CONNECTICUT ENERGY EFFICIENCY BOARD

Evaluation Studies and Results, 2016

A REPORT TO THE ENERGY AND TECHNOLOGY COMMITTEE OF THE CONNECTICUT GENERAL ASSEMBLY

Connecticut Energy Efficiency Board Evaluation Committee

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Final Report

PREFACE FROM THE EEB EVALUATION COMMITTEE

The Energy Efficiency Board (EEB) Evaluation Committee is proud to present the Annual Report of the studies, results and recommendations via the EEB program evaluation, measurement, and verification (EM&V) process. Connecticut has one of the longest EM&V histories, contributing to some of the nation's strongest efficiency programs.

EM&V is very important to the efficiency programs' successes. Evaluations are designed to be comprehensive, independent, actionable and cost-effective. Impact results provide verification that the Fund is being used appropriately and provide beneficial programs and savings. Recommendations also provide essential information on how programs can be improved, additional measures developed and customer needs met. The use of outside evaluators provides for independence and also allows Connecticut to take advantage of the successes and failures of other programs and jurisdictions. The EEB EM&V evaluation process provides funding, leadership, and data, and also reviews studies managed by Northeast Energy Efficiency Partnerships (NEEP).

What follows is a compilation of results and recommendations from studies completed in the last year. Links to the appropriate sections of the Board website will lead you to the full reports, should you want more detail.

Additionally, this report is intended to provide an introduction to the wide range of studies typically completed by the EEB. These current and new studies cover evaluations of program savings, customer and vendor reception to program offerings, assessment of new opportunities and examinations of what pockets of savings remain available in areas already covered.

We believe that you will find the report informative. Please contact us with any questions you may have.

Offered by the EEB Evaluation Committee
Taren O'Connor, Chair
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Dornbos
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PREFACE FROM THE EVALUATION ADMINISTRATORS --- OVERVIEW AND VERIFICATION OF THE 2016 EVALUATION OF CONNECTICUT'S ENERGY EFFICIENCY FUND ACTIVITIES

The evaluation efforts conducted in 2016 were designed and managed by third-party independent experienced evaluators.[1] The evaluations themselves were also conducted by independent evaluation teams, operating under the guidelines of Connecticut's Evaluation Roadmap, which instituted policies to assure independence.

The evaluations completed in 2016 add to the evaluation evidence of accomplishments from the use of Connecticut's Energy Efficiency Fund (EEF).

The Evaluation Consultant Team[2] verified that the 2016 completed evaluations and on-going evaluations meet or exceed the rigor and energy efficiency evaluation practices conducted across the United States. The evaluation results and recommendations are similar to energy efficiency evaluation results elsewhere. The accumulation of the evaluations continues to demonstrate that activities supported by Connecticut's EEF are making reasonable energy efficiency achievements.

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[1] The Evaluation Consultant and the evaluation contractors conduct energy efficiency program evaluations across the nation and beyond. They are independent from Connecticut utilities and Connecticut boards, state regulatory staff and state agencies. All of the evaluators conducting Connecticut evaluation activities provide objective evaluation and verification, following evaluation ethics and "Guiding Principles for Evaluation" from the American Evaluation Association.

[2] The current Evaluation Consultant, contracted in 2016, is a team of experienced independent evaluators led by Skumatz Economic Research Associates (SERA) and includes Ralph Prahl and Associates, Cx Associates, LLC, Wirtshafter Associates, and Jacobson Energy Research, LLC. Each consultant on the team has between 20 and 35 years of experience in the field, and has conducted work nationwide. The offices of these firms are located in Colorado, Florida, Vermont, Pennsylvania, and Rhode Island.

Table of Contents

1. INTRODUCTION

The Energy Efficiency Fund (EEF) and Utility Companies have a long history of providing efficiency programs to Connecticut energy consumers. An integral part of creating, delivering and maintaining quality programs is performing independent evaluations of programs and the markets they serve. The evaluators make recommendations for program modifications that are considered in prospective program development and implementation.

In 1998 the Energy Efficiency Board or EEB (previously the Energy Conservation Management Board) was formed and charged with responsibility to advise and assist the utility distribution companies in the development and implementation of comprehensive and cost-effective energy conservation and market transformation plans. The EEB has worked closely with the Companies to ensure all evaluations are relevant, independent, cost-effective and meet the needs of program administrators and planners who are charged with achieving substantial public benefits. In 2005, the EEB formed an Evaluation Committee that works with an EEB Evaluation Consultant to oversee evaluation planning and completion. In 2009, the Department of Public Utility Control (DPUC) decided that the EEB's Evaluation Committee and their consultant would be independent from and totally responsible for all aspects of the evaluation process.

Since that time, the evaluation process and oversight have changed through additional DPUC (now Public Utility Regulatory Authority (PURA)) decisions which were adopted and extended by PA 11-80, sec. 33, amending Conn. Gen. Stat. sec. 16-245m, in 2011. PA 11-80 required an independent, comprehensive program evaluation, measurement and verification process to ensure the Connecticut Energy Efficiency Fund's (CEEF) programs are administered appropriately and efficiently, comply with statutory requirements, and programs and measures are cost effective; evaluation reports are accurate and issued in a timely manner; evaluation results are appropriately and accurately taken into account in program development and implementation; and information necessary to meet any third-party evaluation requirements is provided.

The essential information gained through studies such as those discussed in this report is provided very cost-efficiently. The three-year 2016-2018 C&LM Plan budget is $633 million. The accompanying three-year evaluation budget is $9 million for all evaluation and related research studies. This is an evaluation percent of 1.4%, which represents a decrease compared to figures of 1.9% in 2013 and 2.1% in 2012.

Research completed within the evaluation group provides many types of information. Impact and process evaluations form the bulk of budget for studies completed. Additional studies support how the current and future efficiency programs are developed, supported and improved through careful research into:

- Current market opportunities for program expansion
- New end uses and equipment that may be included cost-effectively, including assessment of the associated barriers for inclusion of each
- Customer segmentation, market assessment, market progress, and market research,
- Examination of best practices in other jurisdictions

The EEB Evaluation Committee ensures the independence and objectivity of Evaluation Measurement and Verification (EM&V). It is critical that the programs be evaluated, measured, and verified in ways that provide confidence to the public that savings are real and enable the Companies and EEB to use

savings estimates and Evaluator's recommendations to improve and advance programs with full confidence.

1.1 Definition of Evaluation Types

There are many types of evaluation supported by EEF funding. Research studies assist regulators, policy makers, the EEB and program administrators to maintain excellent practices and develop new programming options to meet Connecticut's growing efficiency needs throughout program formation and evolution.

- Process Evaluations determine the efficacy of program procedures and measures. Process Evaluations assess the interactions between program services and procedures and the customers, contractors, and participating ancillary businesses. Process evaluation is essential to support development of improved program delivery, increased cost effectiveness and customer satisfaction.
- Impact Evaluations verify the magnitude of energy savings and the reasons for differences between projected and realized savings. The results and value of energy efficiency programs are reported to regulatory bodies, ISO-New England, Company management, and program planners and administrators. Many different types of impact studies may be completed including end-use metering, engineering modeling, billing analyses, participant interview, surveys and combinations of these.
- Market Assessments examine overall market conditions related to energy efficiency products and services, including current standard practices, average efficiency of equipment, consumer purchasing practices, and identification of market barriers. The assessments ascertain the extent to which efficiency programs are likely to influence customer adoption of measures and practices. Assessments are conducted to identify effective ways to influence key market players to take efficiency actions and increase the breadth and depth of the actions taken.
- Impact Support Studies (including measure effects / performance and methods studies) assess the adequacy of engineering methodologies and background assumptions, supporting the Program Savings Document (PSD) and providing the foundation against which evaluations will assess program performance. Methods studies address methodological issues and develop best practices for evaluation research.
- Baseline Studies provide direct impact support by assessing pre-conditions that will no longer be measurable after program interventions have occurred.
- Evaluation Protocols are produced within the Regional EM&V Forum to provide direction to states new to the evaluation process and to ensure consistency to all of the states within the Forum. Cost-effective regional evaluations are coordinated through the Forum. The EEB is an active participant in the EM&V Forum, providing leadership, quality control, data and funding to its efforts.

Collectively, these types of studies are sometimes referred to as Evaluation, Measurement and Verification (EM&V; defined at the top of the page). The evaluation process is a critical tool to measure energy savings, as well as other key attributes of each program, to allow optimum program design and careful management of consumer conservation funds. The various types of evaluation studies are utilized to support ongoing improvement in program offerings and to measure the results of those programs. The audiences for evaluation include regulatory bodies, the regional electric system operator (ISO-New England), Company management and program planners and administrators, all of whom need

the information to make decisions about program design and efficacy to enhance existing cost-effective programs and redesign program that are not cost-effective to make them successful. Evaluation research provides the basis for determining program direction or focus; increasing participation and savings; expanding the reach of programs, developing messaging more relevant to the non-participating customers where appropriate; reducing costs; and fine-tuning procedures.

1.2 Organization of the Report

The remainder of this report is organized in chapters, based on the current status of the study.

- **Chapter 2 - Completed Studies** includes descriptions, costs and summary results from completed studies that were filed in the last 12 months. Findings and recommendations are summarized; links to the full reports are found at the end of each study description.
- **Chapter 3 – Studies in Progress** includes descriptions, costs and summary results from commercial studies in progress.

The following table, Figure 1, summarizes the completed and in-progress and Regional EM&V studies addressed in this Evaluation Legislative Report. Each is described in more detail in subsequent chapters, as noted.

Figure 1: List of Studies Addressed in the 2016 Legislative Report (by category)
(R=Residential; C=Comm'l / Industrial)

COMPLETE 2016 (Chapter 2)	Report Status
R4. Connecticut Single-Family Process Evaluation	Complete
R31. Real-time Research: HES / HES-IE	Complete
R46. HES/HES-IE Decisions and Financing	Complete
R152. Impact of Connecticut Clean Energy Communities Program on HES Participation and Measure Uptake	Complete
R15. Connecticut Single-Family Potential Study	Complete
R32.Persistence of Eversource HER Program	Complete
R33. Connecticut Residential Program Database Interviews	Complete
R91. Review of Impact Evaluation Best Practices	Complete
R113. Ductless Heat Pump Evaluation	Complete
R151. Connecticut HES Air Sealing, Duct Sealing, and Insulation Practices	Complete
R154. Connecticut LED Lighting Study	Complete
R157. Multifamily Initiative Process Evaluation	Complete
IN PROGRESS (Chapter 3)	Report Status
C1630. Largest Energy Savers Impact Evaluation	In Progress
C1639. SBEA Impact & Process Evaluation	In Progress
C1641. BES & PRIME Impact Evaluation	In Progress
C1663. Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation	In Progress

2. COMPLETED STUDIES

2.1 Residential

NMR Group, Inc., and its partner The Cadmus Group were contracted by the Connecticut Energy Efficiency Board (EEB) to conduct a process evaluation of its Home Energy Solutions (HES) and HES Income Eligible (HES-IE) programs—known as the R4 Project. This evaluation included assessments of program processes, short-term persistence, net-to-gross analysis (NTG), non-energy impacts (NEIs), health and safety concerns that could limit service provision, contractor development, and database and document quality. The EEB also contracted the evaluation team to conduct a separate study (R31), included in this report, which piloted the effectiveness of performing participant surveys addressing program processes and decision making in a timeframe closer to their dates of participation. The R31 study addressed not only HES and HES-IE, but also end-user rebates obtained outside of HES. Finally, the report also includes two additional projects leveraged with R4 and R31: the R46 Project, which examined decision making and financing, and the R152 Project, which assessed the impact of the Connecticut Clean Energy Communities (CCEC) program on HES participation and deeper-measure uptake.

These four studies collectively included eight modules that focused on critical issues related to HES, HES-IE, rebate programs, and the CEC program. Table 1 outlines the modules and their objectives and research questions, while Table 2 maps each module to the research tasks designed to answer these questions.

Table 1: Research Modules, Objectives, and Questions

Module	Major Objectives / Research
Module 1: Program Processes, Experience	Program awareness, experience, satisfaction; clarity of program materials; wait time for receiving services
Module 2: Health and Safety	Degree to which health and safety concerns limit services; types of concerns found; mitigation of health and safety concerns
Module 3: Decision making and Financing (Study R46)	Awareness / use of rebates, financing; role of rebates, financing in decision to install measures; ease of applying for rebates, financing; vendor experience promoting rebates, financing
Module 4: Non-energy Impacts	Whether participants experience non-energy impacts; which they experience; value placed on impacts; impacts expected by non-participants; vendor discussion of impacts
Module 5: Net-to-Gross Ratios	Likelihood of purchasing measures without program incentives; additional purchases made because of program experience
Module 6: Persistence and Effective Useful Life	On-site verification of persistence of portable measures in HES-IE multifamily buildings; self- reported persistence of additional measures (via telephone); early check-in for effective useful life (EUL)
Module 7: Connecticut Contractor Development	Degree to which program has increased revenue, staff for program vendors and energy- efficiency service providers more generally; degree of reliance on HES for work
Module 8: Clean Energy Communities (Study R152)	Degree to which activities performed through the Clean Energy Communities Program induces participation in HES and uptake of deeper measures

Table 2: Mapping of Study Modules and Tasks

	Task 1: Participant and Nonparticipant Surveys	Task 2: HES- IE MF Landlord Interviews	Task 3: On- site Visits	Task 4: Program database review	Task 5: Program document review	Task 6: Bench-marking	Task 7: Vendor Interviews	Task 8: CCEC in-depth interviews and database analysis
Sample Size	*R4 Parts = 833 R31 Parts = 299 R4 Non parts = 240*	*30*	*Sites = 13 Units = 86*	*N/A*	*N/A*	*N/A*	*23*	*6*
Module 1: Process and Experience	X	X	X	X	X	X		
Module 2: Health & Safety	X	X					X	
Module 3: Decision making, Financing	X	X			X	X	X	
Module 4: Non-energy Impacts	X	X			X	X	X	
Module 5: Net-to-Gross	X	X				X		
Module 6: Persistence & EUL	X	X	X			X		
Module 7: Connecticut Contractor Development							X	
Module 8: CEC Impact on HES								X

Although the projects were conducted jointly for efficiencies, the results are presented separately below.

R4 - HES/HES-IE Process Evaluation

The R4 project included assessments of HES and HES-IE program processes, short-term persistence, net-to-gross analysis (NTG), non-energy impacts (NEIs), health and safety concerns that could limit service provision, contractor development, and database and document quality. Brief descriptions of the four relevant programs follows:

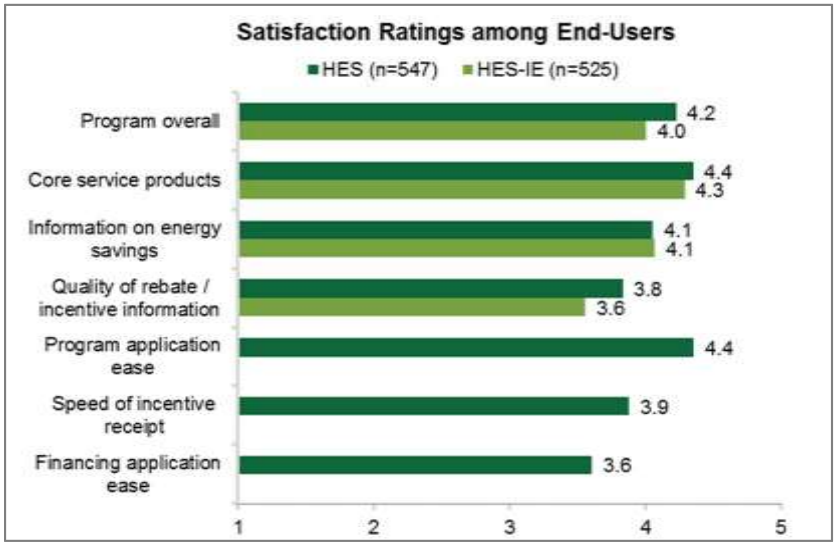
- **Home Energy Solutions** is the "flagship" program funded by the Connecticut Energy Efficiency Fund (CEEF). Program vendors perform energy assessments of single-family and multifamily residences, providing "core services" measures such as efficient light bulbs, faucet aerators, showerheads, air sealing, and duct sealing for a nominal fee. Vendors provide recommendations to participants on add-on measures that are not core services that they could adopt to achieve deeper energy savings. These measures are usually eligible for rebates, zero- or low-interest program financing, or both.
- **Home Energy Solutions – Income Eligible** shares many characteristics with HES, but services are limited to low-income households. Participating households receive the same core services as in HES, but they are not subject to a co-pay; add-on measures are generally provided for free to owner-occupants, although landlords may be subject to co-pays. The list of add-on measures differs somewhat between HES and HES-IE (e.g., HES-IE does not include central air conditioning), and some HES-IE participants simultaneously receive services from the Department of Energy's Weatherization Assistance Program (WAP)[3].

[3] Exploring and explaining the criteria for which participants receive WAP services is beyond the scope of this study, but involves a mixture of eligibility for other social services and fuel assistance programs and availability

Program Processes

The study examined program processes using nearly all research tasks, except vendor and CEC-focused interviews. The primary findings from the exploration of the program processes include the following: Satisfaction is high, program awareness is moderately high, word of mouth and utility outreach are effective marketing approaches, desire to save energy and energy costs drives participation, nonparticipants do not or cannot prioritize energy efficiency, many participants observe energy savings, and participants offer[4] a variety of suggestions for program improvements.

Figure 2: Satisfaction Ratings



Short-Term Persistence and Effective Useful Life

On-site visits to HES-IE multifamily buildings sought to determine the persistence of five portable measures distributed by the program: CFLs, LEDs, faucet aerators, showerheads, and refrigerators. This inquiry resulted in the primary findings listed in Table 3:

- Observed measures exceed counts in program data.
- On-sites indicate limited measure removal.

Table 3: On-site Persistence Results

Measures	Sites Visited	Units Visited	Verified Installed	Verified Installation Rate	Number Removed	Measure Persistence Rate[1]
CFLs	12	70	275	107%	18	93%
LEDs	3	17	41	47%	0	100%
Faucet Aerators	12	83	107	184%	4	96%
Showerheads	12	83	53	196%	3	95%
Refrigerators	3	5	3	150%	0	100%

[1] Based on measures verified as received

of WAP program funds.

Participant telephone surveys also measured short-term persistence. In general, the results confirm the on-site visit results (Table 4):

- Removal occurs due to breakage and dissatisfaction.
- Light bulbs diverged from other measures.
- Removals occur soon after participation for HES participants but can take up to a year for HES-IE participants.

Table 4: End-user Participant Survey Respondents – Verified Measures, Removal Rate, and Timing of Removal

Measure	HES			HES-IE		
	N	% Removed	Average Time Removed[1]	N	% Removed	Average Time Removed[1]
Light bulbs	481	14%	3.4	431	11%	5.2
Water saving measures	247	7%	3.5	330	7%	4.9
Air Sealing	292	2%	3.8	281	1%	1.3
Water pipe wrap	225	<1%	4.0	107	2%	4.0
Duct sealing	81	2%	4.0	27	4%	12.0

Note: Responses are unweighted. [1] Indicates average number of months from installation to removal.

Net-to-gross

Using findings from CATI surveys with HES end-user participants, the study estimated a free ridership rate of **0.22** and a spillover rate of **0.02**, resulting in a weighted[5] NTG ratio of **0.80** for the HES program [*(1 – 0.22) + 0.02 = 0.80*].[6, 7]

Free ridership

- **Two-score approach.** Following industry best practices for estimating free ridership from survey responses and using a weighting scheme based on the number of measures and gross savings estimates, the analysis resulted in an HES free ridership score of **0.22** at the 90% confidence level with precision of +/- 3%.
- **Importance of Insulation Rebate.** Free ridership for insulation was notably low (0.06) and the study calculated the free ridership rate in absence of insulation measures, arriving at a somewhat higher overall free ridership rate of0.26 (Table 5).[8]

Table 5: HES End-user Participant Survey Respondents – Selected Free Ridership Rates

Measures (n=369	N	Average Free	Confidence Interval[1]

[5] The free ridership rate is weighted by number of measures (as compared to the population) and by gross annual savings. Spillover is weighted by the average savings values present in the program database associated with the respective measure types (where possible).

[6] The study also estimated net-to-gross ratios of 0.95 for HES-IE and 0.93 for rebate-only programs. The evaluation suggests not using the HES-IE and rebate-only net-to-gross ratios formally because HES-IE programs generally assume a net-to-gross ratio of 1.0, and sample sizes are small among rebate-only respondents.

[7] When compared to similar programs in the Northeast, the HES net-to-gross ratio is somewhat lower, with other programs having ratios greater than 1.0.

[8] The non-insulation measures included in the 0.26 estimate are both core services (air sealing, duct sealing, light bulbs, water pipe wrap, and water-saving measures) and other add-on measures besides insulation (AC equipment, clothes washers, heat pumps, hot water heaters, and windows).

respondents)		Ridership Rate	Maximum	Minimum
Light bulbs	158	0.55	0.62	0.49
Water pipe wrap	66	0.28	0.37	0.19
Water saving	76	0.20	0.28	0.13
Insulation	140	0.06	0.09	0.03
Total[2]	**601**			
Overall Weighted Average Free Ridership Rates[2]				
With insulation		**0.22**	**0.25**	**0.19**
Without insulation		**0.26**	**0.30**	**0.23**

[1] Figures are at a 90% confidence level.

[2] The total and overall weighted average free ridership rates include all measures presented in Section 5, not just the three shown in this table. The overall average free ridership rate is weighted by number of measures (as compared to the population) and by gross annual savings.

