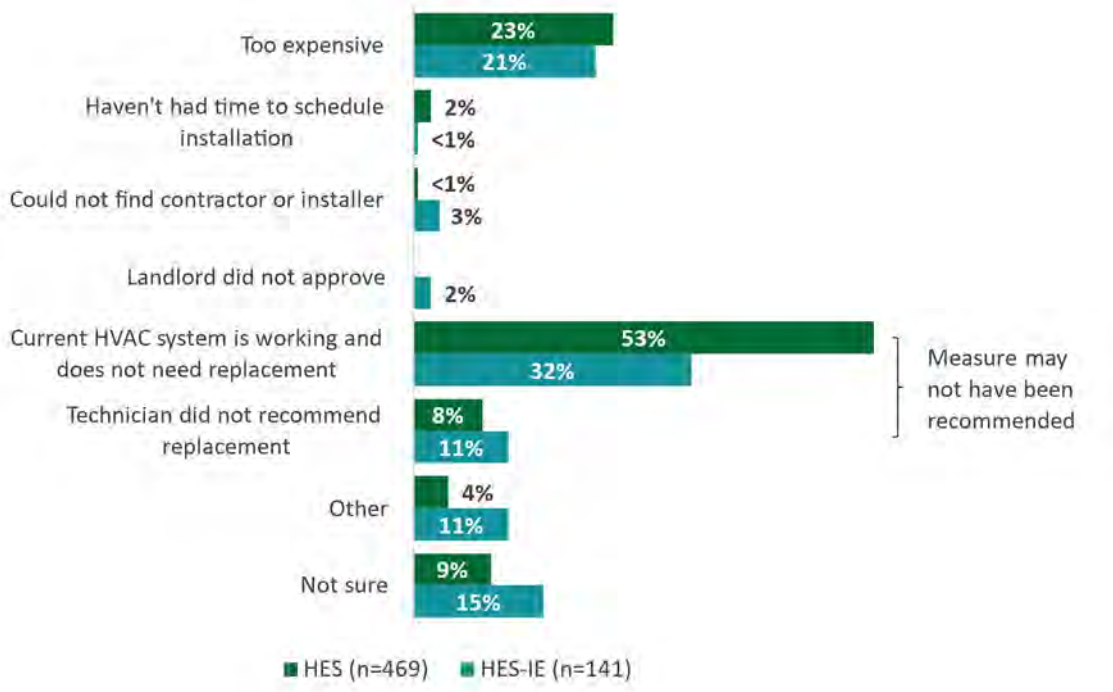


B.4.5.2 HVAC

More than one-fifth of respondents (23% of HES and 21% of HES-IE respondents) did not install HVAC measures following the assessment because it was too expensive (Figure 61). More than half of HES respondents (53%) and one-third of HES-IE respondents (32%) did not upgrade their HVAC system because their current system was working. According to the Statewide Dashboard, technicians recommended HVAC to 58% of HES participants (Figure 54); up to 42% of the respondents may not have received a recommendation.

Figure 61: Barriers to Installation of HVAC

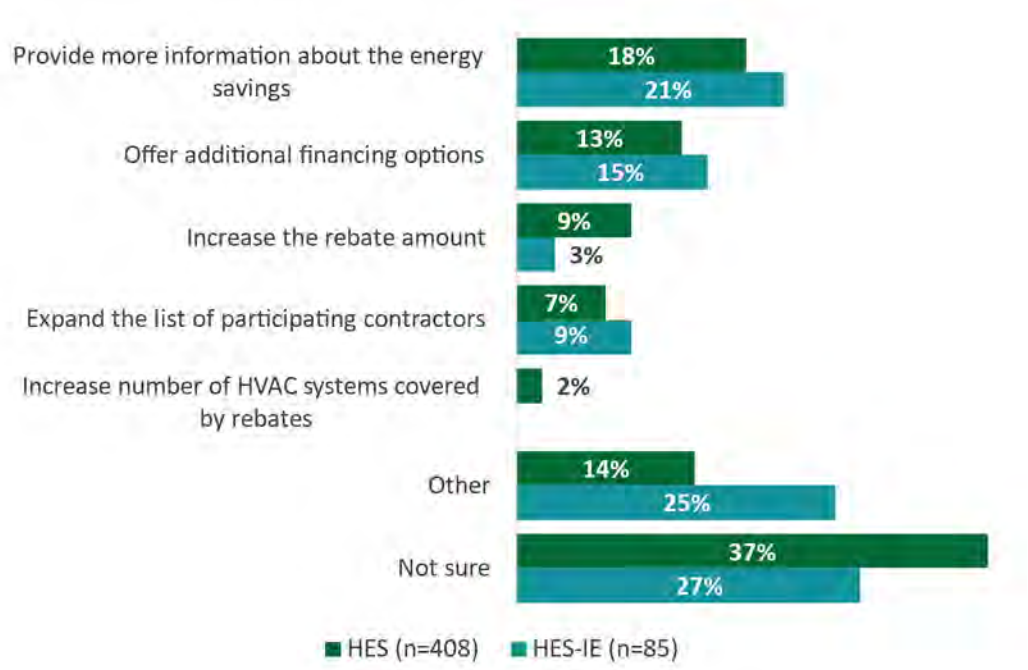
(Source: Participant survey; multiple responses allowed)



Among respondents who identified a barrier to installing HVAC following their assessment, the most frequently suggested solutions were to provide more information about energy savings for replacing the HVAC system and offer additional financing options (Figure 62).

Figure 62: Solutions to HVAC Barriers

(Source: Participant survey)



"Other" responses were either not applicable or were issues that could not be directly addressed by the program, including concerns about installations due to COVID-19 or unwillingness to take on an additional home improvement project.

Vendor interviewees answered questions about whether their companies sold heat pumps, and whether they were a substantial part of the business or a potential area of expansion. Two vendors said they install heat pumps, two plan to install heat pumps in the future, and two said they refer customers to HVAC contractors for heat pumps. One vendor noted:

> *"The heat pump is a big seller right now. And there's a lot of customers that are interested in heat pumps. There are other customers who don't understand [how they work]. So, you have to explain that to them, and then it's just a personal choice. They'll say my oil furnace is only 15 years old and if I were to try to move to [a heat pump], it's going to cost me X amount of dollars, or whatever the case may be. But it's in their minds. The seed gets planted. They're totally receptive to heat pumps*."

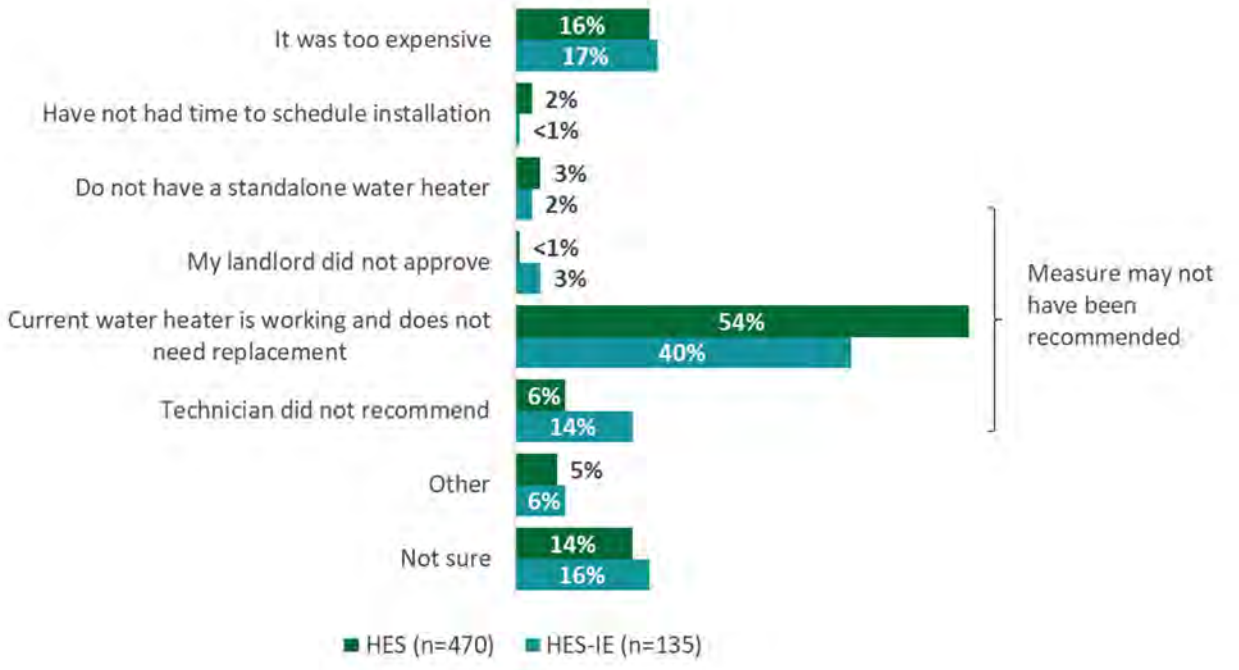
B.4.5.3 Water Heaters

Nearly one-fifth of respondents (16% of HES and 17% of HES-IE) said they did not replace their water heater following the assessment because it was too expensive (Figure 63). According to the Statewide Dashboard, technicians recommended a new water heater to 31% of HES participants; more than two-thirds of these respondents may not have received a recommendation. According to the Statewide Dashboard (see Figure 54 above), technicians recommended a new water heater to 31% of HES participants; more than two-thirds of these respondents may not have received a recommendation. More than half of HES respondents

(54%) and 40% of HES-IE respondents said their current water heater is working and does not need to be replaced.

Figure 63: Barriers to Water Heater Installation

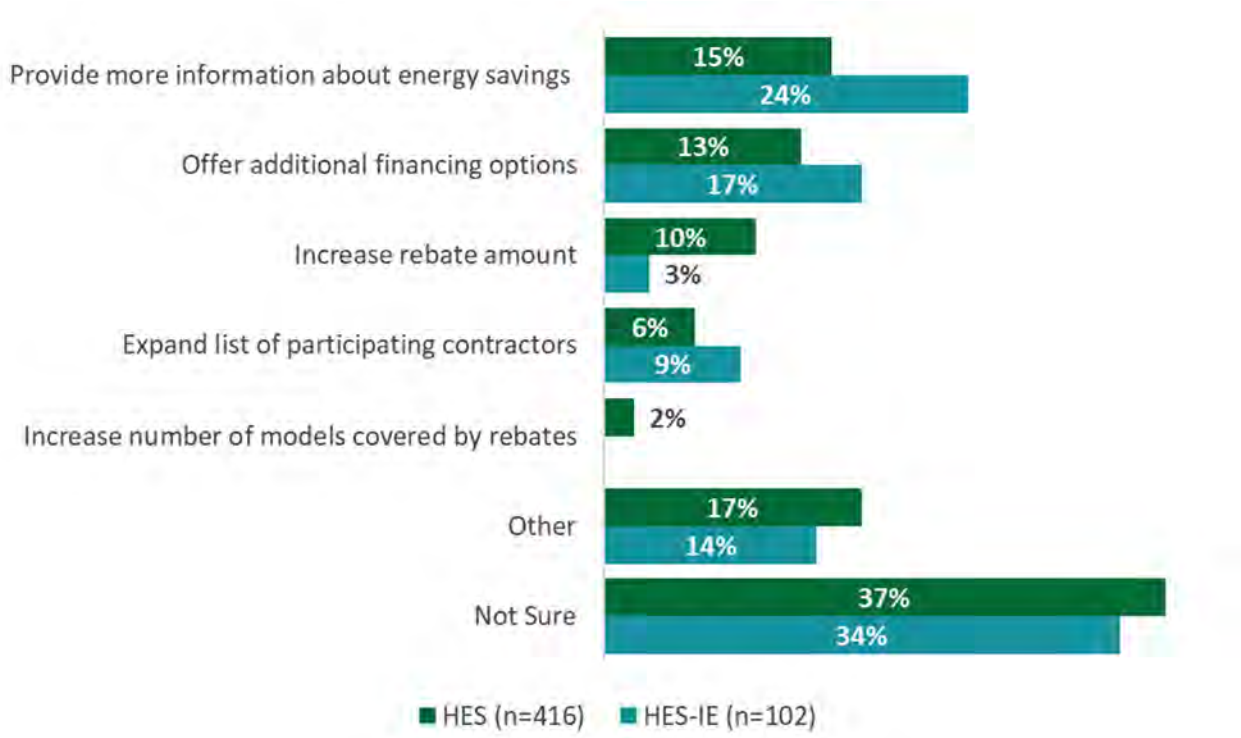
(Source: Participant survey; multiple responses allowed)



As shown in Figure 64, respondents who identified a barrier to installing water heaters most frequently requested that the program provide more information about energy savings (15% of HES respondents and 24% of HES-IE respondents) and expand financing options (13% of HES respondents and 17% of HES-IE respondents).

Figure 64: Solutions to Water Heater Barriers

(Source: Participant survey)

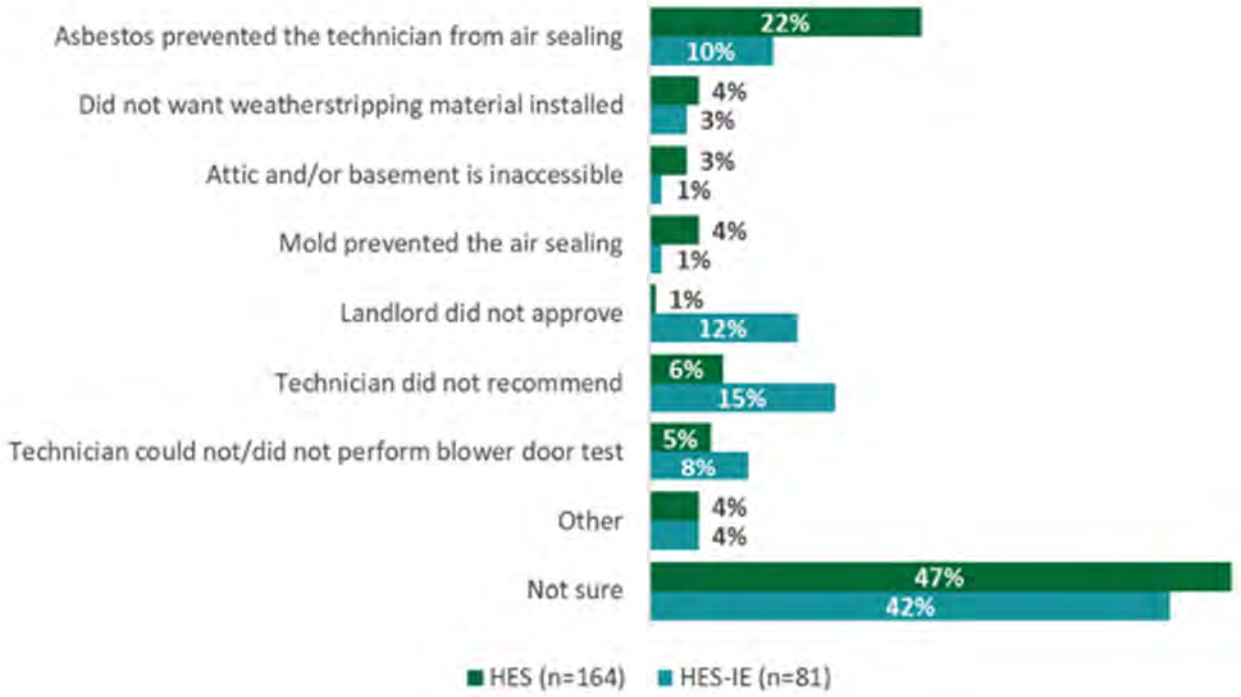


B.4.5.4 Air Sealing

Nearly half of HES respondents (47%) and 42% of HES-IE respondents were not sure why they did not receive blower-door-guided air sealing (Figure 65). Poor recall on this question is not surprising given that participants may not realize what they missed, particularly if they received complementary air sealing without the blower door test. Nearly one-quarter of HES respondents (22%) and 10% of HES-IE respondents said they did not receive air sealing due to the presence of asbestos or vermiculite insulation.

Figure 65: Barriers to Air Sealing

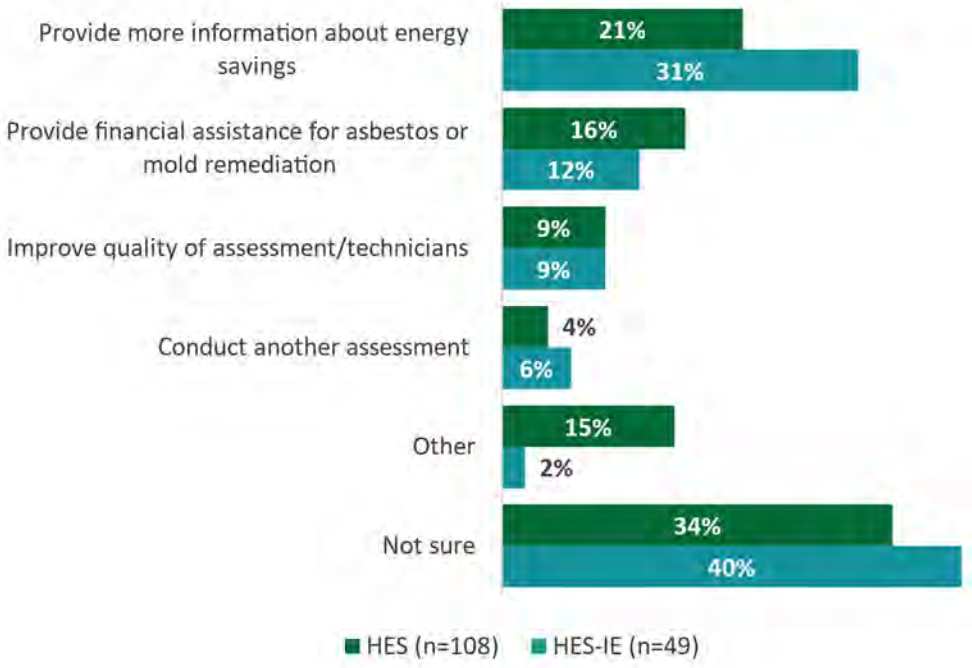
(Source: Participant survey; Base: Respondents that did not receive blower door-guided air sealing)



Among respondents who identified a barrier to air sealing, the most frequently suggested solutions were to provide more information about energy savings (21% of HES and 31% of HES-IE respondents) and provide financial assistance for the remediation of asbestos or mold (16% of HES and 12% of HES-IE respondents). Respondents who suggested *improving the quality of the assessment/technicians* (9%) were concerned that they received poor quality service or did not receive information about the benefits of air sealing during the assessment (Figure 66).

Figure 66: Solutions to Air Sealing Barriers

(Source: Participant survey)



B.4.6 Energy Affordability

Cost was a primary barrier mentioned by respondents who did not install HVAC, insulation, or a water heater following their assessment. Four of the community member stakeholder interviewees commented on the challenges their communities faced in affording energy bills. The most common challenge cited was affording energy costs while on a fixed income. Other challenges mentioned included elderly community members struggling to meet their energy costs and the rising cost of housing, energy, and health and safety remediation.

One interviewee who served as president of their NRZ described the energy burdens they see in their community:

> *"Most places don't include the utilities as a part of the rent, so people are making choices all the time on what they can afford, how much of what bill to pay. Someone like my mom, who is low-income and believes in having a warm house, will turn on the heat and figure out how to pay later. Low-income renters think about that, not wanting to live in discomfort."*

B.4.7 Barriers for Renters

Nearly two-thirds of HES-IE renters (62%, n=47) and one of nine HES renters cited lack of permission from their landlord as barriers to installation of at least one of the measures mentioned above (insulation, HVAC, water heater, or air sealing).

Community stakeholders described issues between landlords and tenants as a barrier to additional measure installations. Some attributed landlords' fears of unearthing code violations as

an obstacle to home maintenance and repairs. Other community stakeholders described scheduling issues that might prevent customers in their community from being available to receive an assessment.

One member of a municipal organization that helps underserved communities complete energy efficiency upgrades described landlord-tenant issues as a primary challenge:

> *"We quickly learned we needed to be mediators of trust for issues between landlords and tenants."*

One community stakeholder interviewee who served on their town's energy commission elaborated on split incentives:

> *"In some municipalities, organizations like ours have worked really hard to develop relationships between landlords and tenants. It takes a long time to get [both of] them to say "yes" and see why [energy efficiency] is a good thing. So many people who have never had HES are tenants who pay the electric bill, so the landlord has no incentive in his view to allow the work to be done."*

Another community stakeholder interviewee who worked as a private contractor on home energy audits described similar experiences:

> *"Most of the cases we get [are] very motivated tenant[s], and [we get] no response from landlords. There's very little incentive to respond, even though the upgrades will come at no cost to the landlord. In all these cases, these were HES-IE customers, and we could have solved meaningful problems: full insulation, new hot water heater, new windows in some cases."*

B.5 Rebates and Financing

HES and HES-IE participants are eligible for rebates and financing to incentivize deeper energy savings and ease the financial burden of installing additional measures following their assessment. Technicians discuss the options with the participant during the kitchen table wrap-up at the end of the assessment.

B.5.1 Key Findings

- HES respondents who applied for rebates were asked to rate their satisfaction with the application process (4.2), the amount of the rebate (3.9), and the time it took to receive the rebate (4.1) on a scale from 1 to 5, where 1 is "not at all satisfied" and 5 is "very satisfied" (see Satisfaction for additional information). Dissatisfied respondents cited a complicated, lengthy application process, customer service issues, long waits for the rebate, and rebate amounts that were too low to be worth the hassle.
- HES respondents (34%) were over twice as likely as HES-IE respondents (14%) to say they recalled technicians discussing **financing options** with them.
- Vendors suggested that the program improve processing times, scale up marketing efforts, and increase the number of measures eligible for 0% financing to help customers take advantage of financing options.

B.5.2 Rebates for Additional Measures

Two-thirds of HES respondents (65%) recalled technicians discussing rebated measures with them during the kitchen table wrap-up, compared to fewer than one-quarter (22%) of HES-IE respondents (Figure 67). HES participants are responsible for applying for rebates, while technicians submit eligibility paperwork for add-on measures on behalf of HES-IE participants. Despite the difference in program requirements, HES-IE participants may benefit from more thorough explanations about eligible measures and next steps following the assessment.

Figure 67: Recall of Technicians Discussing Rebated or Add-on Measures

(Source: Participant survey)

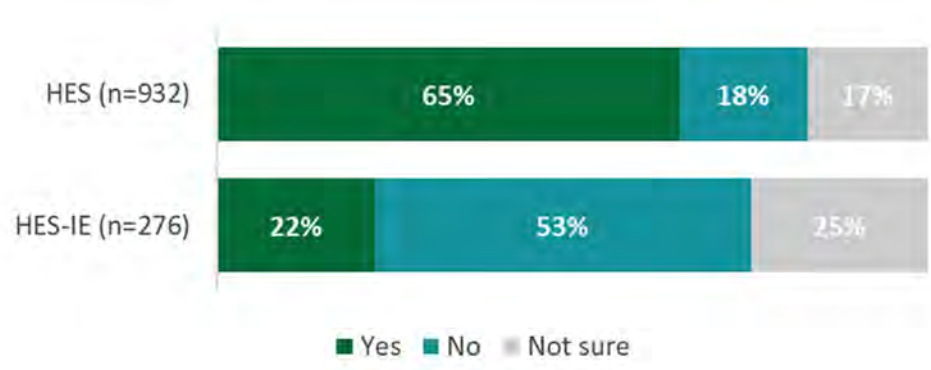


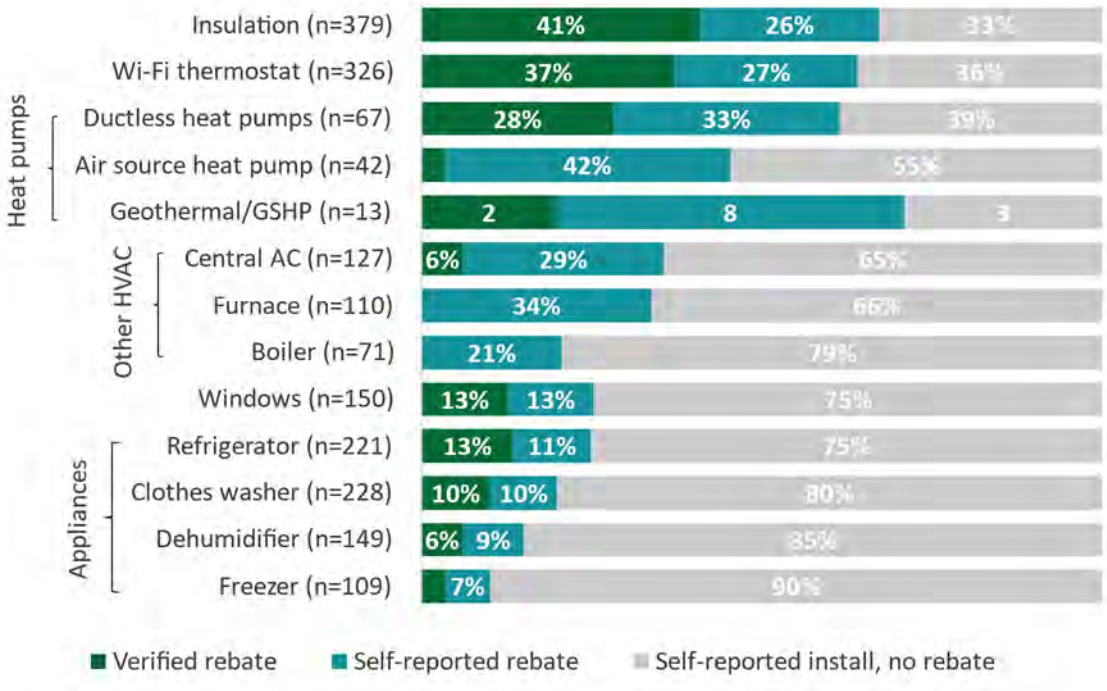
Figure 68 shows the percentage of eligible measures installed after the assessment for which the respondent applied for a rebate. Complete program data was not available for all measures. If a rebated measure was matched with a respondent, the survey asked the respondent to verify they had received the measure and applied for a rebate (*Verified rebate*).[147] All respondents were given the opportunity to self-report the installation of additional measures and whether they had applied for a rebate (*Self-reported rebate*) or not (*Self-reported install, no rebate).* As the study is unable to verify the efficiency of these self-reported measures, the study could be capturing routine replacement of equipment that failed.

More than half of HES respondents applied for rebates for insulation and Wi-Fi thermostats. Most respondents who reported installing heat pumps applied for rebates; the initial purchase price of heat pumps is higher compared to other HVAC equipment (furnaces, boilers, and central AC) with a lower rate of rebate applications. Appliances had the lowest proportion of rebates per installed measure; appliance rebates are $25 to $50 per unit. These rebates are similar to those offered for appliances in MA ($30 to $50)[148] and Rhode Island ($40 to $50).[149]

[147] All *Verified rebate* respondents received a rebate, according to the program tracking data; respondents recalled applying for the rebates 83% to 100% of the time, depending on the measure.
[148] https://www.masssave.com/residential/rebates-and-incentives
[149] https://www.rienergy.com/RI-Home/Energy-Saving-Programs/rebate-programs

Figure 68: Rebate Applications for Eligible Rebated Measures, HES

(Source: Participant survey and program tracking data)



Survey questions asked respondents who self-reported installing a rebated measure that did not receive a rebate why they had not applied for one. However, the data available could not support classifying these self-reported measures as eligible, so the study excluded these results from the findings to preserve reliability.

B.5.2.1 HES-IE Participants

Survey questions asked HES-IE participants the same questions about awareness and application for the rebates and incentives available for add-on measures. However, responses may be artificially depressed due to differences in program design. According to the field implementation manual, the vendor is responsible for submitting a proposal to the Companies on the customer's behalf for certain qualifying measures, such as windows. Many HES-IE customers may not have been as involved in the rebate application process as HES customers.

As shown in Figure 69, nearly one-fourth of HES-IE respondents (22%) recalled technicians discussing rebates with them, compared to one-half who could not recall that discussion (53%), and one-fourth who were not sure (25%).

Figure 69: Discussion with Technician about Rebates, HES-IE
(Source: participant survey; n=276)

B.5.2.2 Rebate Application Process

HES respondents rated their satisfaction with the rebate application process a 4.2, on average (see Satisfaction section). Respondents who rated the application process a 1 or 2 (n=40) were asked why:[150]

- One-third of respondents (33%) said the application process was confusing or too complicated.
- Nearly one-quarter of respondents (23%) said the process took too long.
- One-fifth of respondents (20%) said their application for the rebate was rejected and 13% of respondents never received the rebate.
- Two respondents who self-installed their measures had difficulty satisfying the documentation requirements.
- Three respondents (8%) had to make multiple follow-up calls regarding their application.
- Another 8% of respondents experienced difficulty reaching customer service to resolve their issue.
- Three respondents requested an online application.
- One respondent requested additional information about which measures qualified for the rebate.
- One respondent said that the process was so difficult that they would not do it again.

HES-IE respondents rated their satisfaction with the rebate application process a 4.3, on average (see Satisfaction section). One respondent who rated their satisfaction a 2 explained that it required lots of follow-up calls to complete their application.

B.5.2.3 Rebate Amount

HES participants who applied for rebates rated their satisfaction with the amount of the rebate a 3.9, on average (see Satisfaction section). Respondents who rated their satisfaction a 1 or 2 (n=35) were asked why:[151]

[150] Excludes respondents who said, “not applicable,” “I’m not sure,” or that they were not aware of the rebates.
[151] Excludes 20 respondents who said, “not applicable”, “I’m not sure,” or indicated that they did not receive the rebate due to an ineligible measure, rejected application, or an expired application.

- Over one-half of the respondents (57%) said the rebate amount was too low. In particular, one respondent noted that the rebate was not high enough to encourage replacing their equipment while it was still working.
- One-fifth of the respondents said the rebates were too complicated (9%) or not worth the hassle (11%).
- Other respondents felt that the actual rebates received did not match their expectations (6%) or requested that additional models be considered for eligibility (3%).
- One respondent was disappointed that they installed their insulation prior to 2020 and did not receive their insulation for free.[152]

HES-IE participants who applied for rebates rated their satisfaction with the amount of the rebate a 4.4, on average (see Satisfaction section). This was the most highly rated program element among HES-IE respondents; one plausible explanation might be that rebates are more generous for HES-IE participants than HES participants. The one respondent who rated their satisfaction with the amount of the rebate a 2 indicated that the rebate process was too complicated.

The 13 vendors who weighed in on rebate effectiveness believed they influenced customer decisions for most add-on measures. For insulation, five respondents said rebates were very or somewhat effective, noting that the decrease from $2.20 to $1.70 per square foot in 2021 made them less effective. Three respondents commented on the demand and cost for insulation increasing just as the rebates decreased. One respondent noted:

> *"Insulation rebates during the past year [2020 – 2021] were great [and] generated a lot of business for us. When the rebates are good, everyone is happy. We are making a lot of money, the customers are getting a lot [of benefits], and the utilities are getting their savings. They just dropped the insulation rebate, which is unfortunate. All materials have gone up in price. The customers don't have the same buying power right now, and neither do the businesses, so the insulation rebate should go back up, or at least not have dropped quite as much*."

Two respondents considered the HVAC rebates to be effective and one respondent thought the appliance rebates were effective. Three respondents did not believe the window rebates were high enough to influence customer decisions. One respondent stressed the importance of tying rebates to audits:

> *"Insulation is the only one that has a big enough incentive to make a difference. They have all these instant rebates for light bulbs, instant rebates for heating systems, just straight rebates. You don't have to even get an audit. But your potential energy savings by putting in a high efficiency furnace is not going to be there if you don't test the system and find and fix the leaky ductwork. You should never have an incentive on energy efficiency that isn't driven [by] the audit."*

[152] The bonus rebate offered for insulation was $2.20 per square foot, meaning that many people received rebates for the entire project.

Three vendors commented on the HES Bonus Rebate, which customers may qualify for when installing insulation.[153] All three vendors thought it was very effective in getting customers to install additional measures. One respondent said they offered copay refunds for customers who adopted certain measures, and one respondent believed the program did not allow this.

B.5.2.4 Rebate Delivery Time

HES participants who applied for rebates rated their satisfaction with the time it took to receive their incentive a 4.1, on average (see Satisfaction section). Respondents who rated their satisfaction a 1 or 2 (n=29) were asked why:[154]

- More than half of respondents (55%) said it took too long to receive their rebate; several respondents indicated it took more than six months.
- Nearly one-third of respondents said it took multiple follow-up calls (24%) or an appeal of a denied application (7%) to ultimately receive the rebate.
- Nearly four in ten respondents said they had not received their rebate (28%) or their application was rejected (10%).

HES-IE participants who applied for rebates rated their satisfaction with the time it took to receive their incentive a 4.2, on average (see Satisfaction section). The two respondents who rated their satisfaction a 1 said it took a long time to receive the rebates, with one respondent reporting that it was time intensive to follow up on their application.

B.5.3 Financing

The survey asked participants whether they recalled technicians discussing financing options, including zero-interest loans, on-bill repayments, or Connecticut Green Bank resources.[155] Follow-up questions asked whether respondents had found the information on financing options helpful and if they had applied for any of them when installing their rebated measure, if applicable.

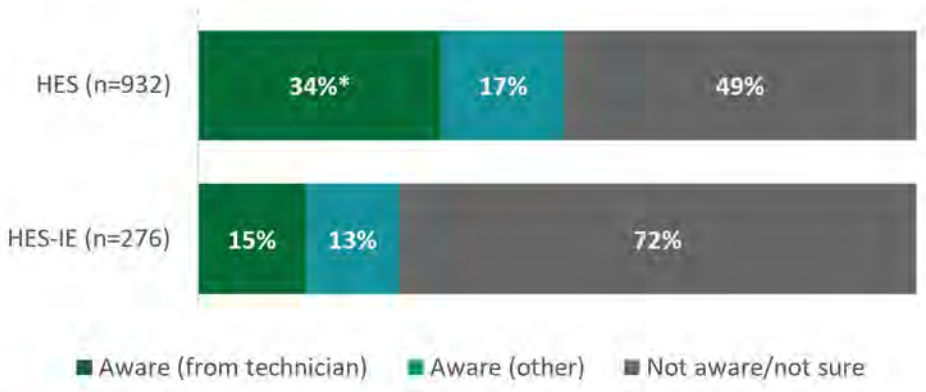
B.5.3.1 Awareness of Financing Options

About one-half of HES respondents (51%) and one-quarter of HES-IE respondents (28%) said they were aware of financing options, such as zero-interest loans, on-bill repayments, or Connecticut Green Bank resources (Figure 70). HES respondents were more than twice as likely (34%) as HES-IE respondents (15%) to have heard about the financing options from their technician.

[153] "2019 - 2021 Conservation & Load Management Plan", Connecticut Department of Energy & Environmental Protection, last modified November 19, 2018; accessed October 2022, https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Final20192021CLMPlan111918pdf.pdf.
[154] Excludes respondents who said, "not applicable" or "I'm not sure." Counts sum to greater than 29 because multiple responses were allowed.
[155] Energize CT. "Residential Financing Options." https://energizect.com/financing/residential-options. Accessed May 2023.