Spillover

- **Eligibility.** Nearly one-fifth of the HES respondents, following their participation in the program, installed or performed an energy-saving measure that did not receive an incentive *and* indicated that their decision to move forward was influenced by the program.
- **Initial results after weighting.** The analysis resulted in an average *initial* spillover value of 0.06 for the HES program.[9]
- **Results after adjusting.** The adjusted spillover value for the HES program resulted in **0.02** [*0.06 * (1/3)*].

Non-Energy Impacts

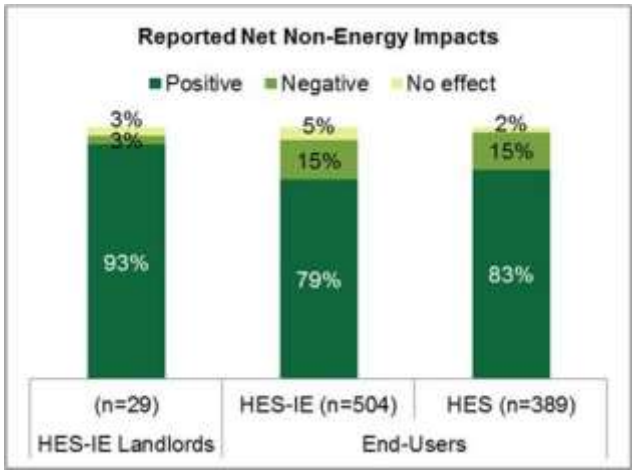
The addition of the value of NEIs to the programs' benefit-cost ratios (BCR; the ratio of monetized value of program benefits to the costs of program administration) has the potential to increase program benefits by millions of dollars. To estimate NEIs from a participant perspective, the study asked participants if the program had a positive, negative, or no effect on various non-energy-related elements in their households or properties. For any elements for which participants observed positive or negative impacts as a result of the program, interview or survey questions asked them to compare the value of that NEI, and then finally all NEIs in aggregate, to the impact of the program on energy savings. From these inputs, the study estimated NEI values using methods consistent with industry best practices.

Net Non-Energy Impacts

Participants experienced positive net impacts from program NEIs, and in comparison, to neighboring Northeast programs, they valued program NEIs relatively highly, as well. The vast majorities of end-user and landlord and property manager participants reported positive net impacts. The analysis found overall NEI values of **0.87** for HES end-users, **0.90** for HES-IE end-users, and **0.73** for HES- IE landlords and property manager participants. These values can be considered multipliers that can be translated as a percentage of household energy savings; for example, for every dollar that the average HES household saves on energy costs, the household perceives that they have received an additional 87 cents in NEIs. Adding the end-user NEI values to the programs' Total Resource BCRs could mean increases in program total resource benefits of **$155.6 million** for HES (45% increase) and **$95.6 million** for HES-IE (64% increase) over the 2016 to 2018 program period.

[9] Savings values for all fuel types (electric, gas, oil, and propane) were converted into MMBtu. The average MMBtu was used for the weighting.

Figure 3: Reported Net Non-Energy Impacts



- **Specific Impacts**
  Comfort, safety, and property value were positively impacted.
  Negative NEIs are minimal.
- **NEIs as Participation Drivers**
  Customers may not be tuned into possible NEIs.
  NEIs act as program drivers for landlords.
- **Common Health and Safety Issues Found**
  Participants reported some health and safety issues.
  Assessors most often discovered asbestos and vermiculite insulation and knob and tube wiring.
  Nonparticipants discovered issues on their own—primarily issues with mold.
- **Barriers to Participation**
  Vendors cited health and safety issues as major barriers to participation.
  Participant and nonparticipation remediation are hindered by cost.

Overarching Conclusion and Recommendations

Data collection and management.[10]
The on-site persistence visits identified apparent errors in the program tracking database. As these were discovered after the R33 study was conducted, that study did not address them. The data for several sites appeared to incorrectly indicate the presence or absence of program measures.
Recommendation 1: The evaluation recommends that the Companies work closely with the program implementers and vendors to ensure that program data are entered into the tracking database correctly. Explore ways to enhance quality assurance/quality control procedures to verify the accuracy of data entry.[11]

[10] The database review yielded additional insights but those have been addressed in the R33 Database Management Study.
http://www.energizect.com/sites/default/files/Observations_Recommendations_CT%20Resi%20Pgm%20Database%20Interviews%20%28R33%29%20-%20Final%20Report%2C%201.26.16.pdf
[11] It should be noted that the Companies have been recognized by the U.S. Department of Energy (DOE) as already having a robust quality assurance/quality control model. Source: Richard Oswald, UI; February 16, 2016; draft report comments, "R4 HES/HES-IE Process Evaluation and R31 Real Time research."

Recommendation 2: It is critical for tracking databases to be developed/organized to account for evaluation aims as well as program implementation. Specifically, if CEEF-funded and non-CEEF-funded measures are installed in program units, it is important to impact evaluations that the total number and type of measures installed through any funded source be listed. The study recommends encouraging vendors and community action agencies to follow the Companies' preferred standardized protocols for listing all measures installed in units regardless of the funding source in order to improve the accuracy of impact evaluations.

Program Processes

Participant satisfaction. Some persistence issues among end-users were also linked to product quality.
Recommendation 3: It may be beneficial to reevaluate the quality of the actual materials that vendors are installing. See Recommendation 16 below for specific recommendations on lighting.
Program awareness. Nonparticipants reported moderately high awareness of the programs.
Recommendation 4: Participants themselves suggested that the program increase its advertising.[12]
Program drivers. Participants' desire to save energy and energy costs drove them to participate.
Recommendation 5: Any new advertising should emphasize the proven energy and energy cost savings that the program improvements will create for participants. The messaging could focus on addressing customers' skepticism that there is not a need to make improvements or on their "haven't gotten around to it" attitudes, and stressing how little the assessments themselves cost, especially when compared to the value of the services provided.
Communication. HES-IE landlords and property managers found that the entire participation process took longer than they expected and expressed frustration with program communications.
Recommendation 6: The property managers and landlords had insightful suggestions for improving communications like creating a single contact for all program-related communications, communicating more clearly about timelines upfront, carrying out more direct communication as opposed to relying on third-party contractors, and clearly conveying what to expect from the technicians. The study suggests that the program address the timing issue by focusing on increasing the speed of rebate processing and communication response time with landlords.

Short-Term Persistence and Effective Useful Life

On-site visits verified high short-term persistence rates on portable measures.
Recommendation 7: The study finds no evidence to justify downwardly adjusting persistence rates or measure lives for CFLs, LEDs, faucet aerators, showerheads, or refrigerators in HES-IE multifamily units. The Companies should continue to use current assumptions as listed in the 2015 PSD at this time.[13]
LEDs persistence exceeds that for CFLs.
Recommendation 8: Given the increased marginal savings achieved by LEDs over CFLs, the greater tendency for participants to keep program LEDs installed compared to CFLs, and the longer measure life for LEDs, the program should continue its efforts in the 2016 to 2018 program cycle to shift resources from CFLs to LEDs, eventually making LEDs the default standard socket lighting measure for the program.[14]

[12] It should be noted that The Companies fully expended their marketing budgets in 2015. Refining or targeting this marketing may improve the cost-effectiveness of the program's marketing efforts.
[13] United Illuminating Company and Connecticut Light and Power. 2014. Connecticut Program Savings Document: 10th Edition for 2015 Program Year. Document dated November 5, 2014.
[14] The program increased its courtesy LED offering in 2016 from four lamps to six bulbs, and plans to offer more in the future. An unlimited number of LEDs are offered through the HES program at a subsidized price in conjunction with customer co-pay.

Net-to-gross (NTG) ratios

When compared to similar programs in the Northeast, the HES NTG ratio of 0.80 is somewhat lower, with other programs having ratios greater than 1.0.

Recommendation 9: The evaluation team suggests that the Companies consider the findings of this study when revising overall program free ridership, spillover, and realization rates in the PSD *for the HES Program*. For some HES measures, the confidence intervals are small enough and sample sizes large enough to serve as measure-specific free ridership values that the evaluation team suggests using for the PSD: insulation (0.06), water saving measures (0.20), and water pipe wrap (0.28). Two measures with adequate sample size require special attention. First, while the HES light bulb confidence interval was small and the sample size was large, the evaluation team suggests using the upstream lighting NTG ratios of 51% for CFLs and 82% for LEDs (as reported in the R86 Lighting NTG and LED Market Assessment study).[15] Second, as reviewers have pointed out, the type of air sealing customers perform on their own most likely would not be blower- door guided; therefore, a free ridership rate of zero should be assumed for this HES measure.

Insulation free ridership

Free ridership for insulation was notably low (0.06) and the study calculated the free ridership rate in absence of insulation measures, arriving at a somewhat higher overall free ridership rate of 0.26.

Recommendation 10: Considering the low free ridership rate and also the enthusiasm among customers for the insulation rebate opportunity that vendors observe, the program will benefit from continuing to offer its generous incentive for this cost-effective measure.

Recommendation 11: Given the relatively low free ridership rates and higher adoption rates for insulation coupled with the claim by participants that would adopt more measures with deeper incentives, free ridership rates for some measures may actually decrease if the Companies increase incentives. That is, free ridership may be higher at lower incentive amounts, but higher incentive amounts really move people to adopt a measure that they otherwise would not have adopted.

Overall Non-Energy Impact values

Participants experienced positive net impacts from the program. These positive NEIs far outweighed any negative NEIs.

Recommendation 12: The evaluation suggests that the program consider structuring future evaluation efforts to estimate how NEI values such as these could be added to program BCRs to increase program total resource benefits. Because the current study was not structured to provide fuel or measure-specific NEIs, the evaluation does not recommend revising the current BCRs.

Perceptions of NEIs

HES-IE landlords and property manager participants perceived potential NEIs as a driver for their participation.

Recommendation 13: While the program should continue prioritizing energy savings as a central marketing message, the divergence between nonparticipants' lower expectations for NEIs and participants' actual experiences with NEIs suggests that increasing the emphasis on NEIs in program marketing materials may also be warranted. NEI messaging should focus on the positive impacts on comfort, property value, and safety, perhaps through end-user testimonials.

[15] NMR Group, Cadmus Group, and DNV GL. 2015. R86: Connecticut Residential LED Market Assessment and Lighting Net-to-Gross Overall Report. Delivered to the Energy Efficiency Board, May 2015. http://www.energizect.com/your-town/ct-residential-led-lighting-market-assessment-and-lighting-ntg-r86final

Health and safety as barriers to participation

Vendors perceive health and safety issues as major barriers to participation, estimating that these issues impact close to one-fourth of all jobs.

Recommendation 14: Continuing to provide clear and effective health and safety-oriented messaging and support to end-users, landlords, and vendors may help to address these issues over the long term. Additionally, the program should continue its efforts in improving the tracking of the prevalence of these barriers and working with health and safety partners throughout the state to refer homes with identified health and safety barriers to these organizations for assistance.

Remediation costs. Both participants and nonparticipants said that the costs associated with remediation of health and safety issues are a hindrance.

Recommendation 15: For both HES and HES-IE end-user participants and landlords/property managers, provide more information on the financing options— including some external to the program—that cover at least part of the costs of remediating health and safety issues. Continue encouraging financing partners to improve options for financing or assisting with remediation.

Recommendation 16: When replacing light bulbs, make certain that the lumens duplicate or exceed the lumens of the bulb being replaced, unless doing so creates additional safety concerns (e.g., the wattage of the new bulb would be too great to use safely in the fixture).

R31- Real-time Research: HES / HES-IE and End-User Rebates

The Connecticut Energy Efficiency Board (EEB) contracted the evaluation team to conduct a separate study (R31), which piloted the effectiveness of performing participant surveys addressing program processes and decision making in a timeframe closer to their dates of participation. The R31 study addressed not only HES and HES-IE, but also end-user rebates obtained outside of the HES and HES-IE umbrella. For example, households could adopt central air conditioning or ductless heat pumps without going through the HES programs. Participants buy these measures on their own or through a contractor and submit forms for a rebate. The study did not examine any upstream rebate programs (e.g., those for lighting, water heating, and other measures) in which rebates go to manufacturers, retailers, or contractors.

- **Preferences**
  Participants prefer rebates to financing.
  Participants want rebates that cover roughly one-half of project costs.
- **Awareness of program rebates, incentives, and financing**
  Vendors actively promote program opportunities.
  Program Processes
  Participant satisfaction is high among end-user.

Program offering information

Some end-users expressed disappointment with the quality of rebate and incentive information. However, short-term survey respondents were significantly more likely to be highly satisfied with the quality of the rebate and incentive information provided when compared with long-term respondents.

Recommendation 1: Vendors are currently provided with resources to help them understand and explain the program to customers, including language to use when discussing the program offerings. Providing vendors with additional or more detailed talking points and materials to encourage customers to consider add-on improvements may help overcome some of the challenges some end-users have expressed with the quality of information.

Recommendation 2: The program does a good job of providing both print and online materials to support customers. (The website is well-designed and informative, for example.) However, clarifying or

offering additional details about program offerings in customer-facing materials and marketing efforts may also help to address customer concerns over information quality.

Program incentive and rebate levels

The program offerings have been popular with customers, especially the insulation allowance that covers 50% of installed cost.

Recommendation 3: Continue offering substantial rebates for insulation because free ridership is low and participants respond positively to them.

Recommendation 4: If cost-effective, consider increases to incentives for other measures, given the success proven with 50% insulation allowance.

Short-term data collection

Short-term respondents are more satisfied with core services and program information on savings and incentives, are more likely to say they have or will use program rebates and incentives, and exhibit lower levels of free ridership.

Recommendation 5: Weighing all of this information, the study recommends that the EEB and Companies strongly consider fielding **one more** short-term survey using an instrument very similar to R31 within three to six months of program participation. This survey should provide enough information to allow for a definitive recommendation of whether a continuous short-term survey effort is justified for Connecticut HES, HES-IE, and downstream residential rebate programs.

Language barriers

A sizable (but unknown) portion of participants primarily speak other languages, with Spanish being the most common

Recommendation 6: For future studies that reach out to HES-IE participants, the EEB and EEB Evaluation Consultants should attempt whenever possible to ensure that the studies be planned and adequately funded to ensure inclusion of non- English-speaking (primarily Spanish-speaking) customers. Providing adequate resources would allow future evaluations to hire trained bilingual technicians and interviewers, which would improve the exploration and characterization of the substantial non-English-speaking portion of the eligible population.[16]

R46 - HES/HES-IE Decisions and Financing: Participants / Non-Participants, Landlords / Property Managers and Vendors

The R46 study, an expansion of R4 and R31, assessed decision making and financing through the use of computer-assisted telephone interviewing (CATI) surveys with HES participants and nonparticipant end-users, and in-depth interviews with HES-IE landlords/property managers and HES vendors.[17]

- **Preferences**

  Participants prefer rebates to financing.

  Participants want rebates that cover roughly one-half of project costs.

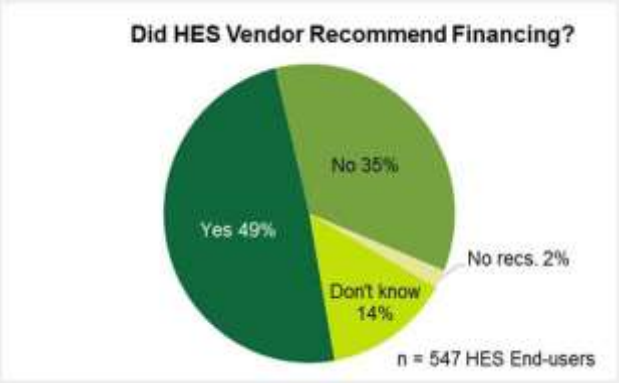
  Zero percent loans and on-bill financing are attractive.

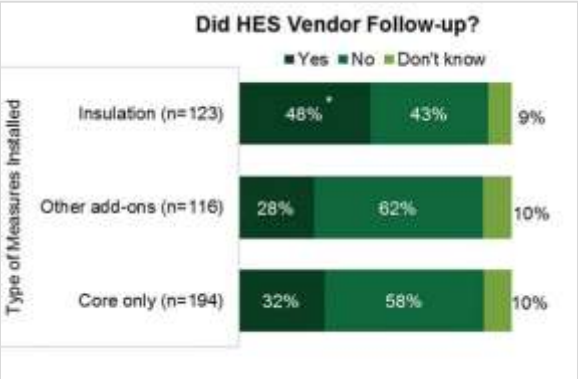
[16] Note that the program already provides many customer-facing materials in both Spanish and English, such as print, newspaper, and radio advertisements, program brochures, and rebate forms. Resources for vendors are also provided in both Spanish and English, such as the POD Booklet to be used by vendors at kitchen table "wrap ups".

[17] This analysis is meant neither to compare and contrast the financing or rebate options nor to make specific recommendations on rebate amounts or financing interest rates and terms. Instead, the study shares the experiences, preferences, and observations of program participants and vendors.

- **Barriers to participation in the financing option**
  Some customers remain averse to financing.
  Lack of perceived need also detracts from partaking in financing.
  Financing is appealing but still not enough for some.
- **Awareness of program rebates, incentives, and financing**
  Vendors actively promote program opportunities.
  Awareness is high among nonparticipants.
- **Pivotal decision-making factors**
  Incentives appear to be pivotal in the decision-making process.
  Vendor recommendations do not always lead to installations.
  Vendor follow-up may be linked to insulation installation.

Figures 4 and 5: Vendor Recommending Financing and Follow-up





Clarity of information
Financing materials and processes confuse some vendors and customers.
Sources vary in nomenclature and may cumulatively add to the participants' and customers' potential confusion.

Barriers to Participation
Vendors cited health and safety issues as major barriers to participation.

Connecticut Contractor Development
The study included interviews with 16 HES vendors who served the program in 2014. The interviews were conducted in combination with those for R46 Financing, R151 Air Sealing, Duct Sealing, and Insulation, and R157 Multifamily Process studies. Questions focused on the qualitative impact of HES on their businesses. The major findings include the following:

- Vendors say that their businesses' viability largely depends on the existence of HES.
- The program has led to increased vendor revenue and staffing levels.
- Vendors believe the program has helped expand their energy efficiency business and the general market for energy efficiency services.

Program-related business varies as portions of vendors' revenue. Vendors who rely almost exclusively on HES for their work (75% to 100%) and those for whom HES supplements (50% or less) their other work.
Vendors are skeptical that HES will continue to grow.

Program Process-Participant satisfaction
Satisfaction is high among landlord and property manager participants. But one of their suggestions was for the program to improve the quality of core services because they had received complaints from tenants about safety concerns stemming from the perception that the efficient lighting was too dim and quality concerns when it came to the air sealing (see Recommendation 24 below).

Decision Making and Financing-Program offering information
The HES program uses a variety of methods to educate customers about program offerings. Utility marketing through bill inserts or through the program website are relatively common sources of awareness of rebates and incentives. The HES program also relies heavily on vendors to promote and explain these offerings to eligible participants.

Program incentive and rebate levels
Program participants as well as nonparticipants often cite not having enough funds to cover the down payment to make improvements as a key reason for not moving forward with the work.
Recommendation 1: Continue offering substantial financing for insulation because free ridership is low and participants respond positively to them.

Financing materials and processes
Financing materials and processes confuse some vendors and customers.
Recommendation 2: Provide an "everyday language" version of the loan application to accompany "legalese" documents through working with loan providers.
Recommendation 3: Continue expanding and updating existing materials that provide financing information, such as the vendor-focused Implementation Manual, or the customer-focused POD Booklet used during the wrap-up after the assessment. It may be useful to provide more details or to clarify the information and language about financing options. In particular, the Implementation Manual could encourage vendors to explain the options in greater detail to better ensure that that the customer understands the options and how best to take advantage of them. Additionally, the POD Booklet could provide a clearer explanation of the relationship between the table of offerings and the Energy Conservation Loan Program described on the following page.
Recommendation 4: Provide vendors with talking points and materials on sales methods to use when customers are initially opposed to the idea of applying for a program loan.

Financing sources vary in nomenclature
These variations in nomenclature may add to participants' and customers' potential confusion.
Recommendation 5: Provide guidance to vendors, website developers, and funding agencies about preferred language to use when referring to financing. Make certain that all websites and materials—vendor, program, and funding agency—use consistent nomenclature. Keep financing option name changes to a minimum, but when changes are necessary update all program materials and websites simultaneous with rolling out the name change.[18] Make certain the vendors and program staff use consistence language, both in informal discussions (this will make the terminology second nature) as well as in written materials, such as the vendor- targeted Implementation Manual.

Indicators of effects

[18] The Companies provide vendors with updates regarding new or changing financing options during quarterly meetings as well as during periodic email communications.

Not only has the program led to increased vendor revenue and staffing levels, but many vendors' businesses' viability largely depends on the existence of HES; in fact, some vendors rely almost exclusively on HES for their revenue.
Recommendation 6: The EEB may wish to conduct a larger study to quantify the extent of program market effects that would generally involve interviews or surveys with product distributors/suppliers and participating and nonparticipating installation contractors.

Program structure
Vendors do not always agree with changes in rebates and measures offered.
Recommendation 7: Given vendors' reliance on the program and the program's implicit reliance on vendors to have an impact on the market (and support program participation), it is pivotal to get vendor input before deciding to make structural program changes to foster a sustainable relationship between the program and its vendors. Additionally, any changes that are made should ideally be accompanied by clear communications to the vendors regarding the reasons for the changes and the mechanics or implications of the changes.

R152 - Impact of Connecticut Clean Energy Communities Program on HES Participation and Measure Uptake

The R152 Project assessed the impact of the Connecticut Clean Energy Communities (CCEC) program on HES participation and deeper-measure uptake. CCEC works with community groups to promote energy efficiency and renewable energy in towns across Connecticut. Towns sign Clean Energy Communities Municipal Pledges and engage in outreach activities that encourage energy efficiency and renewable energy in municipal buildings, residences, and small businesses. Towns earn "points" based on the number of participants and the types of measures they install. Once they have earned 100 points, towns are eligible to apply for grants to fund additional energy-efficiency and renewable energy projects.

Connecticut Clean Energy Communities
The eighth study module, also known as Study R152, involved an assessment of the role played by the Connecticut Clean Energy Communities (CEC) program in boosting participation in HES and uptake of deeper savings measures. This assessment entailed interviews with utility program staff members and leaders of energy-related community groups. The study also examined rates of HES and other CEEF program participation and deeper-measure uptake through statistical analyses of program data available on the Energize Connecticut dashboard and of the HES program tracking databases for 2014.

- Successful CEC communities have a core group of motivated community members to spearhead community engagement.
- Leveraging existing community events improves program outreach.
- Strong utility staff promote program success.
- Community members suggested that additional structure or guidance could be added to the CEC program to aid in community engagement.
- Statistical analyses failed to find a consistent relationship between CEC program outreach, HES participation, and deeper-measure uptake.

Document Review

The document review assessed the materials and resources that Energize Connecticut and the utilities provide in support of the HES and HES-IE programs, and whether those materials and resources are effective, clear, engaging, and accessible to potential program participants and vendors. The document review also assessed the relationship between the evaluation's recommendations and the review findings to help identify successes and possible areas of improvement.

The analysis has indicated that the participation and financing materials and vendor documentation tools offered are generally clear and effective resources for customers and vendors to utilize. Some participants responding to the CATI survey recommended increasing advertising and the quality of information provided about the program. HES short-term respondents were significantly more satisfied than long-term respondents with the quality of program information, and both HES and HES-IE short-term respondents were significantly more satisfied with the rebate and incentive information when compared with long-term respondents, possibly signaling program improvements or superior recall due to more recent participation.[19]

- **Participation materials.** Program materials contain a substantial amount of information about the assessment process that should be easy to understand from the customer perspective.
- **Financing materials.** The program produces a number of materials and resources to support customers as they learn about the financing options that are available to them. The Energize Connecticut website and its online financing tool as well as the Print-on-Demand (POD) Booklet (used by vendors when speaking with customers during the kitchen table wrap-up after the assessment) provide a good deal of background information for customers, but customers may find it valuable to speak with a specialist to clarify the process and specific steps needed (and the order in which steps should be taken). Vendors are provided with a chart of financing options, and the Implementation Manual instructs vendors to refer customers to the Energize Connecticut website to learn more about financing options.
- **Vendor documentation tools.** The program produces a number of materials and resources to support vendors as they work to educate customers about the assessment and program offerings.
- **Marketing materials.** The program provides many different marketing materials to reach potential HES customers.

Connecticut Clean Energy Communities

Structure and guidance for Clean Energy Communities. Clean energy community leaders appreciated the flexibility and creativity afforded to them for hosting community events and reaching out to their constituencies.

Recommendation 1: While the Companies cannot mandate the way that towns organize their own activities, they could suggest that towns formalize CEC positions within the town municipal structure so that if a key person leaves, someone new steps into that role.

[19] Note that this evaluation included an experimental approach to test whether traditional delayed process evaluation results might differ from responses obtained close to the time of actual program participation. "Shortterm"
refers to participants who were surveyed closer to the time of participation (six to nine months postparticipation), and "long-term" survey respondents refer to participants who were surveyed at a later time (after nine months post-participation).

R15 - Connecticut Single-Family Potential Study

This report summarizes the results of a single-family residential potential savings study which NMR conducted on behalf of the Connecticut Energy Efficiency Board (EEB). The study estimates the potential heating oil, natural gas, propane, and electricity savings from upgrading the efficiency of existing single-family homes in the state. It makes use of home energy data gathered over the course of 180 on-site assessments, which were conducted between September 2012 and January 2013 for the Connecticut Weatherization Baseline Assessment.[20]

The results presented in this document describe technical, cost-effective, market achievable, and fuel switching potential savings results. The technical potential, cost- effective, and market achievable savings should be considered as three steps in the same analysis. ***The fuel switching results, however, should be viewed and considered independently***—the savings presented in the fuel switching potential section are not meant to be additive to the savings presented in any of the other sections, as some of the measure upgrades overlap.[21]

The technical, cost-effective, and achievable potential savings include impacts of fuel switching to heat pump technologies; however, they do not include any oil-to-gas or electric-to-gas conversions. The fuel switching potential savings do include conversions from non-gas fuels to natural gas; again, it is important to remember that this analysis was conducted independently of the technical, cost-effective, and achievable potential savings analyses, and the results should be considered independently.

The following descriptions detail each of the four critical study components.

- **Technical potential savings** are the energy savings that are technically feasible[22] over a ten-year period from 2016 to 2025.
- **Cost-effective potential savings**[23] are the energy savings that are technically feasible and cost-effective to achieve over a ten-year period from 2016 to 2025.
- **Market achievable potential savings** are the energy savings that are technically feasible, cost-effective, and achievable over a ten-year period from 2016 to 2025. Market achievable savings are derived by adjusting cost-effective savings to account for the effective useful life of existing equipment and the gradual market adoption of high-efficiency upgrades.
- **Fuel switching potential savings** are the potential impacts resulting from conversion of the heating and water heating equipment in single-family homes currently using oil, propane, biomass, or electric heating to either (a) natural gas space heating and water heating equipment, or (b) electric heat pump spaceheating and water heating equipment.

[20] NMR Group, Inc. "Single-Family Weatherization Baseline Assessment (R5), Final Report" Submitted to The Connecticut Energy Efficiency Fund, Connecticut Light and Power, and The United Illuminating Company, June 3rd, 2014.

[21] For example, a home with an oil boiler that is upgraded to a higher efficiency oil boiler in the core potential study may have the same boiler replaced by a high efficiency gas boiler in the fuel switching analysis; the savings from these two measure upgrades are duplicative.

[22] A technically feasible upgrade, for the purposes of this study, is an upgrade that can possibly be installed in a house given its configuration and existing characteristics. For instance, vaulted ceiling insulation upgrades were only applied to homes where vaulted ceilings are present.

[23] Many of the measures considered for the potential study are not currently incentivized by the Companies and as a result they cannot be screened for cost-effectiveness using the Utility Cost Test. For this reason, the Total Resource Cost test was used to determine whether or not measures were cost-effective.

The study used REM/Rate™ home energy modeling software[24] to calculate potential savings for each study component. The 180 home energy ratings conducted as part of the Connecticut Single-Family Weatherization Baseline Assessment were each modeled in REM/Rate. These "as-built" models were then copied and adjusted to reflect various efficiency upgrades and fuel switching opportunities.[25] The energy consumption from the as-built model was compared to the adjusted model to calculate potential savings. More detail on the methodology can be found in the Methodology section of this report.

Technical, Cost-Effective, and Achievable Potential

Energy Savings

Figure 6 shows baseline consumption and potential savings from each component of the study for the first year (2016) and tenth year (2025) of the study's ten-year window. As shown, annual technical potential electric savings are 59% of baseline consumption in year one and year ten with the inclusion of solar technologies; these values fall to 17% of baseline electric consumption when excluding solar technologies. While annual cost- effective electric savings account for 21% of baseline consumption in year one, by year ten the proportion drops to 10%. This is due largely to changes in federal minimum efficiency standards for lighting and appliances. Market achievable electric savings, which are derived from cost-effective savings and account for the effective useful life of existing equipment and the gradual adoption of upgrade measures over time, account for 5% of baseline consumption in the first year and 4% in the tenth.

Cost-effective fossil fuel savings—including savings in fuel oil, natural gas, and propane— account for 29% of baseline consumption in year one, and drop slightly to 26% in year ten. Market achievable savings increase substantially over the course of the ten years, from 2% of baseline to 8%. This occurs mainly due to the gradually increasing market adoption of upgrade measures over the course of the ten-year window, but also because as years pass, existing equipment ages and is replaced, leading to replace-on-failure savings opportunities.

The drop-in savings from cost-effective to market achievable potential is driven by the following factors:

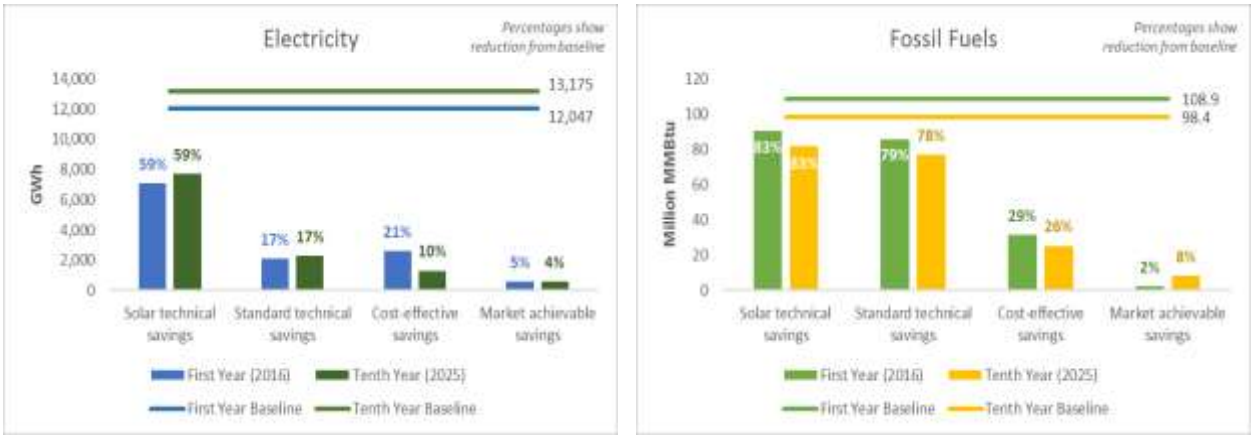
- Conservative assumptions about adoption rates that do not account for the impacts of incentive programs
- Gradual adoption of upgrades over time, as opposed to immediate adoption (which takes place in the technical and cost-effective stages)
- Adjusted baselines due to federal codes and standards for mechanical equipment, lighting, and appliances

The market achievable savings are conservative estimates because they **do not** account for the impacts of incentive programs. Accounting for incentive programs would increase expected consumer adoption rates and could result in expedited equipment retirement and increased achievable savings estimates.

The Achievable Potential section of the report shows that increasing the market penetration rates that were assumed for the market achievable potential analysis increases the electric achievable savings from between 5% and 7% and increases the fossil fuel achievable savings from between 5% and 12% Figure 6.).

[24] REM/Rate is a residential energy analysis software that is commonly used to model the performance of residential buildings—the software is most notably used by the ENERGY STAR® Homes program.
[25] Please note that these models were not calibrated to actual energy consumption.

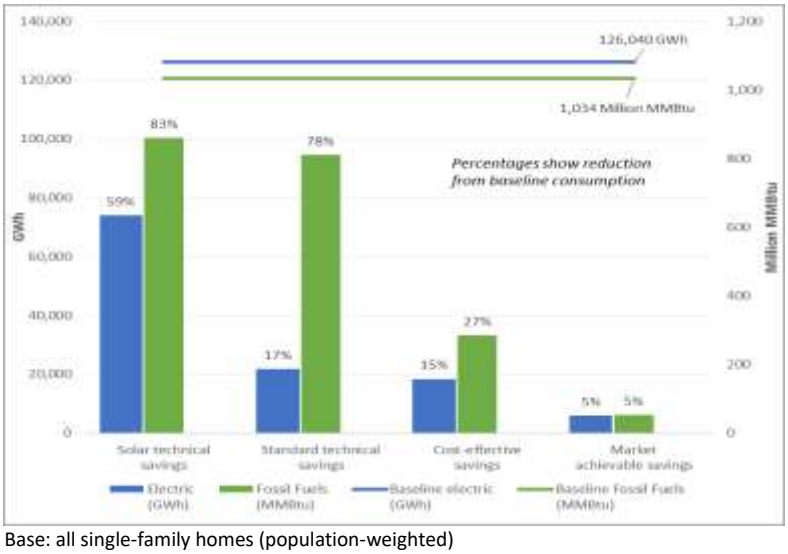
Figure 6: First Year (2016) and Tenth Year (2025) Technical, Cost-Effective, and Market Achievable Potential Savings



Base: all single-family homes (population-weighted)

Figure 7 shows ten-year aggregate technical (with and without solar technologies included), cost-effective, and achievable potential savings. As a percentage of baseline consumption, savings are greater for fossil fuels than electricity in each stage of the analysis except achievable potential, where savings in both fuel types account for 5% of baseline consumption.

Figure 7: Ten-Year (2016-2025) Aggregate Technical, Cost-Effective, and Market Achievable Potential Savings

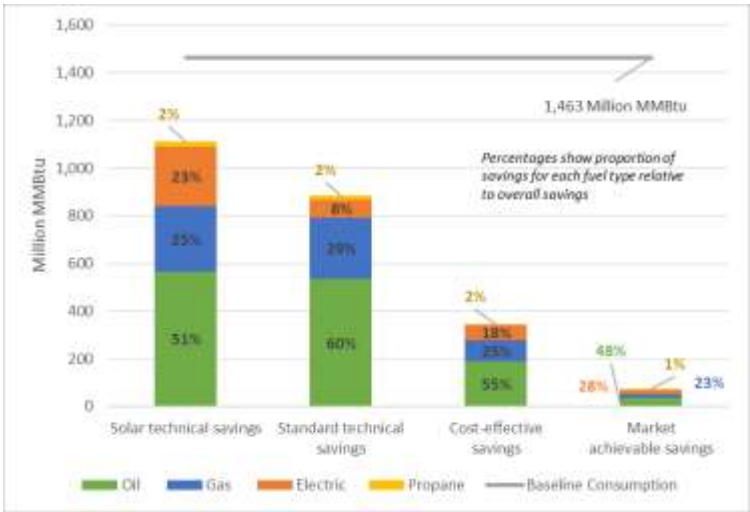


Base: all single-family homes (population-weighted)

Figure 8 shows ten-year aggregate savings by fuel type. As shown, the majority of fossil fuel savings are in fuel oil for each of the potential analyses. This is primarily due to the fact that fuel oil is the most common heating fuel among single-family homes in Connecticut.[26]

[26] Of the 180 homes audited for this study, 111 were primarily heated by fuel oil.

Figure 8: Ten-Year Aggregate Potential Savings by Fuel Type for Technical, Cost-Effective, and Market Achievable Scenarios (2016 to 2025)



Base: all single-family homes (population-weighted

Table 6 shows the following detailed findings from the technical, cost-effective, and achievable potential analyses:

Accounting for all applicable energy efficiency upgrades (including photovoltaics and solar hot water), single-family homes in Connecticut have the technical potential to save about 85% of baseline fuel oil usage, 81% of natural gas usage, and 59% of electric usage over the ten years from 2016 to 2025.

Screening measures for cost-effectiveness diminishes potential savings substantially. Cost-effective fuel oil savings again account for the greatest proportion of baseline consumption, at 29%. Natural gas savings also represent a relatively high proportion of baseline usage in this stage of the study (26%). Propane (19%) and electric savings (15%) accounted for less savings relative to the baseline.

Achievable potential, which accounts for the likelihood of energy upgrade adoption as well as codes and standards, shows that fuel oil (5%), natural gas (5%), propane (3%), and electricity (5%) all have a savings potential between 3% and 5% of baseline consumption over the ten-year period assessed in the analysis.

Table 6: Savings from All Applicable Measures by Fuel—Ten-Year Aggregate (2016 to 2025) *

	Fuel Oil (gal)	Natural Gas (ccf)	Propane (gal)	Electric (kWh)	Fossil Fuels (MMBtu)	All Fuels (MMBtu)
Ten-year baseline consumption	4,795.2	3,372.9	350.3	126,040.4	1,034.3	1,464.4
Ten-Year Aggregate Savings (2016-2025)						
Technical potential including solar	4,081.7	2,729.2	234.5	74,022.4	860.4	1,113.0
Technical potential excluding solar	3,847.7	2,590.9	200.9	21,843.2	811.1	885.6
Cost-effective potential	1,369.6	880.0	68.1	18,399.2	284.2	346.9
Market achievable potential	251.7	165.5	11.4	5,913.6	52.5	72.7
Percent Savings from Baseline (2016-2025)						
Technical potential including solar	85%	81%	67%	59%	83%	76%
Technical potential excluding solar	80%	77%	57%	17%	78%	60%
Cost-effective potential	29%	26%	19%	15%	27%	24%
Market achievable potential	5%	5%	3%	5%	5%	5%

Savings are in millions of units. Base: all single-family homes (population-weighted)

Table 7 shows the top 15 measures that were considered in this study in terms of technical potential savings. The measures are listed in order based on the total technical potential in MMBtu. From left to right the table columns show the following information:

- Technical potential savings (in MMBtu)
- The percentage of homes for which each measure was applicable in the technical potential model runs
- The mean TRC ratio associated with each measure
- The percentage of homes for which the measures passed the TRC test (i.e., homes that had a benefit-cost ratio of greater than or equal to 1.0)
- The estimated market penetration rate, in 2025, that was used for each measure in market achievable potential analysis

Reviewing the table from left to right should help put the drop-in savings that is associated with each study step into some perspective. Specifically, the drop associated with moving from technical potential to cost-effective potential and then also the drop associated with moving from cost-effective potential to market achievable potential.

As shown, in terms of the percentage of homes where measures are applicable, five of the top six measures fall off dramatically from technical potential to cost-effective potential. In fact, three of the top six measures (photovoltaics, ground source heat pumps, and high efficiency windows) did not pass the cost-effectiveness screening tests at any of the applicable homes. As a result, these measures are excluded entirely from the cost-effective and market achievable potential savings estimates.

It is important to keep in mind that the cost-effective potential assessment and market achievable assessment include the same measures. The drop-in savings between these two steps is associated with the fact that the market achievable potential assessment adjusts savings for adoption rates, the gradual adoption of upgrades over time, and adjusted baselines due federal codes and standards for certain measures.

Table 7: Details for Top 15 Technical Potential Measures

Measure	Technical Potential		Cost-Effective and Market Achievable Potential		
	Technical Potential Savings (MMBtu)[i]	% of Applicable Sites	Mean TRC Ratio	% of Applicable Sites (TRC≥1.0)	Market Achievable Penetration Rate in 2025
Install ductless mini-split	51.3	100%	-1.8	6%	40%
Install air source heat pump	23.1	58%	-1.2	7%	40%
Add photovoltaic array	18.5	60%	0.3	0%	n/a
Install ground source heat pump	14.5	57%	-3.4	0%	n/a
Reduce air infiltration	11.1	79%	2.5	96%	34%
Upgrade windows	9.4	100%	0.3	0%	n/a
Add solar hot water system	9.0	61%	0.8	28%	3%
Add above grade wall insulation	7.7	92%	1.3	33%	43%
Add flat attic insulation	6.3	92%	1.9	54%	43%
Add frame floor insulation	5.7	89%	1.2	44%	43%
Increase socket saturation of efficient lighting	4.1	100%	2.2	100%	95%
Increase oil boiler AFUE	3.9	45%	0.7	14%	40%
Add foundation wall insulation	3.7	51%	1.5	49%	43%
Reduce duct leakage	3.0	28%	2.7	84%	34%

Increase gas furnace AFUE	2.1	14%	0.8	40%	40%

[i] In millions.

Comparison to the Weatherization Standard

This section presents a comparison of the potential study cost-effectiveness results and the weatherization standard compliance rates The efficiency levels in the State's weatherization standard are not identical to the individual upgrade measures modeled in the potential study, although they are similar for most measures, and provide a useful context for examining the weatherization standard requirements. Figure 9 compares the percentage of single-family homes in Connecticut that pass the current weatherization standard to the percentage of homes that pass the TRC screening test in the potential study.[27] These comparisons are presented separately for different primary heating fuels as this is often a contributing factor in the cost-effectiveness or applicability of a measure.

Figure 9: Comparison of Compliance with the Prescriptive Weatherization Requirements to the Percentage of Homes that Pass the TRC Test

These are some highlights from the comparisons:

- Air leakage and duct leakage are cost-effective at the majority of homes that fall below the potential study upgrade levels.

[27] In order to pass the TRC test a home must show a benefit/cost ratio that is greater than or equal to 1.0.

- Windows show very high compliance with the current weatherization requirement and already exceed the 80% threshold at the statewide level.
- Core insulation measures (wall insulation, ceiling insulation, frame floor insulation, and foundation wall insulation) show moderate compliance with the current weatherization requirements and moderate cost-effectiveness with the potential study upgrade levels.

These comparisons are all done at the prescriptive level. In reality, the weatherization standard allows trade-offs to achieve compliance. However, this comparison shows that some measures (air leakage and duct leakage) show promise in terms of the state achieving the weatherization target of 80%, while others (insulation measures) pose larger challenges due to the expense associated with retrofits and the limited savings potential in some homes. Core insulation measures may require increased incentives and significant program outreach in order to achieve the 80% weatherization target.