Figure 70: Awareness of Financing Options

(Source: Participant survey)



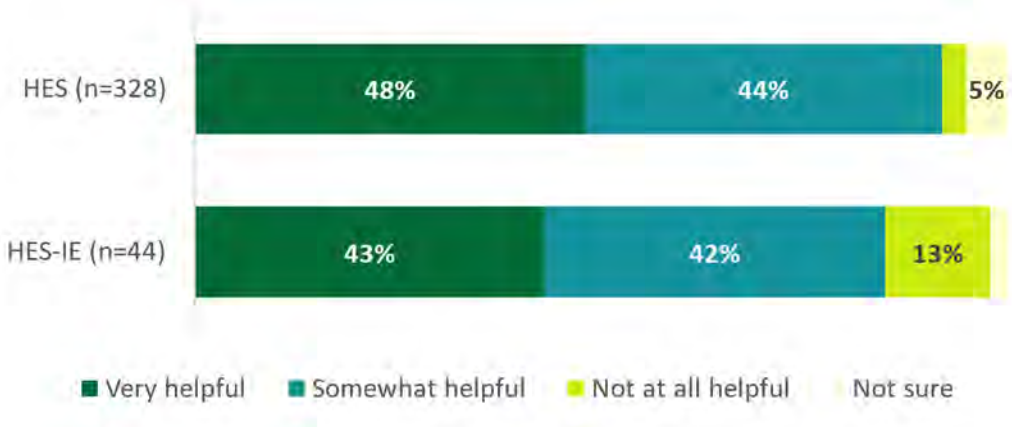
*Significantly different at the 90% confidence level.

While some financing options were designed to be more accessible, including on-bill financing options that do not require a credit check, these options may still be out of reach for HES-IE participants on measures that are not fully covered by the program.

Among respondents who recalled discussing financing options with the technician, most HES and HES-IE respondents found the discussion either "very helpful" or "somewhat helpful" (Figure 71).

Figure 71: Helpfulness of Discussion of Financing Options

(Source: Participant survey)



When discussing financing options, nearly all of the vendors said they always informed customers about financing options, while one vendor one said they did "sometimes."[156] Vendors suggested increasing the number of measures eligible for 0% financing and encouraged the Companies to improve advertising of the financing options to help customers take advantage of financing options.

[156] Twelve vendors responded to questions about financing options.

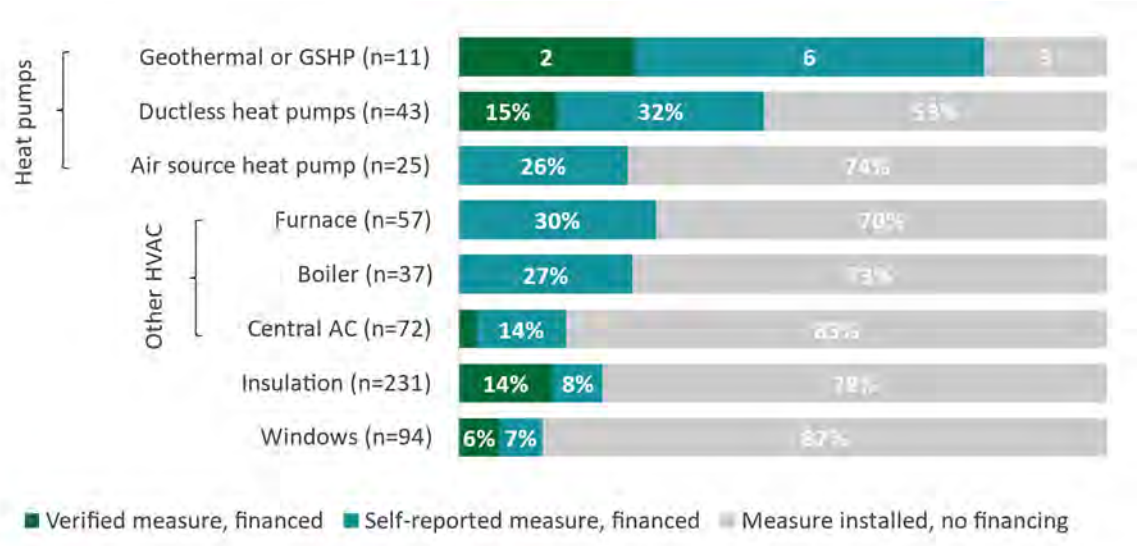
Program staff noted that fewer participants needed financing when incentives were increased for certain measures, such as insulation.

B.5.3.2 Application for Financing

HES respondents reported applying for financing most often for heat pumps (Figure 72). Fewer than one-third of respondents reported applying for financing for furnaces and boilers.[157]

Figure 72: Application for Financing, HES

(Source: Participant survey; Base: Respondents who installed an eligible measure and are aware of financing options)

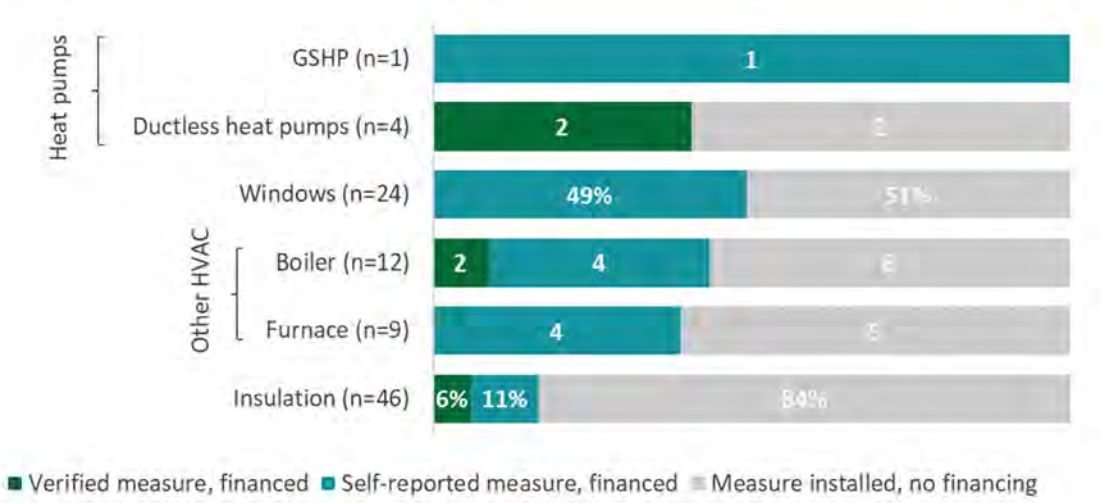


As shown in Figure 73, fewer HES-IE respondents reported applying for financing for their add-on measures. As incentives for HES-IE add-on measures are more generous than those for HES rebated measures, some respondents may not have required financing to receive the measure.

[157] As these measures rely primarily on self-reported data, it is likely some of the furnaces and boilers would not meet energy-efficiency requirements to be eligible for financing.

Figure 73: Application for Financing, HES-IE

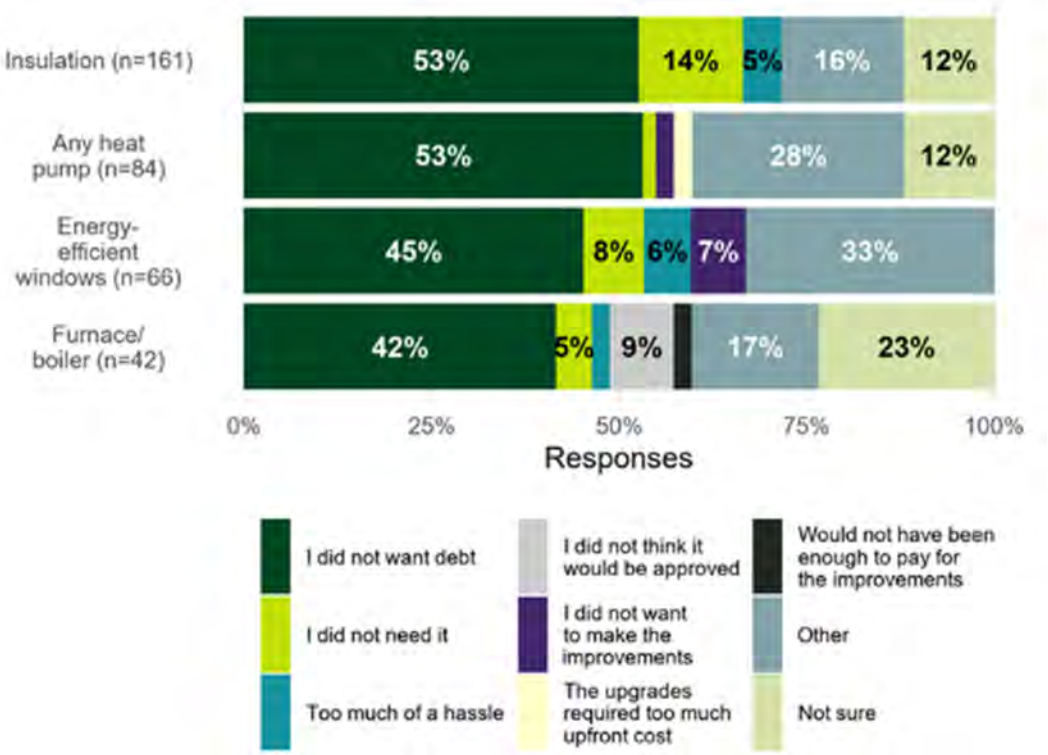
(Source: Participant survey; Base: Respondents who installed an eligible measure and are aware of financing options)



The most common reason HES respondents gave for not applying for financing for their eligible rebated measures was a desire to avoid debt (Figure 74).

Figure 74: Reasons for Not Applying for Financing, HES

(Source: Participant survey, Base: Respondents that installed rebated measures aware of financing who did not apply)



B.5.3.3 Financing Application and Approval

HES respondents rated their satisfaction with the application process to receive financing a 4.1, on average (see Satisfaction). Respondents who rated their satisfaction a 1 or 2 (n=3) elaborated on their rating.[158] One respondent said the process was difficult and the loan ultimately did not cover the entire cost of their upgrade. Another respondent said their application was denied, while a third respondent said it took months to hear back about their application, which caused a significant delay in their heat pump application.

HES-IE participants who received financing rated their satisfaction with the application process a 4.3, on average (see Satisfaction). One respondent who rated their satisfaction a 2 explained that the application process took months and frequent communication to receive the financing.

While one-third of vendors thought the current financing options were adequate for encouraging participants to take advantage of financing options, other respondents noted issues, including customer loan applications being rejected. One of the vendors observed that these issues are one of the reasons they believe moderate-income customers are underserved by the program (see Underserved Customers). Vendors also expressed concern about changes to the approval times for program loans, with one reporting approval times going from 48 to 72 hours to one to two months.

B.6 DOE Home Energy Scores

The Home Energy Score is a rating system of 1 to 10 that the Department of Energy uses to estimate a home's energy use.[159] Technicians are instructed to offer a home energy score for single-family homes or townhouses/rowhomes where they were able to conduct a blower-door test. Customers are required to opt-in and authorize the score to be posted on the Multiple Listing Services (MLS), which provides energy efficiency information about a home on real estate listings.

Survey questions asked respondents if they recalled hearing about the Department of Energy's (DOE) Home Energy Score from the technician visiting their home. The survey then asked whether they had decided to receive the DOE Home Energy Score and how useful it was. Vendors also provided their opinions on the DOE Home Energy Score and described their experiences implementing it in the field and describing the results to their customers.

B.6.1 Key Findings

- Fewer than one-fifth of HES respondents chose to receive the DOE Home Energy Score.
- Vendors generally expressed negative reactions about the Home Energy Score. Several felt that it had limited usefulness to customers, many of whom were wary about making the score part of the Multiple Listing Service (MLS). Moreover, vendors expressed concern that the requirement was an additional burden on technician's time at the customer's home.

[158] Excludes three participants who gave non-applicable responses or said, "I'm not sure."
[159] A rating system of 1 to 10 that the Department of Energy (DOE) uses to estimate a home's energy use; 1 is "higher energy use" and 10 is "lower energy use." www.homeenergyscore.gov. Accessed August 2022.

Fewer than one-third of HES respondents (29%) recalled hearing about the DOE Home Energy Score from their technician.[160] Of the 18% of respondents (n=902) that said they had chosen to receive the score and the accompanying report, nearly all of them reported that they found the score either "very useful" or "somewhat useful" in understanding their home's energy use (Figure 75).

Figure 75: Usefulness of the DOE Home Energy Score, HES
(Source: participant survey; n=164)

Only one vendor provided positive feedback on the DOE Home Energy Score, noting that it was a useful tool for communicating additional savings opportunities to customers.

Of the 29 respondents (11%) who had refused the score, all but one said it was because they had not wanted the score shared with the Multiple Listing Services (MLS). Vendors noted this was the primary reason their customers were hesitant to receive the Home Energy Score.

Vendors also mentioned the following reasons for being dissatisfied with the Home Energy Score requirement:

- Three vendors were also not comfortable with the program requiring vendors to calculate Home Energy Scores for at least 40% of their projects. One vendor mentioned that the requirement meant that vendors could simply pick the homes that were the easiest to score, such as those that had fewer windows.
- Two vendors did not think the score was accurate since it is based on a national scale rather than buildings in Connecticut.
- One vendor noted that calculating a DOE Home Energy Score adds enough time to an assessment that it sometimes meant a technician could only assess one home per day rather than two.

Survey questions also asked HES-IE respondents about their awareness of the DOE Home Energy Score. However, for most of the period covered by this evaluation, the score was not offered to HES-IE participants; only 7% of HES-IE respondents recalled hearing about the score from their technician.[161]

[160] Only participants in single-family detached and attached homes are eligible to receive the DOE Home Energy Score.
[161] The 2019 Field Implementation Manual (Version 7.0, April 5, 2019) specifies that the DOE Home Energy Score is available to HES participants (p.80).

B.7 Training and Workforce Development

Vendors provided feedback on the trainings the program offered, technician requirements, as well as the program's impact on their companies' workforces. Vendors also commented on the effect of the 2017 – 2018 Conservation and Load Management (C&LM) funds diversion on their businesses, referring to the period when the state legislature diverted funds from the state energy efficiency fund, which affected the HES program by increasing the amount of co-pay for certain customers).

Program stakeholder interviewees also weighed in on training and workforce development.

B.7.1 Key Findings

- Vendors expressed concern about maintaining a fully staffed workforce while balancing program training requirements with keeping up with home energy assessments. Vendors requested additional assistance from the program in training new technicians; however, program stakeholders noted that there are barriers to spending federal funding on workers not employed by a participating agency.
- The HES/HES-IE program is a critical revenue source for program vendors. Several vendors noted that the CL&M funds diversion in 2017 and 2018 led to cutbacks, which resulted in staffing shortages when the funding was restored.
- Ten of the 13 vendors interviewed did not believe the state is on track to meet its goal of weatherizing 80% of all residential units by 2030 without significant changes in funding and incentives. Vendors and community stakeholders noted a myriad of challenges, including the age of housing stock, weatherization barriers, workforce shortages, and competing concerns for the customer's limited resources.

B.7.2 Training

Vendors reported facing several challenges regarding training. Four respondents noted it was difficult and expensive to pull people from the field for trainings held during working hours. As one vendor explained:

> *"[Program] trainings are useful, but the problem is pulling people out of the field to do trainings. We don't have enough workers as it is; from a financial standpoint, I can't afford to pull my crews off the road to send them to training. If the program could compensate us, maybe. But the average billing for these jobs is $1,000 or more. I'd rather do the job than do training. The crews get their hourly pay. There are incentives offered to them based off productivity on each house. They are [already] working 40-50 hours a week; they want to go home to their families afterward."*

Three vendors felt that the need for technicians to be certified by the Building Performance Institute (BPI) repeatedly placed a burden on their companies. One vendor noted:

> *"With COVID right now, I've got some guys coming on-board and they all had to get recertified because during the lockdown they lost their certification. We should have the*

ability to do in-house training for that instead of requiring everybody to recertify every [year or two]. If [the program] assisted with the funding, that would help."

According to program staff, federal funds can only be spent on employees of participating agencies, making it difficult to pay for training before technicians are hired by program vendors.

Three vendors also felt the number of hours staff needed to put in to be certified as lead technicians placed an undue burden on them. One noted:

"The qualifications to become a lead tech include required hours for the utilities, which are a little strict. The need for certification is fine; it's just that the hours can be a barrier."

The program requirements for lead technician, as of 2019, include maintenance of four credentials (BPI—Building Analyst, BPI—Envelope Professional, US DOE Home Energy Score Assessor, and EPA Lead certifications) and up to 4,000 hours of industry-specific experience.[162]

Another vendor noted that auditors could use more sales training:

"[A technician's] job is to be able to show the people what they need to do to become more energy-efficient, more durable and have a safer home. [A successful technician has] got to be able to sell [the customer on installing additional measures], not just know the technical aspect."

B.7.3 Workforce Development

Twelve vendors who weighed in on the subject believed a workforce development program would increase the pool of qualified lead technicians. Several vendors explicitly brought up their challenges with shortages of qualified personnel. According to a program stakeholder, vendors face competing incentives to grow their workforce to meet customer demand while maintaining adequate quality control.

When discussing the program's impact on their own companies' staffing, six vendors noted that all or most of their company's staff were involved with the program and they would likely lose their jobs if the HES program ceased to exist. Two vendors said they would have trouble finding additional staff if the program scaled up, though two believed they could handle increased demand.

One program stakeholder described workforce development as a major barrier to the HES/HES-IE program achieving its goals due to a lack of qualified auditors.

B.7.4 Conservation and Load Management (C&LM) Funds Diversion

Two program stakeholders described the C&LM funds diversion in 2017 and 2018 funds diversion as having a large impact, with vendors going out of business or laying off technicians in substantial numbers due to the resulting lack of projects. One stakeholder noted spillover effects with the

[162] Energize CT, Eversource Energy, and Avangrid. April 5, 2019. "Home Energy Solutions Program and HES-Income Eligible Program 2019 Field Implementation Manual, Version 7.0."

state's WAP program too, where fewer cost-sharing opportunities with HES-IE caused some WAP projects to scale back in scope.

Six vendors reported that the funds diversion had led to significant cuts to their operations and one vendor reported moderate cuts. Five vendors noted that they had had to lay off some staff; three of these vendors said that it had been hard to hire staff back after the program returned to full funding levels. One noted:

> *"[The C&LM funds diversion] had a large effect. We had to really scramble to find other things to do and had to lay people off. This is part of the reason that we're having a workforce problem now, people never came back from that."*

B.7.5 Progress Toward Statewide Weatherization Goal

Most vendors (10 of 13) did not believe the state would meet its goal of weatherizing 80% of all residential units by 2030 without significant funding and market changes.

Three of the vendors considered the goal an underfunded mandate and called for higher incentives for weatherization and easier customer access to the necessary services. One respondent said:

> *"They must first define weatherization. Then, delegate a specific budget for this - the CL&M funds alone can't pay for this work. No one has ever quantified the costs of weatherization. A 'goal' is not a mandate, so the 80% by 2030 weatherization goal exists with no arsenal, nothing to back it up. There are no laws, statutes, or DEEP mandates with a strategy/plan to bring this goal to fruition."*

Three vendors stressed the need for more qualified personnel to meet the goal:

> *"Definitely [the program needs] more training, more qualified lead technicians, and the payment structure [wages] should keep up with the times. I think that's where the utility should put their money and not in just one specific region. Let's say you want to hire people in Bridgeport – have a training there because people from Hartford are not going to drive to Bridgeport to get a job."*

Two vendors also felt the weatherization goal would be hard to reach because the housing stock in Connecticut was old and had a lower energy savings potential.

Two community stakeholders pointed to a lack of clarity in the definition of what qualifies as weatherized. A third community stakeholder indicated that the funding for weatherization was insufficient relative to the magnitude of the state's goal.

One member of a town energy commission described the difficulty in determining whether a home was weatherized based on its participation in HES:

> *"Just having a HES visit doesn't mean that a house is weatherized. So, if the powers that be are looking at the number of homes that have had HES visits, that's not a gauge of whether that house has been weatherized."*

Another interviewee who worked for an organization that develops affordable housing and conducts homeowner education weighed in on the statewide weatherization goal:

> *"I know DEEP has gotten pushback on the 80% weatherization goal due to lack of clarity around defining it. They help as a starting point, but for example, the option to install five of ten equipment types listed doesn't mean you have a good thermal envelope. We need tiers (e.g., a baseline and something beyond it). What is air sealing without insulation?"*

B.8 DEMOGRAPHICS AND FIRMOGRAPHICS

Survey questions asked respondents a variety of questions about demographic and economic factors, including number of household occupants, education, income level, ethnicity, and race.

B.8.1 Key Findings

- Respondents used open-end responses in the survey to explain that they could not recall certain questions due to the length of time that had passed since their assessment. For the over one-third (37%) of survey respondents who received an assessment in 2018 or earlier, at least three years passed between the date of their assessment and the survey.
- Survey respondents had higher educational attainment than households in the general population, suggesting that the program may be underserving customers who are low- or moderate-income.
- Compared to the census (30%), fewer survey respondents lived in a household with someone aged 65 years or older (23%), suggesting that elderly customers are underserved by the program.
- The racial and ethnic composition of survey respondents is similar to census estimates, suggesting that the program is equitable by that metric.

B.8.2 Participant Demographics

B.8.2.1 Participation Year

The survey was sent to a higher percentage of participants who participated more recently (2019 – 2020) than earlier in the study period (2017 – 2018) to increase likelihood of program recall (Table 48).

Table 48: Program Participation by C&LM Plan

Program	C&LM Plan Years	Respondents (Unweighted %)
HES	2016-2018	31%
HES	2019-2020	69%
HES-IE	2016-2018	49%
HES-IE	2019-2020	51%
Total	2016-2018	37%
Total	2019-2020	63%

B.8.2.2 Age and Occupancy

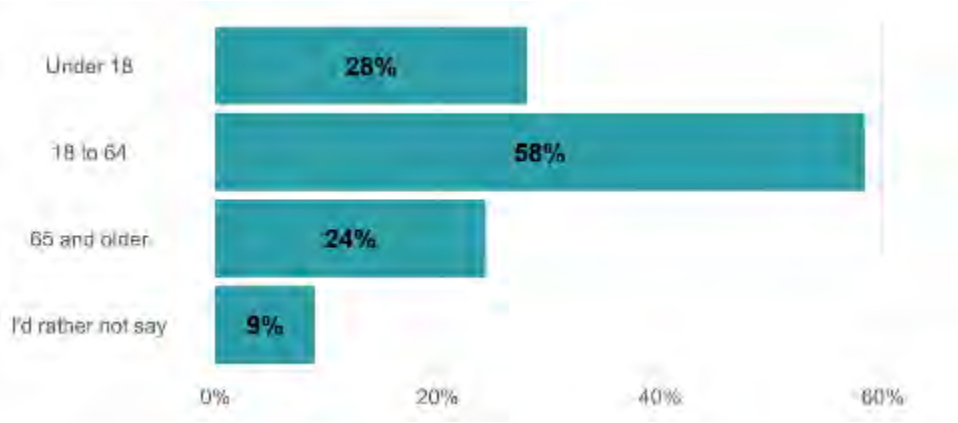
As shown in Table 49, average household size of respondents was 2.4 (HES-IE) to 2.6 (HES).

Table 49: Size of Household

Program	n	Number of Occupants (Median)	Number of Occupants (Mean)
HES	932	2	2.6
HES-IE	276	2	2.4

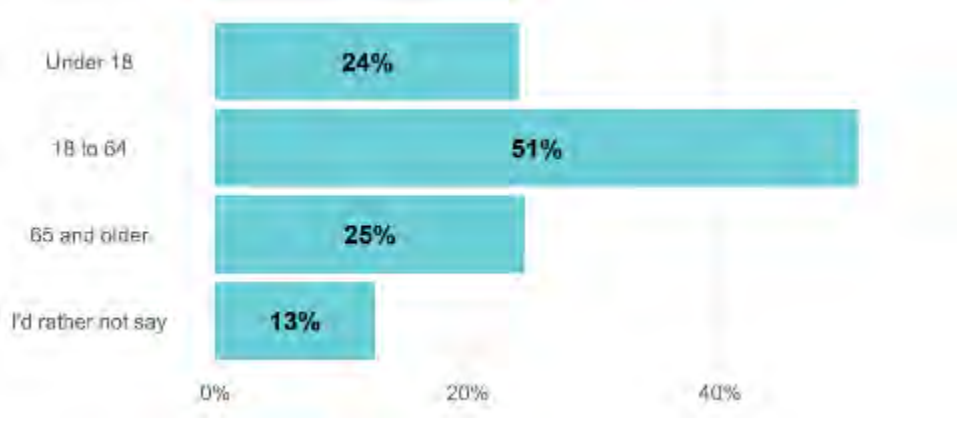
Over one-half of HES households surveyed (Figure 76) had occupants aged between 18 and 64 (58%), compared to one-fourth each with children (28%) and/or seniors (24%).

Figure 76: Household Occupants, HES
(source: participant survey; n=932;
multiple responses allowed)



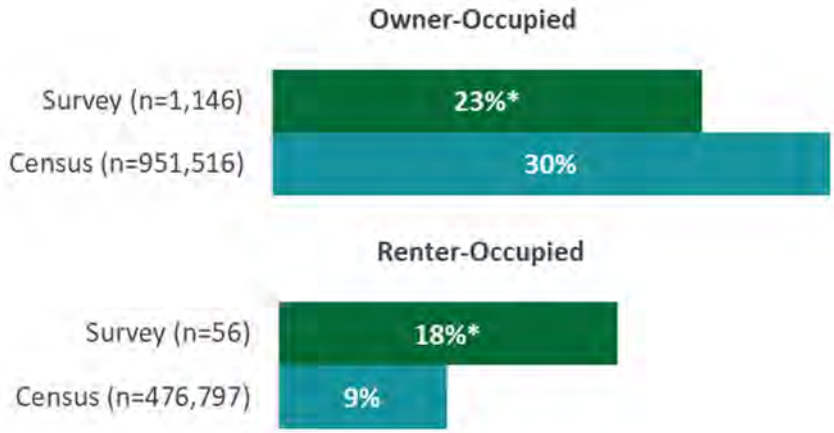
Over one-half of HES-IE households surveyed (Figure 77) had occupants aged between 18 and 64 (51%), compared to one-fourth each with seniors (24%) and/or children (25%).

Figure 77: Household Occupants, HES-IE
(source: participant survey; n=276;
multiple responses allowed)



Less than one-quarter of HES and HES-IE survey respondents (23%) who owned their home lived in a household with someone aged 65 or older, statistically significantly fewer than the number of households in the census (30%) (Figure 78).

Figure 78: Households with Occupants Aged 65+ Compared to the Census



*Significantly different from the census at the 90% confidence level.

B.8.2.3 Race and Ethnicity

Survey respondents reflect the racial composition of single-family households in Connecticut (Figure 79).

Figure 79: Race of Survey Respondents Compared to Census

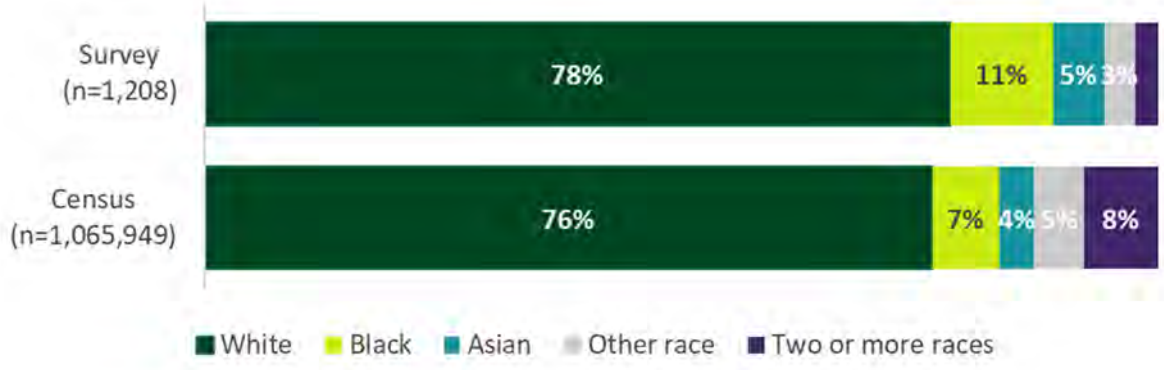


Table 50 shows the race of participants by program type.

Table 50: Race of Participants

(Source: Participant survey)

Race	HES (n=932)	HES-IE (n=276)
White	77%	43%
Black or African American	3%	22%
Asian	5%	4%
Native Hawaiian or Pacific Islander	0%	1%
American Indian or Alaskan Native	0%	<1%
Two or more races	2%	3%
Other	<1%	6%
I'd rather not say	13%	21%

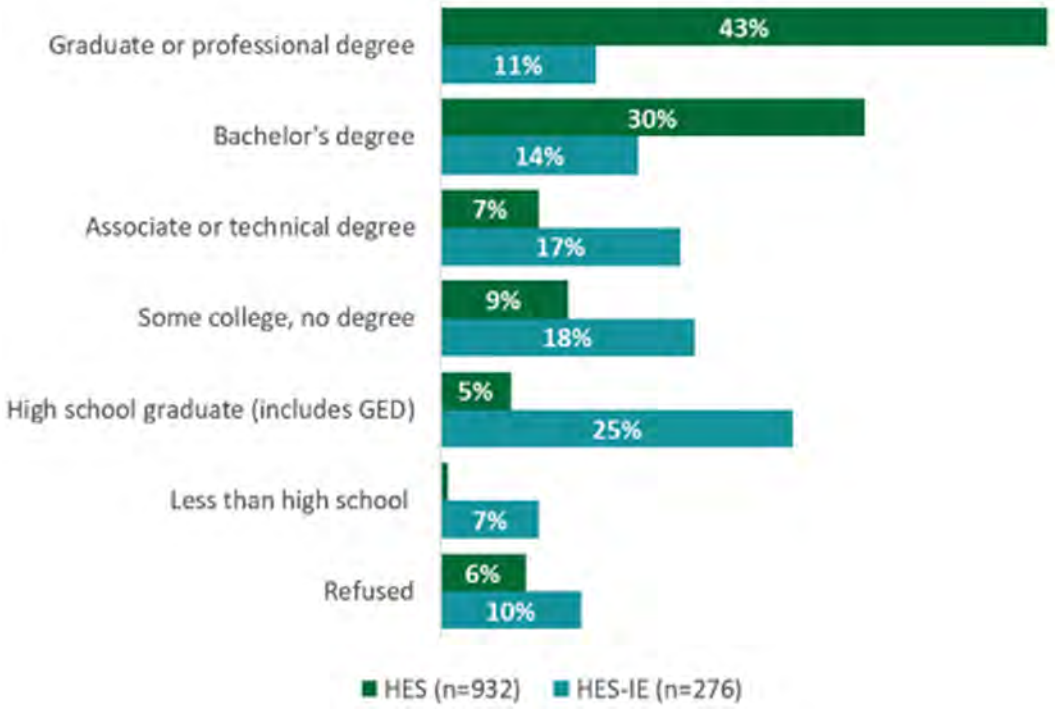
Overall, 12% of HES and HES-IE survey respondents reported that they identified as Hispanic or Latino, the same proportion as in the census (12%). Five percent of HES respondents and 22% of HES-IE respondents identified as Hispanic or Latino.

B.8.2.4 Education

Figure 80 shows the educational attainment of survey respondents by program type. Nearly three-quarters of HES participants have a bachelor's degree (30%) or graduate or professional degree (43%).

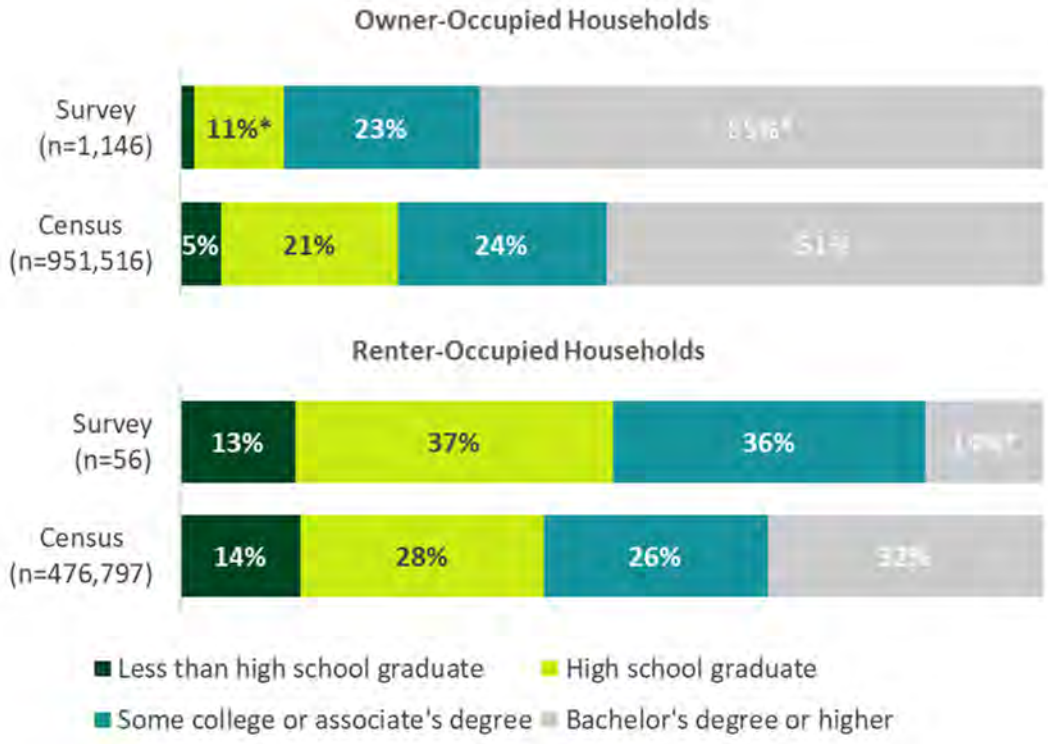
Figure 80: Educational Attainment of Participants

(Source: Participant survey)



Among owner-occupied households, participants with bachelor's degrees or higher are likely overrepresented compared to the general population in Connecticut (Figure 81). The renter-occupied households are shown for illustrative purposes only, as the study only surveyed single-family participants, and many renters likely live in multifamily buildings.

Figure 81: Educational Attainment of Survey Respondents Compared to Census



*Significantly different from the census at the 90% confidence level.

B.8.2.5 Income

Two-thirds of HES respondents (67%) reported incomes above 80% of Connecticut's AMI, compared to over one-tenth (13%) who reported income below this level (Figure 82).[163]

Figure 82: Income Levels, HES
(source: participant survey; n=831)

[163] Six percent of HES-IE respondents reported an income of above 80% AMI (not shown). While this income level would disqualify them for HES-IE eligibility (60% of state median income), their income may have increased between the assessment and taking the survey.

B.8.3 Vendor Firmographics

The vendor in-depth interviews gathered some information about the 17 respondents' companies, the services provided, and their perception of the program's goals.

B.8.3.1 Background

Fourteen of the 17 vendors interviewed had conducted more assessments on HES homes than HES-IE homes in the previous three years; six of these interviewees indicated their companies had only completed HES projects. One vendor's work was split in half; two vendors had had more HES-IE work, with one doing only HES-IE projects.

Among the vendors interviewed, multifamily projects made up a small portion of program work. For HES, one vendor estimated multifamily projects had made up one-half of their HES work, but thirteen vendors estimated multifamily projects had made up less than one-third of their HES work. Similarly, for HES-IE, one vendor estimated multifamily projects had made up one-half of their HES-IE work, but nine estimated they had made up one-third or less of their HES-IE work.

Three vendors reported that *all* their company's residential work comes through the program, and six said *most* of their company's residential work comes through the program. When asked how long they had personally been involved with the HES/HES-IE program, most of the interviewees indicated they had considerable experience with the program. Nine interviewees had worked with the program for more than ten years, with two interviewees having been involved in some capacity since the program's inception. Five interviewees had been involved with the program for more than three but less than ten years, while one had started a few months before the interview.

All 17 interviewees clarified their various responsibilities with respect to the program. Nine were owners of the company, six had administrative responsibilities, three were in the field for at least part of their job, and one had recently transitioned from a role in the field to an office role.

Seven noted that they managed all aspects of their company's participation. More specific activities interviewees noted they were responsible for included quality control and supervision of field crews, customer recruitment, communications with the utilities, use of the tracking system, fieldwork, invoicing, scheduling, ordering materials, and keeping up with program changes.