Comparison to Other Potential Studies

As previously mentioned, these are conservative market achievable estimates because they do not account for program incentives, and therefore the savings are based on more conservative assumptions about market penetration rates than they would be if program incentives were accounted for. 8 presents a comparison between this study and other recent potential studies in New York, Pennsylvania, and Vermont.[28,29, 30, 31] As shown, the market achievable potential found for single-family homes in this study is lower than it is in other studies. It is important to keep in mind that these studies are not directly comparable. First, this study only considered single-family homes whereas most potential studies cover all sectors (residential, commercial, and industrial). Second, this study applied a unique bottom-up modeling approach based on thousands of energy models whereas most studies start with a top-down approach that uses energy forecasts for different markets as the starting point for a potential savings assessment. Lastly, key study parameters such as the market sectors included, the number and type of measures included, the timeline of the study, the efficiency upgrade levels, and the market penetration estimates all have a major influence on the overall findings. These variables change from study to study and those selected for this study differ from the comparison studies.

For example, a recent potential study in New York found achievable potential savings to be 18% for electricity. However, the New York study clearly states that commercial buildings offer a significantly larger portion of electric savings than residential or industrial sectors and that the commercial sector often has more cost-effective opportunities than the residential sector. These types of differences are important to consider when comparing the results of these studies.

Table 8: Comparison to Other Potential Studies

State	Timeframe of Study	Sector	Fuel Type	Cumulative Achievable Potential
Connecticut	2016-2025	Single-Family Residential	Electric	5%
			All fossil fuels	5%

[28] NYSERDA, "Energy Efficiency and Renewable Energy Potential Study of New York State", April, 2014.
[29] GDS, "Electric Energy Efficiency Potential for Pennsylvania" Prepared for Pennsylvania Public Utility Commission, May 10, 2012.
[30] Optimal Energy, "Potential Study for Natural Gas Fuel Efficiency Savings in Vermont" Prepared for Vermont Department of Public Service, February 10, 2015.
[31] Optimal Energy, "Potential for Unregulated Fuel Efficiency Savings in Vermont" Prepared for Vermont Department of Public Service, February 18, 2015.

New York	2013-2032	All sectors	Electric	18%
			Natural Gas	11%
			Oil/Petroleum fuels	20%
Pennsylvania	2014-2023	All sectors	Electric	17%
Vermont	2015-2029	Residential	Natural Gas	10%
		All sectors	Oil/Petroleum fuels	9%

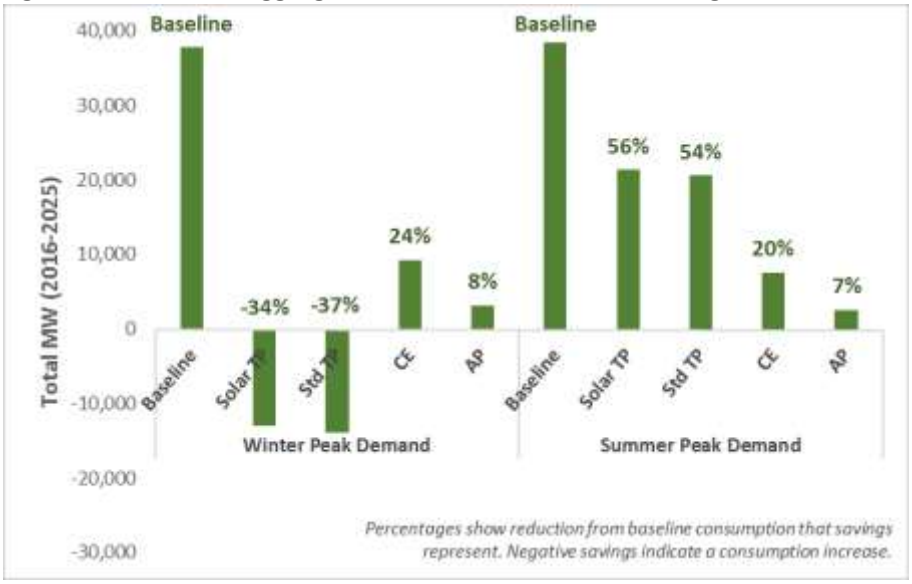
Peak Electric Demand Savings

Figure 10 presents aggregate ten-year peak electric demand savings estimates for each of the scenarios assessed as part of the potential study.[32] Below is a summary of the findings:

In aggregate over the ten years from 2016 to 2025, cost-effective (24% vs. 20%) and market achievable (8% vs. 7%) peak electric demand savings are greater as a percentage of baseline peak demand in the winter than they are in thesummer.

Over the same ten years, total technical potential peak electric demand savings are negative in the winter due to the impact of ductless mini- splits, which were modeled at all sites and result in substantial winter demand for heating. For the same reason, aggregate technical potential summer peak electric demand savings are substantial as a percentage of baseline demand; while the mini-splits result in more demand for heating, their efficiency offsets a sizable proportion of demand for cooling.

Figure 10: Ten-Year Aggregate Peak Electric Demand Savings



Base: all single-family homes (population-weighted)

Fuel Switching Potential

[32] REM/Rate does not include photovoltaics, one of the upgrades in the potential study, in estimates of demand savings. However, it is unlikely that photovoltaics would influence winter peak demand savings as the winter peak in New England is from 5-7 PM during the months of December and January.18 It should also be noted that photovoltaics are not cost-effective at any of the 180 sites and as a result the exclusion of photovoltaics from demand estimates does not impact cost-effective or achievable demand savings estimates

For this analysis, conversions of heating and water heating equipment from oil or propane to natural gas or electricity (heat pumps) were modeled in two ways:

- A **base case**, where all new gas and electric equipment were modeled at baseline efficiency levels,[19] assuming no involvement of an energy efficiency program.
- An **upgrade case**, where all new gas and electric equipment was modeled at the higher efficiency levels utilized in the technical potential analysis. This case describes a scenario wherein the programs incentivize efficient equipment during the fuel switching process.

The fuel switch modeling was applied—using REM/Rate™ energy modeling software—to all homes not currently heating with natural gas. This constitutes 134 (74%) of the 180 homes that were audited during the onsite assessments. A fuel switch to natural gas was modeled for 27% of the sampled homes not currently fueled by natural gas. The remaining 47% of homes were modeled with a fuel switch to electricity for heating (and water heating in the upgrade scenario).

The results of fuel switching are presented over a ten-year period with conversions increasing to the maximum 100% rate of uptake over that time as well as 25%, 50%, and 75% uptake rate scenarios. More detail on the fuel switching methodology can be found in the Methodology section of this report.

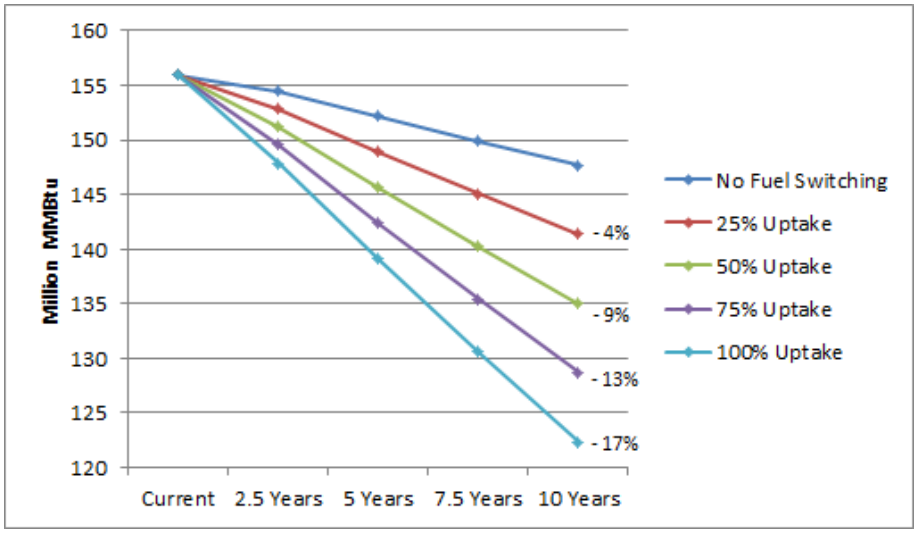
As previously mentioned, the fuel switching results should be viewed and considered independently from the technical, cost-effective, and achievable potential findings. The fuel switching analysis results in a number of key findings.

Base Case Scenario

As Figure 11 demonstrates, total annual fuel consumption in the state is projected to decrease by 5% in the next decade (from 155.9 million MMBtu to 147.7 million MMBtu) if its current trajectory continues.[33] Fuel switching could potentially lead to an additional 4% (base case scenario with 25% conversion rate) to 17% (base case scenario with 100% conversion rate) decrease in annual fuel consumption over the same time period. These savings are primarily due to the fact that naturally-occurring replacement results in more efficient equipment than what is currently present in homes. Note that these values account for increased electric and gas consumption from fuel switching.

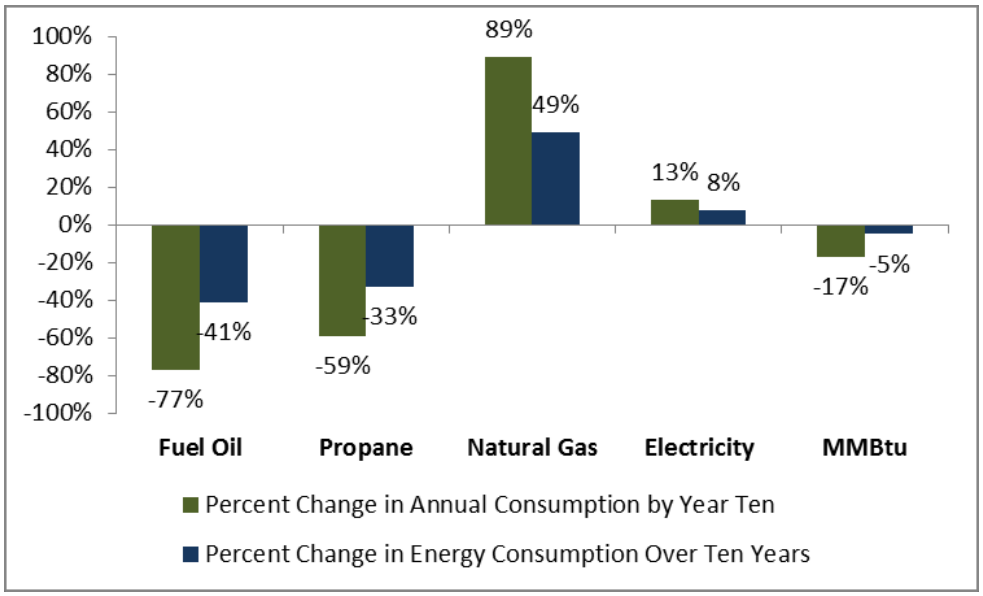
[33] This is based on annual growth projections (see Error! Reference source not found.).

Figure 11: Fuel Switching - Change in Overall Consumption Under the Base Case Scenario (MMBtu)



Potential maximum changes in fuel use due to base case fuel switching include a 77% decrease in annual fuel oil consumption, a 59% decrease in annual propane consumption, an 89% increase in annual consumption of natural gas, and a 13% increase in annual electric usage ten years from now (12). The analysis assumes a gradual increase in fuel switch conversions over the ten-year period. For this reason, the percent change in energy consumption in year ten is greater than the same change measured in aggregate over ten years.

Figure 12: Fuel Switching - Percent Change in Customer Energy Consumption by Fuel Type Under the 100% Conversion Rate Base Case Scenario

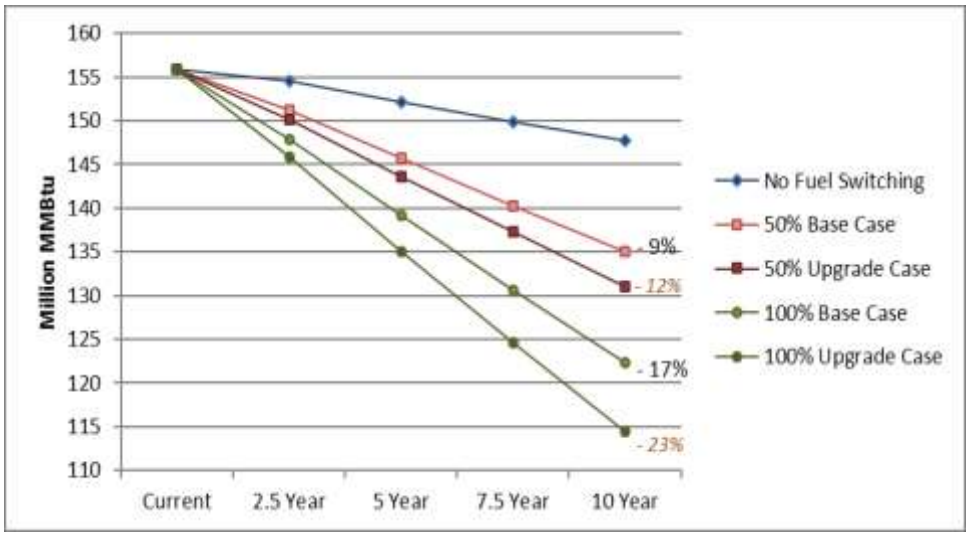


Upgrade Case Scenario

The energy savings from possible program incentives for higher-efficiency equipment (the upgrade case scenario) are substantially smaller than the energy savings from the base case scenario (fuel switching without incentives).

The analysis showed that the maximum impact of program incentives for higher-efficiency equipment would decrease overall annual consumption by about 6% relative to the expected annual consumption ten years from now under the base case fuel switching scenario(Figure 13).

Figure 13: Fuel Switching - Incentive Impact on Overall Consumption in Upgrade Case Scenario (MMBtu)*

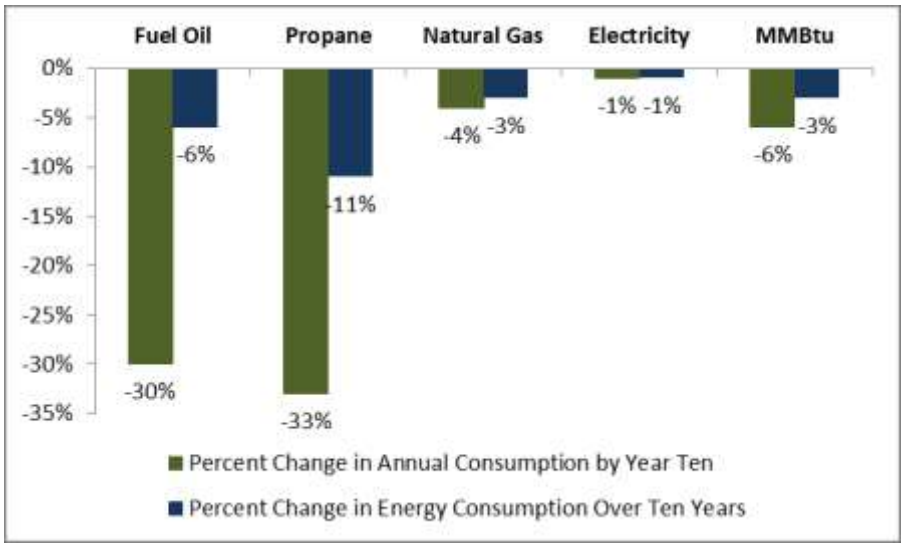


Base case data labels show percent difference from a scenario without fuel switching at year ten. Upgrade case labels (in orange) show percent difference from the basecase.

The maximum potential impacts (under the 100% conversion rate) due to program incentives include annual decreases of 30.1 million gallons of oil (30% decrease from the base case), 4.8 million gallons of propane (33% decrease), 24.3 million ccf of natural gas (4% decrease), and 188.7 million kWh (1% decrease) (Figure 14).

As shown in Figure 14, the percent change in annual consumption by year ten is significantly higher than the percent change in cumulative energy consumption over ten years due to the fact that our analysis assumed gradual adoption over the ten-year period.

Figure 14: Fuel Switching - Percent Change of Upgrade Case from Base Case, in Customer Energy Consumption, by Fuel Type Under the 100% Conversion Rate



Conclusions and Recommendations

The following conclusions and associated recommendations were identified as part of this evaluation. Conclusions and recommendations from the potential savings and fuel switching analyses are listed separately as these results should be considered independent of one another.

Technical, Cost-Effective, and Achievable Potential

- Current program incentives cover the large majority of cost-effective savings.
- Of the 43 measures considered in this study, ductless mini-splits have the greatest technical potential for energy savings.
- Building shell measures—including air sealing and insulation improvements—all screened as cost-effective (on average) under both the utility cost test (UCT) and TRC tests.
- Cost-effective electric efficiency savings opportunities are relatively small and will continue to shrink due to codes and standards.
- Fossil fuel savings represent the greatest cost-effective savings opportunities. These savings are predominantly from space heating measures.

Recommendations: The Companies should maintain—and possibly consider raising—incentive amounts for building shell improvements in existing homes in the coming years. The proportion of savings from shell measures increases over time due to increased market penetration rates for these measures and eroding savings from other measures that are influenced by advancing codes and standards. The adoption rate curve, which influences the achievable potential results, is influenced by program incentives as input assumptions. Increasing program incentives would increase the rate of adoption in the model and, as a result, would increase the achievable potential and expedite the timeline associated with those savings.

Fuel Switching

Under the upgrade case—which assumes that high efficiency equipment is installed during a fuel switch due to program incentives—fuel switching has the potential to decrease fuel oil consumption by 21% and propane consumption by 18% if conversions take place at 25% of potential single-family homes.

Recommendations: Potential fuel oil and propane savings from fuel switching are significant. The Companies should consider the best ways to promote fuel switching among single- family homes in Connecticut.
Incentives designed to influence homeowners to fuel switch will have a more significant impact than incentives for high efficiency equipment installation once a fuel switch has already taken place. Policy changes to allow these incentives would be helpful.

R32 - Evaluation of Persistence in the Eversource Customer Program

This report analyzed a series of evaluations of the Home Energy Reports (HERs) Pilot Program, implemented for Eversource by OPower.[34][1]The objectives included the following:

- Update savings persistence for high-use households[35] that stopped receiving reports no later than April 2013
- Estimate the post-treatment measure life of savings for high-use households
- Explore program cost-effectiveness[36] (high level) and realization rates
- Examine the impact of HERs on participation in other CEEF programs and deeper measure adoption for both high-use and average-use households
- Assess whether Eversource is in danger of "double counting" savings in HERs and
- other CEEF programs for both high-use and average-use households

Note that data on savings persistence and the related concepts of measure life, retention rates, and persistence factors for behavioral programs in the literature is somewhat sparse—and because the behavioral programs differ in delivery and message—so the results cannot easily be transferred from other studies. This study provides specific information for the Eversource program.

Program Description

The HERs Pilot program is a behavior-based program that sends households a report reporting their energy use, providing comparisons to other households, and suggesting ways to save energy. The pilot program uses an experimental design to provide reports to a sample of households, and not provide reports to a specially- selected "control group", facilitating comparisons and impact measurements.

Eversource and program implementer OPower administered a behavior pilot program for the purposes of achieving residential electricity savings and providing value to their customers through the delivery of two-page (printed on front and back) reports. Relying on a randomized control design, these reports present a treatment group with feedback on their electricity use and compare that use to a group of similar households referred to as "neighbors," which are defined as 100 occupied households similar in

[34] The Residential Area Consultant, NMR Group, Inc. (NMR), lead the prior two evaluations and the current one described in this report. NMR Group, Inc. and Tetra Tech. 2013. Evaluation of the Year 1 CL&P Pilot Customer Behavior Program. http://www.energizect.com/government-municipalities/final-clp-behavioral-year-1-program-report-030613 NMR Group, Inc. and Tetra Tech. 2014. Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2). Available at http://www.energizect.com/government-municipalities/evaluation-year-2-clp-pilot-customerbehavior-pgm-r2-final-report-8-8-14

[35] The study refers to "households" rather than "participants" for two reasons: 1) strictly speaking, in an experiment design, members of both the treatment and the control groups are "participants"; and 2) it avoids confusion when speaking about participants in other programs (especially HES and HES-IE) addressed in the process evaluation.

[36] The analysis does not perform a full cost effectiveness assessment, but offers a simple calculation of the ratio of expenditures per kWh.

size and paying the same rate code as the participant home. They also provide lists of energy-saving tips that differ from month to month and year to year. The implementer then compares the energy savings of the treatment group to a control group that did not receive the HERs. The pilot program uses an "opt-out" design (prior research concluded that very few households actually do opt out), so the design does not suffer from the self-selection bias that often plagues other energy efficiency program evaluations. The Year 1 pilot program initially targeted high-use households (average monthly use of 1,600 kWh), but the Year 2 pilot program also included some average-use households (average monthly use of 700 kWh).

Key Definitions

There are a number of definitions around the concept of "measure lifetimes" associated with energy savings. To add to the confusion, persistence, lifetime, and measure life are used casually to mean similar concepts even if the more technically have distinct meanings. Most of the definitions assume adoption of an efficiency measure rather than a behavior. Two critical concepts include the following:[37]

- **Effective Useful Life (EUL):** typically refers to the *median* lifetime for savings from measures, and is typically multiplied by first year savings to yield lifetime savings resulting from the investment in the measure.
- **Technical degradation factor (TDF):** represents how much the savings from a measure decrease over time due to mechanical (e.g., furnace does not operate as efficiently over time; duct insulation comes loose) or behavior degradation (e.g., being less diligent about washing full loads of laundry). There is very little data on TDF in the literature, so usually the concept is folded into measure lifetime, assuming full savings for each year of that EUL.
- For behavioral measures, the TDF is an important component. One does not expect 100% savings each year due to behavioral variation for any number of reasons. Realistically, when examining behavior persistence, studies measure the TDF until savings no longer differ statistically from a control group.
- Considering this, for the purposes of this study, the following definitions apply:
- **Measure life**: number of years the treatment households exhibit statistically significant savings compared to the control group.

Other key concepts include the following:

- **Behavior savings persistence**: for behavior programs, this refers to the savings treatment households achieve after they stop receiving reports. The study also refers to this concept as "persistence of savings." This measure provides the numbers that factor into the TDF.
- **Retention rate**: ratio of annual post-treatment savings achieved relative to treatment savings; **technical retention rate** is the average of this ratio for years with statistically significant savings.
- **Savings degradation rate**: The percentage by which savings decline annually. This differs from the TDF in that the savings degradation rate is the *change* in the TDF.
- **Persistence factor**: Retention rate multiplied by the measure life; serves as a critical input to estimating total lifetime savings. This can be used as another term for the Behavior EUL.

The literature on behavioral programs sometimes uses these terms interchangeably or may even introduce new terms to capture the same concepts, as the nomenclature has not been codified.

[37] Skumatz, Khawaja, and Colby, "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior", CIEE, 11/2009; and Skumatz, "Behavioral Measure Lifetimes, Persistence, Retention, and EULs", 2/5/16.

Likewise, the current study sometimes uses "savings persistence" to serve as an umbrella in terms encompassing all of these concepts.

Another potential point of confusion in this study stems from the many different treatment and sub-treatment groups included in the HERs program between January 2011 and July 2013. Table 5 and Table 6 in the main body of the report provide additional details on these groups and their inclusion in various past and current evaluation analyses. Here, it is important to know the following:

- **High-use Discontinued group (n=16,000)**: Starting receiving reports in January 2011 and stopped receiving reports by April 2012; all had higher than average pre- program energy use
- **Discontinued Monthly group (n=2,000)**: Received monthly reports through April 2012, for an average of 16 reports
- **Discontinued Quarterly group (n=10,000)**: Received reports every three months through April 2012, for an average of five reports
- **Discontinued Persistence group[2] (n=4,000)**: Received an average of eight monthly reports through August 2011 and this discontinued treatment. The "Persistence Group" was so named by OPower and Eversource. The study design sought to determine Year 1 program savings for a sub-treatment group that received reports for eight months (the Persistence group) versus those that received reports for a full year, therefore examining savings persistence for the first four months post-treatment given an abbreviated treatment.
- **High-use Extension group (n=8,000)**: Received reports starting in January 2011 and continued to receive them through at least July 2013, with a hiatus in April to June 2012. As the date treatment ended is not known, the study cannot provide an estimate of the total number of reports received.
- **Average-use Expansion group (n=10,000)**: Received reports July 2012 through at least July 2013. As the date treatment ended is not known, the study cannot provide an estimate of the total number of reports received.
- **Savings estimates presented in this report apply solely to High-use Discontinued households unless otherwise noted.** The High-Use Discontinued Monthly Group exhibited greater savings rates than the High-Use Monthly Extension Group during the first year of treatment (3.62% vs. 1.96% respectively).
- Therefore, the results presented here for the High-use Discontinued Monthly group cannot safely be extrapolated to all high-use monthly report recipients. Likewise, the savings estimates presented here apply only to High-use Discontinued households and not to any average-use households.

Study Methods

- The study used billing analysis to examine persistence of savings for the High-use Discontinued group(s).
- The study *did not / could not* examine the persistence of the High-use Extension or Average-use Expansion groups.
- The study provided information related to program cost effectiveness (measured in a simple way) and realization rates.
- The study explored participation in other programs and deeper measure uptake.

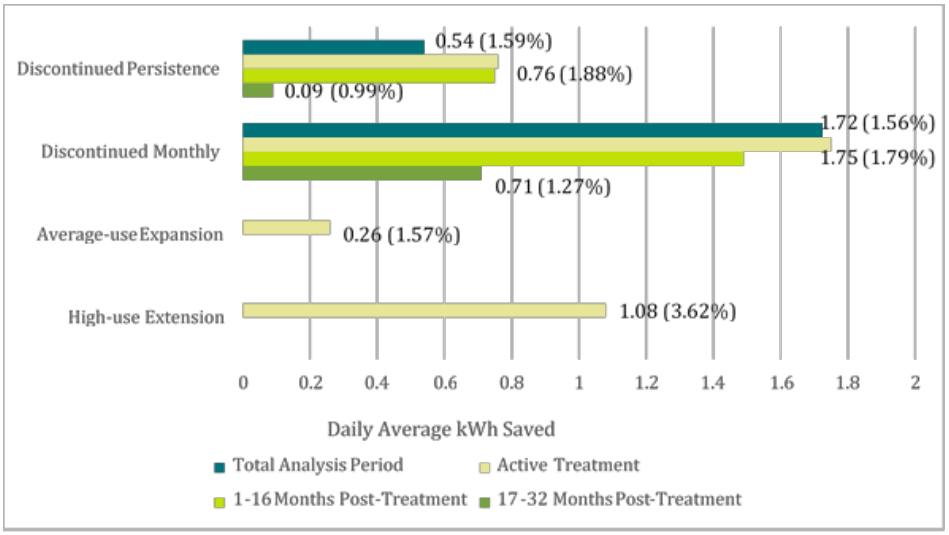
Findings

Persistence of Savings

The HERs program leads to savings during treatment and well after the high-use households received reports. Figure 15[6] summarizes the estimated savings, and retained savings, for the various groups for treatment (actively receiving HER reports), and various lengths of post-treatment periods. The main findings are:

- **Over the entire analysis period:** The discontinued high use households saved an average of 0.78 kWh per day over the 47 months of their analysis period from treatment through post-treatment (January 2011- November 2014).
- **Sub-Periods**: Examining individual periods shows that the Persistence and Monthly households stopped savings energy within 16 months post treatment, while the Quarterly group continued to achieve savings up to 32 months post treatment.

Figure 15: High- use Discontinued Group Average Daily Savings Over Time [1,2,3]



[1] All discontinued households were considered "high users" of electricity prior to receiving home energy reports.

[2] The number of cases per subgroup are as follows: Monthly group (n=1,670), persistence group (n=3,979), quarterly group (n=9,856), control group (n=24,268).

[3] Value in the parenthesis represents the % reduction in usage.

Figure 16 recasts the savings from Figure 15 into annualized figures, and Figure 17 translates these persistence results (from Figure 16) into percentage of treatment year savings retained annually for each study group. The figures show annualized retention rates for these behavioral savings are strong, declining less than 25% on average for each of the 3 years after discontinuation.

Figure 16: Annualized Savings per Household, High-use Discontinued Treatment Groups

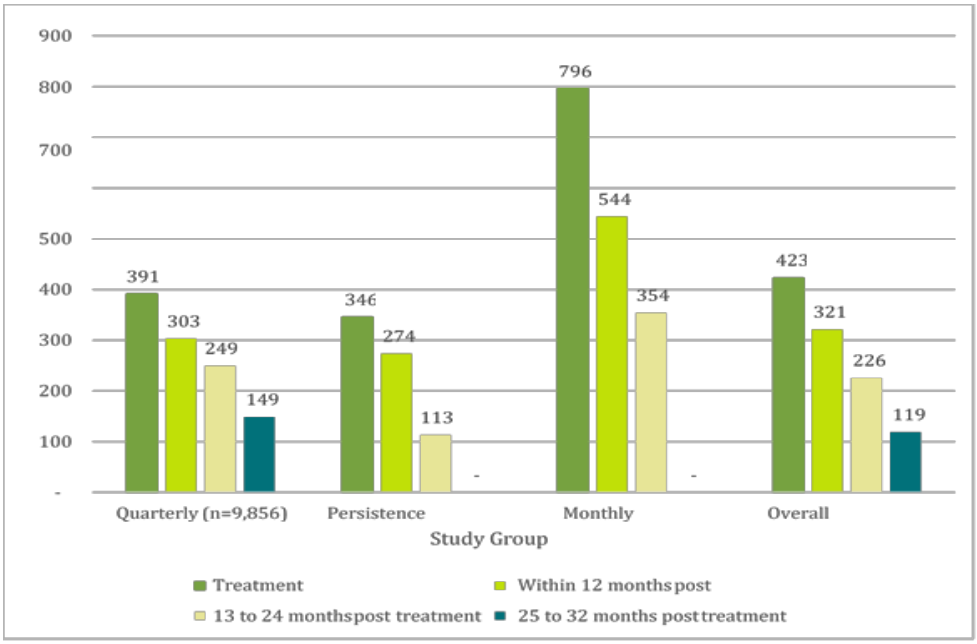
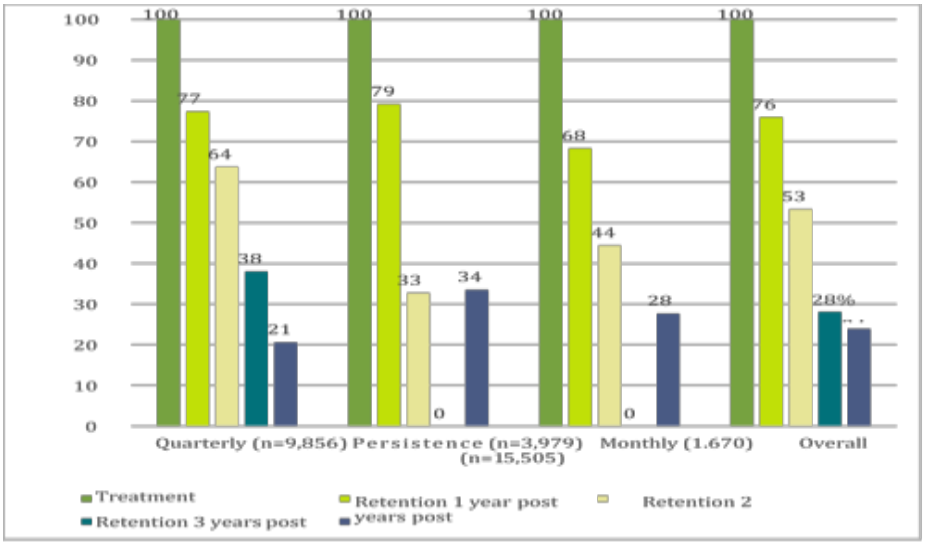


Figure 17: Percentage of Annual Savings Retained Relative to Treatment by High-use Discontinued Treatment Group*



* Statistically significant savings persist two years post treatment for the High-use Discontinued Persistence and Monthly treatment groups and three years for the Quarterly treatment group and all Discontinued households. As discussed in text, the analysis suggests that the Monthly savings would likely be significant if the sample size were larger.

What the Persistence Results Mean for Total Savings and Cost-Effectiveness

The persistence of behavior savings from the High-use Discontinued households in this program are quite strong.

Table 9: Summary of Total Program Savings and Ratio of Expenditures to Savings, Three Discontinued High-Use Treatment Groups

		Quarterly Treatment Group	Persistence Treatment Group	Monthly Treatment Group1
Actual – 1 year treatment, no persistence	kWh savings including retention	391	346	796
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.031	$0.035	$0.015
Actual – 1 year treatment, 1 year persistence	kWh savings including retention	693	620	1,340
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.017	$0.019	$0.009
Actual: 1 year treatment, 2 years persistence	kWh savings including retention	944	733	1,694
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.013	$0.016	$0.007
Actual: 1 year treatment, 3 years persistence	kWh savings including retention	1,093	n/a	n/a
	Amount spent / household	$11.94	n/a	n/a
	Cost per kWh	$0.011	n/a	n/a
Scenario / Projected: 4 years continual treatment	kWh savings including retention	1,565	1,383	3,185
	Amount spent / household	$47.76	$47.76	$47.76
	Cost per kWh	$0.031	$0.035	$0.015
Scenario / Projected: 2 years treatment, 2 years persistence1	kWh savings including retention	1,887	1,467	3,393
	Amount spent / household	$23.88	$23.88	$23.88
	Cost per kWh	**$0.018**	**$0.022**	**$0.010**

[1] The results apply only to the High-use Monthly Discontinued Households and cannot be extrapolated to High-use Extension (Continued) Monthly households or Average-use Expansion Monthly households due to differences in savings rates and treatment duration.

The amounts in Table 9 imply that lower cost per kWh is achieved if the program delivery design leverages off the fact that the program has strong savings persistence. As suggested by Rogers and Allcott (2012)[38], "cycling" customers may be more cost-effective than continual delivery of HERs. In fact, based on estimates presented in Table 16 of the main report and summarized in Table 10 below, a four-year cycling design in which HERs are sent to rotating groups of customers over a four-year period could result in 68% greater energy savings—and for two-thirds of the cost—than sending one group HERs for a continual four years.

Table 10: Summary of Savings and Cost: Cycling vs. Continuous Program Designs

	Cycling Design	Continuous Design
Number of households	3,000 (1,000 / year)	1,000 (same each year)
Accumulated Four Year Savings (kWh)	2,879	1,715
Accumulated Four Year Costs	$48.00	$48.00
Cost per kWh	$0.017	$0.028
Percent Greater Savings from Cycling	68%	

[38] Allcott, H., T. Rogers, 2012. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation" National Bureau of Econ Research. Cambridge, MA. Link: http://scholar.harvard.edu/files/todd_rogers/files/the_short.pdf. See especially page 31 and Table 8 in the original report.

The study could not estimate retention rates for High-use Extension households and Average-use Expansion households; given the number of customers in these groups, their persistence of savings should be documented in future studies and credited to the program in assessing cost-effectiveness.

The study did not have access to savings as reported from OPower, which would be necessary to assess realization rates. Therefore, we have no option but to suggest Eversource maintain an assumed treatment period realization rate of 100%, as stated in the PSD.

Outside Program Participation and Deeper Measure Impact

HERs treatment households—High-use and Average-use—take part in HES at higher rate (4.69%) than the control households (3.96%).

Insulation is the only deeper measure adopted at a greater rate by treatment households (8.93% versus 7.09% for control households), and only by High-Use Extension households.

Table 11: Deep Measure Adoption among HERs Study Group Households

		Sample Size	Insulation	Furnace / Boiler	HVAC	Fridge/ Freezer	Water Heater Heat Pump	Window
High-Use Discontinued	Treatment	15,519	7.43%	0.08%	1.77%	2.51%	1.94%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
High-use Extension	Treatment	8,047	8.93%*	0.09%	0.58%	0.23%	1.88%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
Average- use Expansion	Treatment	10,217	7.14%	0.14%	1.94%	2.26%	1.87%	0.32%
	Control	10,242	6.81%	0.13%	1.75%	2.23%	1.91%	0.35%

Indicates that the treatment group measure adoption rate is significantly different than the control group measure adoption rate (X^2=30.62, p<0.001).

There is little danger of double counting of savings across HERs and other programs due to small rates of adoption of deeper measures by HERs treatment households.

Conclusions and Recommendations

The study draws the following conclusions and related recommendations.

Persistence of Savings

The HERs program induces energy savings for High-use Discontinued households not only during the treatment period but for months and even years post-treatment.

Recommendation 1: Eversource should consider revising the PSD to reflect the findings from this study. The specific values are summarized in Table 12.

Table 12: Recommended Revisions to the Program Savings Document

	High-use Discontinued Quarterly	High-use Discontinued Persistence	High-use Discontinued Monthly[2]
Treatment Savings in kWh[1]	391	346	796
Persistent Factor[3] (use in place of EUL)	1.79	1.12	1.13

[1] Assumes a treatment period of about one-year. Longer treatment periods, such as those of the High-use Extension households, may yield different annual savings.

[2] Based on a treatment savings rate of 3.6%, which is significantly higher than the 2.0% of the High- use Extension Monthly group or the 1.2% of the Average-use Expansion Monthly group; therefore, results should not be extrapolated beyond the High-use Discontinued Monthly households.

[3] To be multiplied by Treatment Savings and the two values summed to yield total lifetime savings per household.

Recommendation 2: Until we have sufficient data to revise the estimate, Eversource should retain a realization rate of 100% for the treatment period. The evaluators did not have access to updated estimates of energy savings as provided by OPower, so the study could not provide realization rates. However, it is our experience that most OPower estimates of savings *during the treatment period* tend to align with those estimated from third-party evaluations. Thus, the study recommends a treatment period realization rate of 100%. To calculate realization rates for post-treatment periods, Eversource will need to compare the savings estimates presented in this report with those provided by OPower.

Cost-Effective Program Design

Due to the sheer number of people in the treatment group, the HERs program yields a great deal of savings relative to the program expenditures during the treatment period. Factoring in the persistence of savings only increases the already high program cost to savings ratio, suggesting that the most cost-effective design may involve bursts of treatment activity followed by "down" periods when the program reaps persistence savings.

Recommendation 3: Eversource should *consider* the most appropriate length of treatment—and possible downtimes between treatment—given that savings persist for at least two years post treatment, yielding savings that rival continued treatment but at a lower cost to the program. The analyses suggest that program designs that involve cycling—that is, an "on/off" treatment design involving rotating groups of HERs recipients—likely yield greater savings at lower costs than sending reports repeatedly. Eversource, the EEB, and OPower would need to weigh various factors of costs, savings, and equity (e.g., inclusion or exclusion of average-use households) as part of this consideration.

Participation in other CEEF-funded programs and deeper measure adoption

The study concludes that the HERs program induces participation in the HES program across all treatment groups and greater uptake of insulation among High-use Extension households. However, due to the relatively small number of treatment households taking part in other CEEF programs or adopting deeper measures, the analysis finds little danger of double-counting of savings across programs.

Recommendation 4: Do not adjust the HERs program savings to avoid double counting with other CEEF programs**.** Although a few HES-installed deeper measures do result in statistically significant savings in treatment households, their effect does not diminish the estimated savings from the HERs program. Therefore, Eversource should not make any adjustments to the savings calculations for HES or HERs in the Program Savings Document to correct for double counting. Though the study is not currently recommending abbreviating program savings to account for double counting, it is the current industry standard to do so. Therefore, Eversource should monitor savings in both the HERs program and the HES program. If savings increase substantially in either, then Eversource may need to take actions to avoid double-counting, although the nature of the adjustment may require future inquiry.

R33 - Observations and Recommendations from CT Residential Program Database Interviews

The purpose of this project was to document strategies that can improve the efficiencies of working with evaluation data from the Connecticut Companies, memorializing suggestions for both the Companies and for the evaluators. NMR conducted this project in three phases. First, NMR conducted an internal review of challenges we have experienced working with Connecticut data from Eversource and United Illuminating ("the Companies") based on evaluation project experience over the last three years.

Second, NMR identified and proposed energy efficiency program administrators to interview for this study and compare against the Companies' practices. The Team proposed organizations for interviews based on a combination of its experience with program data from other jurisdictions and a search for papers and studies addressing program databases and tracking in recent IEPEC proceedings and the CALMAC website.

Third, NMR conducted interviews with Eversource and UI staff who are responsible for the Companies' residential databases and for responding to our requests for data[39] to discuss interim findings and gather additional context and options. The Company interviews made it clear that the Companies are not in a position to establish completely new customer tracking systems, and as we explain in more detail below, many of the database issues the Team identified could be traced to difficulties of communication. Given this, it made little sense to interview program administrators about proprietary customer information databases that the Companies were not in a position to adopt. Since the California Public Utilities Commission (CPUC) has addressed the issue of inconsistency among billing databases of the state's investor-owned utilities (IOUs) by establishing a statewide IOU customer database, and this seemed like an appropriate analogy to the Connecticut situation, with approval of the EEB Evaluation Consultant, the Team interviewed just one other organization in addition to the Companies, a representative of the CPUC's statewide IOU customer database.

In this report, we summarize key observations from the interviews and recommend solutions in light of the information gathered.

Key Observations and Recommendations

Clarifying data requests through the use of data dictionaries. As we have noted previously, the team found the variable names in the UI data to be unclear; that is for, some variables, the names did not clearly indicate to someone outside the program the type of data contained in field and the meanings of values, particularly ones that denote missing or imputed information. Eversource has a data dictionary that the team has found useful for developing data requests. UI does not currently have a data dictionary and voiced concern about the time it would take to develop a data dictionary for the hundreds of variables in its database versus the likely return. UI has offered to develop a template that evaluators can use to submit requests and that could improve the likelihood of data requests yielding the information needed the first time. This might be less time-consuming than developing a data dictionary. It would be helpful for UI to review Eversource's

[39] We interviewed two systems administrator staff for the Eversource HES and HES-IE programs. We interviewed a system developer, a senior systems analyst, and two managers with United Illuminating HES and HES-IE program responsibilities.

data dictionary in order to understand what a data dictionary entails and explore the possibility of developing a UI data dictionary modeled on Eversource's dictionary.

Recommendation 1: We recommend that the Evaluation Team work with the Connecticut Energy Efficiency Board (EEB) Evaluation Consultants and appropriate staff of both Companies to develop Lists and descriptions of the information that are most commonly requested for (1) process evaluation and (2) impact evaluation. The lists should include the variable names under which each Company stores the information. The lists should also note what values are used to denote missing data for each variable and what special values might be found in each data field that could affect analysis. (For example, the information that an ID number of an Eversource's HES or Multifamily participant that ends in -2 supersedes an ID number that ends in -1 but is otherwise identical.)

- Company-specific data request templates. The templates would be built on the lists of information and variable names described above. The purpose of the template would be to standardize data collection requests as much as possible.
- We recommend that Eversource consider sharing its data dictionary with select UI staff to help UI staff in planning for a UI data dictionary.
- Developing the UI-specific data request template should take UI much of the way toward putting together a data dictionary. We recommend that UI staff review Eversource's data dictionary to assess what additional work would be needed to complete a UI data dictionary.