B.8.3.2 Additional Services Provided

Insulation and window insulation were the two most common energy-efficiency measures provided by program vendors in addition to performing home energy assessments through the program (Table 51).

Table 51: Additional Services Provided by Program Vendor's Companies

(Source: Vendor interviews)

Additional Service	Number of Vendors
Insulation	6
Windows	4
Renovations and Additions	3
HVAC	2
Fuel Delivery	2
Plumbing	2
Roofing	2
Solar	1

Appendix C Additional Net-to-Gross and Installation Rate Findings

This section presents further in-depth NTG findings from the HES and HES-IE participant survey.

C.1 FREE-RIDERSHIP

This section details additional findings for the first major input into the NTG ratio, free-ridership (FR). The participant survey asked 932 HES participants about measures they had installed through the program. The NMR team obtained usable responses from 925 HES participants, representing 9,721 MMBTU/year in gross savings across 17 different measure types.[164] Each respondent answered free-ridership questions about up to two measures.[165]

C.1.1 Influence and Intent Scores

To estimate the HES FR rate, the study used the average of the influence and intent scores. Intent scores comprise timing, quantity, and efficiency scores.

C.1.1.1 Influence

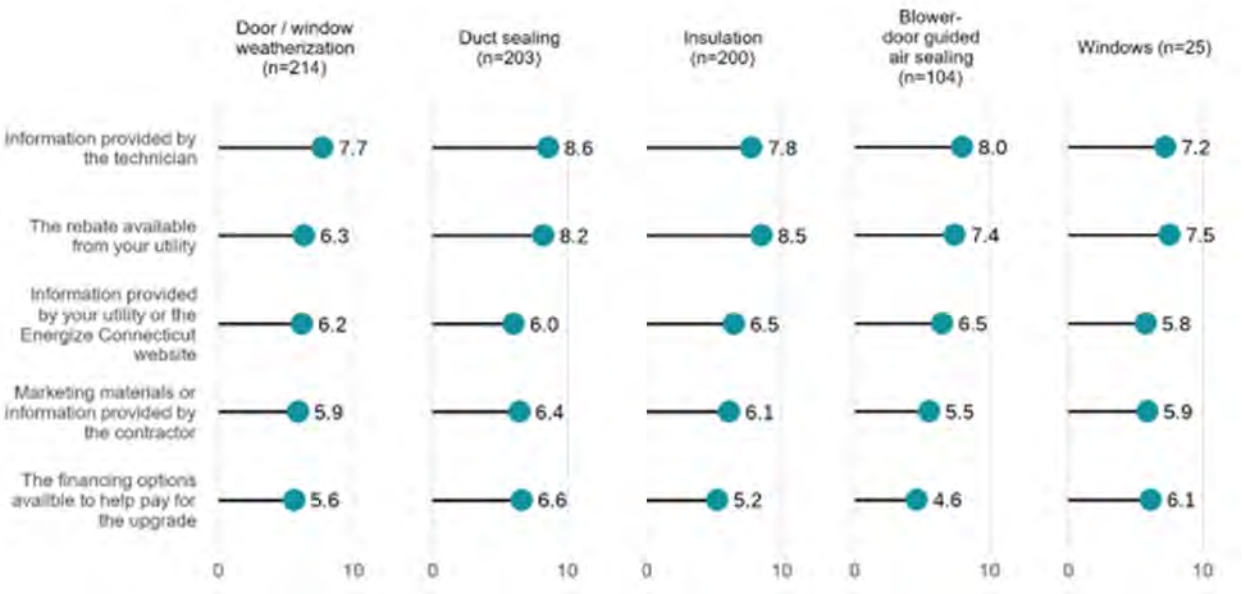
For each measure, the FR algorithm used the maximum influence score from all program elements each respondent rated. Where applicable, the survey instrument omitted program elements not relevant to the respondent's self-reported experience with the program. For example, the instrument only asked about the influence of a rebate and/or financing if a respondent self-reported applying for them. The algorithm then inverted the 0 to 10 scale and converted it to a 0 to 1 scale.

- **Building Envelope.** Information provided by the technician and the availability of a rebate were the most influential program elements for respondents who installed building envelope measures. Marketing materials and financing options were the least influential.

[164] The seven removed respondents either displayed inconsistency across survey verification questions or did not pass quality control checks after the survey's completion.

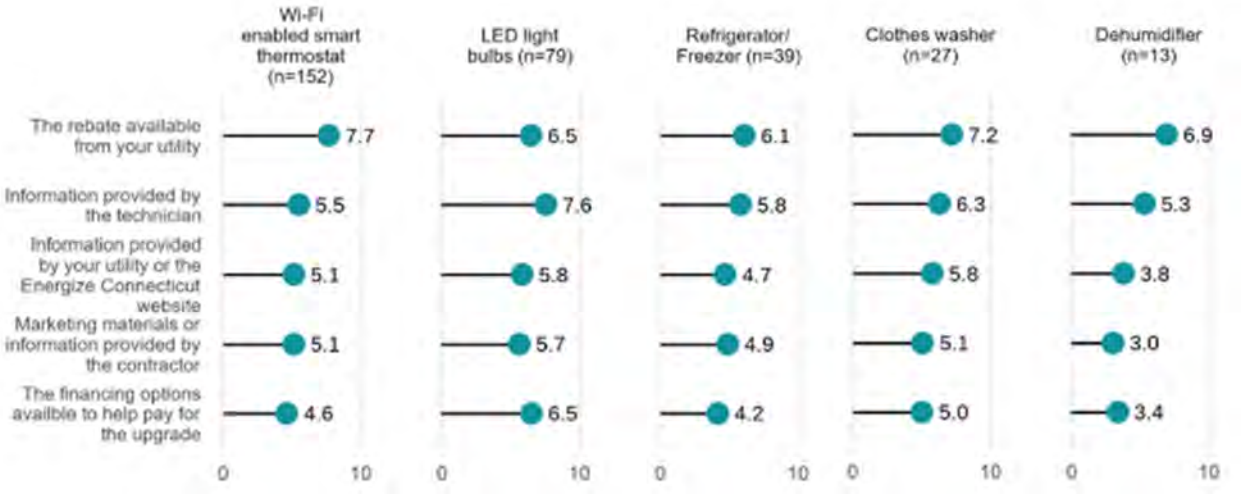
[165] The sampling defaulted to asking respondents about add-on measures wherever possible to maximize response rates for high savings, low-incidence measures. A respondent only received free-ridership questions about measures in the tracking database that respondents verified receiving and that were installed. The savings come from the program database; electric, gas, oil, and propane savings have been converted into MMBtu/year.

Figure 83: Average Free-Ridership Influence Rating by Element, Building Envelope Measures
(source: participant survey)



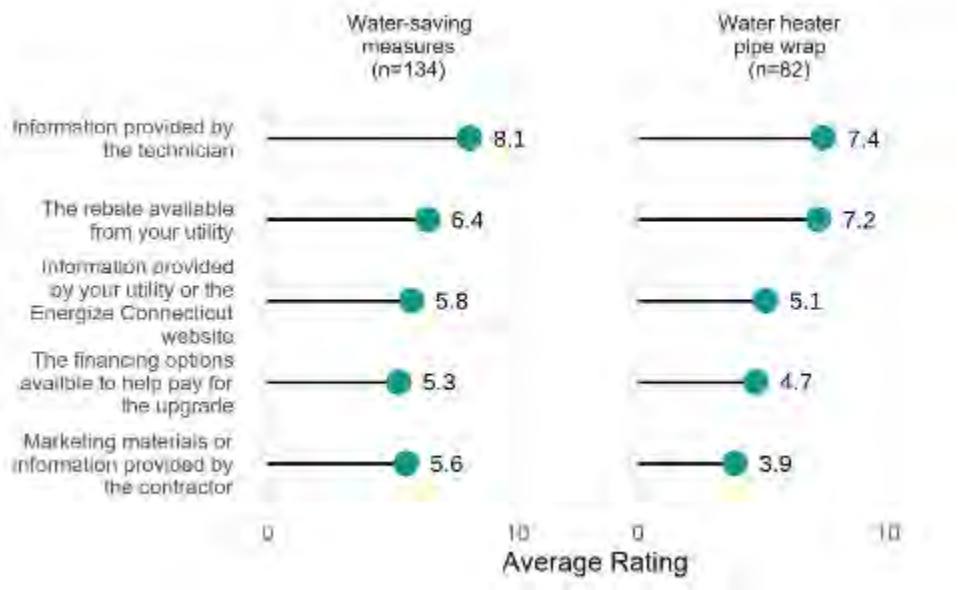
- **Appliances.** The availability of a rebate and information provided by the technician were the most influential program elements for respondents who installed appliances. Marketing materials and financing options were the least influential.

Figure 84: Average Free-Ridership Influence Rating by Element, Appliances
(source: participant survey)



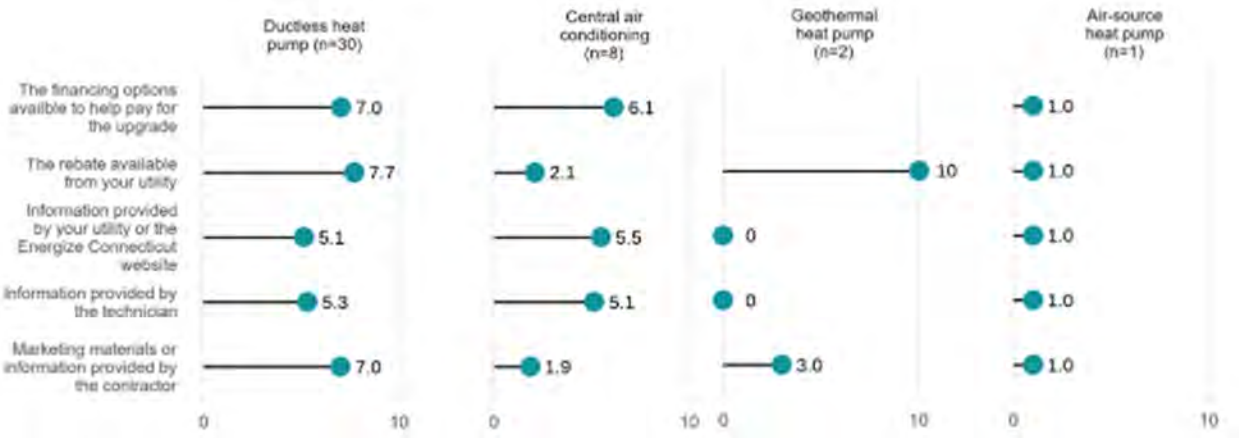
- **Domestic Hot Water.** Information provided by the technician was the most influential program element, followed closely by the availability of a rebate. Marketing material was the least influential program element.

Figure 85: Average Free-Ridership Influence Rating by Element, Domestic Hot Water
(source: participant survey)



- **HVAC.** Ductless heat pumps were the only HVAC measure with over ten respondents who answered the question. The availability of the rebate, financing options, and marketing materials were the most influential program elements.

Figure 86: Average Free-Ridership Influence Rating by Element, HVAC
(source: participant survey)

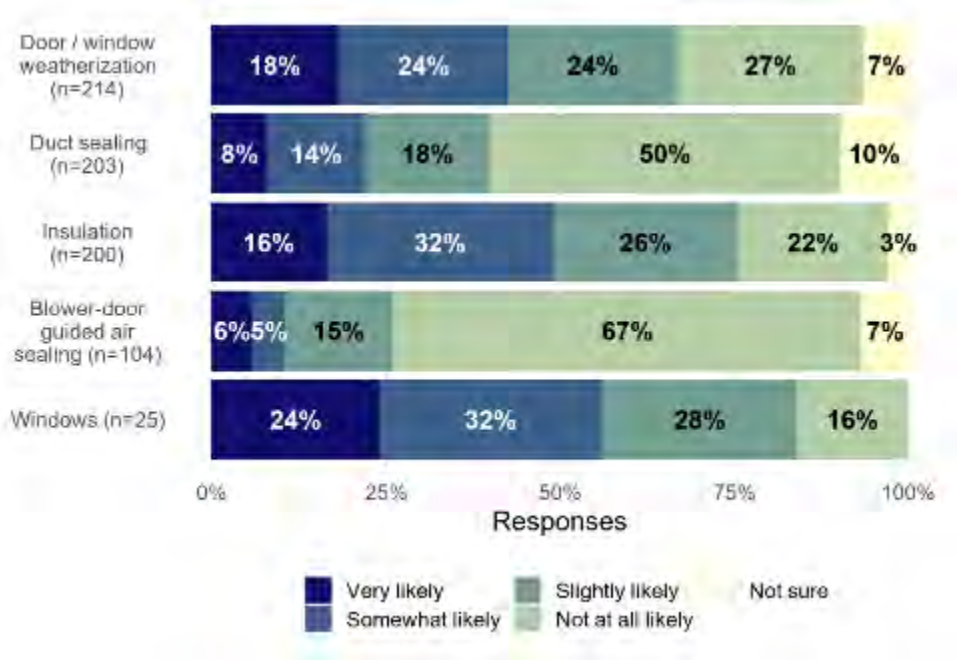


C.1.1.2 Timing

Timing is one of the three components that comprise a free-ridership intent score. The survey instrument asked respondents about the likelihood that they would have installed the measure when they did if the rebate, financing, and/or program support had not been available. If the measure was mechanical equipment or an appliance, respondents also indicated whether it was new or installed to replace an existing piece of equipment.

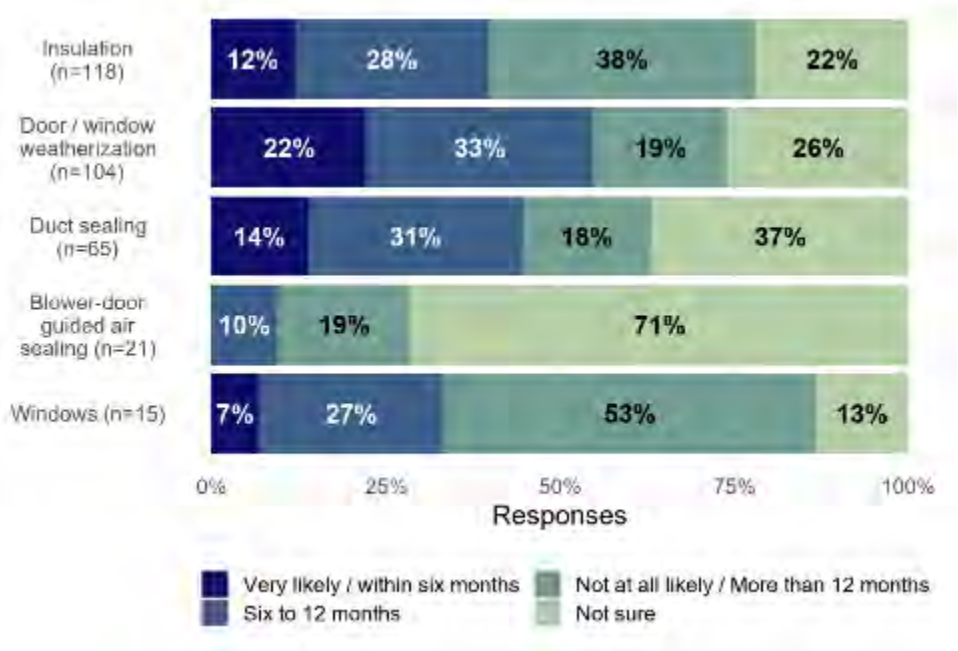
- **Building Envelope.** Respondents who had installed door/ window weatherization, insulation, and/or windows through the Program were most likely to have installed the measure at the same time they did, even without program support. Unsurprisingly, respondents who had conducted blower-door air sealing with program support were least likely to say the same.

Figure 87: Free-Ridership Timing Likelihood, Building Envelope Measures
(source: participant survey)



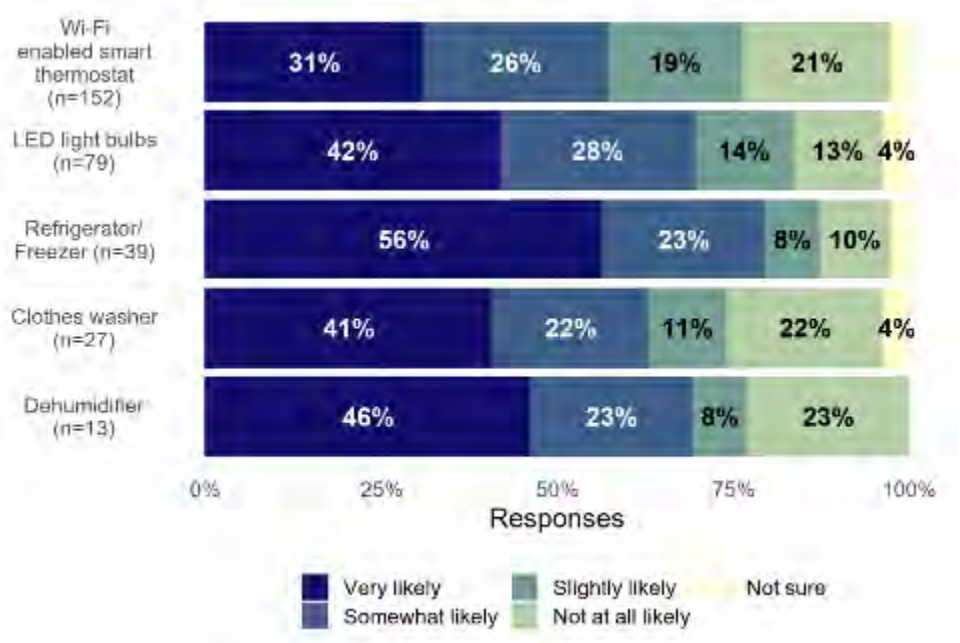
Respondents who said they were somewhat or slightly likely saw a follow-up question that asked when they would have installed the measure. Here again, respondents who installed door/ window weatherization were most likely to say they would have installed it within six months.

Figure 88: Free-Ridership Timing Follow-Up, Building Envelope Measures
(source: participant survey)



- **Appliances.** Respondents who had installed any appliance were more likely than not to say they would have installed the measure at the same time they did, even without program support. Those who purchased refrigerators and freezers were most likely to say this.

Figure 89: Free-Ridership Timing Likelihood, Appliances
(source: participant survey)



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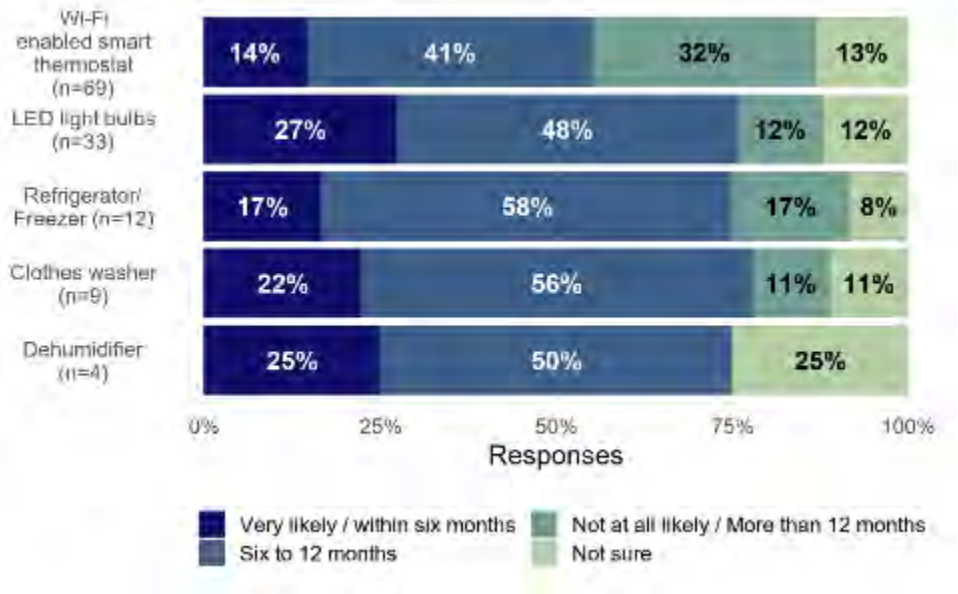
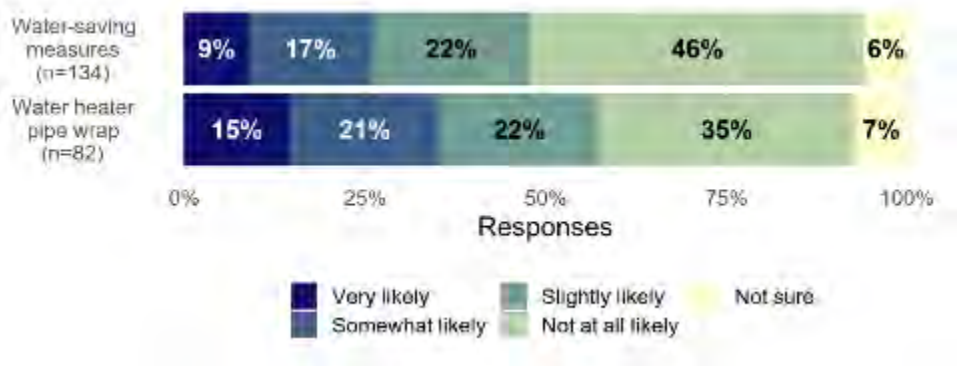
Respondents who said they were somewhat or slightly likely saw a follow-up question that asked when they would have installed the measure. Between two- and three-fifths (41% through 58%) of these respondents said they would have installed the appliance within six to 12 months without program support.

Figure 90: Free-Ridership Timing Follow-Up, Appliances
(source: participant survey)



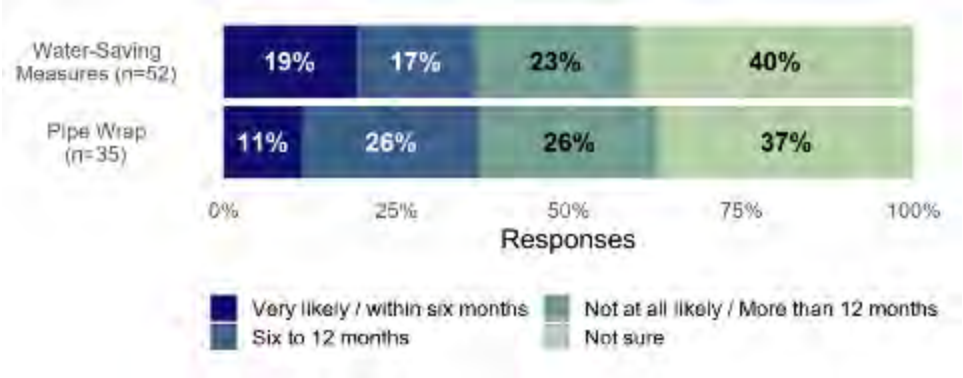
- **Domestic Hot Water.** Respondents who had installed pipe wrap were more likely than those who had installed water-saving measures (aerators, showerheads) to say they would have installed the measure when they did without program support.

Figure 91: Free-Ridership Timing Likelihood, DHW
(source: participant survey)



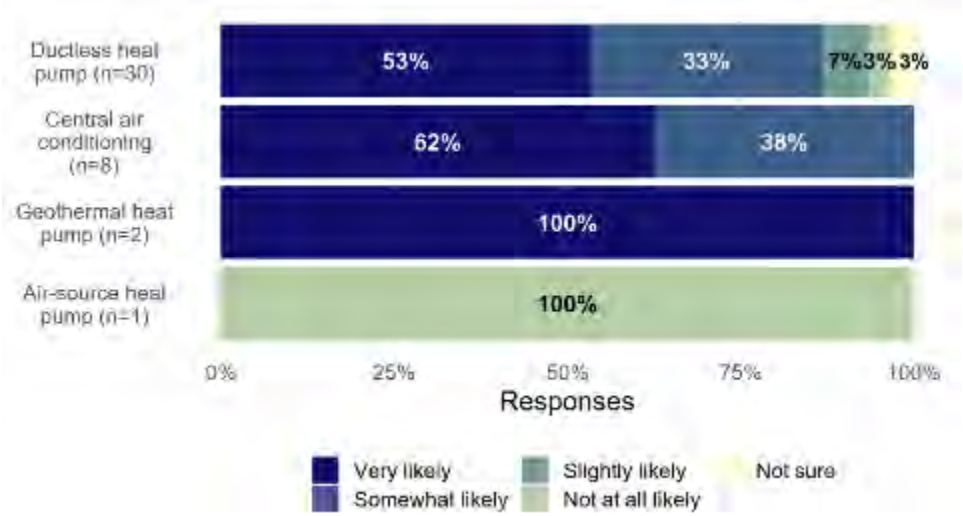
Respondents who said they were somewhat or slightly likely saw a follow-up question that asked when they would have installed the measure. Roughly one-third each of respondents who installed water-saving measures and/or pipe wrap said they would have installed them within 12 months without program support.

Figure 92: Free-Ridership Timing Follow-Up, DHW
(source: participant survey)



- **HVAC.** Ductless heat pumps were the only HVAC measure with over 10 respondents who answered the question. Over four-fifths (86%) of these respondents said they were somewhat or very likely to have installed the ductless heat pump when they did without program support.

Figure 93: Free-Ridership Timing Likelihood, HVAC
(source: participant survey)



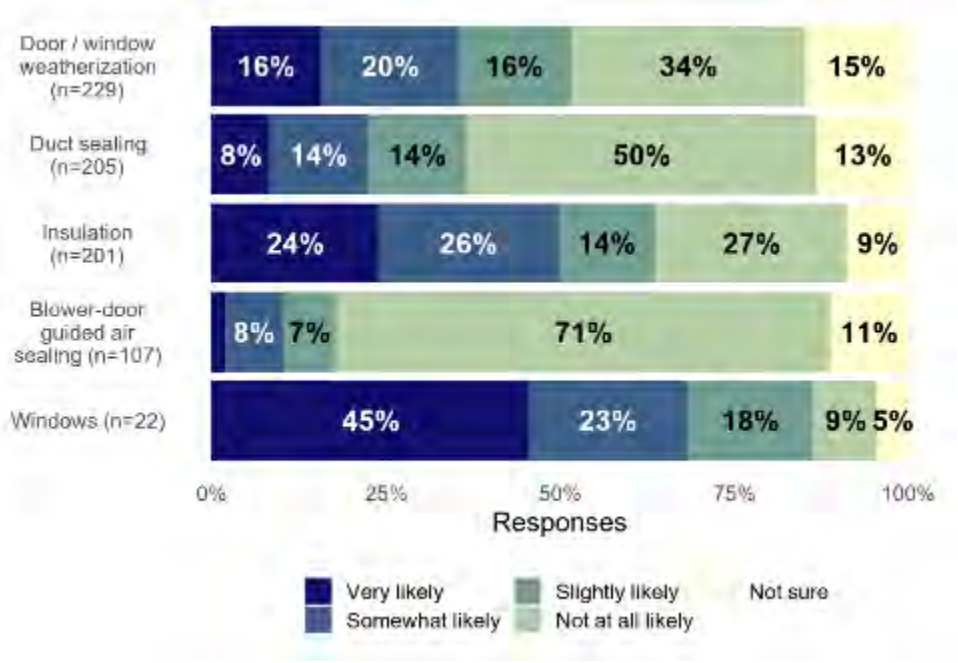
Of the 12 customers who installed ductless heat pumps and said they were somewhat or very likely to have installed them when they did without program support, five said they would have done so within 12 months.

C.1.1.3 Quantity

Quantity is the second of three components comprising a free-ridership intent score. The survey instrument asked respondents to indicate the likelihood of their installing the same number of units (in the case of mechanical equipment, appliances, lighting, thermostats, or windows) or amount/percentage of the measure (in the case of air sealing, duct sealing, weatherization, and insulation).

- **Building Envelope.** Respondents who had installed windows were most likely to say they would have installed the same amount without program support, followed by those who had installed insulation, then door/ window weatherization.

Figure 94: Free-Ridership Quantity Likelihood, Building Envelope Measures
(source: participant survey)



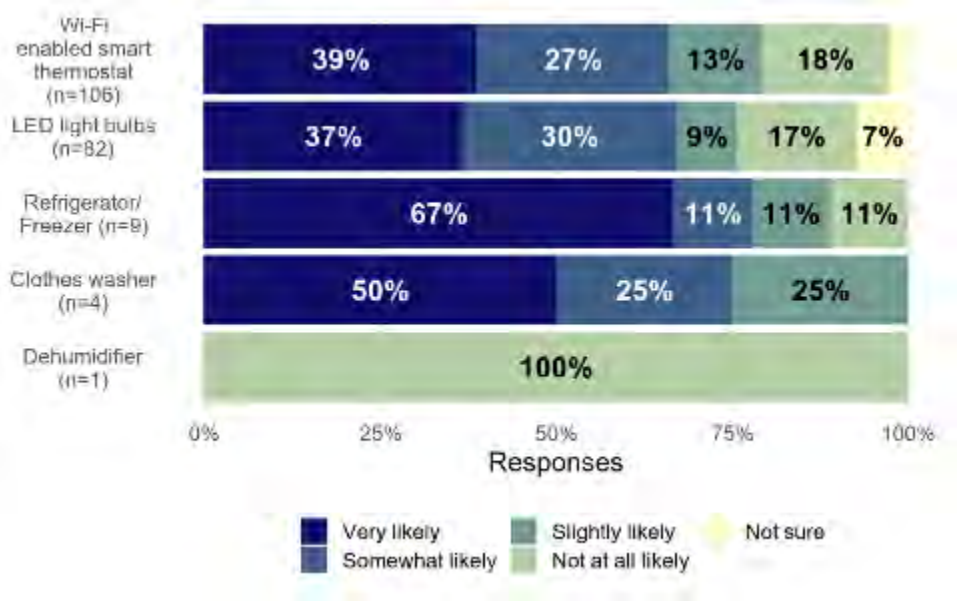
Respondents who said they were somewhat or slightly likely to have installed the same number or performed the same amount of each measure then quantified the percentage they would have installed. For windows, the survey instrument asked for a number of installed windows with and without program support, rather than directly asking for a percent.

Table 52: Free-Ridership Quantity Percent, Building Envelope Measures
(source: participant survey)

Measure	n	Average % Measure Installed Without Program Support
Insulation	80	71%
Door / window weatherization	77	56%
Duct sealing	57	52%
Windows	25	12%
Blower-door guided air sealing	17	34%

- **Appliances.** Among measures with sample sizes above 30, thermostats and light bulbs, two-thirds of respondents (66% and 67%, respectively) said they would have very or somewhat likely installed the same number of each measure without program support.

Figure 95: Free-Ridership Quantity Likelihood, Appliances
(source: participant survey)



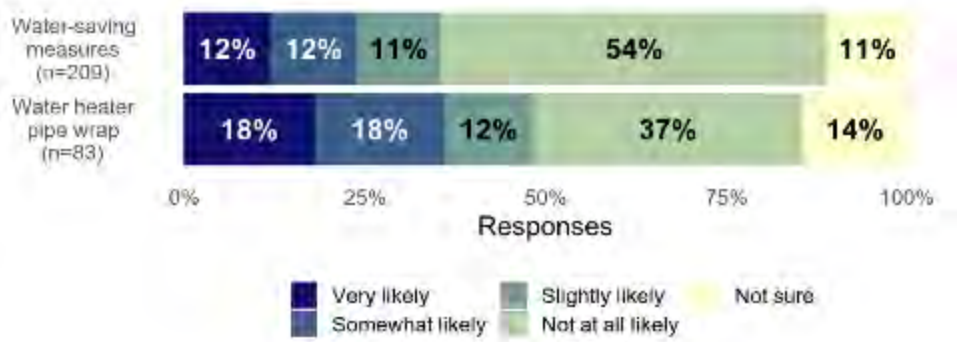
Respondents who said they were somewhat or slightly likely to have installed the same number or performed the same amount of each measure then quantified the percentage they would have installed. For windows, the survey instrument asked for a number of installed windows with and without program support, rather than directly asking for a percent.

Table 53: Free-Ridership Quantity Percent, Appliances
(Source: Participant survey)

Measure	n	Average % Units Installed Without Program Support
Wi-Fi enabled smart thermostat	152	17%
Refrigerator/Freezer	39	2%
LED light bulbs	30	66%
Clothes washer	27	3%
Dehumidifier	13	0%

- **DHW.** Respondents who installed pipe wrap were more likely than those who installed water-saving measures to say they would have installed the same quantity of each measure without program support.

Figure 96: Free-Ridership Quantity Likelihood, DHW
(source: participant survey)



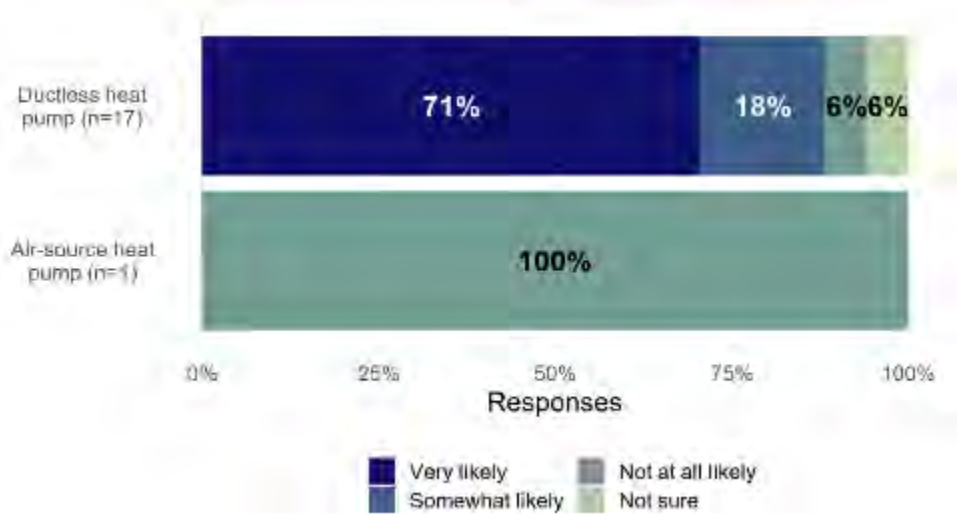
Respondents who said they were somewhat or slightly likely to have installed the same number or performed the same amount of each measure then quantified the percentage they would have installed. For windows, the survey instrument asked for a number of installed windows with and without program support, rather than directly asking for a percentage.

Table 54: Free-Ridership Quantity Percent, DHW
(source: participant survey)

Measure	n	Average % Units Installed Without Program Support
Water-saving measures	31	60%
Water heater pipe wrap	24	80%

HVAC. Respondents who installed multiple ductless heat pumps (n=17) were more likely than those who installed any other measure to say that they would have installed the same quantity without program support.

Figure 97: Free-Ridership Quantity Likelihood, HVAC
(source: participant survey)



Respondents who said they were somewhat or slightly likely to have installed the same number or performed the same amount of each measure then quantified the percentage they would have installed.

Table 55: Free-Ridership Quantity Percent, HVAC
(Source: Participant survey)

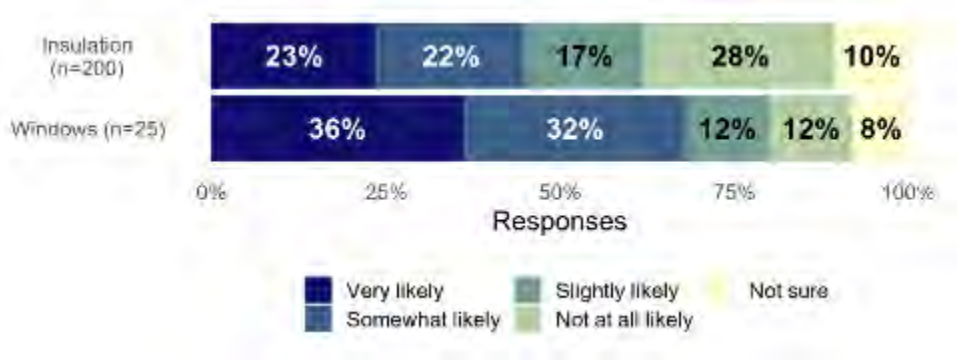
Measure	n	Average % Units Installed Without Program Support
Ductless heat pump	30	7%
Geothermal heat pump	2	0%
Air source heat pump	1	0%

C.1.1.4 Efficiency

Efficiency is the third and final component comprising a free-ridership intent score. The survey instrument asked respondents to indicate the likelihood of their installing a measure with the same level of efficiency as the program-supported measure. This question was asked about all add-on measures. For core measures, the survey only asked about lighting because efficiency levels for services such as air sealing, duct sealing, door and window weatherization, and water-saving measures do not have meaningful variations in efficiency.

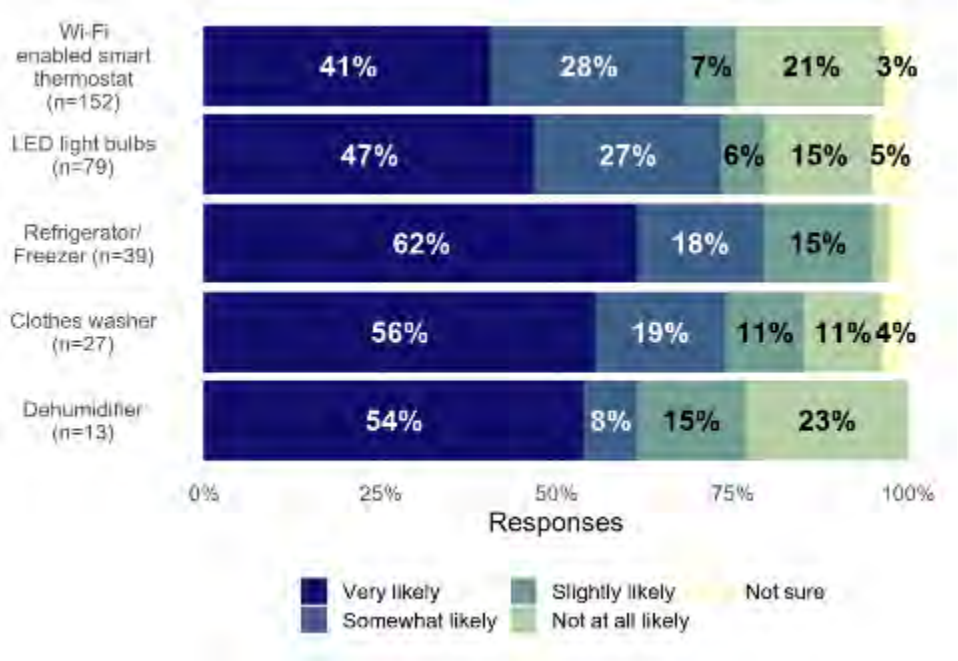
- **Building Envelope.** Respondents who installed windows were more likely than those who installed insulation to say they would have installed the same efficiency level of each measure without program support. The survey did not ask this question about the three core HES weatherization measures: blower-door guided air sealing, door/ window weatherization, and duct sealing.

Figure 98: Free-Ridership Efficiency, Building Envelope Measures
(source: participant survey)



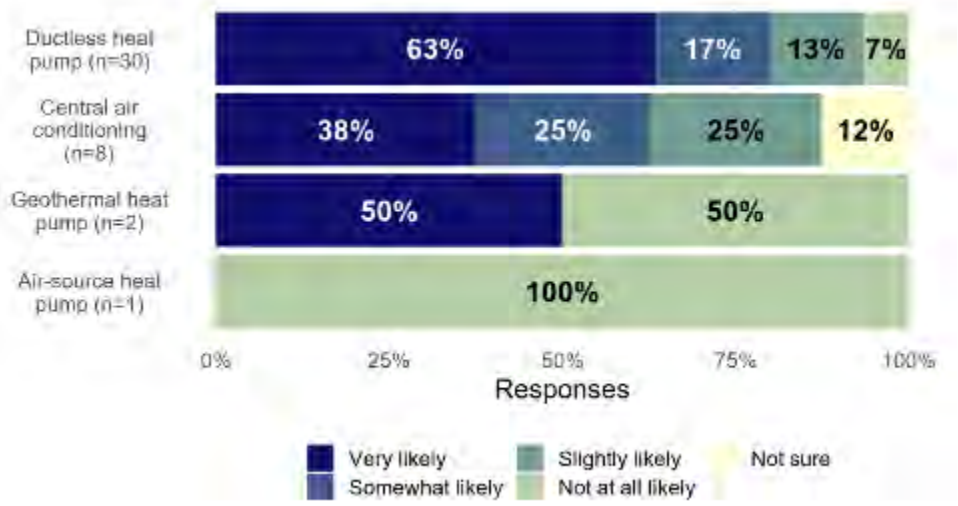
- **Appliances.** Respondents who installed refrigerators/ freezers were most likely to say they would have installed the same efficiency level for each measure without program support, followed by those who installed clothes washers and/or LED light bulbs.

Figure 99: Free-Ridership Efficiency Likelihood, Appliances
(source: participant survey)



- **DHW.** The survey did not ask questions about water-saving measures (aerator, showerhead) or pipe wrap efficiency.
- **HVAC.** Respondents who installed ductless heat pumps were the only ones with a sample size above 30. Among these, over three-fourths (80%) said they were somewhat or very likely to have installed the same efficiency level without program support.

Figure 100: Free-Ridership Efficiency, HVAC
(source: participant survey)



C.1.2 Early Replacement

The survey asked questions that did not directly figure into the FR algorithm but did provide context for respondents' decisions around installing rebated measures. First, respondents specified whether the measures they installed replaced existing equipment or were new equipment.

For those who replaced existing equipment, survey questions asked what condition that equipment was in before it was removed, and if it needed at worst minor repair, whether the replaced equipment might have lasted another two years.

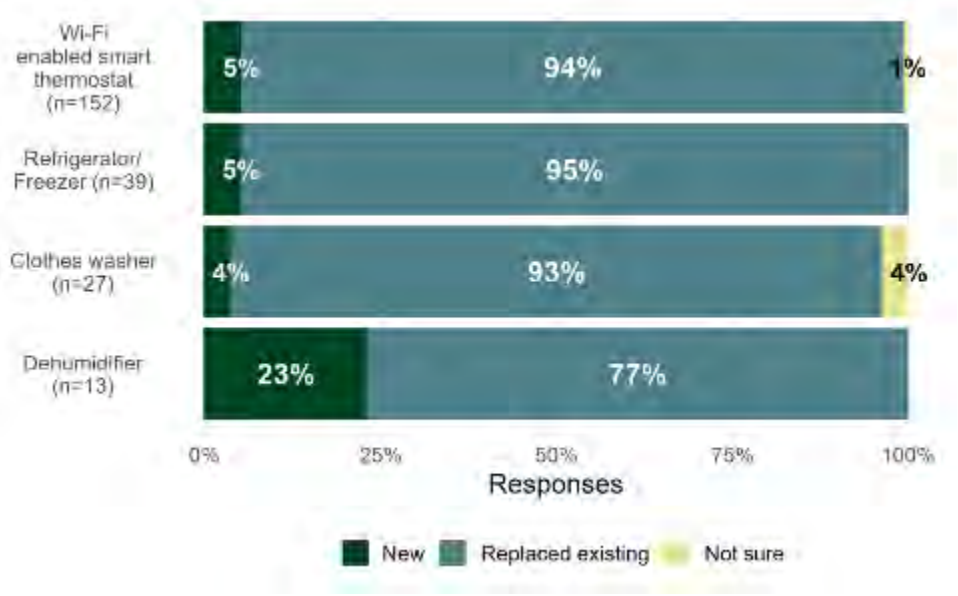
- **Windows.** Respondents who installed windows (n=25) were almost entirely (96%) replacing existing ones. Among those who replaced existing equipment, over half (54%) said their windows needed major repair (Figure 101).

Figure 101: Free-Ridership Condition of Replaced Equipment, Windows
(source: Participant survey)

All nine respondents who said their replaced windows needed minor or no repair said the windows would have lasted another two years.

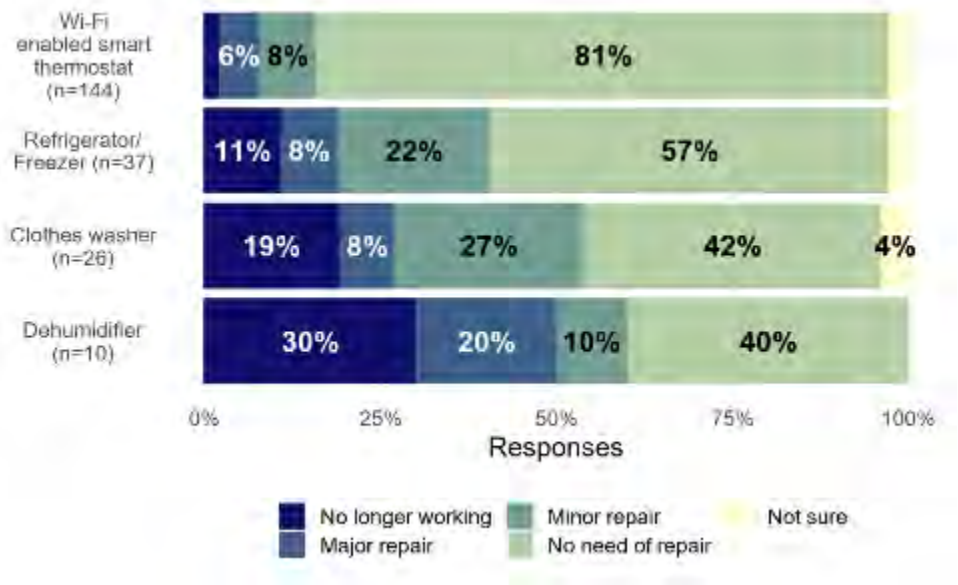
- **Appliances.** Among groups with sample sizes over 30 – Wi-Fi enabled smart thermostats and refrigerators/freezers – nearly all respondents (93% or greater) were replacing existing measures (Figure 102).

Figure 102: Free-Ridership New or Replacing Existing Equipment, Appliances
(source: participant survey)



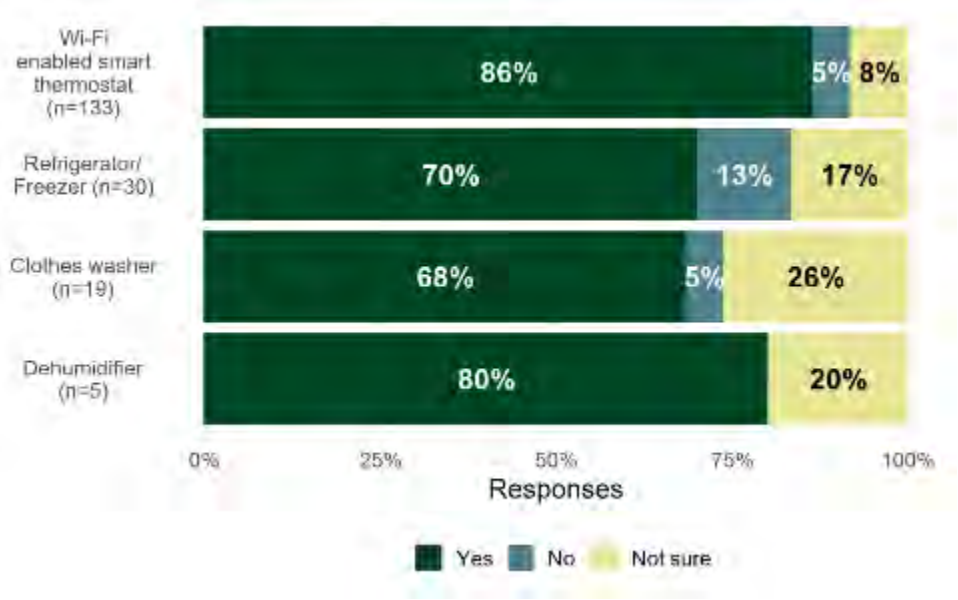
Among respondents who replaced existing appliances, four-fifths of those who installed smart thermostats (81%) said their existing thermostats were in no need of repair (Figure 103). Over one-half of those who installed refrigerators/freezers (57%) said their equipment was in no need of repair. The results for respondents who installed clothes washers and/or dehumidifiers were similar, albeit with smaller sample sizes.

Figure 103: Free-Ridership Condition of Replaced Equipment Condition, Appliances
(source: participant survey)



For each appliance, over two-thirds of respondents who said their appliance needed minor or no repair said their replaced equipment would have lasted another two years (Figure 104).

Figure 104: Free-Ridership Early Replacement, Appliances
(source: participant survey)



- **HVAC.** Three-fifths of respondents who installed ductless heat pumps (60%) were installing new systems (Figure 105).

Figure 105: Free-Ridership New or Replacing Existing Equipment, HVAC
(source: Participant survey)

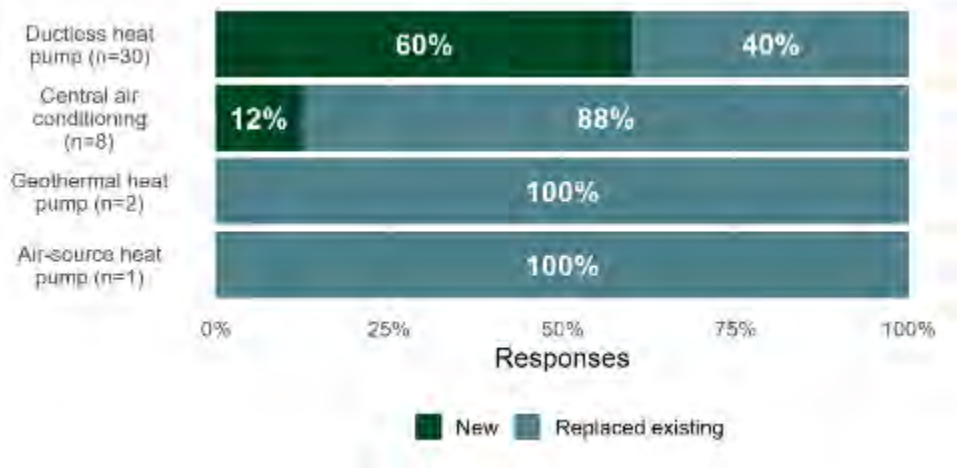
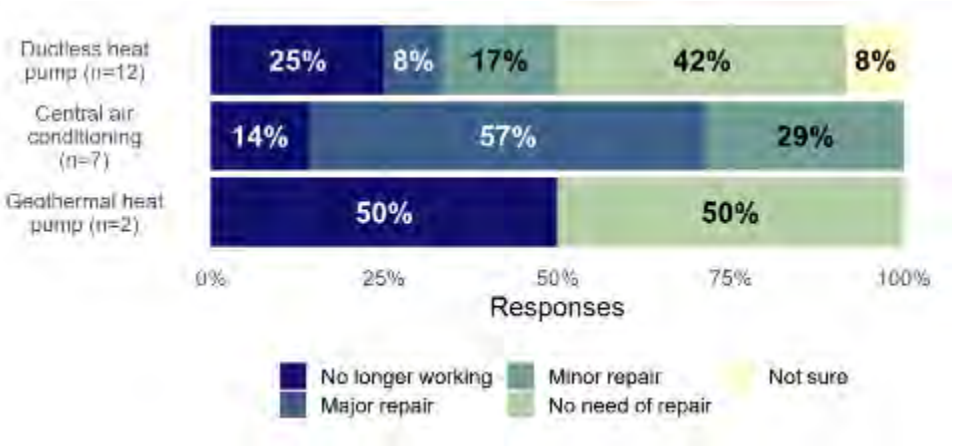


Figure 106 shows the condition of equipment replaced by ductless heat pumps, central air conditioners, and geothermal heat pumps.

Figure 106: Free-Ridership Condition of Replaced Equipment, HVAC
(source: Participant survey)



Among respondents whose previous HVAC equipment needed minor or no repair, six of eight respondents who installed ductless heat pumps and one respondent who installed a geothermal heat pump thought their equipment would have continued working for another two years.

C.1.3 FR Benchmarking

Table 56 shows free-ridership values from other NTG studies in the mid-Atlantic and Northeast that estimated NTG by measure. For the purposes of comparison to past Connecticut HES studies, we note that the R4 study had a different NTG approach than the R1983 study, which used the Massachusetts NTG algorithm with a LAM-adjusted scale. Due to the similarities in NTG methodology and program design, the Massachusetts values are likely the closest benchmark for the measure-level free-ridership reported in R1983.

Table 56: Free-Ridership Benchmark Values

Measure	R1983 FR	Benchmark FR	Benchmark Year	State
Door and/or window weatherization	28%[1]	--	--	--
Duct sealing	14%	18%	2014	CT[3]
Water-saving measures[2]	20%	20%	2014	CT[3]
Blower-door-guided air sealing	11%	25% 12%	2014 2019	CT[3] MA[4]
Pipe/tank insulation	28%	28% 21%[8]	2014 2018-19	CT[3] PA (PECO)[6]
Energy-Efficient LED Light Bulbs[2]	36%	55% 53-58%	2014 2018-2019	CT[3] PA (PECO)[6]
Insulation	23%	6% 20%	2014 2019	CT[3] MA[4]
Smart Thermostat	34%	26% 40%	2019 2019-2020	MA[4] PA (DLC)[7]

Measure	R1983 FR	Benchmark FR	Benchmark Year	State
Energy-Efficient Windows	33%	5%	2014	CT[3]
Central Air Conditioning System	38%	17% 35% 56%	2014 2019 2019-2020	CT[3] MA[4] PA (DLC)[7]
Heat Pumps (any)	38%	31-34% 25%[9] 40-42% 63%	2019 2014 2018-2019 2019-2020	MA[4] CT[3] PA (PECO)[6] PA (DLC)[7]
Refrigerator / Freezer	47%	31-48% 52% 68%	2014 2018-2019 2019-2020	CT[3] PA (PECO)[6] PA (DLC)[7]
Clothes Washer	42%	65%	2018-2019	PA (PECO)[6]
Dehumidifier	43%	42% 48%	2019 2019-2020	MA[5] PA (DLC)[7]

[1] Unweighted due to lack of savings for this measure in program data; savings for door and/or window weatherization measures were presumed to be included with air sealing savings.

[2] LED free-ridership values and benchmarks are shown for informational purposes only; the workplan specifies that the study will interpret the result of the billing analysis for lighting as net savings.

[3] NMR Group, Inc. April 13, 2016. "Project R4 HES/HES-IE Process Evaluation and R31 Real-time Research." Microsoft Word - R4HES-HESIE_Process_Eval2016_0413_Final (energizect.com).

[4] Guidehouse Inc. October 8, 2021. "Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures." MA20R28-B-NTGRCDP Report (ma-eeac.org).

[5] NMR Group, Inc. and DNV, Inc. June 8, 2021. "Residential Products Net-to-Gross Study (MA20X04-E-PRODNTG). MA20X04-E-PRODNTG_Res-Products-NTG-Report_FINAL_2021.06.08.pdf (ma-eeac.org).

[6] Guidehouse, Inc. November 15, 2019. "Final Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129. Program Year 10 (June 1, 2018 – May 31, 2019). Prepared for PECO."

[7] Guidehouse, Inc. February 15, 2021. "Final Annual Report to the Pennsylvania Public Utility Commission Phase III of Act 129. Program Year 11 (June 1, 2019—May 31, 2020). Prepared for Duquesne Light Company."

[8] This FR value was for the entire Whole Home Solution, which included pipe wrap as a direct-install measure.

[9] The free-ridership value of 25% was for ductless mini-split heat pumps only.

C.2 SPILLOVER

This section details findings for the second major input into the NTG ratio: spillover.

C.2.1 Participant Spillover

Participant spillover (PSO) estimates the impact of participants installing additional energy-efficient measures due to their previous involvement with the program, without program incentives to do so.

Of the 925 HES participants surveyed, 13% reported that they were influenced by the HES program to install an energy-saving measure that met these conditions. As Table 57 shows, these respondents reported 303 eligible SO measures in total, the most common being thermostats (4% of respondents) and dehumidifiers (3%).

Table 57: HES Participation Spillover Measures

Program-Influenced Measure Installed Outside of Program	% of Respondents, Unweighted (n=925)	Average Gross Savings (MMBtu/yr)[1]
Thermostat	4%	5.9
Dehumidifier	3%	0.8
Window replacement	2%	21.3
Insulation	2%	12.2
Air sealing	2%	4.2
LED Light bulbs/light fixtures[2]	2%	2.1
Clothes washer	2%	1.0
Refrigerator	2%	0.9
Central air conditioning system	2%	0.7
Furnace	1%	21.9
Ductless heat pump	1%	12.7
Heating or cooling system tune-up/maintenance	1%	0.8
Water heater	1%	2.1
Air purifier	1%	0.8
Water pipe wrap	1%	0.5
Freezer	1%	0.4
Clothes dryer	1%	0.3
Dishwasher	1%	<0.05
Boiler	<0.5%	21.9
Air source heat pump	<0.5%	21.9
Geothermal heat pump	<0.5%	21.9
Heat pump water heater	<0.5%	3.3
Duct sealing	<0.5%	2.3
Water-saving measures	<0.5%	0.4
Total[3]	**13%**	**1,549**

[1] Average savings in the program database associated with each measure. Electric, gas, oil, and propane savings have been converted into MMBtu/year. The source of average savings for eligible spillover equipment not present in the program database is the 2021 PSD.

2 After discounting by 70% to account for upstream lighting rebates, average LED savings is 0.7 MMBtu/yr.

3 Multiple spillover measures for some respondents; "total" represents the number of respondents with at least one spillover measure and total MMBtu for all spillover measures.

Weighted PSO for the HES program is 7% with a 90% confidence interval (5.7%, 10.8%). This score represents a weighted average of the percentage of respondents who reported eligible SO measures, where the weights for each spillover measure are the annual average gross savings shown in Table 57.

The study included several sensitivity analyses on the overall PSO estimate:

Lighting. In Connecticut, LEDs were discounted at retailers through an upstream lighting program until 2021, when the program supported only reflector lighting incentives in hard-to-reach

markets.[166] The likelihood is high that HES participants who purchased LEDs before 2021 obtained an upstream program-incented bulb even if they did not realize it. Furthermore, the free-ridership rate for non-HTR (hard-to-reach) upstream LEDs in the 2022 Connecticut PSD is 70%. As such, the study discounted lighting savings by 70% and counted 30% of the savings from lighting towards spillover (reducing the average savings from 2.11 to 0.63 MMBtu). This adjustment did not have a substantial effect on overall SO value; it increased by tenths of a percentage point. We recommend using a spillover value of 7%, particularly because we are not recommending adjusting to exclude people who reported similar spillover measures to those they received through the program, as described below.

Tracking data cross-check. Fewer than one in 10 respondents (7%) identified spillover measures that they had also verified as receiving through their participation in the HES program. The most conservative approach would be to assume these respondents misunderstood the spillover battery and exclude these measures from the spillover analysis. Total spillover with these measures excluded is 6%, compared to 7% with these measures included (and the discount rate for LED lighting SO as described above). Therefore, the effect of potential double-counting of SO measures is limited and the evaluation recommends using the 7% value.

Benchmarking. The Massachusetts residential coordinated delivery (RCD) reports a participant spillover value of 12% at the program level.[167] Similar to the Connecticut HES program, residential customers receive an energy assessment and have an opportunity to adopt deeper savings measures. Program-level participant spillover for the MA study also includes multifamily households and other program tracks, so while it is not a direct comparison, this evaluation can reasonably recommend a 7% participant spillover value for the R1983 HES study.

C.2.2 Non-Participant Spillover (NPSO)

Most of the vendor interviewees indicated that most or all of their residential work came through the HES program or related services (e.g., insulation or HVAC installation). The few respondents whose companies had residential work outside the program had difficulty estimating the program impact on their non-program practices. In addition, sometimes the non-program installations occurred in other departments of the company, and the vendors could not speak confidently about work done in other departments. For these reasons, the study could not quantify non-participant spillover, but gleaned the following qualitative findings from vendor interviews:

- **Energy assessments conducted outside the program**. Due to their familiarity with the program, respondents referred non-participant customers through the program so that the customers could gain program benefits and receive an assessment for the cost of the program co-pay. One vendor said that some of their solar customers were not eligible to

[166] "2021 Plan Update to the 2019-2021 Conservation & Load Management Plan." Filed March 1, 2021. https://www.energizect.com/sites/default/files/2021-04/Final%202021%20Plan%20Update%20%28Refiled%203-15-21%29.pdf. Accessed June 14, 2021.
[167] Guidehouse Inc. October 8, 2021. "Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures." MA20R28-B-NTGRCDP Report (ma-eeac.org). Accessed June 30, 2022.

participate in HES again due to recent program participation; in these cases, the company performed a "clipboard audit"[168] to move them through the solar installation process.

- **High-efficiency equipment recommended to non-participant customers.** Like questions about non-program energy assessments, respondents indicated that they encouraged customers to participate in the program to access program incentives. Vendors with non-participant customers elaborated on their business practices:
  1. One vendor who estimated that only 30% of their company's residential work came through the HES program said that they recommended high-efficiency equipment to their customers, depending on their fuel systems and budget. Generally, the vendor noted that customers were willing to go along with their recommendations.
  2. One vendor said that they made the same recommendations on equipment to non-participating customers that they would to HES participants, even if the non-participants are not eligible for any incentives. The majority of the respondent's customers were program participants. This vendor expressed that the program has been very influential on their business practices and the program affiliation affords the company credibility to all its customers.

Another vendor with non-participant residential new construction customers said that it was the responsibility of the new construction project's architect or general contractor to recommend equipment, rather than an energy auditor at the respondent's company.

C.3 INSTALLATION RATES

The installation rate represents the percentage of incented measures that program participants ultimately installed. For each measure associated with their household in the program tracking data, HES participant survey respondents were asked to confirm which of the measures were still installed in their homes, installed then removed, or never installed.

Table 58 lists two installation rates for each measure; the first is unweighted (i.e., a tally of responses), whereas the second is weighted by respondents' measure-specific savings. For example, the weighted installation rate for pipe wrap represents the percentage of all respondents' pipe wrap savings associated with those who reported installing it. Savings associated with respondents who never installed the pipe wrap count against the installation rate, but not those who answered, "I'm not sure".

As the installation rate for windows in the 2022 PSD was 100%, and this estimate (93%) could be skewed by a small sample size, we recommend averaging the two installation rates (100% and 93%) for a window installation rate of 97.5% (98%).

[168] The vendor did not provide clarification on this term, but it can be interpreted to mean a less-intensive energy assessment that would fulfill the requirements for installing solar, as the customer had previously received an assessment through the HES program.

Table 58: Installation Rate by Measure

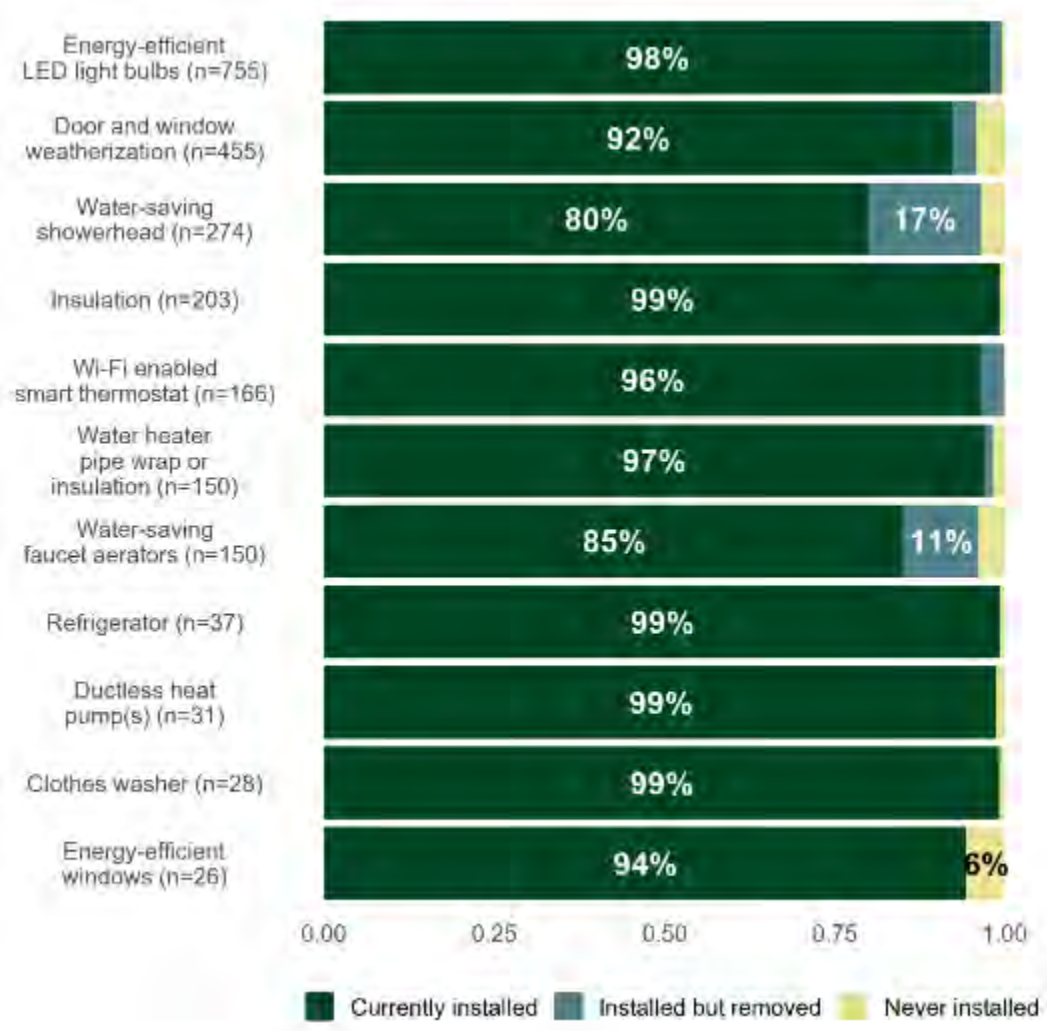
Measure	n	Installation rate, unweighted (%)	Installation rate, weighted (%)
Energy-efficient LED light bulbs	755	98%	98%
Door and window weatherization	455	92%	92%
Water-saving showerhead	274	81%	82%
Insulation	203	100%	100%
Wi-Fi-enabled smart thermostat	166	96%	96%
Water-saving faucet aerators	150	86%	85%
Water heater pipe wrap or insulation	150	97%	97%
Refrigerator	37	97%	97%
Ductless heat pump(s)	31	97%	98%
Clothes washer	28	96%	96%
Energy-efficient windows1	26	96%	93%
Dehumidifier	13	100%	100%
Central air conditioning system	7	100%	100%
Freezer	3	100%	100%
Geothermal or ground-source heat pump	2	100%	100%
Air-source heat pump	1	100%	100%

[1] One respondent reported that the windows associated with their address in the program tracking data were "never installed;" this was a high-savings project and as such the weighted installation rate for windows is reduced accordingly. The NMR team recommends averaging this installation rate with the installation rate in the 2022 PSD for an installation rate of 98%.

The first set of figures below shows how respondents answered the survey questions that determined each measure's installation rate, prior to incorporating a savings-based weighting scheme. Among HES respondents with measures where the number of respondents was less than 25, all respondents said the measures were currently installed.

Figure 107: Installation Status of Program Measures, HES

(Source: Participant survey)

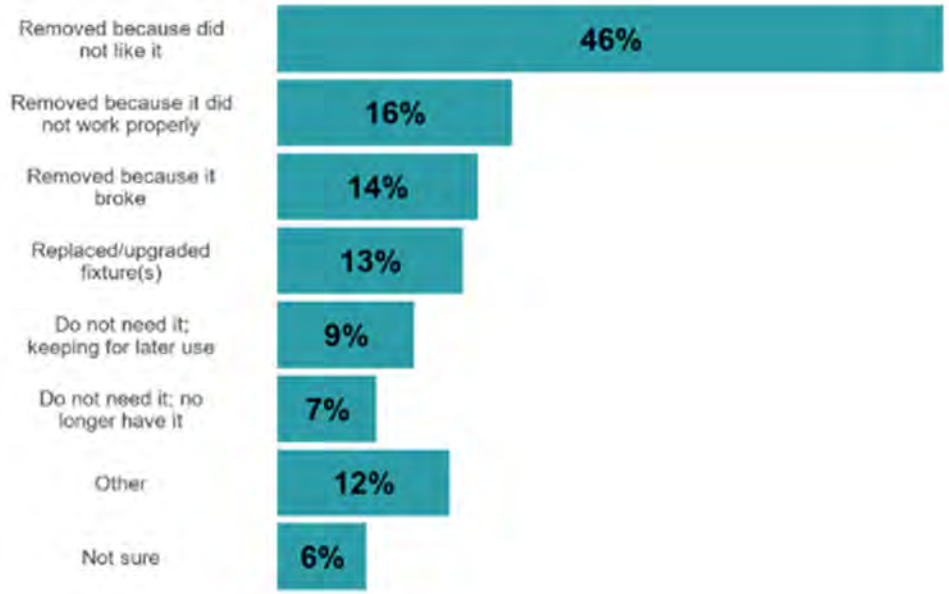


Depending on their answers, survey questions asked some respondents additional questions about why they might have removed measures and whether they have plans to install them in the future. Among the two measures with over 20 respondents – door/ window weatherization and water-saving showerheads – the most common responses were that they removed them because they broke, they did not like it, and/or it did not work properly.

Among the respondents in Figure 108 who self-reported that their water-saving measures (aerators and/or showerheads) were no longer installed (n=86), nearly one-half said they removed it because they did not like it (46%).

Figure 108: Reasons Why Respondents Removed Water-Saving Measures, HES

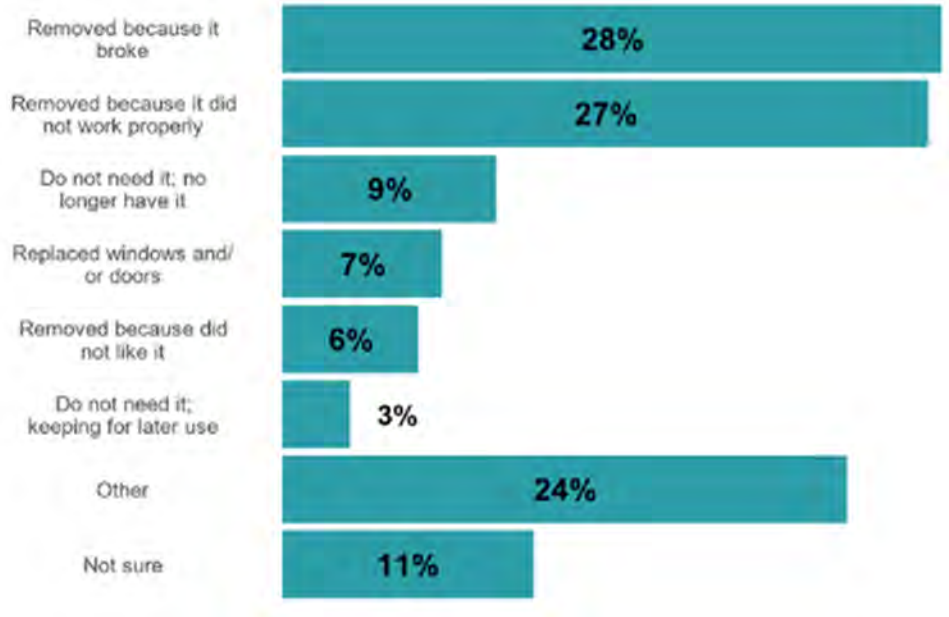
(Source: Participant survey; multiple responses allowed)



Among the respondents in Figure 109 who self-reported that their door/ window weatherization was no longer installed (n=48), over one-fourth each said they removed it because it broke (28%) and/or because it did not work properly (27%).