Improving the tracking of measure-specific inputs and providing details regarding calculations. Previously we have noted instances of missing measure-specific inputs and lack of details regarding calculations. In our conversations with the Companies about these instances, we found that the measure-specific inputs and calculations the evaluators thought were missing actually *do* exist in the databases. Either these inputs and calculations have only recently been added (the Companies are continually adding new elements to their databases) or the evaluators asked for the information in a manner that was not immediately understood by the Companies' database managers. Had we communicated about the issues directly with the Companies' staff who are responsible for the program databases, we most likely would have come to understand that the data were available and thus we would have been able to request and obtain this information in a manner more readily understood by the database managers.

In previous communications about data issues the team has suggested a need for data quality assurance checks. In their interviews, the Companies described quality control processes to reduce data entry errors. For example, Eversource verifies account numbers with its customer information system (CIS) and automatically populates the program record with demographic information from the CIS in order to avoid errors. Eversource uses system reporting features to identify projects that are out of variance with pre-determined parameters and reviews these on a quarterly basis. UI also described a system of automated checks to avoid data entry errors. These include checks for internal data consistency and data that are out of range that happen as system users input data, and a final review by the program manager when closing out projects. To help reduce data entry errors, at both Companies HES field techs enter data on a handheld device. While HES-IE techs at both Companies still record data on paper, data entry by handheld device will soon be available for HES- IE as well.

The Companies also described their processes and quotas for inspecting projects undertaken in single-family and multifamily homes through HES, HES-IE, and the multifamily initiative, as well as how this information is recorded for each program in the database. Both UI and Eversource inspect

a sample of program homes after measure installation. Errors in work or recording of data found in the inspections are corrected in the program database. How these are recorded varies by program and utility.

It appears to the team that the Companies have instituted some of the quality control measures that the team has suggested since 2011. Interviewees indicated that such improvements occur on a regular basis based on requests from program managers. The team also believes that a lack of communication about the variation in the databases has led to misunderstandings regarding quality control.

Recommendation 2: Third-party evaluation staff, the EEB Evaluation Consultant, and Companies establish an expectation that each evaluation will include at least two formal meetings about data requests: (1) A meeting at the beginning of each evaluation for third party evaluation staff to communicate directly with designated Company program database staff. The purpose of this meeting would be for evaluators to learn in an efficient and timely fashion what relevant data are available for a study and provide them with the information they need to develop complete and clear data requests for the Companies. (2) A "data request kick-off meeting" promptly after the third-party evaluator delivers the data request for a project. The purpose of the data request kick-off meeting is to encourage detailed discussion of the intent of the data request, data format, and data terminology. Both meetings would include the EEB Evaluation Consultant.

Oftentimes third-party evaluation staff have new questions once they begin cleaning or analyzing the data. These questions are typically time-sensitive. Once third-party evaluation staff and Company program database staff have had the data request kick-off meeting, the EEB consider allowing third-party evaluators and Company database staff to ask each other data-specific questions and provide data-related clarification as the need arises over the course of a study by phone and email without waiting for the EEB Evaluation Consultant to be available for these ad hoc communications.

During the evaluation planning stage, even before an evaluation one-page description is approved, the EEB consider allowing third-party evaluation staff and Company database staff to communicate about data in the presence of the EEC Consultant, as part of formal or informal assessments of the evaluability of particular questions or programs. Assessing a study's evaluability—including the data available that are relevant to the study—before approving work plans would help EEB spend evaluation funds more effectively. The EEB should set aside budget for these evaluability assessments to ensure that evaluators are paid for the exploratory work on projects ultimately deemed "not evaluable."

Consistency between utility tracking systems for programs and measures. As we have documented previously, team members have found what appear to be errors and inconsistencies within utility databases, and inconsistent data formats and terminologies between utility databases.

In the interviews, the Companies noted that they already align units and terminology in their respective program databases with those that appear in the Program Savings Document (PSD), and thus with each other. During our interview, we discussed issues of consistency both within each Company's database and between the two Companies' databases. Within a Company, in some cases, the Companies may be able to make specific changes to a program database in response to a

need identified by evaluators. For example, in recent years Eversource added fields to track the equipment recommended to a participant as a result of an audit. Such changes would need to be addressed on a case-by-case basis because they can be time consuming for the Companies.

In the course of our conversations, the team found that some instances of what appeared to be inconsistency within or across data fields in one or the other Company's database were not inconsistencies—but the key to understanding them was not included with the data. For example, in the Eversource program database, changes resulting from quality control inspections lead to additional ID numbers being added to the database that duplicate original numbers, but end in -1 or - 2. Data are associated with each ID number. The ID number that should be used for analysis in these cases—the original number or the one ending in -1 or -2—varies depending on the program. During the interviews, we did not have time to delve into each of the inconsistencies we had identified previously, but the example illustrates a source of confusion regarding which inputs to use in our studies—a source that nevertheless serves a very real and important purpose to the Companies. Having the ability to communicate more readily with Company database staff about data-related questions as they arise in data analysis would help avoid future data misunderstandings.

Looking across Companies, the Companies noted that aligning other terminology—such as field names and codes for missing data, etc.—between the Companies' databases would be a difficult and expensive undertaking requiring management approval. This is especially true for billing data for those customers with both natural gas and electric service and the information associated with it. Even something as simple as the way in which an address is tracked reflects a legacy at each Company. Using the "|" as the element delimiting fields,[40] one Company may list a home as Jane Doe, | 123 Main Street #3| Anywhere | 06000, while another lists John Doe | 123 | Main St.| Apt. 3 | Anywhere | CT| 06000. The simple differences—listing different household members as the contact and the structure of the address—can make it extremely difficult for evaluators to link electric and gas accounts and program information. Yet, it is also the case that altering the fields tracked in the databases is not a simple matter for the Companies, requiring complex and expensive reprogramming of their systems.

California may point to a solution. In California, the CPUC has addressed the issue of inconsistency among the billing databases of Pacific Gas & Electric, San Diego Gas & Electric, Southern California Edison, and Southern California Gas ("the IOUs") by establishing a statewide IOU customer database. The California IOUs are mandated to provide the CPUC's third-party evaluator with customer billing data. The CPUC's evaluator aligns the different data names and file formats, consolidates the data into one format, and makes the data available on an as-needed basis to qualified users to conduct approved studies. This system does not require the IOUs to make any changes in file format, naming convention, etc., but it does require that the CPUC hire a third-party data management company on a continued basis. Massachusetts is moving toward a customer database model that is similar to California's. In the section California's Statewide Customer Database, we describe the origins of the California database and how it works.

Recommendation 3: The EEB and Companies may wish to explore establishing a statewide residential electric and gas customer billing and participation database similar to California's, to be managed by a third-party firm. This database would contain customer electric and gas use and

[40] For example, "|" signals a new column in a spreadsheet.

program participation information. (For more details about California's database, see the section" California's Statewide Residential Customer Database.")

Tracking of project data for multifamily buildings with consistent unit-level reporting. Previously the team identified issues of inconsistency unit-level data in multifamily buildings, primarily those in UI data. UI is aware of the difficulties of matching electric and gas meters and accounts for the same building. In their interview, UI staff noted that their service territory includes many mixed-use multifamily homes with commercial space on the ground floor and dwelling units above, and matching electric and gas meters with individual buildings will be particularly difficult for this type of situation. This is because the residential units often have individually metered electric heat, and there is one large boiler in the basement to heat the commercial space. From the electric perspective, there are multiple residential customers, but from the gas perspective there is one commercial customer. Residential units with tenants who choose to participate in HES or HES-IE each get their own project number, while the gas-heated space would be a separate commercial project with its own project number, since a different customer would pay the gas bill. UI is exploring ways to match up all the units and commercial spaces within a single multifamily building, regardless of fuel type. Matching meters serving a particular building should facilitate grouping project numbers associated with particular buildings.

UI has already begun work to address this issue. Because this is a complex issue and it could easily take well over a year to implement the recommendation, allowing evaluators and Company program database staff to communicate more readily should help evaluators deal with this problem until it is resolved.

Accurate tracking of both electric and gas account numbers. Previously the team identified issues in the UI data with incomplete or inaccurate unit number and address information. At the time, the UI data management system did not have unique project identifiers to facilitate mapping of energy-efficiency projects at the customer level to both electric and gas billing data. It appears that since then, UI has addressed the issues, and there does not seem to be need for further action. In the interview with UI staff, we learned that they have been addressing this issue in a variety of ways. First, UI has been working with auditors to improve the quality of the gas account information they collect. Second, in January 2015, UI began to assign a unique project ID to each project and use this to cross-reference electric and gas information. Third, in March 2015, UI began requiring vendors to use the Eversource project number with participants served by Connecticut Natural Gas and Southern Connecticut Gas, both of which are Eversource utilities. For these customers, the Eversource project number is now being used as the mechanism for uploading project data into UI's system. This is expected to alleviate difficulties matching electric and gas account data on projects served by these utilities.

R91- Review of Impact Evaluation Best Practices Final Report

The R91 study, conducted by the NMR Group and Cadmus (collectively referred to as the evaluation team), presents a review of best practices in impact evaluation of residential retrofit programs. The study surveys authoritative manuals and protocols for such impact evaluations and presents a detailed overview of the most commonly used methodologies for evaluation of savings. As a case study for this

review, R91 examines the R16 impact evaluation carried out by the evaluation team, which employed several different evaluation methodologies in developing both *ex ante* and *ex post* savings values.[41]

In 2014, the Connecticut Energy Efficiency Board (EEB) commissioned the R16 impact evaluation of the Program Year 2011 (PY2011) Home Energy Services (HES) and Home Energy Services-Income Eligible (HES-IE) programs offered by the following Connecticut utilities: Connecticut Light & Power (CL&P), The United Illuminating Company (UI), Connecticut Natural Gas (CNG), Southern Connecticut Gas (SCG), and Yankee Gas Services Company (YGS). This evaluation sought to provide evaluated estimates of energy and demand savings associated with measures installed through these programs.

The R16 impact evaluation calculated savings and realization rates at a measure level using a multimethod approach, including billing analysis, building simulation, and engineering algorithms. The evaluation found that several key measures had divergent realization rates for gas consumption, as shown in Table 3.

Table 13. R16 Impact Evaluation Realization Rates and Savings Estimation Methodologies for Selected Gas Measures

Category	Measure	Realization Rate	
		HES	HES-IE
HVAC	Duct Sealing	42%	16%
Shell	Air Sealing	91%	61%
Shell	Attic Insulation	76%	129%
Shell	Wall Insulation	50%	32%

The R91 best practices study provides an opportunity to better understand key drivers of the differences between evaluation and PSD approaches, with particular attention to best practices in savings estimation methodologies.

This report is framed in two sections, respectively seeking to survey best practices generally and to apply these best practices specifically to the case of the HES and HES-IE PY2011 impact evaluation:

Section 1: Best Practices in Impact Evaluation. The study's best practices review encompasses three topic areas:

Literature Review:

- Methodology-Specific Discussions and Guidelines for Application.
- Recommendations for Calculating Oil and Propane Savings.
- Section 2: R16 Case Study—Comparison of Evaluation Approaches.

The study's literature review encompassed five commonly-referenced manuals and guidelines that discuss in great detail many of the most common evaluation practices, including their strengths, weaknesses, and best applications. The sources reviewed in full are:

- International Performance Measurement and Verification Protocol (IPMVP)
- Uniform Methods Project (UMP) Protocols

[41] The Cadmus Group, Inc. and NMR Group, Inc. Impact Evaluation: Home Energy Services–Income-Eligible and Home Energy Services Programs (R16). December 2014. Available online: http://www.energizect.com/yourtown/hes-and-hes-ie-impact-evaluation-r16-final-report-12-31-14.

- The State and Local Energy Efficiency Action (SEE Action) Network's Energy Efficiency Program Impact Evaluation Guide
- California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting
- Requirements for Evaluation Professionals ("Evaluators' Protocols")
- Northwest Power and Conservation Council Regional Technical Forum Roadmap (RTF)

Additional sources are provided in the References section at the end of this report. Readers are encouraged to review these sources directly where additional detail is desired.

Overviews, Constraints, and Development

Following the literature review, the study describes five prevalent approaches to impact evaluation, specifically those most appropriate for residential retrofit programs. Data requirements, constraints, and best applications are noted for each methodology to assist in comparison of each approach's strengths and weaknesses.

Billing Analysis

Billing analysis describes the process by which records of participants' energy usage—typically their utility bills—are compared before and after program participation in order to estimate the savings attributable to program activities. Billing analysis can be used to derive whole-house and, in some cases, measure-specific savings, and reflects participants' behavioral adjustments as well as measure-driven changes in consumption. Weather normalization of customer billing data and use of an appropriate comparison group allow billing analysis to provide high-accuracy results. Billing analysis relies on both utility tracking data and billing data, and requires that the following criteria be met:

The average reduction in usage must be relatively large (i.e., have a high "signal to noise" ratio) to derive high-precision results through billing analysis.

Program treatment of the participant group should be relatively consistent in the intensity, type, or magnitude of treatment.

There must be a sufficiently large sample of participants across which to average consumption data.

There must be sufficient consumption data available over a long enough period before and after program treatment.

Building Simulation

Building simulations offer a qualified simulation software user the ability to determine the effects of various building retrofit techniques. Building simulations are most appropriately used to determine the energy impacts of weather sensitive measures. A building simulation can be described as a large set of engineering calculations.

Using building simulation, a modeler will either develop a simulation to replicate the conditions observed in a particular building or develop one or more prototypes representative of a population. The outputs of these models—energy usage at varying levels of temporal granularity and specificity of end-use—can then be employed to determine savings for a facility, a measure, or a program. Building simulations allow interactions between different measures to be considered when calculating energy usage patterns, although they rely on numerous modeler assumptions and approximations. By calibrating simulation models to a set of participant billing data, inputs and assumptions can be adapted to provide a relatively accurate representation of the participant or population under consideration.

Equipment Metering
Residential evaluation metering studies are typically reserved for technology-specific energy efficiency programs. Challenges arise when using metering in whole-house program evaluation because envelope, thermostat, and HVAC measures are highly interactive and metering savings at a measure-level may not capture these effects, or may not be able to attribute them to a specific measure. The distribution of measures in the sample of metered sites would have to statistically match the distribution of measures in the program population for whole-house metering to be an appropriate approach. This is typically a logistically demanding and expensive task because metering samples are more difficult to collect than samples that don't require site visits, such as billing samples.

Engineering Algorithms
In select cases in which a measure implemented through an energy-efficiency program is well understood and has minimal interactive effects, an algorithmic approach may appropriately capture the savings derived from installation of this measure. Algorithms based on engineering principles typically employ site-specific data, including details of the measure installed (e.g., quantity), and assumptions about the home, measure, or other interactions occurring. An algorithmic approach is often the least time-intensive method of calculating savings for specific measures, although it is rarely appropriate for programs through which multiple interactive measures may be installed, or where little program- or location-specific data are available.

Multimethod Approaches
Where time, cost, and data constraints allow, using two or more of the methodologies discussed above can mitigate the shortcomings of each, providing a check for consistency of findings and allowing for a greater depth in explanation of drivers of results. Billing analysis and engineering analysis (i.e., building simulation and/or engineering algorithms) are commonly paired, as the former allows for an accurate accounting of reductions in participant consumption, while the latter permits greater scrutiny of savings at the measure level.

Guidance on Application
There is no "one size fits all" to impact evaluation, and each program has its unique requirements and constraints that shape the recommended approach. Table 9 in the main body of the report presents a comparison of the strengths and weaknesses of the five different approaches considered, and the decision trees in Figure 8 through Figure 11 offer recommendations for appropriate evaluation approaches depending on study aims and constraints.

Oil and Propane Savings Calculations
Delivered fuels are common in New England but not as prevalent in other parts of the country, providing fewer models of best practices in evaluating their savings. Moreover, the nature of these fuels—often stored in a tank on site—poses specific difficulties to evaluation. The R91 study specifically examines best practices in assessing these savings, reviewing past evaluations and papers, and providing appropriate recommendations.

Cadmus determined from the literature review that the best practice for evaluating oil and propane program savings is to convert savings values derived using a natural gas billing regression. The underlying assumption for this approach is that per-measure gas savings are statistically equal to per-measure oil or propane savings. Conclusions from evaluations of the U.S. Department of Energy (DOE) National Weatherization Assistance Program (WAP) support this hypothesis. If a regression from the

billing analysis is inconclusive, a whole-house gas billing analysis can dictate the whole-house oil or propane savings, as long as the distribution of measures is statistically equal between the oil or propane population and the billing sample of gas consumers.

In cases in which these approaches are statistically inconclusive, the building energy simulation is the next best option. This approach is considered less robust because a billing analysis relies on actual program consumption data, rather than assumptions of savings from modelling simulations.

The least preferred option is the engineering review of algorithms. This study recommends that evaluators should use this approach only when the first two are statistically inconclusive or inappropriate. Other approaches (the metering study and billing analysis using deliverable fuel invoices) are not considered suitable for most evaluations because they require difficult pre-installation operations and are often statistically inconclusive.

Section 2: R16 Case Study—Comparison of Evaluation Approaches

Differing Methodologies

The R91 study examines the methodologies and specific approaches employed both in the R16 impact evaluation and in the development of PSD savings for duct sealing, air sealing, attic insulation, and wall insulation measures. Table 4 presents the different methodologies used to develop *ex ante* and *ex post* gas savings for each of these measures. The study describes each of these approaches in detail in order to facilitate comparison and discussion of differences.

Table 14: R16 Impact Evaluation and PSD Savings Estimation Methodologies for Selected Gas Measures

Category	Measure	HES Evaluation Method	HES-IE Evaluation Method	PSD Method
HVAC	Duct Sealing	Simulation Modeling	Simulation Modeling	Simulation Modeling
Shell	Air Sealing	Billing Analysis (±14%)	Billing Analysis (±31%)	Simulation Modeling
Shell	Attic Insulation	Simulation Modeling	Simulation Modeling	Engineering Algorithm
Shell	Wall Insulation	Simulation Modeling	Billing Analysis (±30%)	Engineering Algorithm

Realization Rate Drivers and Key Differences

The drivers of differences between PSD and R16 savings estimates varied based on the measure in question and the methodology used in either source. Several common themes, indicated below, emerged through this review; additional differences and details are discussed in the body of this report.

Site-specific and behavioral factors. Billing analysis accounts for behavioral factors, such as participant take back, as well as occupancy changes, vacation schedules, participant education, and other similar factors that influence usage. Furthermore, it reflects the quality of measure application, reducing savings where measure savings do not persist or are incompletely administered.

Building simulation input assumptions. For measures where simulation modeling was used to develop either *ex ante* or *ex post* savings estimates, the assumptions made when constructing a simulated "prototype model" significantly affect the estimated measure savings. The R16 evaluation's input assumptions were shaped through calibration to participant billing data, as well as construction of multiple prototype homes for single family and multifamily homes, and for HES and HES-IE participants.

Measure interactivity. Weather-sensitive measures such as the four considered in this study can be substantially influenced by the concurrent installation of other weather-sensitive measures, especially when envelope and HVAC measures are combined. Billing analysis, by considering aggregate differences in consumption before and after measure implementation, accounts for this interactivity.

Geographic specificity of results. The PSD uses statewide weather profiles to develop savings estimates using both building simulations and engineering algorithms. The evaluation developed building simulations with separate weather profiles for Hartford and Bridgeport participants, and the billing analysis relies on participants' zip codes to determine their nearest weather station and their local weather profile.

Robust sources of assumptions. The PSD building simulations assume that all homes have a natural gas furnace with a total *system efficiency* (combined equipment and distribution efficiency) of 75%, with these savings adapted to other fuel types (e.g., electric, propane, oil) using efficiency assumptions and unit conversions. Similarly, engineering algorithms used to calculate insulation measure savings assume that gas furnaces have a 75% system efficiency. However, system efficiency assumptions are based on PSD developer estimates. Billing analysis captures customers' actual heating equipment type and efficiency, and the evaluation's simulations, having been calibrated to billing data, have also been adjusted to reflect the participant population's heating curves.
Furthermore, PSD insulation measures adjust the heating degree-days (HDD) input to reflect the likelihood that participants do not heat their homes for all hours where the outside temperature is below 65 °F.

Use of year- and program-specific consumption data. In the R16 evaluation, savings were developed using consumption data specific to the HES and HES-IE programs in PY2011, either directly through the billing analysis or through calibration of the building simulation models. The evaluation results are therefore specific to the program year under consideration, while PSD estimates were developed to be applicable across years and programs.

Recommendations and Conclusions
The R91 study recommends that the following topics be further explored in order to improve alignment between evaluation results and the PSD.

- **Update simulation models for air and duct sealing**. Revise models to use an hourly-iterative simulation software and draw upon participant home characteristics, differentiating between different building, customer, and HVAC types to award the most appropriate savings.
- **Differentiate savings values based on population segment.** Certain population segments may not be reflected accurately by the savings developed for an average participant home in the PSD.
- **Account for interactivity between HVAC and envelope measures**. Individual measure savings are lowered if installed concurrently.
    1. Consider whether additional weather and location assumptions can improve savings estimates.
    2. Verify that heating HVAC efficiency assumptions remain valid.
    3. Assess whether the HDD adjustment factor for insulation measures should be updated

R113 - Ductless Heat Pump Evaluation

This study was undertaken to identify the causes of the lower than expected realization rate for ductless heat pumps (DHPs) reported in the R16 Impact Evaluation of the 2011 program year, "Impact Evaluation: Home Energy Services— Income Eligible and Home Energy Services Programs (R16)," (herein described as the R16 Impact Evaluation). A secondary objective of the study was to provide forward-looking information to assist the utilities and EEB in getting the most impacts from DHPs.