Figure 109: Reasons Why Respondents Removed Door and Window Weatherization, HES

(Source: Participant survey; multiple responses allowed)



Appendix D Additional Impact Findings

This appendix provides some additional details regarding the impact tasks completed as part of R1983. However, most of the study's additional impact findings are documented in the supplementary **Impact Evaluation Supporting Documentation** workbook. Readers are encouraged to use that workbook to find additional impact findings for all HES and HES-IE measures.

D.1 Air Sealing & Insulation: Results Using Multiple Estimation Approaches

As noted in Section 5, the study estimated air sealing and insulation savings using three different methodologies that all produced results lower than the program's ex ante savings. These methods included:

- **Billing Analysis Model.** PPR with matched control, used to report official ex post savings from this study.
- **Billing Data Comparison.** Difference of differences approach comparing unmodeled but weather-normalized annualized consumption for treatment and control groups.
- **Building Simulation.** Based on pre- and post-participation tracking data and billing data calibrated.

Table 59 compares the results of the three estimation approaches.

Table 59: Air Sealing & Insulation Savings: Comparison of Multiple Methods (CCF/Year for Natural Gas Heated Participants)

	HES		HES-IE	
	Air Sealing Only	Air Sealing & Insulation	Air Sealing Only	Air Sealing & Insulation
Billing Analysis Model	**17**	**77**	**11**	**108**
Billing Data Comparison	10	68	0	96
Building Simulation	66	154	31	144

As evident above, the two billing data-centric approaches (one modeled, one unmodeled) produced generally similar savings, whereas the building simulation resulted in higher savings estimates. However, notably higher savings observed savings from the building simulation (relative to any billing data-based approach) is typical and consistent with several other recent evaluations that utilized both approaches.

Numerous other studies have shown that overprediction of energy use and savings by residential energy modeling methods is a common problem. Our team's literature review found the issue is

particularly acute for older, poorly insulated homes containing aging mechanical systems.[169,170,171] These are, of course, the very homes where the most opportunities exist and, accordingly, are targeted by weatherization programs like HES & HES-IE. Specifically, an NREL study found that simulation software overpredicted natural gas space heating by an average of 41% for homes built before 1960 compared to a 13% overprediction for homes built after 1989. This finding is largely consistent with the disparity between billing data-based approaches and the building simulation approach observed by this study.

In fact, evaluations of the benchmarked market rate programs found a similar disparity between the two methodologies. The ratio of billing analysis-to-building simulation results, shown in Table 60 for HES participants that air sealed and installed insulation, is in line with benchmarked studies. This alignment in relative methodological results across studies reinforces the reasonableness of this study's billing analysis result.

Table 60: Air Sealing & Insulation Savings: Comparison Billing Analysis and Building Simulation Results Across Evaluations of Market Rate Programs (CCF/Year for Natural Gas Heated Participants)

Program (Cohort Analyzed)	**Billing Analysis**	**Building Simulation**	**Difference** (Ratio of Billing Analysis to Building Simulation Savings)
HES (CT: 2019)	**77**	**154**	**50%**
EWSF (RI: 2017–2018)	93	245	38%
HES (MA: 2015–2016)	125	194	65%

D.2 Air Sealing & Insulation: Control Group Experimentation

As also noted in Section 5, the study estimated air sealing and insulation savings using both future participants in each program, which is considered industry best practice, as well as with a pool of general population customers as the control group. In both instances, the study matched customers in the control group to a participant in the treatment group based on the similarity of the two customers' pre-program energy consumption.

As shown below, the results using both control groups were similar and not statistically different. This confirmed that the decrease in consumption over time exhibited by the "future" participants was consistent with broader usage trends amongst residential customers in Connecticut and that it was prudent to continue to use the future participants as the control group when reporting ex post savings – which is, again, industry best practice.

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[169] Field Assessment of Energy Audit Tools for Retrofit Programs Edwards, D. Bohac, C. Nelson, and I. Smith NorthernSTAR Building America Partnership. https://bbe.umn.edu/sites/bbe.umn.edu/files/Field%20Assessment%20of%20Energy%20Audit%20Tools%20for%20Retrofit%20Programs.pdf

[170] Assessing and Improving the Accuracy of Energy Analysis for Residential Buildings B. Polly, N. Kruis, and D. Roberts. https://www.nrel.gov/docs/fy11osti/50865.pdf

[171] Ternes, M.P. (2007). Validation of the Manufactured Home Energy Audit (MHEA). ORNL/CON-501 and the second part of the study referenced in Ternes, M.P; Gettings, M.B. (2008). Analyses to Verify and Improve the Accuracy of the Manufactured Home Energy Audit. ORNL/CON-506.

Table 61: Air Sealing & Insulation Savings: Using Different Control Groups (CCF/Year for Natural Gas Heated Participants, HES)

Matched Control Group	Air Sealing Only	Air Sealing & Insulation
Future Participants	17 ± 5	77 ± 9
General Population	19 ± 6	84 ± 10

D.3 AIR SEALING & INSULATION: BY VENDOR

Vendor-specific results did not differ at a statistically significant level. Sample sizes did not allow the study to model statistically significant vendor-specific savings via billing analysis. To assess potential differences across vendors, the study instead compared unmodeled differences in average pre- and post-program consumption for each vendor. To be clear, this approach is different from and more simplistic than modeled savings shown in Table 16. As a result, the figures below labeled as "Changes in Natural Gas Consumption", not "savings".

As evident in the figures below, the average change in consumption varied meaningfully vendors. However, largely due to sample sizes, none of these differences are statistically different from each other or the modeled ex post savings. (The green bands represent the confidence interval for each vendor.) Also, because this approach is unmodeled and does not include a control group, the changes in pre- and post-consumption may be attributable to factors beyond vendor's influence (e.g., changes in occupancy, behavioral changes, economic factors, weatherization as part of a remodel). The study team has removed vendor names to ensure anonymity.

Figure 110: Changes in Natural Gas Consumption (in CCF) by Vendor (HES 2019 – Participants that Installed Rebated Insulation)

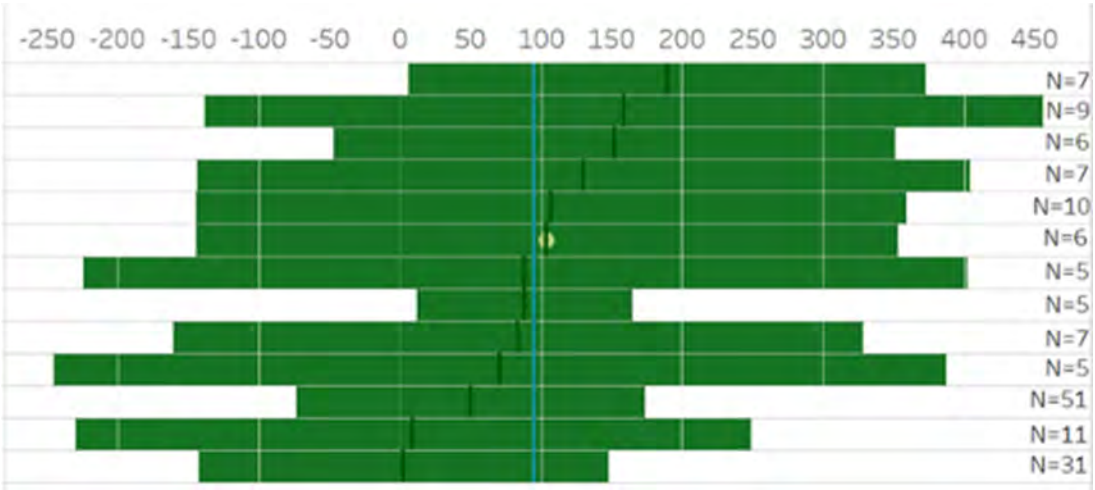
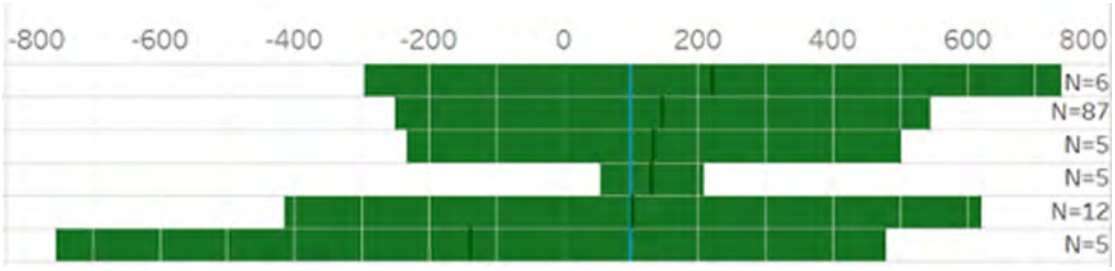


Figure 111: Changes in Natural Gas Consumption (in CCF) by Vendor (HES-IE 2019 - Participants that Installed Add-on Insulation)

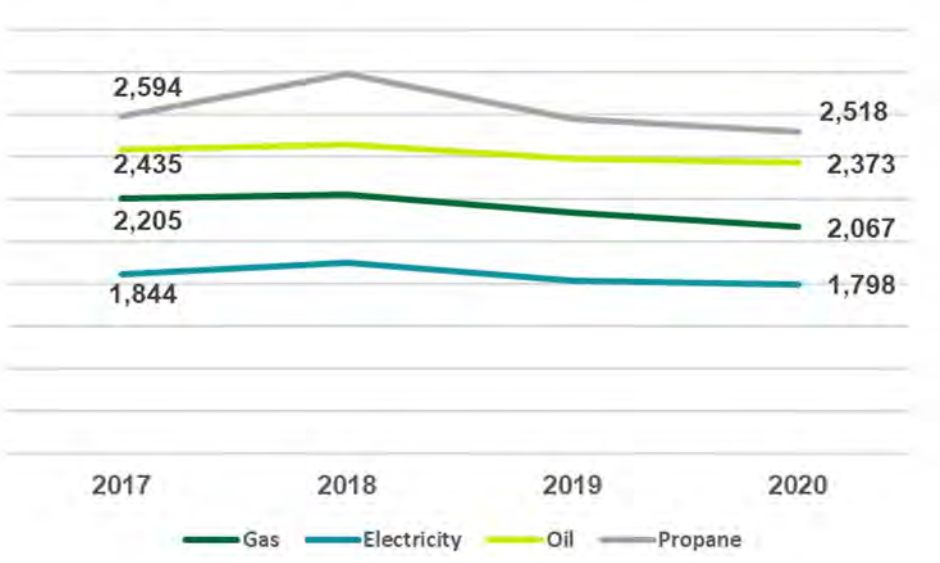


D.4 CHANGES IN HES CUSTOMERS OVER TIME

In Section 5, the study notes some changes in the composition of HES participants over time based on the provided program data. The following figures show:

- **Less Conditioned Space.** HES tracking data shows the program has serviced smaller homes (i.e., less above grade conditioned space) from 2017 to 2019. Less average conditioned space/participant is consistent with lower consumption over this time, as well as lower savings.

Figure 112: HES Average Participant Heated Square Footage by Year and Fuel Type[172]

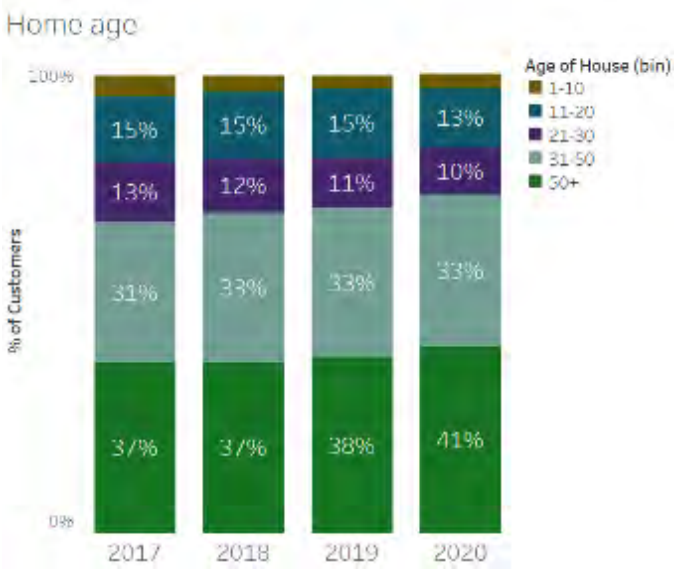


- **Older Homes.** HES tracking data also indicates the program is servicing older homes. As shown in Figure 113, the percentage of homes in HES that were built more than 30 years before participating increased from 68% to 74% between 2017 to 2020. Although older homes can represent an opportunity, they also more frequently present challenges (i.e.,

[172] It is important to note the difference in home size by heating fuel type. This is one of the engineering adjustments the study made when leveraging the results of the natural gas billing analysis to evaluate other fuel types – especially heating oil and propane, which cannot be analyzed via billing analysis.

pre-weatherization barriers such as knob and tube wiring, mold, or asbestos) to fully weatherize.

Figure 113: Home Age (Average Age/Participant)
(HES 2017-2020)

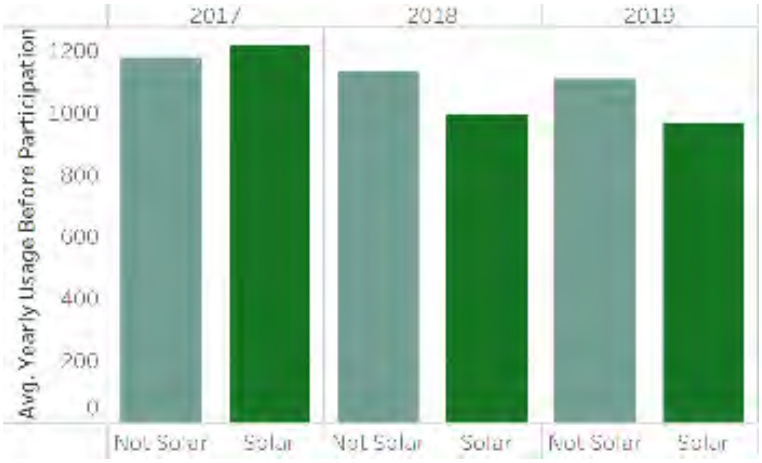


- **More Solar Homes.** Another theoretical driver behind declining trend in consumption relates to the current requirement that homes seeking to install rooftop solar must first receive a home energy assessment. The theory that follows is this: that the requirement is leading to more efficient homes – with lower total consumption and less opportunity for weatherization savings – taking part in the program. Unfortunately, the program data provided to the study did not include an indicator for the installation and/or presence of rooftop solar. Consequently, the study attempted to identify "solar" participants using the provided consumption data. Specifically, the study flagged any HES participants with negative electricity consumption during the summer months as "solar" customers since the consumption data strongly suggests residential solar power generation.[173] Figure 114 and Figure 115 show that, in general, participants with solar live in newer homes and consume less energy (natural gas in this context).

[173] It is possible some solar customers never generated sufficient solar power to exceed their household usage; such customers would not have been flagged by the study.

Figure 114: Home Age Accounting for the Likely Presence of Solar (Average Age/Participant - HES 2017-2019)

Figure 115: Pre-Program Natural Gas Consumption Accounting for the Likely Presence of Solar (HES 2017-2019)



D.5 About Using Multiple Impact Evaluation Methodologies

As noted in the Methodology section, the study team prefers billing analysis to report savings whenever possible. This is because billing analysis results – at appropriate level of specification – offer the most accurate assessment of program savings. This is largely due to billing analysis' inherent ability to account for the myriad of factors (installation quality, uninstallation rates, behavior changes, interactive effects, etc.) that influence realized savings.

Though it is the preferred approach, billing analysis does have limitations – it does not reliably estimate energy savings for measures that have small energy savings (i.e., less than 5% of consumption) or for measures with limited installation counts. The study team aggregated these smaller savings and less frequently installed measures to increase our chances of estimating savings via billing analysis, but none of the billing analysis specifications yielded statistically significant energy savings for these measures in the presence of weatherization (natural gas) and lighting (electric).

Therefore, the study team used two approaches to estimate per-unit savings estimates for these measures. First, the study *calculated* per-unit savings using the 19th edition PSD-prescribed algorithms. Second, for measures where the study identified either an input parameter or algorithm that could be updated to better align with industry best practice and best available data, the team also *evaluated* per-unit savings using updated parameters/algorithms.

As shown in Figure 116 and Figure 117, 82% of HES and 81% of HES-IE 2019 total ex ante annual savings (across all fuel types) were estimated through billing analysis, either directly or indirectly. Conversely, measures where the study used an engineering approach, collectively constitute 18% for HES and 19% for HES-IE of total savings.

As documented throughout this report, the study used billing analysis to directly report savings for a given measure and fuel type – most notably for lighting for electricity (86% for HES, 84% for HES-IE) and weatherization (76% for HES, 73% for HES-IE) for natural gas heated homes. For similar measure powered by a delivered fuel, the study team leveraged the results of the billing analysis to estimate savings for delivered fuels (e.g., using the natural gas weatherization billing analysis-based savings to report savings for weatherized oil and propane heated homes). In these cross-fuel uses of billing analysis results, the study team accounted for differences in space heating equipment efficiencies across fuel types. This cross-fuel, billing analysis-informed approach, referred to as Billing Analysis Informed savings, allowed the study to realize the benefits of billing analysis results for more measures, most notably for delivered fuel measure as they reflect a large portion of total program savings and where the team did not have access to participant's consumption history.

Figure 116: Total HES Savings by Evaluation Approach and Fuel (2019)

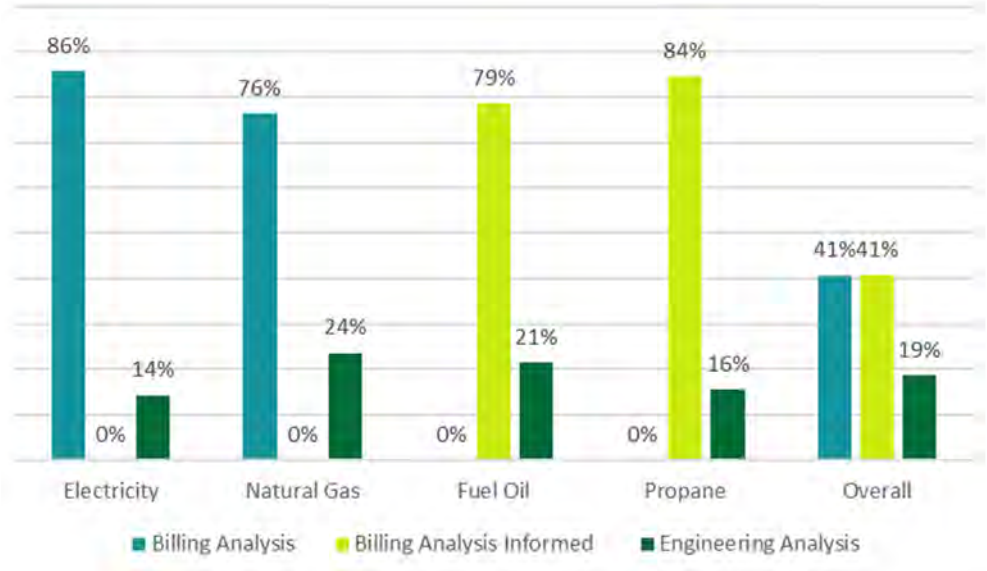
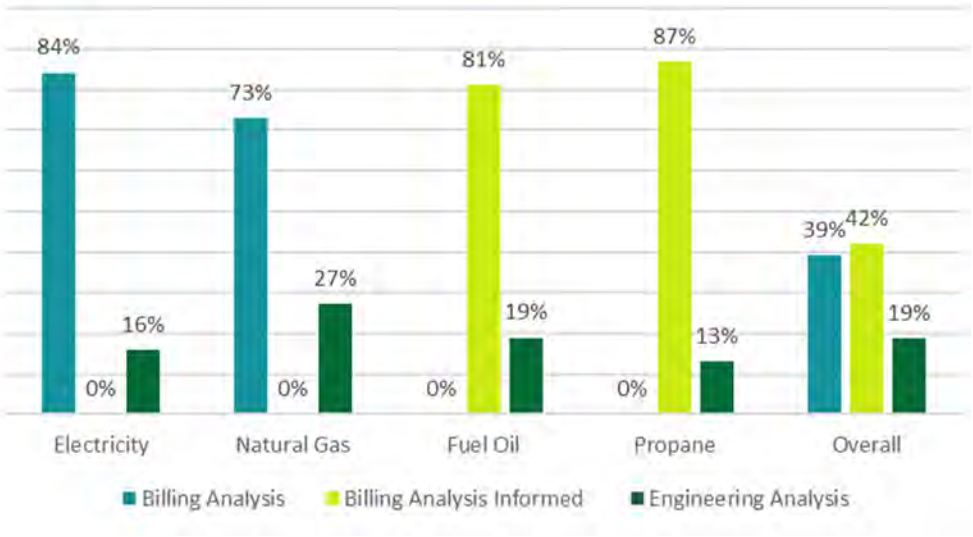


Figure 117: Total HES-IE Savings by Evaluation Approach and Fuel (2019)



D.6 About The Impact Evaluation Supporting Documentation Workbook

The Impact Evaluation Supporting Documentation workbook contains a full set of impact evaluation results as well as the body of information required to arrive at the results.

The workbook contains four sections:

1. The **Per Unit Savings** section summarizes the per-unit energy savings and realization rates for electric, natural gas, propane, and heating oil measures, which are linked to the Measure-Specific tabs where the detailed calculations occur. An example of this section is shown below:

Per-Unit Savings	
Tab Name	**Description**
Savings Summary	Provides a summary of engineering analysis savings results for measures included in scope of analysis.
Realization Rates	Provides a summary of the gross realization rates calculated as part of the engineering analysis.
Recommended PSD Updates	Provides a summary of the opportunities that the study identified to revise existing PSD measure algorithms and/or specific input parameters.
Gas Savings Reconciliation	Provides a reconciliation analysis between the natural gas billing analysis results (top down) and the engineering analysis results (bottom up).

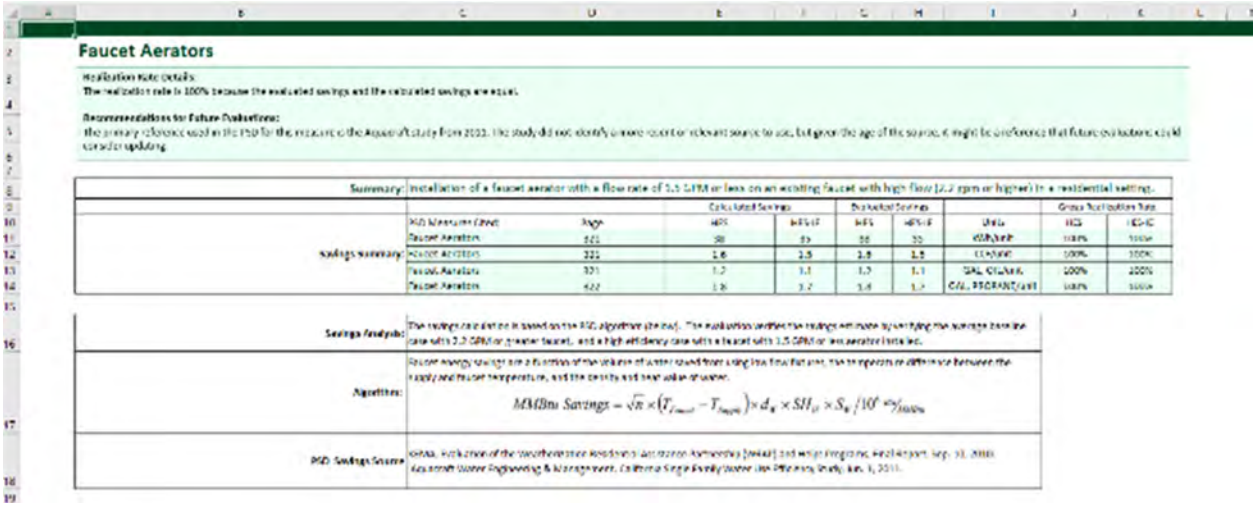
2. The **Background Material** section contains relevant results from other sections of the R1983 report, including ISR and NTG values and billing analysis results.

Background Material	
Tab Name	**Description**
Measure Scope Summary	Contains the list of measures included in the engineering analysis scope.
ISR_NTG	Includes the ISR and NTG results compiled by NMR (for full discussion of these metrics, refer to the final report).
Billing Analysis Results	Contains a summary of the billing analysis results (for full discussion of these results, refer to the final report).

3. The **Measure-Specific Calculations** section, which comprises the bulk of the workbook, documents the ex ante and ex post savings for each measure, as well as the detailed calculations behind the savings estimates. The study team used the algorithms documented in the current PSD as the basis for these calculations and integrated the billing analysis and building simulation results where relevant. Each measure is documented on its own tab and accessible via the Table of Contents shown below.

Measure-Specific Detailed Calculations	
Measure Group	**Measure**
Domestic Hot Water	Faucet Aerators
	Showerheads
	Pipe Insulation
Lighting	Lighting
Controls	WIFI Thermostat
Appliances and Electronics	Refrigerator
	Freezer
	Dehumidifier
	Clothes Washer
	Advanced Power Strip
Weatherization	Air Sealing - Blower Door
	Air Sealing - Prescriptive
	Insulation - Wall, Ceiling, Floor
Distribution	Duct Sealing
HVAC	Heat Pumps
	Heat Pumps - Ductless
	Furnaces
	Boilers
	ECM Circulator Pump
Windows	Windows

Below is an example of a measure-specific calculation tab, in this case faucet aerators. Each measure-specific calculation tab is structured the same: the text box at the top summarizes the realization rate details along with any recommendations for future evaluations (if identified), followed by a summary of the per unit savings results. Below that summary, the team included a synopsis of the savings approach, the PSD algorithm, and the PSD-supplied sources.



Each table also includes a detailed savings calculations section, which is show below, again, for faucet aerators. Data inputs are linked to the relevant tab within the Supporting Material section, and color coded for ease of reference.

KEY
Filled from audit data
Assumption
Calculation

	Calculated Savings Estimate		
Input	Input Values	Notes	Source
Faucet Baseline Flow	2.2		US EPA WaterSense High-Efficiency Lavato
Faucet Retrofit Flow	1.5		US EPA WaterSense High-Efficiency Lavato
Average Duration per Event (min)	0.6167		Aquacraft Water Engineering & Managem
Average Total No. of Faucets per Household, na	2.01	Using the value listed in Table 4-	Aquacraft Water Engineering & Managem
Median Number of Faucet Events per Day per Household, ne	13.8	Using the value listed in Table 4-	Aquacraft Water Engineering & Managem
Days/yr	365.00		Constant
Drain Factor	0.795		Illinois Statewide Technical Reference Mar
Number of Low-Flow Faucet Aerators Installed per HH, HES	1.9		ES 2019 Program Data
Number of Low-Flow Faucet Aerators Installed per HH, HES-IE	1.6		ES 2019 Program Data
Gallons of water saved per year per faucet aerator	860		Calculated
Annual Gallons Saved per HH, HES	1200		Calculated
Annual Gallons Saved per HH, HES-IE	1102		Calculated
Annual Gallons Saved per installed aerator, HES	617		Calculated
Annual Gallons Saved per installed aerator, HES-IE	731		Calculated
Faucet Temperature	80		CT PSD Table 4-WWWW (no reference liste
Cold water temperature	55.00		CT PSD Table 4-WWWW (no reference liste
Annual MMBtu Savings per HH, HES	0.25		Calculated
Annual MMBtu Savings per HH, HES-IE	0.23		Calculated
Gas water heater efficiency	0.78		Illinois Statewide Technical Reference Mar
Electric water heater efficiency	0.98		Illinois Statewide Technical Reference Mar
Oil Water Heater Efficiency	0.78		Illinois Statewide Technical Reference Mar

Each table also includes a notes section, which adds clarity and transparency to the calculation process.

Notes
According to the PSD calculation, the energy and water savings per aerator is based on the average number of aerators per household (2.01 aerators according to the PSD).
The savings per household associated with installing low-flow aerators is calculated by multiplying the total water savings per aerator by the square root of the number of installed low flow aerator based on the calculation presented in the PSD.
The team then calculated the energy and water savings per installed low-flow aerator by dividing the total energy and water saved per household by the number of low-flow aerators installed.

The team benchmarked the calculated savings per unit with other TRMs, and found that savings per unit were similar for other states in the region:
MA TRM: 43 kWh per unit, 0.21-0.22 MMBtu per unit fossil fuel savings
RI : 28 kWh per unit, 0.14-0.15 MMBtu per unit fossil fuel savings

4. The last section, the **Supporting Material** section, contains all relevant program data, secondary assumptions, and constants that the study used and are linked within the individual measure tabs for consistent calculations and ease of reference. These tabs also include the measure mapping that the study completed to categorize the Companies' raw data.

Supporting Material	
Tab Name	**Description**
Program Data Inputs	Contains descriptions and values for program data inputs.
Secondary Input Assumptions	Contains sources and descriptions of algorithm inputs.
Constants	Contains descriptions and values for engineering constants used in calculations within this workbook.
ES Measure Mapping	Contains the full measure name mapping between the raw ES data and the PSD measures, as well as the measure group categorization
UI Measure Mapping	Contains the full measure name mapping between the raw UI data and the PSD measures, as well as the measure group categorization

Appendix E Additional Customer Profile Findings

This appendix describes the analyses completed to examine the types of customers that participated and the extent of their participation in all of Connecticut's residential energy efficiency programs (downstream programs only) from 2017 through 2020. The profiling process consisted of four major steps:

1. Data preparation (described in Appendix A)
2. Calculation of participation metrics (described in Appendix A)
3. Single characteristic analyses
4. Multiple characteristic analyses
5. Outlier sensitivity analysis

The evaluation analyzed the IE and non-IE programs independently because they are administered separately and have different demographic targets and objectives.

E.2 Distribution of Savings

An initial assessment of the distribution of savings compared the proportion of households in areas with electric service and areas with gas service that are classified as low-income. For this study, low-income was defined as incomes less than or equal to 50% of the area median income. Table 62 shows these distributions. About one-fourth (27%) of households with electric service are classified as low-income, and about 30% of households with gas service are classified as low-income. The proportion of total savings from the income-eligible programs (Table 63) is approximately the same as the proportion of low-income households in both cases (33% for electric and 32% for gas). This pattern indicates that at the broadest level of analysis, savings from the energy efficiency programs are distributed commensurately with population distributions.

Table 62: Household Distributions by Income Level

Programs	Block Groups with Electric Service	Block Groups with Gas Service
Moderate or higher income	73%	70%
Low income	27%	30%

Table 63: Savings Distributions by Program Type

Programs	Electric Savings (kWh)	Gas Savings (CCF)	Electric Savings (%)	Gas Savings (%)
Non-Income-Eligible	125,814,158	7,106,794	67%	68%
Income-Eligible	61,294,181	3,413,870	33%	32%
Total	187,108,339	10,520,664	100%	100%

E.3 INCOME ELIGIBLE PROGRAMS ANALYSIS

E.3.1 Single Characteristic Analyses

This section examines participation rates in the IE programs based on single characteristics at a time.

E.3.1.1 Electric Savings Rate

Table 64 shows the pairwise correlation coefficients (Pearson's r) for the major demographic variables and electric savings rate for the IE programs. A full correlation matrix for all variables considered during the study is included in Section E.5.

The correlations indicate that IE program savings is positively correlated with all the examined variables. This means that areas with higher concentrations of English isolation, low incomes, moderate incomes, multifamily housing[174], renter-occupied housing, pre-1950 construction, or that were on the state distressed list sometime over the past three years tend to have higher levels of electric savings (relative to consumption) than areas with lower concentrations of those variables. Thus, overall, despite commonly acknowledged participation barriers, the electric IE energy efficiency programs have not been underdelivered to areas with high concentrations of equity-related demographics.

In contrast, areas with greater concentrations of high incomes or single-family housing tend to have lower electric savings from the IE programs than areas with lower concentrations of those variables.

Table 64: Pairwise Correlations – IE Programs, Electricity

	Electric Saving Rate
Limited English	0.268
Low income	0.363
Moderate income	0.056
Multifamily housing	0.384
Renter-occupied housing	0.355
Pre-1950 construction	0.072
Distressed last three years	0.242
High income	-0.317
Single-family	-0.343

All correlations are statistically different from 0 ($p<0.01$)

E.3.1.2 Gas Savings Rate

Table 65 shows the pairwise correlation coefficients (Pearson's r) for the major demographic variables and gas savings rate. A full correlation matrix for all variables considered during the study is included in Section E.5.

[174] Although statistically greater than zero, the correlation between moderate income and electric savings rate is low.

The correlations indicate that IE program savings is positively correlated with all the examined variables. This means that areas with higher concentrations of English isolation, low incomes, moderate incomes, multifamily housing[175], renter-occupied housing, or that were on the state distressed list sometime over the past three years tend to have higher levels of gas savings (relative to consumption) than areas with lower concentrations of those variables. Thus, overall, despite commonly acknowledged participation barriers, the electric IE energy efficiency programs have not been underdelivered to areas with high concentrations of equity-related demographics.

In contrast, areas with greater concentrations of high incomes or single-family housing tend to have lower gas savings from the IE programs than areas with lower concentrations of those variables.

Table 65: Pairwise Correlations – IE Programs, Gas

	Gas Saving Rate
Limited English	0.169
Low income	0.236
Moderate income	0.077
Multifamily housing	0.242
Renter-occupied housing	0.224
Pre-1950 construction	0.029
Distressed last three years	0.155
High income	-0.231
Single-family	-0.223

All correlations are statistically different from 0 ($p<0.01$), except pre-1950 construction which is not statistically different from 0.

E.3.1.3 Correlations Between Demographic Variables

Table 66 shows the correlations between the demographics variables. It demonstrates that the listed demographic variables tend to occur together in the same areas. In other words, areas with high concentrations of multifamily units also tend to have high concentrations of renter-occupied households, low-income households, and households with limited English proficiency, and to have been on the distressed community list in the previous three years.

High income and single-family are correlated with each other, which means they tend to occur in the same areas. However, they are each negatively correlated with the other variables, which means they tend to be mutually exclusive of those characteristics. In other words, areas that tend to have high incomes or high concentrations of single-family housing, tend to have low concentrations of low-income households, multifamily housing, or renters.

[175] Although statistically greater than zero, the correlation between moderate income and electric savings rate is low.

Table 66: Pairwise Correlations – Demographics

	Limited English	Low income	Moderate income	Multifamily housing	Renter-occupied housing	Pre-1950 construction	Distressed last three years	High income	Single-family
Limited English	1.000	0.582	0.106	0.371	0.569	0.308	0.363	-0.512	-0.562
Low income	0.582	1.000	0.099	0.526	0.788	0.464	0.504	-0.822	-0.779
Moderate income	0.106	0.099	1.000	0.152	0.252	0.186	0.328	-0.468	-0.261
Multifamily housing	0.371	0.526	0.152	1.000	0.724	0.103	0.256	-0.494	-0.763
Renter-occupied housing	0.569	0.788	0.252	0.724	1.000	0.480	0.451	-0.742	-0.931
Construction year pre-1950	0.308	0.464	0.186	0.103	0.480	1.000	0.387	-0.451	-0.468
Distressed last three years	0.363	0.504	0.328	0.256	0.451	0.387	1.000	-0.575	-0.471
High income	-0.512	-0.822	-0.468	-0.494	-0.742	-0.451	-0.575	1.000	0.752
Single family	-0.562	-0.779	-0.261	-0.763	-0.931	-0.468	-0.471	0.752	1.000

All correlations are statistically different from 0 ($p<0.01$)

E.3.2 Multiple Characteristic Analyses

This section presents several approaches to analyzing IE program participation while taking multiple characteristics into account.

E.3.2.1 Regression Modeling

The evaluation ran a series of regression models to identify whether any of the simultaneously occurring demographics variables was more strongly related to electric or gas savings rates than the others.

None of the demographics variables appears to be more important than the others when it comes to IE program electric savings. For the IE program electric savings, each demographic variable retained a statistically significant relationship with savings rate, even after controlling for the effects of the other variables. Table 67 shows the results of four different regression models used to test the mediation of the demographics variables through multifamily concentration.

Table 67: IE Electric Savings Rates Regression Models

Model	Descriptive Variable	Coefficients	p-value
1	Intercept	-0.001	0.076
	Renter-occupied housing	0.013	0.000
	Multifamily housing	0.030	0.000
2	Intercept	-0.003	0.000
	Low income	0.025	0.000
	Multifamily housing	0.030	0.000
3	Intercept	0.000	0.388
	Distressed 2018, 2019, or 2020	0.008	0.000
	Multifamily housing	0.038	0.000
4	Intercept	0.000	0.651
	Limited English Proficiency	0.041	0.000
	Multifamily housing	0.037	0.000

None of the demographics variables appears to be more important than the others when it comes to IE program gas savings. For the IE program gas savings, each demographic variable retained a statistically significant relationship with savings rate, even after controlling for the effects of the other variables. Table 68 shows the results of four different regression models used to test the mediation of the demographics variables through multifamily concentration.

Table 68: IE Gas Savings Rates Regression Models

Model	Descriptive Variable	Coefficients	p-value
5	Intercept	0.001	0.582
	Renter-occupied housing	0.015	0.000
	Multifamily housing	0.031	0.007
6	Intercept	-0.003	0.074
	Low income	0.029	0.000
	Multifamily housing	0.032	0.003
7	Intercept	0.001	0.582
	Distressed 2018, 2019, or 2020	0.009	0.000
	Multifamily housing	0.041	0.000
8	Intercept	0.002	0.106
	Limited English Proficiency	0.047	0.000
	Multifamily housing	0.039	0.000

E.3.2.2 Savings Distribution

Because IE program electric and gas savings were negatively correlated with single-family housing, it is possible that the programs could be under-reaching low-income families in single-family housing. However, the demographic correlations (Table 66) demonstrate that low-income families tend to live in multifamily rather than single-family housing. Thus, the negative correlation between IE program savings and single-family could be due to other variables. To assess how well the programs are serving low-income customers living in single-family homes, the evaluation compared the distribution of households and the distribution of IE program savings in block groups that had high and low concentrations of low-income and high and low concentrations of single-family housing. The determination of high and low concentrations was based on a median-split of the percentage of households in the block group with either low income or in single-family housing. Thus, block groups that are in the low-low category have median or less percentage low-income homes and median or less percentage of single-family homes.[176]

Table 69 shows the distributions of households and IE program electric savings across the low-income and single-family dimensions. These results show that IE program electric savings are disproportionately concentrated in low-income, multifamily areas. Approximately 41% of households are in these areas, while 72% of IE program electric savings occur in these areas. The other three combinations have lesser proportions of savings than households. The high-income, single-family areas are especially disproportionately low on savings, but this is not a

[176] It should be noted that this is a geographic analysis rather than a household-level analysis. These analyses reveal information about groups of homes that might not be true for any specific home. For example, 6% of IE program electric savings occurred in block groups that have relative high concentrations of low income and single family homes. However, we cannot say with certainty that the participation in those areas occurred in *homes* that are low-income or single-family.

major issue for an income-eligible program. It does appear that low-income, single-family areas are somewhat underserved: 9% of households are in these areas while only 6% of the electric savings occur there.

Table 69: IE Electric Savings Distributions

Label	Concentration of Low-income homes	Concentration of Single-family homes	% of Households	% of IE electric savings
High-income, multifamily	Low	Low	11%	7%
High-income, single-family	Low	High	39%	14%
Low-income, multifamily	High	Low	41%	72%
Low-income, single-family	High	High	9%	6%

Table 70 shows the distributions of households and IE program gas savings across the low-income and single-family dimensions. These results show that IE program gas savings are also disproportionately concentrated in low-income, multifamily areas. Approximately 41% of households are in these areas, while 70% of IE program gas savings occur in these areas. High-income areas have lesser proportions of savings than households, particularly the high-income, single-family areas, but this is not a major issue for an income-eligible program. For gas savings, low-income, single-family areas appear to be receiving savings commensurate with their proportion of the household population: 9% of households are in these areas and 10% of the gas savings occur there.

Table 70: IE Gas Savings Distributions

Label	Concentration of Low-income homes	Concentration of Single-family homes	% of Households	% of IE gas savings
High-income, multifamily	Low	Low	11%	7%
High-income, single-family	Low	High	39%	13%
Low-income, multifamily	High	Low	41%	70%
Low-income, single-family	High	High	9%	10%

E.3.3 IE Programs Outlier Sensitivity Analysis

The large savings outliers do not have a substantial effect on the relationship between IE program savings rates and the demographics variables. Table 71 shows the correlations for electric and gas savings rates and the demographics variables when the outliers are removed from the analysis. All correlations are in the same direction and of similar magnitude as the correlations when the outliers are included in the analysis.

Table 71: IE Program Correlations – Outliers Removed

	IE Electric	IE Gas
Limited English	0.316	0.247
Low income	0.456	0.39
Moderate income	0.172	0.19
Multifamily housing	0.299	0.084
Renter-occupied housing	0.412	0.264
Pre-1950 construction	0.239	0.299
Distressed last three years	0.382	0.438
High income	-0.457	-0.391
Single-family	-0.408	-0.214

All correlations are statistically different from 0 ($p<0.01$)

E.4 Non-Income Eligible Programs Analysis

E.4.1 Single Characteristic Analyses

This section examines participation rates in the Non-IE programs based on single characteristics at a time.

E.4.1.1 Electric Savings Rate

Table 72 shows the pairwise correlation coefficients (Pearson's r) for the major demographic variables and electric savings rate for the Non-IE programs. A full correlation matrix for all variables considered during the study is included in Section E.5.

Non-IE electric program savings are negatively correlated with all the examined variables except for multifamily housing and renter-occupied housing. Negative correlations indicate that areas with high concentrations of these variables tend to have lower electric savings rates in the non-IE programs. This pattern suggests that for the most part, the commonly acknowledged participation barriers among areas with equity-related demographics are affecting the non-IE programs.

One exception is multifamily housing, where the positive correlation indicates that areas with high concentrations of multifamily housing tend to have higher savings rates. The other exception is renter-occupied housing, where there is no detectable relationship between the concentration of renters and electric savings rates.

Two caveats should be noted. First, not all variables represent an underlying driver. Later analyses will attempt to identify if any of these variables is more strongly related to savings rates than the others. Second, the non-IE programs are not designed to serve the equity-related populations. That is what the IE programs are designed to do. While most of the correlations for the non-IE programs are negative, they are weak correlations that do not indicate particularly strong relationships. Thus, the non-IE programs are only slightly underserving these areas, despite program goals and design that does not focus on serving these areas.

Table 72: Pairwise Correlations – Non-IE Programs, Electricity

	Electric Saving Rate
Limited English	-0.063
Low income	-0.076
Moderate income	-0.044
Multifamily housing	0.103
Renter-occupied housing	-0.005
Pre-1950 construction	-0.085
Distressed last three years	-0.094
High income	0.054
Single-family	0.002

All correlations are statistically different from 0 ($p<0.01$), except renter-occupied housing and single-family which are not statistically different from 0.

E.4.1.2 Gas Savings Rate

Table 73 shows the pairwise correlation coefficients (Pearson's r) for the major demographic variables and electric savings rate for the Non-IE programs. A full correlation matrix for all variables considered during the study is included in Section E.5.

Non-IE gas program savings are negatively correlated with all the examined variables except for multifamily housing. Negative correlations indicate that areas with high concentrations of these variables tend to have lower electric savings rates in the non-IE programs. This pattern suggests that for the most part, the commonly acknowledged participation barriers among areas with equity-related demographics are affecting the non-IE programs. The exception is multifamily housing, where there is no detectable relationship between the concentration of renters and electric savings rates.

In contrast, areas with high incomes and high concentrations of single-family housing tend to have higher gas savings rates through the non-IE programs.

Two caveats should be noted. First, not all variables represent an underlying driver. Later analyses will attempt to identify if any of these variables is more strongly related to savings rates than the others. Second, the non-IE programs are not designed to serve the equity-related populations. That is what the IE programs are designed to do. While the majority of the correlations for the non-IE programs are negative, they are weak correlations that do not indicate particularly strong relationships. Thus, the non-IE programs are only slightly underserving these areas, despite program goals and design that does not focus on serving these areas.

Table 73: Pairwise Correlations – Non-IE Programs, Gas

	Gas Saving Rate
Limited English	-0.116
Low income	-0.166
Moderate income	-0.049
Multifamily housing	-0.013

	Gas Saving Rate
Renter-occupied housing	-0.132
Pre-1950 construction	-0.159
Distressed last three years	-0.182
High income	0.149
Single-family	0.128

All correlations are statistically different from 0 ($p<0.01$), except Multifamily housing which is not statistically different from 0.

E.4.1.3 Correlations Between Demographic Variables

Table 66 (see previous section) shows the correlations between the demographic variables. It demonstrates that the listed demographic variables tend to occur together in the same areas. In other words, areas with high concentrations of multifamily units also tend to have high concentrations of renter-occupied households, low-income households, and households with limited English proficiency, and to have been on the distressed community list in the previous three years.

E.4.2 Multiple Characteristic Analysis

This section presents several approaches to analyzing IE program participation while taking multiple characteristics into account. The evaluation only ran the multiple regression analyses on the non-IE program savings rates.

The evaluation ran a series of regression models to identify whether any of the simultaneously occurring demographics variables was more strongly related to electric or gas savings rates than the others.

None of the demographics variables appears to be more important than the others when it comes to Non-IE program electric savings. For the Non-IE program electric savings, each demographic variable retained a statistically significant relationship with savings rate, even after controlling for the effects of the other variables. Table 74 shows the results of four different regression models used to test the mediation of the demographics variables through multifamily concentration.

Table 74: Non-IE Electric Savings Rates Regression Models

Model	Descriptive Variable	Coefficients	p-value
9	Intercept	0.012	0.000
	Renter-occupied housing	-0.014	0.000
	Multifamily housing	0.025	0.001
10	Intercept	0.014	0.000
	Low income	-0.020	0.000
	Multifamily housing	0.022	0.002
11	Intercept	0.011	0.000
	Distressed 2018, 2019, or 2020	-0.006	0.000
	Multifamily housing	0.015	0.008
12	Intercept	0.011	0.000
	Limited English Proficiency	-0.033	0.000
	Multifamily housing	0.016	0.008

None of the demographics variables appears to be more important than the others when it comes to Non-IE program gas savings. For the Non-IE program gas savings, each demographic variable retained a statistically significant relationship with savings rate, even after controlling for the effects of the other variables. Table 75 shows the results of four different regression models used to test the mediation of the demographics variables through multifamily concentration.

Table 75: Non-IE Gas Savings Rates Regression Models

Model	Descriptive Variable	Coefficients	p-value
13	Intercept	0.030	0.000
	Renter-occupied housing	-0.023	0.000
	Multifamily housing	0.020	0.003
14	Intercept	0.031	0.000
	Low income	-0.028	0.000
	Multifamily housing	0.012	0.076
15	Intercept	0.029	0.000
	Distressed 2018, 2019, or 2020	-0.011	0.000
	Multifamily housing	0.003	0.617
16	Intercept	0.027	0.000
	Limited English Proficiency	-0.041	0.000
	Multifamily housing	0.004	0.519

E.4.3 Non-IE Programs Outlier Sensitivity Analysis

The large savings outliers have a substantial effect on electric and gas savings in the Non-IE programs. Table 76 shows the correlations for electric and gas savings rates and the demographics variables when the outliers are removed from the analysis. The savings are all in the same direction as when the outliers are included but are much stronger. Negative correlations are more negative, and the positive correlations are more positive. This indicates that to the extent the Non-IE programs are reaching areas with high concentrations of equity-related demographics, they are doing so via the outliers. The outliers are predominantly large multifamily properties, so when the Non-IE programs tended to reach the equity-related areas via multifamily installations.

Table 76: Non-IE Program Correlations – Outliers Removed

	Non-IE Electric	Non-IE Gas
Limited English	-0.315	-0.229
Low income	-0.403	-0.303
Moderate income	-0.122	-0.087
Multifamily housing	-0.284	-0.209
Renter-occupied housing	-0.407	-0.325
Pre-1950 construction	-0.256	-0.202
Distressed last three years	-0.296	-0.21
High income	0.704	0.503
Single-family	0.757	0.575

All correlations are statistically different from 0 ($p<0.01$)

E.5 FULL CORRELATION MATRICES

This appendix shows the correlation of all variables with electric and gas participation rates. The large, multifamily outliers are *included* in these correlations. Shaded cells are statistically significantly different from zero at a 99% confidence level (p<0.01).

Table 77: Full Electric Correlation Matrix – IE Programs

	Location-level participation	Savings participation rate	Urban PA households ratio	Rural PA households ratio	Without internet	With internet	Limited English	Low income	Moderate income	Middle income	High income	Public assistance	Less than high school	High school	Less than bachelors	Bachelors	Advanced degree	Age 65 or older	Single Family housing	Duplex, triplex, fourplex housing	Multifamily housing	Mobile home	Renter-occupied housing	Construction year pre-1950	Construction year post-1950	Heating, Utility Gas	Heating, Electricity	Heating, Oil and Kerosene	Heating, Solar	Heating, Other Fuel	Total years on Distressed List	Distressed last three years
Location-level participation	1.000	0.259	0.172	-0.172	0.273	-0.273	0.160	0.295	0.216	0.046	-0.372	0.327	0.317	0.327	0.114	-0.388	-0.381	-0.064	-0.195	0.275	0.026	-0.015	0.190	0.200	-0.200	0.249	0.016	-0.211	0.033	-0.201	0.377	0.358
Savings participation rate	0.259	1.000	0.119	-0.119	0.352	-0.352	0.268	0.363	0.056	-0.076	-0.317	0.393	0.322	0.172	-0.025	-0.243	-0.230	-0.042	-0.343	0.141	0.384	-0.026	0.355	0.072	-0.072	0.121	0.274	-0.245	0.001	-0.127	0.262	0.242
Urban PA households ratio	0.172	0.119	1.000	-1.000	0.156	-0.156	0.230	0.248	0.067	-0.065	-0.223	0.222	0.196	0.080	-0.110	-0.096	-0.086	-0.118	-0.315	0.253	0.244	-0.097	0.279	0.195	-0.195	0.494	0.148	-0.422	-0.032	-0.595	0.232	0.226
Rural PA households ratio	-0.172	-0.119	-1.000	1.000	-0.156	0.156	-0.230	-0.248	-0.067	0.065	0.223	-0.222	-0.196	-0.080	0.110	0.096	0.086	0.118	0.315	-0.253	-0.244	0.097	-0.279	-0.195	0.195	-0.494	-0.148	0.422	0.032	0.595	-0.232	-0.226
Without internet	0.273	0.352	0.156	-0.156	1.000	-1.000	0.441	0.569	0.219	-0.090	-0.562	0.624	0.563	0.429	-0.022	-0.513	-0.488	0.025	-0.531	0.409	0.396	0.024	0.538	0.297	-0.297	0.238	0.282	-0.358	-0.032	-0.174	0.432	0.407
With internet	-0.273	-0.352	-0.156	0.156	-1.000	1.000	-0.441	-0.569	-0.219	0.090	0.562	-0.624	-0.563	-0.429	0.022	0.513	0.488	-0.025	0.531	-0.409	-0.396	-0.024	-0.538	-0.297	0.297	-0.238	-0.282	0.358	0.032	0.174	-0.432	-0.407
Limited English	0.160	0.268	0.230	-0.230	0.441	-0.441	1.000	0.582	0.106	-0.129	-0.512	0.546	0.668	0.261	-0.186	-0.394	-0.366	-0.251	-0.562	0.494	0.371	-0.054	0.569	0.308	-0.308	0.356	0.260	-0.446	-0.037	-0.256	0.392	0.363
Low income	0.295	0.363	0.248	-0.248	0.569	-0.569	0.582	1.000	0.099	-0.278	-0.822	0.749	0.664	0.439	-0.090	-0.547	-0.501	-0.300	-0.779	0.665	0.526	-0.023	0.788	0.464	-0.464	0.384	0.405	-0.554	-0.042	-0.269	0.535	0.504
Moderate income	0.216	0.056	0.067	-0.067	0.219	-0.219	0.106	0.099	1.000	-0.046	-0.468	0.216	0.207	0.322	0.106	-0.320	-0.338	-0.123	-0.261	0.239	0.152	0.036	0.252	0.186	-0.186	0.119	0.153	-0.183	0.066	-0.101	0.327	0.328
Middle income	0.046	-0.076	-0.065	0.065	-0.090	0.090	-0.129	-0.278	-0.046	1.000	-0.163	-0.201	-0.151	0.142	0.209	-0.091	-0.113	0.052	0.129	-0.108	-0.096	0.048	-0.162	-0.097	0.097	-0.105	-0.040	0.112	-0.011	0.071	-0.031	-0.026
High income	-0.372	-0.317	-0.223	0.223	-0.562	0.562	-0.512	-0.822	-0.468	-0.163	1.000	-0.676	-0.617	-0.586	-0.051	0.661	0.636	0.297	0.752	-0.649	-0.494	-0.015	-0.742	-0.451	0.451	-0.349	-0.409	0.525	0.016	0.252	-0.600	-0.575
Public assistance	0.327	0.393	0.222	-0.222	0.624	-0.624	0.546	0.749	0.216	-0.201	-0.676	1.000	0.691	0.462	-0.070	-0.575	-0.540	-0.295	-0.684	0.593	0.455	-0.032	0.721	0.444	-0.444	0.360	0.285	-0.465	-0.026	-0.253	0.586	0.543
Less than high school	0.317	0.322	0.196	-0.196	0.563	-0.563	0.668	0.664	0.207	-0.151	-0.617	0.691	1.000	0.329	-0.191	-0.582	-0.551	-0.226	-0.589	0.548	0.353	-0.020	0.599	0.394	-0.394	0.334	0.245	-0.422	-0.033	-0.231	0.522	0.491
High school	0.327	0.172	0.080	-0.080	0.429	-0.429	0.261	0.439	0.322	0.142	-0.586	0.462	0.329	1.000	-0.069	-0.718	-0.729	-0.116	-0.354	0.397	0.133	0.065	0.342	0.216	-0.216	0.151	0.115	-0.201	-0.005	-0.082	0.480	0.476
Less than bachelors	0.114	-0.025	-0.110	0.110	-0.022	0.022	-0.186	-0.090	0.106	0.209	-0.051	-0.070	-0.191	-0.069	1.000	-0.291	-0.249	0.045	0.116	-0.080	-0.102	0.032	-0.114	-0.081	0.081	-0.141	-0.028	0.133	0.032	0.101	0.002	0.014
Bachelors	-0.388	-0.243	-0.096	0.096	-0.513	0.513	-0.394	-0.547	-0.320	-0.091	0.661	-0.575	-0.582	-0.718	-0.291	1.000	0.594	0.134	0.463	-0.471	-0.229	-0.042	-0.459	-0.304	0.304	-0.213	-0.183	0.290	0.011	0.130	-0.549	-0.535
Advanced degree	-0.381	-0.230	-0.086	0.086	-0.488	0.488	-0.366	-0.501	-0.338	-0.113	0.636	-0.540	-0.551	-0.729	-0.249	0.594	1.000	0.173	0.392	-0.431	-0.161	-0.044	-0.392	-0.239	0.239	-0.152	-0.149	0.218	-0.002	0.092	-0.494	-0.486
Age 65 or older	-0.064	-0.042	-0.118	0.118	0.025	-0.025	-0.251	-0.300	-0.123	0.052	0.297	-0.295	-0.226	-0.116	0.045	0.134	0.173	1.000	0.335	-0.367	-0.158	0.084	-0.377	-0.291	0.291	-0.210	-0.075	0.220	0.011	0.148	-0.256	-0.237
Single Family housing	-0.195	-0.343	-0.315	0.315	-0.531	0.531	-0.562	-0.779	-0.261	0.129	0.752	-0.684	-0.589	-0.354	0.116	0.463	0.392	0.335	1.000	-0.757	-0.763	-0.016	-0.931	-0.468	0.468	-0.441	-0.557	0.684	0.039	0.324	-0.513	-0.471
Duplex, triplex, fourplex housing	0.275	0.141	0.253	-0.253	0.409	-0.409	0.494	0.665	0.239	-0.108	-0.649	0.593	0.548	0.397	-0.080	-0.471	-0.431	-0.367	-0.757	1.000	0.169	-0.071	0.704	0.629	-0.629	0.446	0.207	-0.502	-0.037	-0.286	0.502	0.465
Multifamily housing	0.026	0.384	0.244	-0.244	0.396	-0.396	0.371	0.526	0.152	-0.096	-0.494	0.455	0.353	0.133	-0.102	-0.229	-0.161	-0.158	-0.763	0.169	1.000	-0.070	0.724	0.103	-0.103	0.245	0.644	-0.549	-0.022	-0.252	0.284	0.256
Mobile home	-0.015	-0.026	-0.097	0.097	0.024	-0.024	-0.054	-0.023	0.036	0.048	-0.015	-0.032	-0.020	0.065	0.032	-0.042	-0.044	0.084	-0.016	-0.071	-0.070	1.000	-0.069	-0.100	0.100	-0.111	-0.036	0.055	-0.002	0.264	-0.021	-0.012
Renter-occupied housing	0.190	0.355	0.279	-0.279	0.538	-0.538	0.569	0.788	0.252	-0.162	-0.742	0.721	0.599	0.342	-0.114	-0.459	-0.392	-0.377	-0.931	0.704	0.724	-0.069	1.000	0.480	-0.480	0.411	0.540	-0.647	-0.033	-0.310	0.496	0.451
Construction year pre-1950	0.200	0.072	0.195	-0.195	0.297	-0.297	0.308	0.464	0.186	-0.097	-0.451	0.444	0.394	0.216	-0.081	-0.304	-0.239	-0.291	-0.468	0.629	0.103	-0.100	0.480	1.000	-1.000	0.407	0.004	-0.365	-0.002	-0.222	0.415	0.387
Construction year post-1950	-0.200	-0.072	-0.195	0.195	-0.297	0.297	-0.308	-0.464	-0.186	0.097	0.451	-0.444	-0.394	-0.216	0.081	0.304	0.239	0.291	0.468	-0.629	-0.103	0.100	-0.480	-1.000	1.000	-0.407	-0.004	0.365	0.002	0.222	-0.415	-0.387
Heating, Utility Gas	0.249	0.121	0.494	-0.494	0.238	-0.238	0.356	0.384	0.119	-0.105	-0.349	0.360	0.334	0.151	-0.141	-0.213	-0.152	-0.210	-0.441	0.446	0.245	-0.111	0.411	0.407	-0.407	1.000	-0.091	-0.829	-0.026	-0.576	0.354	0.363
Heating, Electricity	0.016	0.274	0.148	-0.148	0.282	-0.282	0.260	0.405	0.153	-0.040	-0.409	0.285	0.245	0.115	-0.028	-0.183	-0.149	-0.075	-0.557	0.207	0.644	-0.036	0.540	0.004	-0.004	-0.091	1.000	-0.423	-0.019	-0.160	0.160	0.133
Heating, Oil and Kerosene	-0.211	-0.245	-0.422	0.422	-0.358	0.358	-0.446	-0.554	-0.183	0.112	0.525	-0.465	-0.422	-0.201	0.133	0.290	0.218	0.220	0.684	-0.502	-0.549	0.055	-0.647	-0.365	0.365	-0.829	-0.423	1.000	0.006	0.390	-0.381	-0.376
Heating, Solar	0.033	0.001	-0.032	0.032	-0.032	0.032	-0.037	-0.042	0.066	-0.011	0.016	-0.026	-0.033	-0.005	0.032	0.011	-0.002	0.011	0.039	-0.037	-0.022	-0.002	-0.033	-0.002	0.002	-0.026	-0.019	0.006	1.000	0.017	-0.004	-0.008
Heating, Other Fuel	-0.201	-0.127	-0.595	0.595	-0.174	0.174	-0.256	-0.269	-0.101	0.071	0.252	-0.253	-0.231	-0.082	0.101	0.130	0.092	0.148	0.324	-0.286	-0.252	0.264	-0.310	-0.222	0.222	-0.576	-0.160	0.390	0.017	1.000	-0.274	-0.271
Total years on Distressed List	0.377	0.262	0.232	-0.232	0.432	-0.432	0.392	0.535	0.327	-0.031	-0.600	0.586	0.522	0.480	0.002	-0.549	-0.494	-0.256	-0.513	0.502	0.284	-0.021	0.496	0.415	-0.415	0.354	0.160	-0.381	-0.004	-0.274	1.000	0.944
Distressed last three years	0.358	0.242	0.226	-0.226	0.407	-0.407	0.363	0.504	0.328	-0.026	-0.575	0.543	0.491	0.476	0.014	-0.535	-0.486	-0.237	-0.471	0.465	0.256	-0.012	0.451	0.387	-0.387	0.363	0.133	-0.376	-0.008	-0.271	0.944	1.000

Table 78: Full Gas Correlation Matrix – IE Programs

	Location-level participation	Savings rate participation	Urban PA households ratio	Rural PA households ratio	Without internet	With internet	Limited English	Low income	Moderate income	Middle income	High income	Public assistance	Less than high school	High school	Less than bachelors	Bachelors	Advanced degree	Age 65 or older	Single Family housing	Duplex, triplex, fourplex housing	Multifamily housing	Mobile home	Renter-occupied housing	Construction year pre-1950	Construction year post-1950	Heating, Utility Gas	Heating, Electricity	Heating, Oil and Kerosene	Heating, Solar	Heating, Other Fuel	Total years on Distressed List	Distressed last three years
Location-level participation	1.000	0.321	0.093	-0.093	0.325	-0.325	0.187	0.347	0.191	0.009	-0.407	0.354	0.349	0.323	0.111	-0.411	-0.403	-0.088	-0.237	0.273	0.077	-0.024	0.226	0.210	-0.210	0.102	0.112	-0.152	0.041	-0.144	0.405	0.386
Savings rate participation	0.321	1.000	0.045	-0.045	0.193	-0.193	0.169	0.236	0.077	-0.051	-0.231	0.221	0.208	0.154	-0.029	-0.180	-0.181	-0.077	-0.223	0.086	0.242	-0.025	0.224	0.029	-0.029	-0.006	0.197	-0.121	0.003	-0.049	0.168	0.155
Urban PA households ratio	0.093	0.045	1.000	-1.000	0.088	-0.088	0.087	0.125	0.075	0.014	-0.153	0.109	0.101	0.091	-0.006	-0.088	-0.115	-0.073	-0.132	0.119	0.086	-0.100	0.123	0.133	-0.133	0.182	0.057	-0.163	0.001	-0.283	0.101	0.106
Rural PA households ratio	-0.093	-0.045	-1.000	1.000	-0.088	0.088	-0.087	-0.125	-0.075	-0.014	0.153	-0.109	-0.101	-0.091	0.006	0.088	0.115	0.073	0.132	-0.119	-0.086	0.100	-0.123	-0.133	0.133	-0.182	-0.057	0.163	-0.001	0.283	-0.101	-0.106
Without internet	0.325	0.193	0.088	-0.088	1.000	-1.000	0.420	0.552	0.168	-0.112	-0.538	0.615	0.546	0.414	-0.036	-0.512	-0.483	0.038	-0.495	0.373	0.351	0.010	0.506	0.275	-0.275	0.124	0.268	-0.286	-0.036	-0.128	0.403	0.377
With internet	-0.325	-0.193	-0.088	0.088	-1.000	1.000	-0.420	-0.552	-0.168	0.112	0.538	-0.615	-0.546	-0.414	0.036	0.512	0.483	-0.038	0.495	-0.373	-0.351	-0.010	-0.506	-0.275	0.275	-0.124	-0.268	0.286	0.036	0.128	-0.403	-0.377
Limited English	0.187	0.169	0.087	-0.087	0.420	-0.420	1.000	0.558	0.082	-0.134	-0.499	0.512	0.657	0.251	-0.191	-0.399	-0.375	-0.254	-0.532	0.466	0.319	-0.048	0.539	0.287	-0.287	0.242	0.254	-0.390	-0.037	-0.159	0.346	0.316
Low income	0.347	0.236	0.125	-0.125	0.552	-0.552	0.558	1.000	0.056	-0.317	-0.823	0.741	0.659	0.435	-0.090	-0.564	-0.519	-0.326	-0.764	0.646	0.476	-0.033	0.775	0.447	-0.447	0.258	0.390	-0.500	-0.040	-0.173	0.507	0.476
Moderate income	0.191	0.077	0.075	-0.075	0.168	-0.168	0.082	0.056	1.000	-0.060	-0.435	0.189	0.174	0.299	0.101	-0.296	-0.317	-0.146	-0.229	0.216	0.117	0.011	0.224	0.163	-0.163	0.039	0.135	-0.113	0.063	-0.105	0.302	0.301
Middle income	0.009	-0.051	0.014	-0.014	-0.112	0.112	-0.134	-0.317	-0.060	1.000	-0.115	-0.229	-0.175	0.112	0.180	-0.043	-0.074	0.074	0.142	-0.119	-0.098	0.072	-0.179	-0.108	0.108	-0.103	-0.046	0.127	-0.002	0.052	-0.050	-0.042
High income	-0.407	-0.231	-0.153	0.153	-0.538	0.538	-0.499	-0.823	-0.435	-0.115	1.000	-0.672	-0.613	-0.580	-0.035	0.669	0.649	0.333	0.748	-0.642	-0.452	-0.005	-0.741	-0.439	0.439	-0.213	-0.401	0.459	0.013	0.182	-0.577	-0.551
Public assistance	0.354	0.221	0.109	-0.109	0.615	-0.615	0.512	0.741	0.189	-0.229	-0.672	1.000	0.676	0.463	-0.069	-0.595	-0.554	-0.301	-0.660	0.568	0.403	-0.034	0.699	0.432	-0.432	0.254	0.269	-0.412	-0.023	-0.170	0.563	0.522
Less than high school	0.349	0.208	0.101	-0.101	0.546	-0.546	0.657	0.659	0.174	-0.175	-0.613	0.676	1.000	0.302	-0.198	-0.593	-0.559	-0.230	-0.567	0.533	0.301	-0.033	0.575	0.379	-0.379	0.246	0.236	-0.378	-0.048	-0.176	0.491	0.460
High school	0.323	0.154	0.091	-0.091	0.414	-0.414	0.251	0.435	0.299	0.112	-0.580	0.463	0.302	1.000	-0.099	-0.704	-0.730	-0.118	-0.335	0.399	0.086	0.060	0.328	0.202	-0.202	0.071	0.102	-0.129	0.000	-0.069	0.464	0.466
Less than bachelors	0.111	-0.029	-0.006	0.006	-0.036	0.036	-0.191	-0.090	0.101	0.180	-0.035	-0.069	-0.198	-0.099	1.000	-0.264	-0.224	0.049	0.119	-0.071	-0.107	0.038	-0.112	-0.065	0.065	-0.113	-0.041	0.133	0.044	0.049	0.029	0.037
Bachelors	-0.411	-0.180	-0.088	0.088	-0.512	0.512	-0.399	-0.564	-0.296	-0.043	0.669	-0.595	-0.593	-0.704	-0.264	1.000	0.617	0.150	0.457	-0.485	-0.183	-0.021	-0.461	-0.312	0.312	-0.135	-0.170	0.232	0.007	0.115	-0.560	-0.545
Advanced degree	-0.403	-0.181	-0.115	0.115	-0.483	0.483	-0.375	-0.519	-0.317	-0.074	0.649	-0.554	-0.559	-0.730	-0.224	0.617	1.000	0.173	0.392	-0.450	-0.118	-0.053	-0.392	-0.239	0.239	-0.092	-0.144	0.175	0.003	0.095	-0.493	-0.488
Age 65 or older	-0.088	-0.077	-0.073	0.073	0.038	-0.038	-0.254	-0.326	-0.146	0.074	0.333	-0.301	-0.230	-0.118	0.049	0.150	0.173	1.000	0.361	-0.390	-0.148	0.073	-0.413	-0.338	0.338	-0.182	-0.098	0.234	-0.012	0.099	-0.261	-0.235
Single Family housing	-0.237	-0.223	-0.132	0.132	-0.495	0.495	-0.532	-0.764	-0.229	0.142	0.748	-0.660	-0.567	-0.335	0.119	0.457	0.392	0.361	1.000	-0.727	-0.734	-0.010	-0.925	-0.446	0.446	-0.271	-0.556	0.626	0.037	0.186	-0.459	-0.417
Duplex, triplex, fourplex housing	0.273	0.086	0.119	-0.119	0.373	-0.373	0.466	0.646	0.216	-0.119	-0.642	0.568	0.533	0.399	-0.071	-0.485	-0.450	-0.390	-0.727	1.000	0.075	-0.057	0.672	0.629	-0.629	0.348	0.160	-0.428	-0.030	-0.186	0.462	0.426
Multifamily housing	0.077	0.242	0.086	-0.086	0.351	-0.351	0.319	0.476	0.117	-0.098	-0.452	0.403	0.301	0.086	-0.107	-0.183	-0.118	-0.148	-0.734	0.075	1.000	-0.049	0.689	0.037	-0.037	0.059	0.653	-0.495	-0.023	-0.107	0.213	0.188
Mobile home	-0.024	-0.025	-0.100	0.100	0.010	-0.010	-0.048	-0.033	0.011	0.072	-0.005	-0.034	-0.033	0.060	0.038	-0.021	-0.053	0.073	-0.010	-0.057	-0.049	1.000	-0.059	-0.092	0.092	-0.075	-0.024	0.056	-0.016	0.171	-0.017	-0.021
Renter-occupied housing	0.226	0.224	0.123	-0.123	0.506	-0.506	0.539	0.775	0.224	-0.179	-0.741	0.699	0.575	0.328	-0.112	-0.461	-0.392	-0.413	-0.925	0.672	0.689	-0.059	1.000	0.446	-0.446	0.253	0.544	-0.600	-0.011	-0.185	0.448	0.403
Construction year pre-1950	0.210	0.029	0.133	-0.133	0.275	-0.275	0.287	0.447	0.163	-0.108	-0.439	0.432	0.379	0.202	-0.065	-0.312	-0.239	-0.338	-0.446	0.629	0.037	-0.092	0.446	1.000	-1.000	0.370	-0.029	-0.318	-0.012	-0.186	0.402	0.382
Construction year post-1950	-0.210	-0.029	-0.133	0.133	-0.275	0.275	-0.287	-0.447	-0.163	0.108	0.439	-0.432	-0.379	-0.202	0.065	0.312	0.239	0.338	0.446	-0.629	-0.037	0.092	-0.446	-1.000	1.000	-0.370	0.029	0.318	0.012	0.186	-0.402	-0.382
Heating, Utility Gas	0.102	-0.006	0.182	-0.182	0.124	-0.124	0.242	0.258	0.039	-0.103	-0.213	0.254	0.246	0.071	-0.113	-0.135	-0.092	-0.182	-0.271	0.348	0.059	-0.075	0.253	0.370	-0.370	1.000	-0.263	-0.752	-0.026	-0.411	0.217	0.234
Heating, Electricity	0.112	0.197	0.057	-0.057	0.268	-0.268	0.254	0.390	0.135	-0.046	-0.401	0.269	0.236	0.102	-0.041	-0.170	-0.144	-0.098	-0.556	0.160	0.653	-0.024	0.544	-0.029	0.029	-0.263	1.000	-0.406	-0.013	-0.108	0.133	0.106
Heating, Oil and Kerosene	-0.152	-0.121	-0.163	0.163	-0.286	0.286	-0.390	-0.500	-0.113	0.127	0.459	-0.412	-0.378	-0.129	0.133	0.232	0.175	0.234	0.626	-0.428	-0.495	0.056	-0.600	-0.318	0.318	-0.752	-0.406	1.000	-0.001	0.268	-0.279	-0.275
Heating, Solar	0.041	0.003	0.001	-0.001	-0.036	0.036	-0.037	-0.040	0.063	-0.002	0.013	-0.023	-0.048	0.000	0.044	0.007	0.003	-0.012	0.037	-0.030	-0.023	-0.016	-0.011	-0.012	0.012	-0.026	-0.013	-0.001	1.000	0.012	-0.015	-0.021
Heating, Other Fuel	-0.144	-0.049	-0.283	0.283	-0.128	0.128	-0.159	-0.173	-0.105	0.052	0.182	-0.170	-0.176	-0.069	0.049	0.115	0.095	0.099	0.186	-0.186	-0.107	0.171	-0.185	-0.186	0.186	-0.411	-0.108	0.268	0.012	1.000	-0.166	-0.177
Total years on Distressed List	0.405	0.168	0.101	-0.101	0.403	-0.403	0.346	0.507	0.302	-0.050	-0.577	0.563	0.491	0.464	0.029	-0.560	-0.493	-0.261	-0.459	0.462	0.213	-0.017	0.448	0.402	-0.402	0.217	0.133	-0.279	-0.015	-0.166	1.000	0.952
Distressed last three years	0.386	0.155	0.106	-0.106	0.377	-0.377	0.316	0.476	0.301	-0.042	-0.551	0.522	0.460	0.466	0.037	-0.545	-0.488	-0.235	-0.417	0.426	0.188	-0.021	0.403	0.382	-0.382	0.234	0.106	-0.275	-0.021	-0.177	0.952	1.000