The findings presented here describe the households that installed DHPs in single and multifamily residences in Connecticut through the Connecticut Energy Efficiency Fund (CEEF) programs and describes the HVAC equipment and participants before and after installing DHPs in 2011 (included in the R16 Impact Evaluation). It also included customers who participated in the DHP rebate program between 2013-14 through the first quarter of 2015.

In 2014, the EEB published the final report for the R16 Impact Evaluation, a comprehensive evaluation that estimated the program impacts for multiple measures installed through the Home Energy Solutions (HES) and Home Energy Solutions Income Eligible (HES-IE) programs.[42] The evaluation found mixed results for the realized energy savings form the DHP measure, which yielded a 46% realization rate.

The R16 Impact Evaluation identified several potential reasons as possible culprits of the low realization rate:

- Differences in participant types between those that were used in the study that informed the Connecticut Program Savings Documentation (PSD) and the R16 Impact Evaluation
- Other factors that may be attributed to customer behavior, like "take- back effects" occurring due to an increase in room temperature or operating hours in anticipation of lower operating costs, or changes in equipment operations resulting in the switch to a handheld remote control from a traditional thermostat Program description

DHP rebates are available to all Eversource and UI residential customers via whole house retrofit and HVAC rebate programs. DHPs are eligible measures in Energize Connecticut's (EnergizeCT's) HES and HES-IE programs. They can also be rebated independent of these direct install initiatives when installed by a contractor certified by the manufacturer of the product and that has attended an EnergizeCT training seminar. Customers with income at or below 60% of state median income that have not participated in weatherization services in the previous 18 months are eligible for the HES-IE Program and may qualify to receive a DHP at no cost to them.

As an example, the Butter Brook Hill Apartments in New Milford provides seniors with independent living options and was one of many multifamily properties to receive DHPs with funding from the HES-IE Program in 2011.

[42] Connecticut Energy Efficiency Fund, Final Report, Impact Evaluation: Home Energy Services— Income-Eligible and Home Energy Services Programs (R16), December 2014. http://www.energizect.com/your-town/hes-and-hes-ie-impact-evaluation-r16-final-report-12-31-14, p.7.

Study methods

The study employed a variety of quantitative and qualitative methods. Given the study objectives, it was necessary to collect data from both 2011 participants evaluated in the R16 Impact Evaluation and recent participants from the 2013–2014 and first quarter of the 2015 program years.

- One hundred and twenty-four computer- aided telephone surveys were completed.
- A subset of 20 telephone survey respondents was recruited to participate in an on-site survey.
- DNV GL conducted in-depth vendor interviews.

The study reviewed the 2012 Connecticut PSD used in the R16 impact study as well as the current (2015) PSD. The PSD reviews assessed the pre and post installation heating and cooling assumptions that informed the PSD savings factors and provided a high-level comparison of the DHP PSD calculations for with ex-ante calculations from other cold climate states such as Massachusetts, New York, New Jersey and the Mid-Atlantic Technical Reference Manual. Finally, this report contains a billing analysis case study and a brief literature review. The case study offers recommendations on possible ways to improve precision of the savings estimates. The literature review includes results from several DHP evaluations and other published technical reports.

Findings

The good news

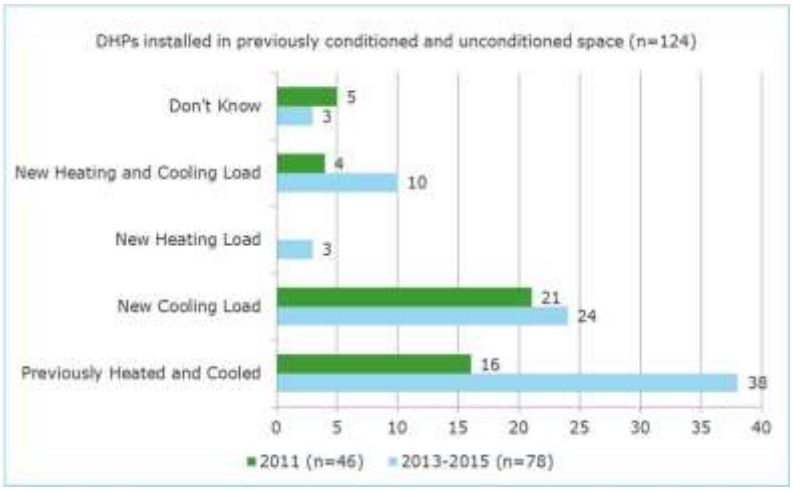
Program participants from all years surveyed and visited in this study are overwhelmingly satisfied and happy with the DHP installed through the program, and some described the quality of the heat as "better." It is clear that the DHPs are meeting participant expectations. The preponderance of duel fuel households and customer operating strategies may be hindering program savings, but the customers believe they are getting good value from their investment and have very positive feelings about the program.

The cause of low realization rate in R16

The first objective of this study is to understand the primary drivers of the realization rate of 45%. This study identified three primary drivers of the realization rate in the R16 Impact Evaluation. DHPs in the Northeast have far greater savings on the heating side than the cooling side, with heating savings being the primary focus of most studies performed in the region. The analysis suggests that it is the primary driver of the R16 realization rate.

Participants in the R16 study had a moderate number of installations that added to heating loads, which was not accounted for in the PSD calculation used at the time. In this study, roughly 11% of 2011 participants surveyed reported that the DHP was installed in a space that was either not previously heated or was an addition.

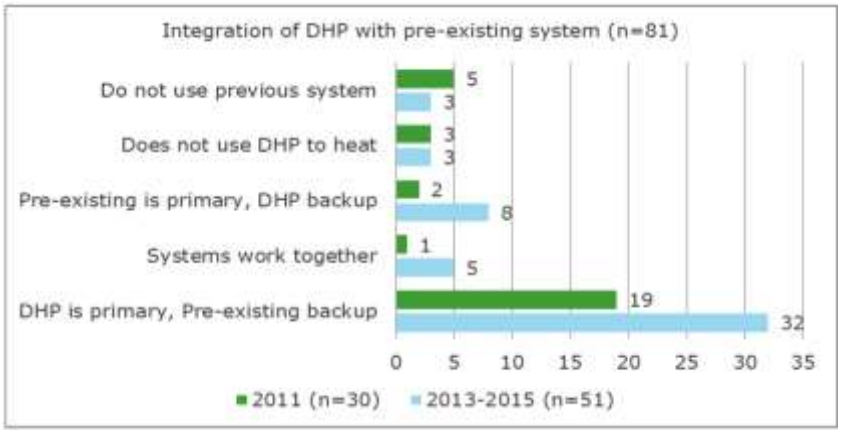
Figure 18. Pre-existing space conditioning.



The PSD cooling saving factor is based on program operations and installation conditions that differ from conditions among the 2011 participants (the reference year of the R16 impact study). In this study, nearly 61% of 2011 sites did not have cooling serving the space before DHP installation.

There is evidence that many customers are adopting control strategies that reduce the overall efficiency of their DHPs. In this study, nearly 17% of 2011 participants reported that they are either not using their DHP in the winter or they are using it as a back up to the pre-existing system (Figure 19).

Figure 19: Integration of DHP and the Pre-Existing Heating
Evaluation risks in future years



In many ways, it appears that the 2013–2015 participant groups are at increased risk of low electric savings realization rates compared to the 2011 group evaluated in the R16 study. There are several reasons why electric savings among the 2013-2015 group of participants are likely to be lower than savings estimated from the PSD, even with the use of the R16 realization rate.

- As noted earlier, electric heating and cooling loads are added when DHPs do not replace existing electric equipment serving the same space.
- In addition to new loads due to DHP installation in locations not previously conditioned, it is also important to note that non-electric fuels heated many spaces where a DHP was installed.

- Many DHPs are not primary heating systems, but function as a backup or are supplemented by electric resistance baseboard and non-electric fossil systems.
- Of the seven on-site participants with pre-existing oil heat, three stated that they reverted to oil as their sole heat source because oil prices were so low.
- Low oil prices are also likely to slow program growth among participants who might normally enter the program specifically to mitigate the high price of fossil fuels.

Education

How the customer controls the DHP has a direct effect on its operating efficiency. The remote-control device is new and the operational patterns that optimize DHP efficiency do not align with the conventional wisdom surrounding traditional HVAC equipment. This includes the potential that the customer has to increase the temperature setting in order to produce the same ambient temperature as their pre-existing system. **It is clear that the programs rebating DHP take customer education seriously based on the amount of training time spent, although there some noted areas for improvement**.

In the Northeast, many DHP users integrate a DHP with a secondary heating system. Under these circumstances, education about integrating the pre-existing system with the DHP becomes an even more critical factor for the DHP to realize anticipated levels of savings.

Take-back effects

An objective of this study is to identify evidence of take-back effects from increased interior temperatures in anticipation of lower operating costs. This behavior and a subsequent increase in indoor temperature settings were suggested as contributing to the low realization rate noted in the R16 study. **After collecting information on customer's thermostat practices, interior set points before and after the DHP was installed, and customer attitudes, there was not enough evidence to conclude that temperature take-back was a factor in the low realization rate.** To the extent the analysis was able to identify the conventional behaviors associated with thermostatic take-back, it appears to be an isolated phenomenon. In this study's estimation, there are many other operational patterns identified that are likely to have a much greater influence on energy savings than take-back.

Other conclusions

- The majority of pre-existing cooling systems that were replaced by DHPs are no longer in use.
- The operational patterns of DHP users indicate that DHPs are a candidate measure for a two-stage, variable degree-day billing analysis approach when the pre-existing heating system is electric.
- Using billing analysis methods to evaluate customers with pre-existing oil heat is not recommended because, although theoretically possible, delivered fuel consumption data is largely unavailable based on our experience throughout the region 3.
- The Connecticut PSD formula for calculating DHP electric savings can be considered state of the art when compared to other jurisdictions. However, the savings factors from the 2009 study of the ductless pilot program are most accurate when the pre and post conditions of the DHP sites inherent in the savings factors are similar to those under evaluation.

Recommendations

The following recommendations are intended to help improve the accuracy of tracking savings estimates, mitigate future evaluation risks, and maximize electric savings from DHP installations.

Recommendation 1: *Update the current PSD.* The current PSD formula should be updated to better reflect the conditions in which DHPs are being installed and operated. The majority of participants in R16 were from a unique customer base (multifamily under relatively controlled circumstances) which is

not representative of subsequent participants. These revisions should account for instances of load added when the unit is installed in a previously unconditioned space or when it displaces non-electric heating sources (i.e., fossil fuel or wood).

Recommendation 2: *Perform a billing analysis using a representative sample of recent program participants with electric heat as their pre- existing system.* This result could be used to in the PSD as a factor to adjust the savings derived from the DHP formula when a customer is known to have had pre-existing electric heat.

Recommendation 3: *As an alternative or supplemental effort to Recommendations 1 and 2 above, perform an on-site engineering analysis* on more recent participants over a range of baseline scenarios. Such a study would provide new cooling and heating savings factors for the PSD based upon current DHP installation pre and post conditions. It could also provide non-electric savings impacts for purposes of understanding greenhouse gas emission reductions associated with DHPs.

Recommendation 4: *Educate customers on DHP operation strategies that generate the highest savings rates.* This study suggests that customer education and knowledge of how to integrate the DHP with their pre-existing system diminishes over time. Some ideas to help maintain high levels of desirable DHP operation includes providing additional information on the EnergizeCT web site on control, maintenance and operations strategies to supplement the functional information already provided on the site (e.g. "How a Heat Pump Works" and Heat pump FAQs).[4] A new section might be called "How to Maximize your DHP Savings."

Recommendation 5: *Increase program engagement with electric resistance heating customers who have the highest savings potential.* Create a target- marketing campaign directed to those electric resistance customers with the highest savings potential (where the DHP is displacing electric resistance heat, there is pre-existing RAC's that are removed from service and customer education focuses on how to integrate the use of DHP with the pre-existing heating system). There is also an opportunity to increase marketing efforts to customers with relatively high cooling loads.

Recommendation 6: *Use a two-stage, variable degree-day approach for all future applications of billing analysis to estimates DHP savings.* If the EEB opts to perform the billing analysis in recommendation 2, we recommend the use of a two-stage variable degree-day billing approach. The PA's should favor using 12 months pre- and post-installation period over a shorter evaluation timeline. An option to better understand if customer use of DHPs change over time is to conduct a billing analysis using 24 to 36 months of post-installation billing data to measure changes in normalized energy consumption over an extended period.

Recommendation 7: *Consider minor changes to the DHP application form.* There are two items we suggest be included on the form in the future - a checkbox to note when it is being installed in an addition or new space, and ask whether the DHP was purchased for its cooling capability, its heating capability, or both.

R151- Connecticut HES Air Sealing, Duct Sealing, and Insulation Practices Report

This report presents the results of the Connecticut Home Energy Solutions (HES) Air Sealing, Duct Sealing, and Insulation practices study (R151). The Connecticut Energy Efficiency Board (EEB) contracted NMR Group, Inc., to conduct a study to identify opportunities for the program to

increase savings related to these three measures of interest through the program. Due to the divergent ways in which participants enter the program, along with vendor and property owner decision making, this study does not include HES- Income Eligible or multifamily projects.

This study draws on multiple perspectives and consists of eight primary research tasks, as outlined below. In the detailed findings sections of the report, the related tasks and data sources are identified by the color scheme shown in Table 15. Data collection for some of these different tasks was closely coordinated with other research efforts, including R4 HES/HES-IE Process Evaluation and R157 Multifamily Initiative Process Evaluation. This coordinated approach sought to maximize efficient outreach to program stakeholders and minimize respondent fatigue.

Table 15: Evaluation Tasks

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

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

Program Focus and Goals

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

The program is designed to help participants reduce their energy consumption and related costs. While program staff and vendors' perspectives on program goals aligned, vendors expressed some concern regarding how best to achieve them. Vendors reported uncertainty as to whether the

program's goal was to provide deeper services to a smaller number of participants or lower-cost services to a greater number of participants. Program staff, on the other hand, expressed clarity on this subject: that vendors should always prioritize savings in each individual home, rather than attempting to maximize the number of homes visited. Vendors believe that attempting to be profitable while still achieving high-quality, cost- effective measure installations in each and every home is a substantial challenge. Additional analysis related to program focus and goals can be found in the Program Focus section.

Findings

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

Opportunities

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

Based on our on-site quality inspections, and confirmed by interviews with vendors and discussions with one QA/QC vendor, we know that HES vendors also leave readily achievable savings on the table at HES participant homes.[43] NMR auditors saw readily accessible gaps and penetrations in the building shell or duct work in essentially every home visited—homes that generally had not reached a minimum ventilation threshold. In cursory inspections, NMR auditors quickly saw easily visible, exposed penetrations that were sources of air leakage in basements and attics. Encouraging more time spent on-site and a greater attention to detail (including via program QA/QC oversight) could reduce this amount of *low- hanging fruit*. HES vendors indicated that much of the actual work on site is performed by an assistant technician rather than the lead, BPI-certified technician, who would typically handle the customer interactions and paperwork, resulting in work being completed by non- BPI-certified staff with limited oversight or quality review, particularly if the vendors are running short on time (based on their self-imposed time constraints).

For example, thorough attic air sealing, a program priority, is not a universal practice. NMR estimates that 42% of the accessible attics we saw (n=52) had no attic air sealing performed, and we confirmed that 46% of the attics had readily accessible air-sealing opportunities.[44]

[43] Connecticut Energy Efficiency Fund, Final Report, Impact Evaluation: Home Energy Services—Income-Eligible and Home Energy Services Programs (R16), December 2014. http://www.energizect.com/your-town/hes-and-hes-ie-impact-evaluation-r16-final-report-12-31-14, p.7.

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

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

Air Sealing

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

Duct Sealing

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

Insulation

Of the 38 insulation jobs that NMR could assess on site, 23 (61%) of them were Grade I, based on RESNET standards, meaning high quality, with limited gaps and compression. Ten (24%) were Grade II (Good/Fair), and only four (11%) were Grade III (Poor). While the quality of insulation installation through the program is mostly high (particularly in attics), an opportunity exists for improvement in installation techniques for basement ceiling (frame floors), and rim joists. The program may also have an opportunity to increase measure persistence by discouraging vendors from using lower quality fiberglass batt insulation— especially in applications where it may sag or bunch, such as frame floors. In addition, an opportunity remains for the program to increase the proportion of customers who receive recommendations for attic insulation and also increase the rate of uptake in that measure.

Participation Patterns

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

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

serve more homes, they may be leaving more opportunities behind, particularly at large homes that might require more time to fully air seal.

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

Fourteen percent of participating homes received insulation through the HES program: 16% of the total Eversource homes and 9% of the total UI homes that participated in 2014. Among Eversource homes in which insulation upgrade opportunities were identified (31% of homes), renter-occupied homes were roughly four times less likely than owner-occupied homes to install insulation (14% versus 54%). The section on Participation Patterns explores these issues in greater detail and breadth.

Vendor Practices

Having vendors take part in the on-site visits for this evaluation allowed for an in-person assessment of vendor practices that complemented other evaluation activities, such as reviewing vendor's in-field protocols, the quality and comprehensiveness of their actual installations, the recommendations they make to customers, and the customer's perspectives on their practices. The Vendor Practices section of this report supplements the findings in Opportunities, which details the savings that remain after the audit.

The overall quality of vendors varied from company to company and even crew to crew, with each vendor operating under different financial situations and business models.[45] Some vendors attempt to service as many homes as possible, while others delve deeper to achieve greater savings in each individual home (the latter strategy being the one promoted by HES program staff). Vendors agree, despite differences in their approach, that a great deal of ancillary work goes into conducting the home assessment beyond just performing air and duct sealing. Customers report overwhelming satisfaction with the technicians on site and the services offered, even in homes where the actual quality of air- and duct-sealing work was considered unsatisfactory through this study. Not surprisingly, customers appear to respond to the auditors' politeness, punctuality, and behavior rather than making a determination of the quality of their work.

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

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

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

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

Quality Assurance and Quality Control

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

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

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

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

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

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

Drivers, Motivations, Obstacles, and Barriers
Customers indicated that their main motivations to participate in HES were saving money, fixing their homes or identifying areas for savings, and saving energy; program staff correctly identified that participants generally seek out the audit to save money or conserve energy. A smaller contingent of the sample took part in the audit because it was a requirement for having solar panels installed. While the audit allows these customers to benefit from air and duct sealing, these customers have little motivation to pursue deeper savings. Customers cited very few obstacles or barriers to participating: nearly nine out of ten respondents said they did not face any obstacles in their participation. The main obstacle cited by vendors and program staff was health and safety issues encountered in the home. Mold, asbestos, and gas leaks force technicians to pause or terminate the audit because measures can often not be installed until remediation. Vendors estimated that on average health and safety issues occur in roughly one-quarter of all jobs. The provision of incentives specifically to address these issues would allow for accessing greater savings.

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

Recommendation 1: The EEB and program staff should consider whether or not the HES program can be amended to include additional incentives or other possible strategies to aid customers in addressing health and safety issues.
Rationale: Program records indicate 8% of Eversource homes have at least one health and safety issue. Some vendors estimate that the proportion of homes with health and safety issues is actually much higher—roughly 25% on average.

Recommendation 2: The HES program should reinforce proper blower door protocols with HES vendors. Specifically, the Implementation Manual should state that finished or fully heated basements should be treated as conditioned space and included in the building envelope for testing purposes, in accordance with BPI and RESNET guidelines. To ensure consistency and comparability of results between vendors, the program could also require vendors to report on the physical characteristics of basement areas, including level of finish, insulation, and type of heating system present.
Rationale: NMR auditors noted that many HES vendors treat conditioned basements (finished, insulated, and/or heated) as unconditioned spaces and close them off from the house during blower door tests. Without clear guidance from the program, vendors may inflate their air sealing reductions by treating conditioned basements as unconditioned spaces, sealing penetrations between the basement and ambient conditions, and also isolating the conditioned basement from the rest of the house via weather-stripping the door to the basement.

Recommendation 3: The HES program should strongly encourage the use of mastic, rather than foil tape, for proper duct sealing, and ensure that any tape is firmly adhered to clean surfaces.
Rationale: Quality inspections revealed that HES technicians regularly used thin foil tape to seal ducts, and it was often applied to dirty surfaces, preventing firm adhesion. This leads to gaps in the duct sealing work, and premature tape failure.

Recommendation 4: The HES program should promote the use of two-part spray foam to fully cover rim joists in basements, particularly in heated basements, rather than targeted air sealing of

penetrations. The program could also consider minor incentives for HES vendors for this measure because it can also serve as insulation, though the insulation benefit for most homes may often be less than the air sealing benefit.
Rationale: Quality inspections revealed that some HES technicians do not seal individual penetrations in basement rim joists, but rather coat the entire basement rim joist with spray foam. This increases the vendor's materials cost, but air seals far more effectively than sealing individual penetrations (particularly on old homes). In addition, this can provide a high-quality insulation benefit to the homeowners that may not currently be reflected in program savings estimates because the small surface area of rim joists has limited insulation value. Targeted air sealing, when combined with less expensive insulation materials (e.g., fiberglass batts), can be an effective approach to sealing and insulating rim joists in basements, but we recommend encouraging spray foam (applied by trained technicians) given the limited air sealing seen in rim joists and the lower quality fiberglass batt installations seen in rim joists and basement ceilings.