Table 79: Full Electric Correlation Matrix – Non-IE Programs

	Location-level participation	Savings participation rate	Urban PA households ratio	Rural PA households ratio	Without internet	With internet	Limited English	Low income	Moderate income	Middle income	High income	Public assistance	Less than high school	High school	Less than bachelors	Bachelors	Advanced degree	Age 65 or older	Single Family housing	Duplex, triplex, fourplex housing	Multifamily housing	Mobile home	Renter-occupied housing	Construction year pre-1950	Construction year post-1950	Heating, Utility Gas	Heating, Electricity	Heating, Oil and Kerosene	Heating, Solar	Heating, Other Fuel	Total years on Distressed List	Distressed last three years
Location-level participation	1.000	0.077	-0.191	0.191	-0.428	0.428	-0.444	-0.669	-0.276	0.036	0.699	-0.547	-0.497	-0.402	0.061	0.452	0.427	0.301	0.753	-0.582	-0.561	-0.020	-0.731	-0.412	0.412	-0.255	-0.442	0.455	0.009	0.217	-0.484	-0.462
Savings participation rate	0.077	1.000	-0.017	0.017	-0.068	0.068	-0.063	-0.076	-0.044	0.074	0.054	-0.074	-0.105	-0.080	0.037	0.067	0.095	0.032	0.002	-0.105	0.103	-0.013	-0.005	-0.085	0.085	-0.043	0.072	0.000	-0.010	0.016	-0.100	-0.094
Urban PA households ratio	-0.191	-0.017	1.000	-1.000	0.156	-0.156	0.230	0.248	0.067	-0.065	-0.222	0.222	0.196	0.080	-0.111	-0.096	-0.086	-0.118	-0.315	0.253	0.243	-0.097	0.279	0.195	-0.195	0.494	0.148	-0.422	-0.032	-0.596	0.232	0.226
Rural PA households ratio	0.191	0.017	-1.000	1.000	-0.156	0.156	-0.230	-0.248	-0.067	0.065	0.222	-0.222	-0.196	-0.080	0.111	0.096	0.086	0.118	0.315	-0.253	-0.243	0.097	-0.279	-0.195	0.195	-0.494	-0.148	0.422	0.032	0.596	-0.232	-0.226
Without internet	-0.428	-0.068	0.156	-0.156	1.000	-1.000	0.441	0.567	0.218	-0.088	-0.561	0.623	0.565	0.428	-0.026	-0.512	-0.487	0.024	-0.530	0.409	0.394	0.024	0.537	0.297	-0.297	0.237	0.282	-0.357	-0.032	-0.176	0.434	0.408
With internet	0.428	0.068	-0.156	0.156	-1.000	1.000	-0.441	-0.567	-0.218	0.088	0.561	-0.623	-0.565	-0.428	0.026	0.512	0.487	-0.024	0.530	-0.409	-0.394	-0.024	-0.537	-0.297	0.297	-0.237	-0.282	0.357	0.032	0.176	-0.434	-0.408
Limited English	-0.444	-0.063	0.230	-0.230	0.441	-0.441	1.000	0.582	0.106	-0.129	-0.512	0.546	0.669	0.261	-0.189	-0.394	-0.366	-0.252	-0.561	0.494	0.370	-0.054	0.569	0.309	-0.309	0.356	0.259	-0.445	-0.037	-0.256	0.393	0.364
Low income	-0.669	-0.076	0.248	-0.248	0.567	-0.567	0.582	1.000	0.098	-0.277	-0.822	0.749	0.665	0.439	-0.094	-0.546	-0.500	-0.301	-0.779	0.666	0.525	-0.022	0.788	0.464	-0.464	0.384	0.404	-0.553	-0.041	-0.270	0.536	0.505
Moderate income	-0.276	-0.044	0.067	-0.067	0.218	-0.218	0.106	0.098	1.000	-0.045	-0.468	0.215	0.208	0.321	0.104	-0.320	-0.338	-0.123	-0.260	0.239	0.151	0.037	0.251	0.186	-0.186	0.118	0.152	-0.183	0.066	-0.101	0.327	0.328
Middle income	0.036	0.074	-0.065	0.065	-0.088	0.088	-0.129	-0.277	-0.045	1.000	-0.165	-0.200	-0.152	0.143	0.213	-0.093	-0.115	0.053	0.128	-0.108	-0.094	0.048	-0.161	-0.097	0.097	-0.104	-0.039	0.111	-0.011	0.072	-0.031	-0.026
High income	0.699	0.054	-0.222	0.222	-0.561	0.561	-0.512	-0.822	-0.468	-0.165	1.000	-0.676	-0.618	-0.586	-0.048	0.661	0.636	0.298	0.752	-0.649	-0.493	-0.015	-0.742	-0.452	0.452	-0.349	-0.409	0.524	0.016	0.253	-0.601	-0.576
Public assistance	-0.547	-0.074	0.222	-0.222	0.623	-0.623	0.546	0.749	0.215	-0.200	-0.676	1.000	0.692	0.461	-0.072	-0.575	-0.540	-0.296	-0.684	0.593	0.454	-0.032	0.721	0.445	-0.445	0.359	0.284	-0.464	-0.026	-0.253	0.587	0.543
Less than high school	-0.497	-0.105	0.196	-0.196	0.565	-0.565	0.669	0.665	0.208	-0.152	-0.618	0.692	1.000	0.329	-0.191	-0.583	-0.552	-0.226	-0.590	0.549	0.355	-0.021	0.600	0.394	-0.394	0.335	0.246	-0.423	-0.033	-0.231	0.522	0.490
High school	-0.402	-0.080	0.080	-0.080	0.428	-0.428	0.261	0.439	0.321	0.143	-0.586	0.461	0.329	1.000	-0.071	-0.718	-0.729	-0.116	-0.354	0.397	0.132	0.065	0.342	0.216	-0.216	0.151	0.114	-0.200	-0.005	-0.082	0.481	0.476
Less than bachelors	0.061	0.037	-0.111	0.111	-0.026	0.026	-0.189	-0.094	0.104	0.213	-0.048	-0.072	-0.191	-0.071	1.000	-0.290	-0.248	0.044	0.120	-0.081	-0.107	0.032	-0.118	-0.080	0.080	-0.142	-0.030	0.136	0.032	0.100	0.003	0.015
Bachelors	0.452	0.067	-0.096	0.096	-0.512	0.512	-0.394	-0.546	-0.320	-0.093	0.661	-0.575	-0.583	-0.718	-0.290	1.000	0.593	0.135	0.463	-0.471	-0.227	-0.042	-0.458	-0.304	0.304	-0.213	-0.183	0.289	0.011	0.131	-0.550	-0.536
Advanced degree	0.427	0.095	-0.086	0.086	-0.487	0.487	-0.366	-0.500	-0.338	-0.115	0.636	-0.540	-0.552	-0.729	-0.248	0.593	1.000	0.174	0.392	-0.431	-0.159	-0.044	-0.392	-0.239	0.239	-0.152	-0.148	0.217	-0.002	0.093	-0.494	-0.486
Age 65 or older	0.301	0.032	-0.118	0.118	0.024	-0.024	-0.252	-0.301	-0.123	0.053	0.298	-0.296	-0.226	-0.116	0.044	0.135	0.174	1.000	0.336	-0.367	-0.159	0.085	-0.378	-0.291	0.291	-0.211	-0.076	0.221	0.011	0.147	-0.256	-0.237
Single Family housing	0.753	0.002	-0.315	0.315	-0.530	0.530	-0.561	-0.779	-0.260	0.128	0.752	-0.684	-0.590	-0.354	0.120	0.463	0.392	0.336	1.000	-0.757	-0.763	-0.016	-0.931	-0.468	0.468	-0.441	-0.557	0.684	0.039	0.325	-0.514	-0.472
Duplex, triplex, fourplex housing	-0.582	-0.105	0.253	-0.253	0.409	-0.409	0.494	0.666	0.239	-0.108	-0.649	0.593	0.549	0.397	-0.081	-0.471	-0.431	-0.367	-0.757	1.000	0.169	-0.071	0.704	0.629	-0.629	0.446	0.207	-0.502	-0.037	-0.286	0.503	0.465
Multifamily housing	-0.561	0.103	0.243	-0.243	0.394	-0.394	0.370	0.525	0.151	-0.094	-0.493	0.454	0.355	0.132	-0.107	-0.227	-0.159	-0.159	-0.763	0.169	1.000	-0.069	0.724	0.104	-0.104	0.245	0.644	-0.548	-0.022	-0.253	0.285	0.257
Mobile home	-0.020	-0.013	-0.097	0.097	0.024	-0.024	-0.054	-0.022	0.037	0.048	-0.015	-0.032	-0.021	0.065	0.032	-0.042	-0.044	0.085	-0.016	-0.071	-0.069	1.000	-0.069	-0.100	0.100	-0.111	-0.036	0.055	-0.002	0.264	-0.021	-0.012
Renter-occupied housing	-0.731	-0.005	0.279	-0.279	0.537	-0.537	0.569	0.788	0.251	-0.161	-0.742	0.721	0.600	0.342	-0.118	-0.458	-0.392	-0.378	-0.931	0.704	0.724	-0.069	1.000	0.480	-0.480	0.411	0.539	-0.646	-0.033	-0.311	0.497	0.452
Construction year pre-1950	-0.412	-0.085	0.195	-0.195	0.297	-0.297	0.309	0.464	0.186	-0.097	-0.452	0.445	0.394	0.216	-0.080	-0.304	-0.239	-0.291	-0.468	0.629	0.104	-0.100	0.480	1.000	-1.000	0.407	0.004	-0.365	-0.002	-0.222	0.415	0.387
Construction year post-1950	0.412	0.085	-0.195	0.195	-0.297	0.297	-0.309	-0.464	-0.186	0.097	0.452	-0.445	-0.394	-0.216	0.080	0.304	0.239	0.291	0.468	-0.629	-0.104	0.100	-0.480	-1.000	1.000	-0.407	-0.004	0.365	0.002	0.222	-0.415	-0.387
Heating, Utility Gas	-0.255	-0.043	0.494	-0.494	0.237	-0.237	0.356	0.384	0.118	-0.104	-0.349	0.359	0.335	0.151	-0.142	-0.213	-0.152	-0.211	-0.441	0.446	0.245	-0.111	0.411	0.407	-0.407	1.000	-0.091	-0.829	-0.026	-0.576	0.354	0.363
Heating, Electricity	-0.442	0.072	0.148	-0.148	0.282	-0.282	0.259	0.404	0.152	-0.039	-0.409	0.284	0.246	0.114	-0.030	-0.183	-0.148	-0.076	-0.557	0.207	0.644	-0.036	0.539	0.004	-0.004	-0.091	1.000	-0.423	-0.019	-0.161	0.161	0.133
Heating, Oil and Kerosene	0.455	0.000	-0.422	0.422	-0.357	0.357	-0.445	-0.553	-0.183	0.111	0.524	-0.464	-0.423	-0.200	0.136	0.289	0.217	0.221	0.684	-0.502	-0.548	0.055	-0.646	-0.365	0.365	-0.829	-0.423	1.000	0.005	0.391	-0.382	-0.377
Heating, Solar	0.009	-0.010	-0.032	0.032	-0.032	0.032	-0.037	-0.041	0.066	-0.011	0.016	-0.026	-0.033	-0.005	0.032	0.011	-0.002	0.011	0.039	-0.037	-0.022	-0.002	-0.033	-0.002	0.002	-0.026	-0.019	0.005	1.000	0.017	-0.004	-0.008
Heating, Other Fuel	0.217	0.016	-0.596	0.596	-0.176	0.176	-0.256	-0.270	-0.101	0.072	0.253	-0.253	-0.231	-0.082	0.100	0.131	0.093	0.147	0.325	-0.286	-0.253	0.264	-0.311	-0.222	0.222	-0.576	-0.161	0.391	0.017	1.000	-0.274	-0.271
Total years on Distressed List	-0.484	-0.100	0.232	-0.232	0.434	-0.434	0.393	0.536	0.327	-0.031	-0.601	0.587	0.522	0.481	0.003	-0.550	-0.494	-0.256	-0.514	0.503	0.285	-0.021	0.497	0.415	-0.415	0.354	0.161	-0.382	-0.004	-0.274	1.000	0.944
Distressed last three years	-0.462	-0.094	0.226	-0.226	0.408	-0.408	0.364	0.505	0.328	-0.026	-0.576	0.543	0.490	0.476	0.015	-0.536	-0.486	-0.237	-0.472	0.465	0.257	-0.012	0.452	0.387	-0.387	0.363	0.133	-0.377	-0.008	-0.271	0.944	1.000

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Table 80: Full Gas Correlation Matrix – Non-IE Programs

	Location-level participation	Savings rate participation	Urban PA households ratio	Rural PA households ratio	Without internet	With internet	Limited English	Low income	Moderate income	Middle income	High income	Public assistance	Less than high school	High school	Less than bachelors	Bachelors	Advanced degree	Age 65 or older	Single Family housing	Duplex, triplex, fourplex housing	Multifamily housing	Mobile home	Renter-occupied housing	Construction year pre-1950	Construction year post-1950	Heating, Utility Gas	Heating, Electricity	Heating, Oil and Kerosene	Heating, Solar	Heating, Other Fuel	Total years on Distressed List	Distressed last three years
Location-level participation	1.000	0.394	-0.197	0.197	-0.281	0.281	-0.346	-0.497	-0.191	0.093	0.504	-0.415	-0.357	-0.224	0.068	0.300	0.254	0.247	0.573	-0.448	-0.396	0.028	-0.564	-0.347	0.347	-0.441	-0.245	0.565	-0.002	0.271	-0.347	-0.333
Savings rate participation	0.394	1.000	-0.090	0.090	-0.085	0.085	-0.116	-0.166	-0.049	0.061	0.149	-0.148	-0.134	-0.062	0.013	0.100	0.092	0.099	0.128	-0.187	-0.013	0.102	-0.132	-0.159	0.159	-0.213	-0.008	0.189	-0.024	0.163	-0.190	-0.182
Urban PA households ratio	-0.197	-0.090	1.000	-1.000	0.088	-0.088	0.087	0.125	0.075	0.014	-0.153	0.109	0.101	0.092	-0.006	-0.089	-0.115	-0.073	-0.132	0.119	0.086	-0.100	0.123	0.133	-0.133	0.182	0.057	-0.163	0.001	-0.283	0.101	0.106
Rural PA households ratio	0.197	0.090	-1.000	1.000	-0.088	0.088	-0.087	-0.125	-0.075	-0.014	0.153	-0.109	-0.101	-0.092	0.006	0.089	0.115	0.073	0.132	-0.119	-0.086	0.100	-0.123	-0.133	0.133	-0.182	-0.057	0.163	-0.001	0.283	-0.101	-0.106
Without internet	-0.281	-0.085	0.088	-0.088	1.000	-1.000	0.420	0.553	0.168	-0.113	-0.538	0.615	0.546	0.414	-0.036	-0.511	-0.483	0.038	-0.497	0.373	0.355	0.010	0.507	0.274	-0.274	0.124	0.270	-0.287	-0.036	-0.128	0.403	0.377
With internet	0.281	0.085	-0.088	0.088	-1.000	1.000	-0.420	-0.553	-0.168	0.113	0.538	-0.615	-0.546	-0.414	0.036	0.511	0.483	-0.038	0.497	-0.373	-0.355	-0.010	-0.507	-0.274	0.274	-0.124	-0.270	0.287	0.036	0.128	-0.403	-0.377
Limited English	-0.346	-0.116	0.087	-0.087	0.420	-0.420	1.000	0.559	0.082	-0.134	-0.499	0.512	0.657	0.251	-0.191	-0.400	-0.375	-0.254	-0.533	0.466	0.321	-0.048	0.540	0.287	-0.287	0.242	0.255	-0.391	-0.037	-0.159	0.346	0.316
Low income	-0.497	-0.166	0.125	-0.125	0.553	-0.553	0.559	1.000	0.057	-0.316	-0.823	0.742	0.659	0.436	-0.089	-0.566	-0.520	-0.327	-0.765	0.647	0.477	-0.033	0.776	0.449	-0.449	0.259	0.391	-0.500	-0.040	-0.172	0.509	0.478
Moderate income	-0.191	-0.049	0.075	-0.075	0.168	-0.168	0.082	0.057	1.000	-0.060	-0.436	0.188	0.174	0.299	0.101	-0.296	-0.317	-0.146	-0.230	0.216	0.119	0.011	0.225	0.163	-0.163	0.038	0.137	-0.113	0.063	-0.105	0.302	0.302
Middle income	0.093	0.061	0.014	-0.014	-0.113	0.113	-0.134	-0.316	-0.060	1.000	-0.116	-0.229	-0.175	0.112	0.179	-0.042	-0.074	0.074	0.142	-0.120	-0.097	0.072	-0.178	-0.109	0.109	-0.103	-0.045	0.126	-0.002	0.052	-0.051	-0.042
High income	0.504	0.149	-0.153	0.153	-0.538	0.538	-0.499	-0.823	-0.436	-0.116	1.000	-0.673	-0.613	-0.580	-0.036	0.670	0.649	0.334	0.749	-0.643	-0.454	-0.005	-0.742	-0.440	0.440	-0.213	-0.402	0.460	0.013	0.182	-0.578	-0.553
Public assistance	-0.415	-0.148	0.109	-0.109	0.615	-0.615	0.512	0.742	0.188	-0.229	-0.673	1.000	0.676	0.463	-0.069	-0.595	-0.554	-0.301	-0.662	0.567	0.407	-0.034	0.701	0.432	-0.432	0.254	0.271	-0.413	-0.023	-0.170	0.563	0.522
Less than high school	-0.357	-0.134	0.101	-0.101	0.546	-0.546	0.657	0.659	0.174	-0.175	-0.613	0.676	1.000	0.302	-0.199	-0.593	-0.559	-0.231	-0.568	0.533	0.304	-0.033	0.577	0.380	-0.380	0.246	0.238	-0.379	-0.048	-0.175	0.492	0.461
High school	-0.224	-0.062	0.092	-0.092	0.414	-0.414	0.251	0.436	0.299	0.112	-0.580	0.463	0.302	1.000	-0.100	-0.703	-0.730	-0.119	-0.339	0.398	0.091	0.059	0.331	0.202	-0.202	0.070	0.106	-0.131	0.000	-0.068	0.466	0.467
Less than bachelors	0.068	0.013	-0.006	0.006	-0.036	0.036	-0.191	-0.089	0.101	0.179	-0.036	-0.069	-0.199	-0.100	1.000	-0.263	-0.224	0.048	0.118	-0.071	-0.106	0.038	-0.111	-0.066	0.066	-0.114	-0.040	0.132	0.044	0.049	0.029	0.037
Bachelors	0.300	0.100	-0.089	0.089	-0.511	0.511	-0.400	-0.566	-0.296	-0.042	0.670	-0.595	-0.593	-0.703	-0.263	1.000	0.617	0.152	0.461	-0.485	-0.190	-0.021	-0.465	-0.312	0.312	-0.134	-0.175	0.234	0.007	0.115	-0.562	-0.546
Advanced degree	0.254	0.092	-0.115	0.115	-0.483	0.483	-0.375	-0.520	-0.317	-0.074	0.649	-0.554	-0.559	-0.730	-0.224	0.617	1.000	0.174	0.394	-0.450	-0.121	-0.053	-0.394	-0.238	0.238	-0.092	-0.147	0.176	0.003	0.095	-0.494	-0.489
Age 65 or older	0.247	0.099	-0.073	0.073	0.038	-0.038	-0.254	-0.327	-0.146	0.074	0.334	-0.301	-0.231	-0.119	0.048	0.152	0.174	1.000	0.360	-0.390	-0.147	0.073	-0.412	-0.339	0.339	-0.183	-0.097	0.234	-0.012	0.100	-0.261	-0.234
Single Family housing	0.573	0.128	-0.132	0.132	-0.497	0.497	-0.533	-0.765	-0.230	0.142	0.749	-0.662	-0.568	-0.339	0.118	0.461	0.394	0.360	1.000	-0.730	-0.734	-0.011	-0.925	-0.448	0.448	-0.273	-0.554	0.626	0.037	0.186	-0.460	-0.418
Duplex, triplex, fourplex housing	-0.448	-0.187	0.119	-0.119	0.373	-0.373	0.466	0.647	0.216	-0.120	-0.643	0.567	0.533	0.398	-0.071	-0.485	-0.450	-0.390	-0.730	1.000	0.078	-0.057	0.675	0.630	-0.630	0.347	0.163	-0.429	-0.030	-0.186	0.462	0.427
Multifamily housing	-0.396	-0.013	0.086	-0.086	0.355	-0.355	0.321	0.477	0.119	-0.097	-0.454	0.407	0.304	0.091	-0.106	-0.190	-0.121	-0.147	-0.734	0.078	1.000	-0.049	0.688	0.040	-0.040	0.062	0.650	-0.494	-0.023	-0.108	0.214	0.189
Mobile home	0.028	0.102	-0.100	0.100	0.010	-0.010	-0.048	-0.033	0.011	0.072	-0.005	-0.034	-0.033	0.059	0.038	-0.021	-0.053	0.073	-0.011	-0.057	-0.049	1.000	-0.058	-0.092	0.092	-0.076	-0.024	0.056	-0.016	0.171	-0.017	-0.021
Renter-occupied housing	-0.564	-0.132	0.123	-0.123	0.507	-0.507	0.540	0.776	0.225	-0.178	-0.742	0.701	0.577	0.331	-0.111	-0.465	-0.394	-0.412	-0.925	0.675	0.688	-0.058	1.000	0.448	-0.448	0.254	0.542	-0.600	-0.011	-0.185	0.449	0.404
Construction year pre-1950	-0.347	-0.159	0.133	-0.133	0.274	-0.274	0.287	0.449	0.163	-0.109	-0.440	0.432	0.380	0.202	-0.066	-0.312	-0.238	-0.339	-0.448	0.630	0.040	-0.092	0.448	1.000	-1.000	0.370	-0.028	-0.319	-0.012	-0.187	0.402	0.382
Construction year post-1950	0.347	0.159	-0.133	0.133	-0.274	0.274	-0.287	-0.449	-0.163	0.109	0.440	-0.432	-0.380	-0.202	0.066	0.312	0.238	0.339	0.448	-0.630	-0.040	0.092	-0.448	-1.000	1.000	-0.370	0.028	0.319	0.012	0.187	-0.402	-0.382
Heating, Utility Gas	-0.441	-0.213	0.182	-0.182	0.124	-0.124	0.242	0.259	0.038	-0.103	-0.213	0.254	0.246	0.070	-0.114	-0.134	-0.092	-0.183	-0.273	0.347	0.062	-0.076	0.254	0.370	-0.370	1.000	-0.262	-0.753	-0.026	-0.411	0.217	0.235
Heating, Electricity	-0.245	-0.008	0.057	-0.057	0.270	-0.270	0.255	0.391	0.137	-0.045	-0.402	0.271	0.238	0.106	-0.040	-0.175	-0.147	-0.097	-0.554	0.163	0.650	-0.024	0.542	-0.028	0.028	-0.262	1.000	-0.404	-0.012	-0.109	0.133	0.106
Heating, Oil and Kerosene	0.565	0.189	-0.163	0.163	-0.287	0.287	-0.391	-0.500	-0.113	0.126	0.460	-0.413	-0.379	-0.131	0.132	0.234	0.176	0.234	0.626	-0.429	-0.494	0.056	-0.600	-0.319	0.319	-0.753	-0.404	1.000	-0.001	0.269	-0.278	-0.275
Heating, Solar	-0.002	-0.024	0.001	-0.001	-0.036	0.036	-0.037	-0.040	0.063	-0.002	0.013	-0.023	-0.048	0.000	0.044	0.007	0.003	-0.012	0.037	-0.030	-0.023	-0.016	-0.011	-0.012	0.012	-0.026	-0.012	-0.001	1.000	0.012	-0.015	-0.021
Heating, Other Fuel	0.271	0.163	-0.283	0.283	-0.128	0.128	-0.159	-0.172	-0.105	0.052	0.182	-0.170	-0.175	-0.068	0.049	0.115	0.095	0.100	0.186	-0.186	-0.108	0.171	-0.185	-0.187	0.187	-0.411	-0.109	0.269	0.012	1.000	-0.167	-0.178
Total years on Distressed List	-0.347	-0.190	0.101	-0.101	0.403	-0.403	0.346	0.509	0.302	-0.051	-0.578	0.563	0.492	0.466	0.029	-0.562	-0.494	-0.261	-0.460	0.462	0.214	-0.017	0.449	0.402	-0.402	0.217	0.133	-0.278	-0.015	-0.167	1.000	0.952
Distressed last three years	-0.333	-0.182	0.106	-0.106	0.377	-0.377	0.316	0.478	0.302	-0.042	-0.553	0.522	0.461	0.467	0.037	-0.546	-0.489	-0.234	-0.418	0.427	0.189	-0.021	0.404	0.382	-0.382	0.235	0.106	-0.275	-0.021	-0.178	0.952	1.000

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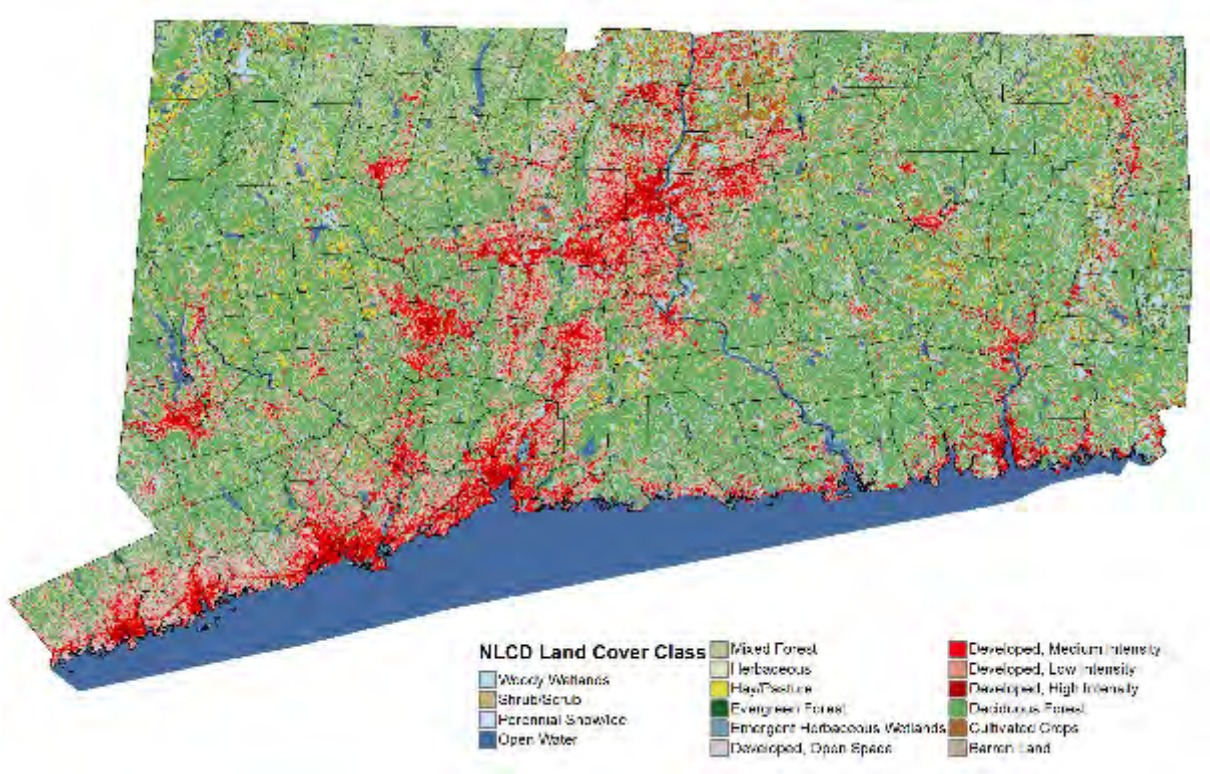
E.6 MAPS

The study generated a series of supporting maps as a visual connection between the tabular data in the summary and correlation analyses and the geographic space where customers are located. The series of maps focuses on presenting a statewide picture and aggregating the underlying customer consumption and savings data up to the block group where the customers are contained. This was done to both protect individual customer data and to enable the analysis to bring the account-level Company data up to the same geographic grain as the socioeconomic data from the American Community Survey.

Connecticut is a mixture of varying degrees of urbanized areas – defined by impervious surfaces like roads and roofs – where people are likely to live and non-urbanized areas like fields, forests, and lakes where people and structures are unlikely to be found. Geographic presentation of data – particularly data that is tied directly to people and structures like energy consumption and savings data – can be visually misleading if this is not taken into account. As seen in Figure 118, the non-urbanized areas will make up a larger portion of the geographic space and provide the appearance of large areas of a specific trend – such as participation in an energy efficiency program – when in reality the physical infrastructure might be highly concentrated into a small urbanized part of the geographic space.

To account for this, the study team applied a masking layer based on the National Land Cover Dataset. Non-urbanized areas, as well as towns with no utility service, are whited out on the maps. This results in a visual display that connects the summary data (participation, usage, and savings) with the urbanized areas – depicted in shades of red in the NLCS map – where the customers are likely to be found and provides a more accurate representation of the physical landscape.

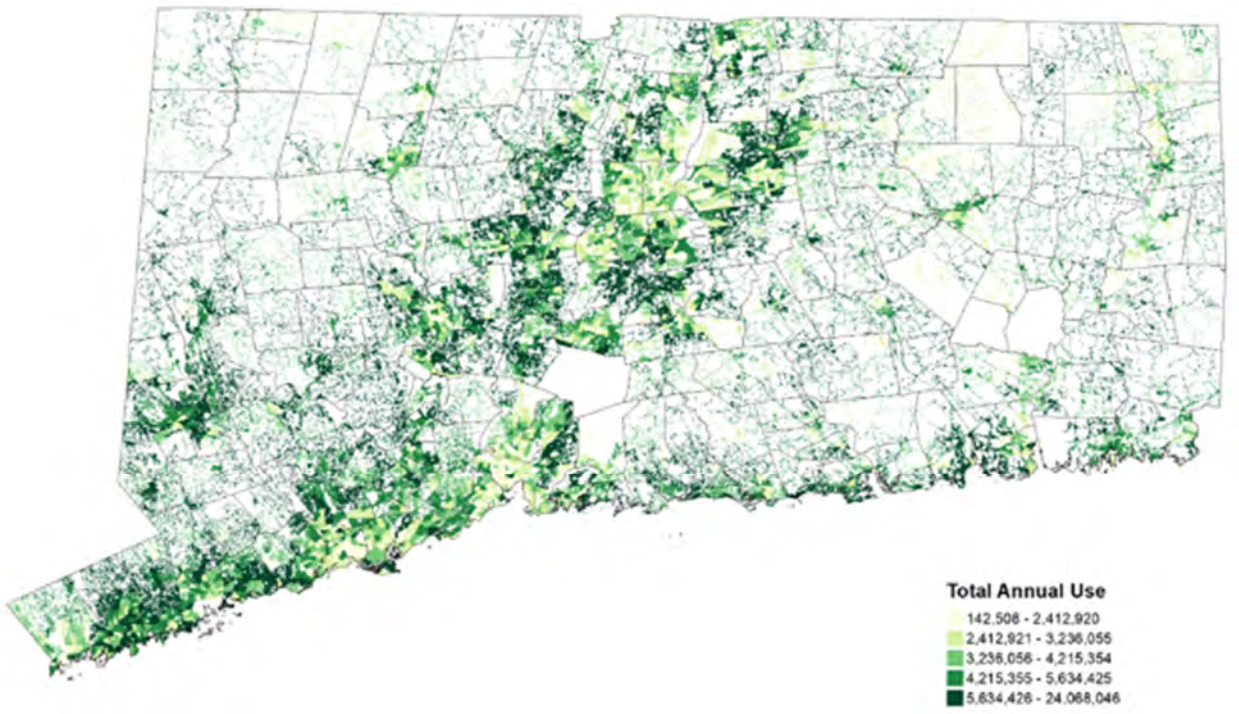
Figure 118: National Land Cover Classification for Connecticut



The geographic analysis used quintile break points to classify each block group relative to the statewide population of block groups served by the utilities. This classification system was selected as it provides an intuitive way to compare a large population of thousands of block groups without readers having to individually assess each block group's specific numbers. Readers can see that a block group is in the bottom 20% of the statewide population for participation yet is in the top 20% of the statewide population for overall savings.

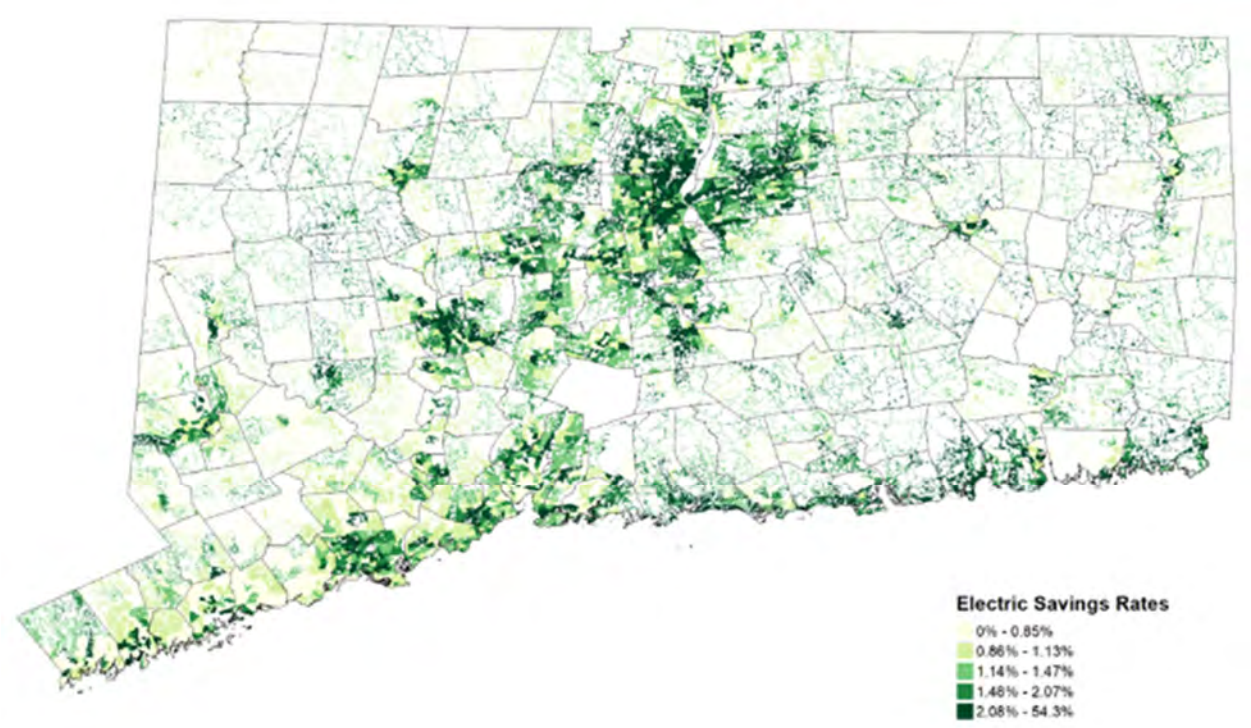
Areas with the largest annual consumption tend to be in the urban outskirts and commuter radius of large cities (Figure 119). Within the urban cores of cities, overall usage per block group is highly variable, and likely reflective of how much of the urban core was residential – often densely developed multifamily housing – versus commercial and industrial buildings. Cities including Danbury, Darian, Stamford, and Bristol had proportionally more block groups that were in the upper quintiles for total annual usage than did New Haven, Bridgeport, and the Hartford region. This is likely due to the interaction of multiple factors including higher shares of multifamily housing, availability of natural gas for heating (rather than delivered fuels or electric heating), and the potential that some of the multifamily buildings might be on residential electric rates but a commercial heating tariff in the event they used a centralized heating system.

Figure 119: Aggregate Block Group Electrical Consumption for Calendar Year 2020



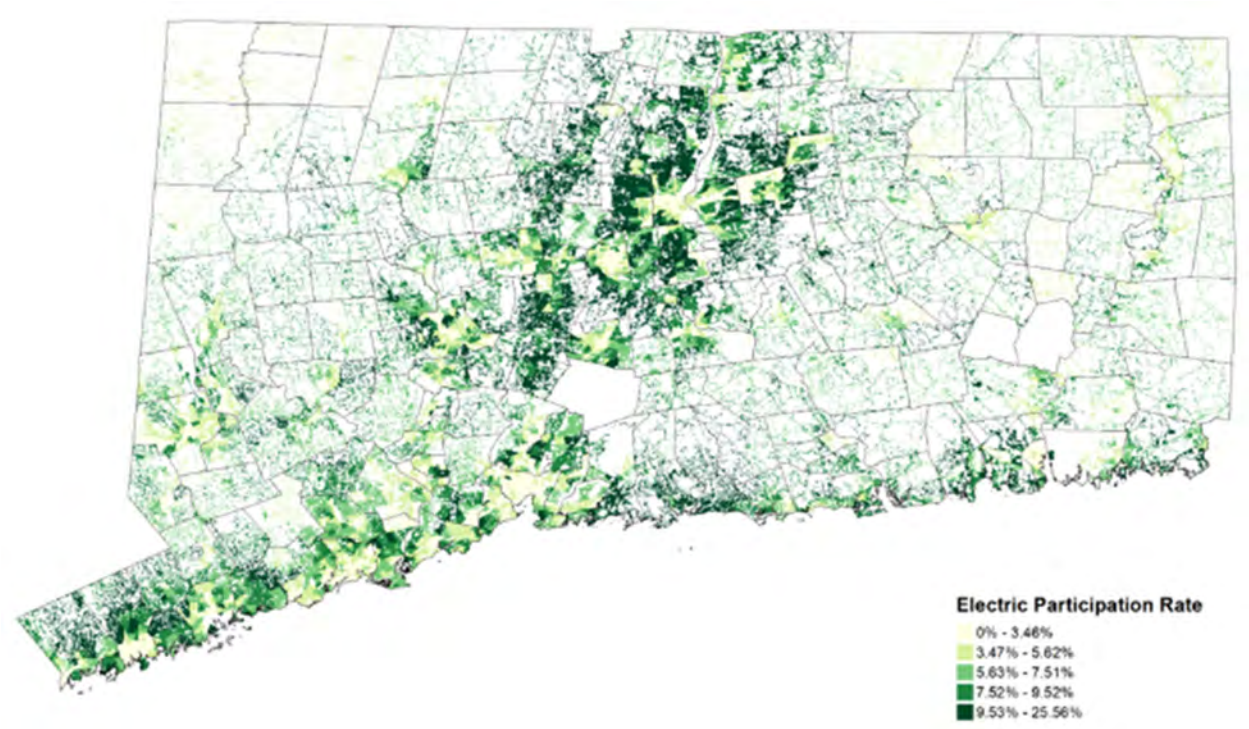
The electric savings rate was calculated using the 2020 electrical consumption as the denominator. Savings as a percentage of consumption tended to be in the upper quintiles in the more rural areas of the state, and to the northeast of Hartford. Waterford is noteworthy in that it had multiple block groups that were in the high quintiles for both consumption and savings, and a deeper review into site-level data may be helpful for understanding if there are successful implementation pathways at work in Waterford that could be translated to elsewhere in the state. Along the coastline, there were fragmented areas where block groups with higher savings rates existed in proximity with block groups of lower savings rates, and additional time series data or insight into if this pattern reflects a persistent trend would be insightful. It is possible that the fragmented pattern reflects a focused outreach on specific neighborhoods during the study period; it may also be indicative that there are neighborhoods along the coastal corridor – particularly in the southwestern portion of the state – where targeted outreach could return additional engagement and savings.

Figure 120: Electrical Savings Rate 2017-2020



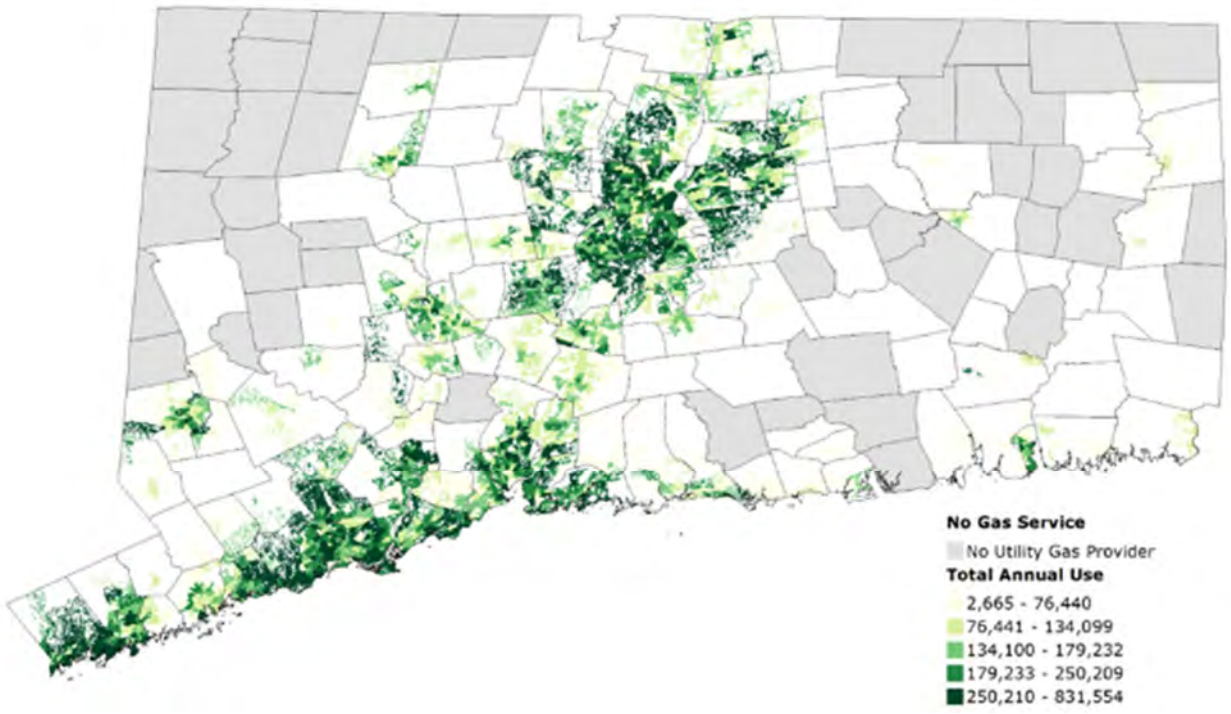
The electrical participation rate illustrates that while participation and savings do share spatial patterns, it is not a strict coupling. There are areas where participation was in the higher quintiles, but savings rates were lower; however, on the whole, the study observed a similar pattern of urban outskirts and commuter areas tending to have higher participation than core urban areas. Some divergence between participation rates (lower quintiles) and savings rates (higher quintiles) was observed in the particularly rural areas of the state to the northwest and northeast. Coupled with the consumption patterns this may be indicative of fewer customers with higher energy usage enacting larger savings measures and seeing a commensurate decrease in overall consumption that exceeds what would otherwise be anticipated based on participation. Participation rates were comparatively higher than savings rates in the southwestern portion of the state and additional insight into drivers of this may yield actionable program insights. These areas did have some higher shares of renters and multifamily and so it is feasible that a larger amount of the instant savings measures, plug load, and upstream measures are being leveraged by customers in these blocks to drive high participation rates but that the larger savings measures that impact building systems are harder to acquire.

Figure 121: Aggregated Block Group Electric Participation Rate 2017 - 2020 program years



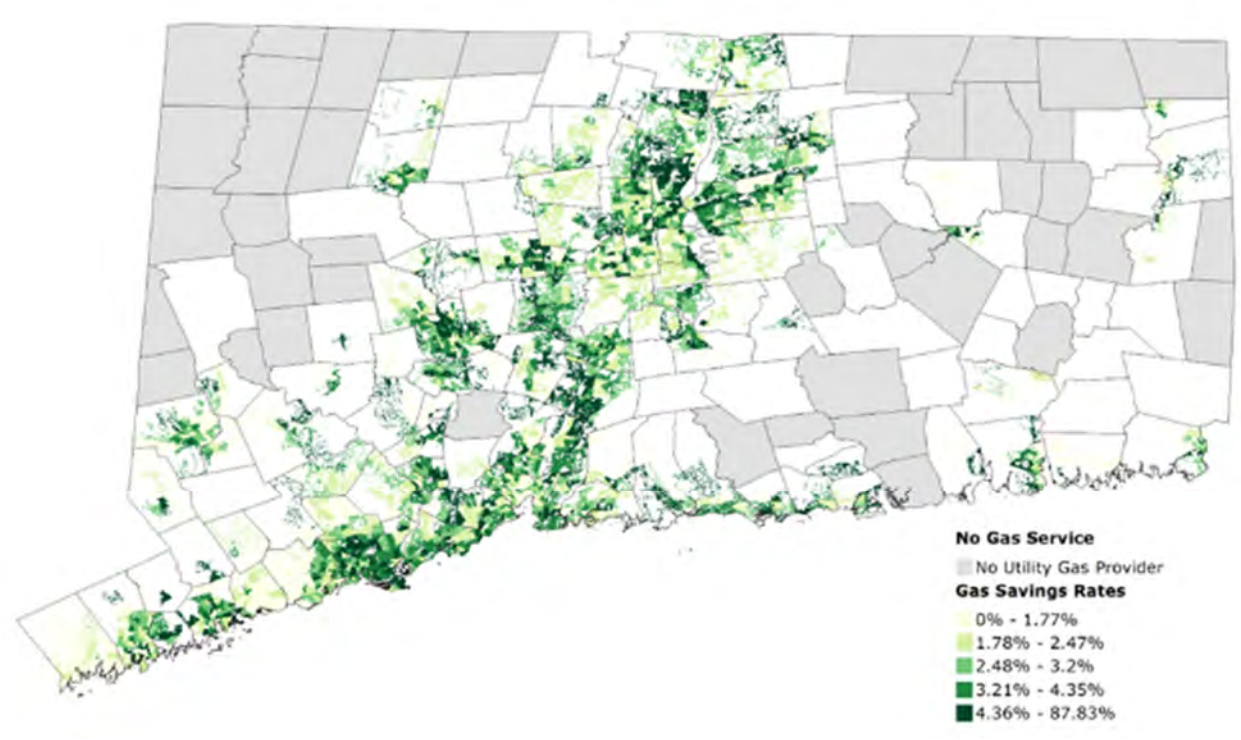
Gas consumption is constrained by where service is available; even within individual block groups not all geographic areas will have access to gas service. In this regard, Figure 122 can be thought of as a rough approximation of where gas service may be an option, with a greater degree of uncertainty for more rural block groups that tend to be larger in area. Block groups in denser developed urban areas tended to have higher gas consumption, which is likely correlated to the denser housing and better access to pipeline infrastructure. Visually, some of the block groups in core urban areas that were in the lower quintiles for electrical consumption are in the higher quintiles for gas consumption further supporting that for these areas, utility gas is likely a prime heating source.

Figure 122: Aggregate Block Group Gas Consumption for Calendar Year 2020



Block groups with higher gas savings rates displayed more spatial clustering than the corresponding map for electrical savings. Bridgeport is notable for block groups in the upper quintiles for both overall consumption and overall savings rates. The towns south of Hartford had savings rates in the lower quintiles despite comparatively higher usage; greater time series data would likely elaborate if this were due to measures previously undertaken outside the analysis window or if it represents a specific geographic region where gas energy efficiency measures may represent a priority focus for outreach.

Figure 123: Gas Savings Rate 2017-2020



Gas participation rates were lower in core urban areas; Bridgeport was again noteworthy as despite being in the upper quintiles for savings ratio and consumption it was in the lower quintiles for participation rates. This may be indicative of larger measures being installed in fewer locations, resulting in deeper overall savings for the block group despite comparatively lower participation rates. South of Hartford the participation rates also tended to be in the lower quintiles, which correlated with the lower savings ratios for these counties. Additional sub-block group insights into property ownership and characteristics could help better illuminate if split incentives between multifamily and/or rental homes and third-party owners is a particular factor impacting the lower participation rates in these areas. The study did look into leveraging tax assessor data, but at the time of this study Connecticut's data, while available online, is highly unstandardized from town to town and so conducting any substantive deeper dives into parcel level drivers was unfortunately not feasible.

Appendix F Summary of PSD Updates

A primary goal of R1983 was to provide updated savings and impact factors for prospective application to future HES and HES-IE programs via the CT PSD. The tables in this appendix summarize those updated savings and impact factors.

To update the PSD conveniently and accurately, the tables below follow the same format as the HES and HES-IE summary table (A3-4) in the 2022 PSD.[177]

A few notes about interpreting the information in Table 81:

- **Low-income programs and net-to-gross.** Consistent with past assumptions in Connecticut and around the country, the study did not assess net-to-gross for any HES-IE measures. All HES-IE measures below have a 0% listed for both free-ridership and spillover.
- **Deemed Savings Measures.** A subset of HES and HES-IE measures are identified as relying on deemed savings in the PSD (versus a participant-specific savings algorithm). It is unnecessary to apply a gross realization rate to these measures, which are indicated below with an asterisk. As such, the study included an "N/A" in the Gross Realization Rate % column for these measures.
- **Lighting Measures.** Because the study used a billing analysis to determine savings for lighting, which implicitly accounts for installation rate and yields net – not gross – savings results, it is inappropriate to apply additional free-ridership, spillover, and installation rate impact factors. As such, the study has included an "N/A" in these columns as well.
- **Weatherization Measures.** Because the study used a billing analysis to determine savings for air sealing, duct sealing and insulation, the results implicitly account for installation rate (i.e., persistence of sealing and/or insulation at the time of the billing analysis). However, unlike lighting, the billing analysis results for weatherization are gross – not net – savings. As such, the study has included an "N/A" in the installation rate column but included the relevant values for free-ridership and spillover.

HVAC Measures. Three measures (furnaces, boilers, and ECM circulator pumps) were included in the gross savings analysis but not the net savings analysis. This is because there was not sufficient participation to sample and survey participants that received these measures. As a result, the study has assigned a pass-through rate of 100% in the free-ridership, spillover, and installation rate columns below. Collectively, the savings (across all fuel types) for these three measures represents less than 1% of total HES program savings in 2019.

[177] In the 2023 PSD, the relevant impact factors are embedded within each measure's section, which adds clarity to the PSD itself but does not work as well for summary reporting across programs, measures, and fuels as required here.

Table 81: Residential Electric & Natural Gas Realization Rates

	Gross Realization %					FR & SO			Net Realization %				
Measure	kWh (or ccf)	Winter Seasonal Peak kW (or Peak Day ccf)	Summer Seasonal Peak kW	Oil, MMBtu	Propane, MMBtu	Free-ridership	Spill-over	Installation Rate	kWh (or ccf)	Winter Seasonal Peak kW (or Peak Day ccf)	Summer Seasonal Peak kW	Oil, MMBtu	Propane, MMBtu
Home Energy Solutions (HES) and HES-Income Eligible, Core Services													
Other measures	100%	100%	100%	100%	100%	0%	0%	100%	100%	100%	100%	100%	100%
Lighting LEDs HES	44%	44%	44%	N/A	N/A	N/A	N/A	N/A	44%	44%	44%	N/A	N/A
Lighting LEDs HES-IE	91%	91%	91%	N/A	N/A	N/A	N/A	N/A	91%	91%	91%	N/A	N/A
Prescriptive air sealing HES, electric / delivered fuels	9%	9%	9%	18%	22%	28%	7%	92%	7%	7%	7%	13%	13%
Prescriptive air sealing HES-IE, electric / delivered fuels	4%	4%	4%	11%	16%	0%	0%	92%	4%	4%	4%	10%	10%
Prescriptive air sealing HES, gas	16%	16%	N/A	N/A	N/A	28%	7%	92%	12%	12%	N/A	N/A	N/A
Prescriptive air sealing HES-IE, gas	10%	10%	N/A	N/A	N/A	0%	0%	92%	9%	9%	N/A	N/A	N/A
Blower door air sealing HES, electric / delivered fuels	9%	9%	9%	18%	22%	11%	7%	N/A	9%	9%	9%	17%	17%
Blower door air sealing HES-IE, electric / delivered fuels	4%	4%	4%	11%	16%	0%	0%	N/A	4%	4%	4%	11%	11%
Blower door air sealing HES, gas	17%	17%	N/A	N/A	N/A	11%	7%	N/A	16%	16%	N/A	N/A	N/A
Blower door air sealing HES-IE, gas	10%	10%	N/A	N/A	N/A	0%	0%	N/A	10%	10%	N/A	N/A	N/A
Duct sealing HES, electric/delivered fuels	11%	11%	11%	13%	18%	14%	7%	N/A	10%	10%	10%	12%	12%
Duct sealing HES-IE, electric/delivered fuels	5%	5%	5%	12%	24%	0%	0%	N/A	5%	5%	5%	12%	12%
Duct sealing HES, gas	12%	12%	N/A	N/A	N/A	14%	7%	N/A	11%	11%	N/A	N/A	N/A
Duct sealing HES-IE, gas	8%	8%	N/A	N/A	N/A	0%	0%	N/A	8%	8%	N/A	N/A	N/A
Water-saving measures, HES	100%	100%	100%	100%	100%	20%	7%	85%	74%	74%	74%	74%	74%
Water-saving measures, HES-IE	100%	100%	100%	100%	100%	0%	0%	85%	85%	85%	85%	85%	85%
Water pipe wrap, HES	100%	100%	100%	100%	100%	28%	7%	97%	77%	77%	77%	77%	77%
Water pipe wrap, HES-IE	100%	100%	100%	100%	100%	0%	0%	97%	97%	97%	97%	97%	97%

	Gross Realization %					FR & SO		Net Realization %					
HES and HES-Income Eligible, Add-On Measures													
Insulation HES, electric / delivered fuels	27%	27%	27%	67%	69%	23%	7%	N/A	23%	23%	23%	56%	56%
Insulation HES-IE, electric / delivered fuels	19%	19%	19%	101%	102%	0%	0%	N/A	19%	19%	19%	101%	101%
Insulation HES, gas	50%	50%	N/A	N/A	N/A	23%	7%	N/A	42%	42%	N/A	N/A	N/A
Insulation HES-IE, gas	46%	46%	N/A	N/A	N/A	0%	0%	N/A	46%	46%	N/A	N/A	N/A
Heat Pump, HES	100%	100%	100%	N/A	N/A	38%	7%	100%	69%	69%	69%	N/A	N/A
Heat Pump, HES-IE	100%	100%	100%	N/A	N/A	0%	0%	100%	100%	100%	100%	N/A	N/A
Ductless Heat Pump, HES	100%	100%	100%	N/A	N/A	38%	7%	98%	68%	68%	68%	N/A	N/A
Ductless Heat Pump, HES-IE	100%	100%	100%	N/A	N/A	0%	0%	98%	98%	98%	98%	N/A	N/A
WIFI Thermostat HES, electric, heating*	N/A	N/A	N/A	N/A	N/A	34%	7%	96%	N/A	N/A	N/A	N/A	N/A
WIFI Thermostat HES-IE, electric, heating*	N/A	N/A	N/A	N/A	N/A	0%	0%	96%	N/A	N/A	N/A	N/A	N/A
WIFI Thermostat HES, electric, cooling*	N/A	N/A	N/A	N/A	N/A	34%	7%	96%	N/A	N/A	N/A	N/A	N/A
WIFI Thermostat HES-IE, electric, cooling*	N/A	N/A	N/A	N/A	N/A	0%	0%	96%	N/A	N/A	N/A	N/A	N/A
WIFI Thermostat HES, gas/delivered fuels*	N/A	N/A	N/A	N/A	N/A	34%	7%	96%	N/A	N/A	N/A	N/A	N/A
WIFI Thermostat HES-IE, gas/delivered fuels*	N/A	N/A	N/A	N/A	N/A	0%	0%	96%	N/A	N/A	N/A	N/A	N/A
Refrigerator, HES*	N/A	N/A	N/A	N/A	N/A	47%	7%	97%	N/A	N/A	N/A	N/A	N/A
Refrigerator, HES-IE*	N/A	N/A	N/A	N/A	N/A	0%	0%	97%	N/A	N/A	N/A	N/A	N/A
Freezer, HES*	N/A	N/A	N/A	N/A	N/A	47%	7%	100%	N/A	N/A	N/A	N/A	N/A
Freezer, HES-IE*	N/A	N/A	N/A	N/A	N/A	0%	0%	100%	N/A	N/A	N/A	N/A	N/A
Dehumidifier, HES*	N/A	N/A	N/A	N/A	N/A	43%	7%	100%	N/A	N/A	N/A	N/A	N/A
Dehumidifier, HES-IE*	N/A	N/A	N/A	N/A	N/A	0%	0%	100%	N/A	N/A	N/A	N/A	N/A
Clothes Washer, electric / delivered fuels, HES*	N/A	N/A	N/A	N/A	N/A	42%	7%	96%	N/A	N/A	N/A	N/A	N/A
Clothes Washer, electric / delivered fuels, HES-IE*	N/A	N/A	N/A	N/A	N/A	0%	0%	96%	N/A	N/A	N/A	N/A	N/A
Clothes Washer, gas, HES*	N/A	N/A	N/A	N/A	N/A	42%	7%	96%	N/A	N/A	N/A	N/A	N/A
Clothes Washer, gas, HES-IE*	N/A	N/A	N/A	N/A	N/A	0%	0%	96%	N/A	N/A	N/A	N/A	N/A

	Gross Realization %					FR & SO		Net Realization %					
Windows, HES	100%	100%	100%	100%	100%	33%	7%	98%	73%	73%	73%	73%	73%
Windows, HES-IE	100%	100%	100%	100%	100%	0%	0%	98%	98%	98%	98%	98%	98%
ECM Circulating Pump*	100%	100%	100%	N/A	N/A	0%	0%	100%	100%	100%	100%	N/A	N/A
Furnaces	96%	96%	N/A	96%	96%	0%	0%	100%	96%	96%	N/A	96%	96%
Boilers	98%	98%	N/A	98%	98%	0%	0%	100%	98%	98%	N/A	98%	98%

As part of this evaluation, the study identified several opportunities to improve existing PSD measure algorithmic approach and/or specific input parameters in a way that would result in more accurate savings. The study applied these improvements when determining each measure's gross savings. The study recommends the Companies apply the same updates – document below in Table 82 – as part of the next PSD update.[178]

Table 82: PSD Parameter Update Recommendations

Measure	Flagged Parameter	Current Value	Current Approach	Current Source	Recommended Value	Recommended Approach	Recommended Source	Rationale for Change
Wi-Fi Thermostat	Savings per unit	Table 3-99 and 3-100 in 2023 PSD	Deemed savings per unit, varies according to savings type (heating or cooling) and equipment/fuel type.	2012 Cadmus Study; 2018 Navigant Study.	Refer to Table 5	Provide deemed savings for heating or cooling by fuel type, but independent of equipment type. Source study shows that savings differ significantly if replacing manual or pro-grammable thermostat; consider providing two deemed savings options depending on baseline replacement.	2021 Guide-house Study	More recent, robust study than the 2012 Pilot Program Cadmus study and 2018 Navigant study referenced in the PSD.
Refrigerator	Retirement & Lost Opportunity Savings per unit	Table 3-182	Table 3-182 provides deemed savings per unit values for Lost Opportunity Savings but uses a calculated approach for Retirement savings.	2018 VT TRM	Lost Opportunity Savings per Unit = 39 kWh per year Retirement Savings per Unit = 914 kWh per year	Use Deemed savings approach for both Lost Opportunity and Retirement savings or specify default values to use when calculating Retirement savings.	Calculated using IL TRM version 10.0.	Unclear source references (for Retirement savings); more recent references identified.

[178] The study initially identified these opportunities when reviewing the 2022 PSD, but confirmed they are all still relevant for the more recently updated 2023 PSD.

Measure	Flagged Parameter	Current Value	Current Approach	Current Source	Recommended Value	Recommended Approach	Recommended Source	Rationale for Change
Freezer	Retirement & Lost Opportunity Savings per unit	Table 3-182	Table 3-182 provides deemed savings per unit values for Lost Opportunity Savings but uses a calculated approach for Retirement savings.	2018 VT TRM	Lost Opportunity Savings per Unit = 43 kWh per year Retirement Savings per Unit = 288 kWh per year	Use Deemed savings approach for both Lost Opportunity and Retirement savings or specify default values to use when calculating Retirement savings.	Calculated using IL TRM version 10.0.	Unclear source references (for Retirement savings); more recent references identified.
Dehumidifier	Retirement & Lost Opportunity Savings per unit	Table 3-182	Table 3-182 provides deemed savings per unit values for Lost Opportunity Savings but uses a calculated approach for Retirement savings.	TRC. 2021. "R1973 Retail Non-Lighting Evaluation." CT Energy Efficiency Board	Lost Opportunity Savings per Unit = 82 kWh per year Retirement Savings per Unit = 489 kWh per year	Use Deemed savings approach for both Lost Opportunity and Retirement savings or specify default values to use when calculating Retirement savings.	Calculated using MA Res 1 Baseline de-humidification baseload assumptions, federal standards, and Energy Star requirements.	Unclear source reference. Updated source compared to 2022 PSD but deemed savings value in Table 3-182 does not match the source.
Clothes Washer	Retirement & Lost Opportunity Savings per unit	Table 3-182	Table 3-182 provides deemed savings per unit values for Lost Opportunity Savings but uses a calculated approach for Retirement savings. are not specified for Retrofit/Retirement savings.	R1706 Residential Appliance Saturation Survey and R1616/R1708 Residential Lighting Impact Saturation Studies	Lost Opportunity Savings per Unit = 105 kWh per year. Retirement Savings per Unit = 355 kWh per year.	Use Deemed savings approach for both Lost Opportunity and Retirement savings or specify default values to use when calculating Retirement savings.	Updated DOE 2018 and ENERGY STAR version 8.0 Standards.	Current approach and source reference is unclear. Updated sources align with most recent standards, and other state TRMs (MA). Note that DOE is currently in the process of updating standards that could significantly increase efficiency requirements for certain units, so it may be useful to wait to update the savings approach until the updated standards are finalized and published.

Measure	Flagged Parameter	Current Value	Current Approach	Current Source	Recommended Value	Recommended Approach	Recommended Source	Rationale for Change
Furnaces	Existing AFUE	78%	N/A	2015 MA HVAC Impact Evaluation	80%	N/A	MA Res 1 Baseline (used in 2022-2024 MA TRM)	More recent data.
Furnaces	EUL	20 years	N/A	2014 CA Public Utilities Database	17 years	N/A	MA Res 1 Baseline (used in 2022-2024 MA TRM)	More recent, region-specific data.
Boilers	EUL	20 years	N/A	2014 CA Public Utilities Database	23 years	N/A	MA Res 1 Baseline (used in 2022-2024 MA TRM)	More recent, region-specific data.

Appendix G Summary of Data Issues Encountered

The study identified several data quality issues that adversely impacted evaluation of the HES and HES-IE programs. This appendix summarizes the data quality issues encountered.

During R1983, this study team identified the data issues outlined in Table 83, which form the organization for this appendix.

Table 83: Summary of Data Issues

Type of Issue	Specific Issues
Data Management Challenges	Different Data Tracking Systems
	Lack of Data Dictionaries
	Iterative Data Deliveries in Different Formats
	Inconsistent Program names
Customer Level Tracking	Multiple Unique Customer IDs per Customer
	Non-Standardized Addresses
	Masked Accounts
Inconsistent or Incomplete Data	Customer Recommendations
	Incomplete Installation Dates
	Inconsistent Measure-Specific Details

G.1 Data Management Challenges

The study encountered four specific issues related to data management.[179]

Different Data Tracking Systems. Eversource and UI use different data management systems to track HES & HES-IE program participation and installed measures. The tracking systems differ in both the information tracked, as well as how systems structure the data.

Aggregating data across multiple sources is not uncommon for evaluations such as R1983. However, the fact that Eversource and UI collect and maintain data on behalf of the other company (i.e., the datasets are overlapping and not mutually exclusive) makes it more difficult to reconcile than disparate datasets in other jurisdictions. For dual utility participants (i.e., when a HES or HES-IE participant receives service from both Eversource and UI), the Companies track data in both systems. However, our study found consistent differences (e.g., different measure installation counts) for the same projects present in both systems, which added ambiguity, uncertainty, and reliance on proper filtering.

The difference in the tracking systems is exacerbated by the fact that neither system had a consistent formalization of a customer and how customers relate to things like account numbers. When the team received account numbers for the same customer in both datasets, the numbers

[179] Per Eversource: The Company has made some more recent changes – such as the shared Hancock Mint Mobile Assessment Platform – that they believe will alleviate some of the challenges experienced by the study and noted in this section.

often differed. In some cases, optional final digits were included that needed to be stripped to enable successful merges.

Lack of Data Dictionaries[180]. Data dictionaries are essential resources that provide third parties, like program evaluators, with critical meta-data necessary to efficiently analyze associated datasets. Eversource provided a data dictionary for their legacy tracking system but not for the newer one, while UI did not provide data dictionaries for any datasets requested as part of R1983.

In general, the study team found Eversource's data columns easier to interpret. When the team had questions, Eversource was able to provide clarifications upon request. The data provided by UI produced a larger set of outstanding questions, many of which UI was unable to answer when contacted.

The lack of data dictionaries slowed down and added inefficiency to the analysis process and resulted in otherwise avoidable communication with the Companies that further slowed the evaluation process and stressed the project budget.

Iterative Data Deliveries in Different Formats. Evaluation data requests often require iteration to make sure the final dataset includes the necessary data elements and describes the correct population. However, during this process for R1983, it became clear that UI was unable to modify and re-run previous data queries. As a result, UI was only able to produce entirely new data sets to try to correct issues. Often the new data sets did not contain the same elements and/or structure as the previous iteration, which required the team to completely reprocess the entire new dataset (versus just the new fields). The new data formats required extra work to read into the team's existing data systems, as well as more time to blend elements from the new datasets.

Inconsistent Program Names. Often, the program names in the data itself, or used as part of file name, were inconsistent, vague, and/or difficult to match to programs identified in the evaluation plan. Programs names typically result from historic naming conventions or adapted into a new version without a name change. Identifying program types (i.e., low income or upstream) proved difficult in the process. This issue primarily impacted the Customer Profiling element of R1983 as it assessed participation across the entire residential portfolio.

G.2 CUSTOMER-LEVEL TRACKING

The study also encountered three specific issues related to customer-level tracking.[181]

Multiple Unique Customer IDs per Customer. The data provided by both Companies did not include a consistent unique identifier for tracking data associated with a single customer across all data sets. This is problematic as evaluations, such as R1983, require analyzing data from

[180] On June 1, 2022, DEEP approved the 2022-2024 CL&M plan. The plan included Condition of Approval #7 which requires UI develop a new data management system. UI has worked with the Evaluation Administrator and the EEB Evaluation Committee throughout the fall of 2022 to create an accurate data dictionary and produce a system to standardize data requests. UI and the Evaluation Administrator will update the Evaluation Committee at their January meeting. This information was in an email to UI sent on November 22, 2022, and referenced on the EEB Announcements website: https://energizect.com/eeb/board-announcements

[181] Similar to the previous section, Eversource believes data management changes made since this evaluation may have alleviated some of the customer-level tracking challenges experienced as part of this study and documented in this section.

multiple perspectives—at customer level, the account level, the building unit level, etc. For example, the data provided by Eversource was organized at the project level with customer identifiers (such as names, addresses and account numbers) shown as properties of each project. However, customer properties were not always consistent for the same customer across multiple projects.

Non-Standardized Addresses. Neither Company provided verified addresses, nor address information stored in a consistent structure. Consequently, the study found:

- Addresses with typos.
- The same address recorded in multiple locations using in a different format.
- Differences in how addresses, particular for multi-unit buildings, were handled (i.e., 123 Maple Street, Unit A and 123B Maple St.)

Again, inconsistent address formats are not uncommon in program data as they are often entered manually. However, dealing with them added cost and time to the evaluation process, as well as uncertainty. The inconsistencies are particularly problematic for portfolio-level analysis like the Customer Profile effort, which sought to assess participation across programs and to tie that participation to specific Census areas. It is important to note that simple solutions for this problem exist, like verifying all addresses for consistency using the United States Parcel Service address verification process.

Masked Accounts. One data set provided by Eversource for the HES-IE program (tagged HES-IE sub2 in the file name) included masked account numbers to protect data security. The study worked with Eversource to unmask the accounts, but a meaningful portion (35%) could not be unmasked and therefore were dropped from the evaluation's billing analysis.

G.3 Inconsistent or Incomplete Data

Customer Recommendations. Despite being included in the study team's original data request, the provided data by both Companies did not initially include measures that were recommended as part of the assessment but not installed. The team did get this data late in the study, but too late to leverage for the customer survey, which would have increased the value and accuracy of the process evaluation.

Incomplete Installation Dates. When the Companies provided multiple years of program participation within the same file, the files were often missing the relevant installation data or program, which made it difficult to associate each participant's savings with a specific year. This is problematic as part of the study's quality assurance process includes comparing summaries of the total savings observed in the program data – by year – to reported annual savings available in other Company program reporting.

Inconsistent Measure-specific Details. The team also observed considerable inconsistency in how measure-specific data is tracked across providers and programs (UI compared to ES, and HES compared to HES-IE). Specifically, the team observed and spend time triaging:

- Inconsistent naming protocol for Ceiling Insulation, Floor Insulation, and Attic Openings which required line-by-line interpretation.

- Uncertainty whether entries with zeros indicated missing data, or a value of zero.[182]
- Missing key information, such as efficiency and capacity for HVAC technologies, which is critical for savings calculations.

[182] The study made informed assumptions that zeros indicated missing data to reduce the impact on program-wide averages, but which required additional analysis adding time and introducing uncertainty into the results.