Recommendation 5: The HES program should consider incentivizing blown or spray-applied insulation materials (e.g., cellulose, fiberglass, spray foam) rather than fiberglass batts. In addition, if homeowners choose spray-foam attic encapsulation or other add-on measures that would result in decreased air leakage, the program should also consider including additional incentives for any additional air leakage reductions that result, such that vendors can be compensated for air sealing as a part of add-on measures, not just for air leakage reductions obtained during the core services visit.
Rationale: While high quality fiberglass batt installations are possible, they are harder to achieve because more labor is required to ensure that the material is installed without gaps or compression, and is cut to fit around obstacles. Spray-applied foam insulation acts as an additional air sealing measure and should be treated as both an insulation and air sealing measure, recognizing the tradeoffs involved in attic encapsulation. This measure decreases air leakage and can bring mechanical equipment and ducts into the conditioned envelope, but can also increase the surface area of the conditioned envelope.

Recommendation 6: The program should consider if the amount of air sealing opportunities being left on the table are acceptable. If not, the program should consider working with HES vendors and coordinate with both QA/QC vendors to ensure that more air sealing opportunities are captured.
Rationale: *We found that vendors left readily visible and accessible opportunities for additional air sealing in 72% of basementrim joists, 74% of basement ceilings, and 46% of accessible attics. In addition, over one- half (56%) of the attic hatches were either unsealed (33%) or poorly sealed (23%). In addition, no air sealing at all was performed in 27% of basement rim joists, 27% of basement ceilings, and 42% of accessible attics.*
Rationale: We found that vendors left readily visible and accessible opportunities for additional duct sealing at most homes with ducts present (72% visited had ducts). Of these 52 homes, program records indicate that vendors did not perform duct sealing at 12 homes (23%). At homes where duct sealing was performed, we observed readily visible and accessible opportunities for additional duct sealing in 53% of homes.

Recommendation 7: The program administrators and both QA/QC vendors should meet as a group to discuss potential changes to the QA/QC protocols based on the QA/QC vendors' field experience, findings from this evaluation, and feedback from the HES vendors. Potential changes to the QA/QC protocols could include:

- Performing both in-progress and post-completion services of core services and add- on measures
- Performing diagnostic testing to confirm the reported post-work envelope and duct leakage rates
- Increasing rate of QA/QC inspections beyond the 5-10% targets
- Regularly performing mid-visit surprise inspections, rather than arriving at the start of a visit
- Inspecting for duct surfaces to be cleaned before applying tape or mastic
- Ensuring that Implementation Manual and QA/QC criteria provide clear guidance on assessing basement conditioning (for duct sealing and blower door testing)
- Coordinating QA/QC protocols and vendor-related findings across utility territories and QA/QC vendors
- Analyzing the percent of recommended measures by type (particularly low rates of attic insulation recommendation, for example) for outliers or suspicious patterns.

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

Recommendation 8: The program should improve its aggregated program records such that evaluators and program staff can more easily assess and report on trends in vendor behavior. Evaluators and QA/QC vendors may be able to provide assistance on useful information. Potential data points for HES and QA/QC vendors to record and provide to evaluators could include the following, many of which could be captured on-site as check-boxes in the HES mobile tool used by HES vendors to avoid unnecessary writing:

- Home volume (absent from UI's aggregated data sets)
- Site receiving courtesy air sealing
- Improvements recommended to the homeowner (e.g., insulation)
- Presence of health and safety issues
- Type of health and safety issue
- Mold, asbestos, gas leak, inadequate duct airflow, reached minimum ventilation guidelines, etc. (The 2016-2018 Electric and Natural Gas Conservation and Load Management Plan appears to require utilities to report annually on these figures starting in March of 2017.[46])
- Location of health and safety issue
- Attic, basement, etc.

[46] DEEP. Approval with Conditions of the Connecticut Energy Efficiency Fund's Electric and Natural Gas Conservation and Load Management Plan for 2016-2018, Dec. 31, 2015. http://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/DEEP_Approval_with_Conditions_of_2016-2018_C&LM_Plan_with_Attachment_A_12-31-15.pdf.

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

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

Considerations

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

Consideration 1: The program staff should clarify to HES vendors that they should implement a two-stage audit approach, where technicians perform an initial walkthrough to identify any issues (including health and safety) that might prevent them from performing core services, along with potentially installing direct install measures, such as light bulbs and water conservation measures. *Rationale: Given the typical structure of a HES visit – energy audit along with installation of lighting and core measures – many vendors reported that they face challenges with providing adequate services, specifically air and/or duct sealing, within the self-imposed time constraints of the visit dictated by their business practices.*

Consideration 2: Incorporating the feedback of the both utilities' QA/QC vendors, the program should consider adjusting the QA/QC scoring criteria such that the quality of the weatherization

services is categorized via more than one metric, allowing the QA/QC vendor to more fully describe and judge the vendor's work.
Rationale: The HES Quality Assurance Plan identifies air sealing as a key priority, but the QA scoring criteria groups quality, completeness, and attic prioritization into one scoring component.
Consideration 3: Understanding that program staff are in regular contact with HES vendors, evaluators believe that the program may benefit from convening a panel of the program's most active vendors to provide regular feedback on the program.
Rationale: Based on feedback from vendors solicited as part of this evaluation, many vendors do not have clarity on program goals and objectives.

Consideration 4: The program should carefully consider whether the pricing structure is properly motivating vendors to go after all accessible and achievable air and duct sealing opportunities, and consider reducing the per-home fixed incentives relative to the savings- based incentives for each home.
Rationale: The program requires vendors to achieve a minimum savings per home on average and provides a pricing structure that rewards vendors for achieving greater savings. For the most part this structure appears to be working—80% of vendor fees were from variable incentives provided based on actual measures installed or CFM reduced.

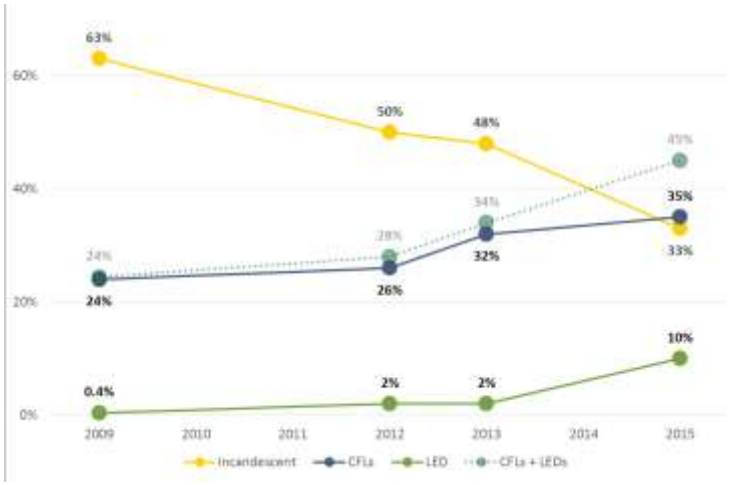
R154 - Connecticut LED Lighting Study Report

This report presents the results of the Connecticut LED Lighting Study (R154) conducted by NMR Group, Inc., which was designed to assess the current residential market for light-emitting diodes (LEDs) in Connecticut. For the R154 study, NMR collected data through 151 telephone surveys of a random sample of homes throughout Connecticut and 81 on-site lighting inventories conducted with the subset of those telephone survey respondents who agreed to the visit. This executive summary focuses on the highlights from sections of the report, including saturation, penetration, storage, purchases, and energy use.

Socket Saturation Trends

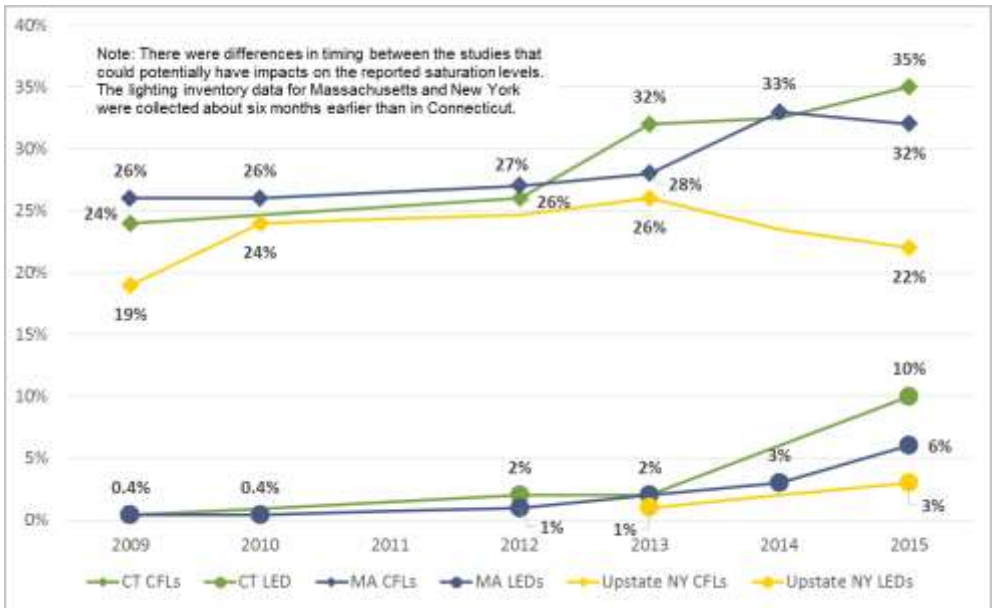
Between 2009 and 2015, Connecticut experienced a steady increase in efficient bulb saturation (the percentage of sockets filled with a specific bulb type) and a corresponding decrease in incandescent bulb saturation. Importantly, LED saturation in Connecticut, which had been rising slowly between 2009 and 2013, increased significantly between 2013 and 2015; LED bulbs now occupy one out of ten sockets in Connecticut (10%), up from just 2% in 2013. CFL saturation growth appears to have slowed, with only relatively small gains in saturation between 2013 and 2015—an increase of only three percentage points (32% to 35%). Combined, LED and CFL saturation has increased an average of six percentage points per year since 2012 20). Linear fluorescent saturation has remained at 11% since 2012. Combined efficient bulbs (CFL, LED, and fluorescent) accounted for more than one-half of all sockets (56%) in 2015, meaning that, for the first time, efficient bulbs represent the majority of bulbs in Connecticut households. Additional analysis related to saturation trends over time in Connecticut can be found in Section 2.1.

Figure 20: Connecticut Saturation Trends, 2009-2015



The use of comparison areas allowed us to place trends in Connecticut saturation in a broader regional context. LED saturation in Massachusetts, a state with similar program activity to Connecticut, appears to be on a similar trajectory to that in Connecticut. Whereas New York, a state that dropped all program support for residential lighting in 2014, has not seen similar increases in LED saturation (Figure 21). Similarly, CFL saturation trends in Massachusetts appear to be similar to Connecticut, while CFL saturation in New York appears to be decreasing in the absence of programs. It should be noted that the lighting inventory data for Massachusetts and New York were collected about six months earlier than in Connecticut; saturation rates in these two states will be studied again this winter with results expected in May 2016. Additional analysis comparing Connecticut to eight comparison areas can be found in Section 2.2.

Figure 21: CFL and LED Saturation in CT, MA, and Upstate NY, 2009-2015



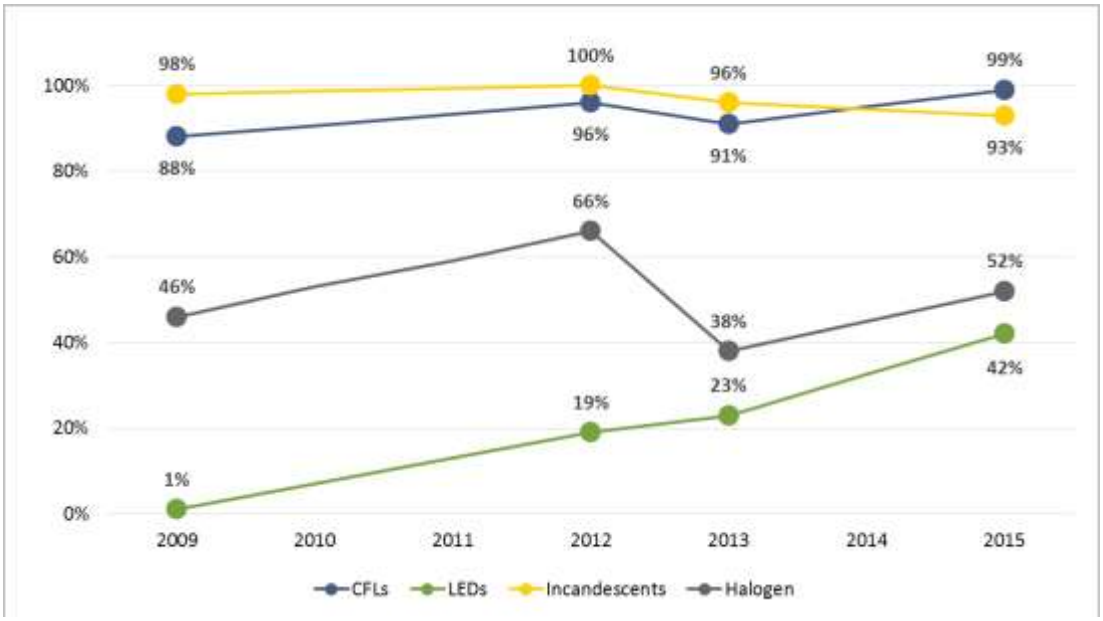
Turning to saturation over time by room type, in Connecticut only three-room types persisted in having less than 50% energy-efficient bulb saturation: dining rooms (22%), foyers (39%) and exteriors (46%). LED saturation was highest in kitchens (21%). Dining rooms had among the lowest LED saturation (4%), which is likely due to their special lighting needs and the price and availability of appropriate LEDs to meet them (dining rooms have the highest specialty socket saturation of all room types—71%). Importantly, sockets in room types with the highest hours of use (HOU), based on the 2014 Northeast Residential HOU Study, were among the room types that had the largest increases in LED socket saturation since the 2013 study: exteriors (5.8 hours per day), kitchens (4.2 hours per day), and living spaces (3.5 hours per day). Additional room-by-room saturation analysis can be found in Section 2.3.

Penetration, Familiarity, and Satisfaction

When examining the market for LEDs, it is important to remember that, at this stage of market adoption, penetration (the percentage of homes with one or more LED bulbs) is likely a better gauge of LED program success than is total saturation. As more households purchase LEDs and penetration rates rise, saturation rates will follow suit. Over the last five years, LED penetration has skyrocketed. In the 2009 study, screw-base general service LED bulbs were present in only one home, while in the 2015 study they were present in 34 of 81 homes (42%). Additionally, LED penetration jumped for all room types from 2013 to 2015; many room types had no LEDs installed as recently as 2013, while LEDs were present in all room types by 2015. Concurrently, incandescent penetration has shown a decrease in all room types over the past few years, which is in line with the decrease in incandescent socket saturation. Additional analysis on penetration by household and room type can be found in Section 3.1.

Similarly, awareness and satisfaction with LEDs are important market indicators for LED programs. The majority (66%) of consumer survey participants were either very or somewhat familiar with LEDs. Those who reported having CFLs or LEDs installed were largely very satisfied or somewhat satisfied with both bulb types; however, when asked, most participants preferred LEDs over CFLs. Additional details on familiarity and satisfaction can be found in Section 3.2.

Figure 22: Connecticut Penetration Trends, 2009-2015



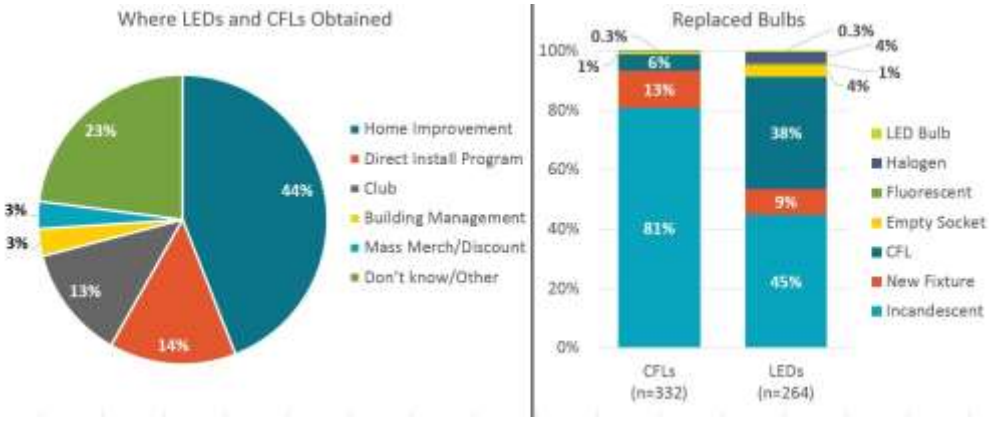
Recent Purchases

More than one-half (55%) of telephone survey respondents reported purchasing screw-base CFLs and nearly two-fifths (37%) reported purchasing screw-base LEDs within the past six months. Approximately one-half (48%) reported purchasing incandescent bulbs, adding to the growing body of evidence suggesting that the implementation of EISA has not completely eroded the market for incandescent bulbs. However, these percentages rely solely on self-reported data and should be treated with some caution—especially considering that most consumers are likely unable to distinguish between halogen and incandescent bulbs.

On-site participants reported that most LEDs and CFLs obtained in the year prior to the study came from home improvements stores. The second most common source from which participants obtained bulbs was through direct-install programs. Study participants who were confirmed as having taken part in a direct-install program (6%) were in line with the proportion of program participants in the state (12%) in 2014. Additional information on sources of new bulbs can be found in Section 4.1.

The following is an examination of the types of bulbs that newly purchased (i.e., excluding self-reported direct-install bulbs) CFLs and LEDs replaced, according to self-reported data provided on-site. The majority (81%) of CFLs replaced incandescents; similarly, a large proportion of LED bulbs also replaced incandescents (45%), though this was followed closely by LEDs replacing CFLs (38%). These newly installed bulbs led to a large drop in the observed wattage of the replaced sockets. Overall, newly installed CFLs reduced the average wattage used in those replaced sockets by 41 watts, and the average energy use in the sockets replaced with LEDs declined by 27 watts. The smaller decrease in delta watts from LEDs reflects the fact that many of these bulbs (two out of five) were reported to have replaced CFLs rather than incandescents 23). When compared to the Massachusetts panel study, where actual observed bulb changes were recorded, the average changes in wattages were very different: for CFLs, 41 delta watts in Connecticut vs. 28 delta watts in Massachusetts; for LEDs, 27 delta watts in Connecticut vs. 38 delta watts in Massachusetts. Given the nature of self-reported data, we place greater faith in the Massachusetts findings. Additional details on bulb replacements, including comparisons to findings from a Massachusetts panel study, can be found in Section 4.2.

Figure 23: Recent Purchases



Storage Behavior

Eight out of ten homes in the on-site study had at least one bulb in storage. While incandescent bulbs were still the most commonly stored bulb type, they have begun to show signs of losing ground to CFLs,

which have increased in number. Most bulbs are being stored for future use, though 15% of incandescent bulbs are reportedly earmarked for disposal.

Slightly more than four out of five (84%) newly purchased CFLs and LEDs were installed within a year of purchase. Notably, newly purchased LEDs were installed at a much quicker rate than newly purchased CFLs, likely due to a mixture of consumer satisfaction, high bulb prices, and fewer bulbs per pack.

In addition to first-year in-service rates, NMR calculated lifetime in-service rates based on guidance from the Uniform Methods Project: Residential Lighting Protocol. To calculate lifetime in-service rates, we relied on lighting installation trajectories from other recent studies. Table 16 provides an overview of in-service rates for each year by bulb type. Section 5 contains additional details on storage behavior, including in-service rates.

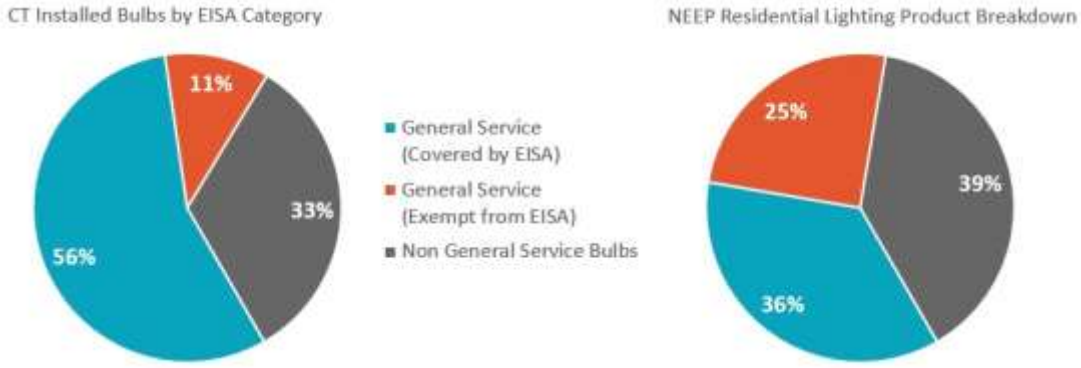
Table 16: Lifetime In-Service Rates

	CFLs	LEDs
First Year ISR	76%	95%
Second Year ISR	86%	97%
Third Year ISR	93%	98%
Fourth Year ISR	97%	100%

EISA Coverage, Exemptions, and Exclusions

In order to help understand the residential lighting market in the post-EISA period, we grouped installed bulbs into three categories: covered by EISA, exempt from EISA, and non-general service bulbs (outside the realm of EISA). Just over one-half (56%) of installed bubs in Connecticut were covered by EISA; the remaining 44% were either non-general service bulbs or exempt from EISA. This means that a large proportion of bulbs currently installed in homes are not directly covered by EISA. Supporting these findings, a recent NEEP paper based on secondary research, including shelf stocking studies, showed that nearly two-thirds (64%) of bulbs currently being sold are not covered by EISA, leading NEEP to conclude that great opportunities remain for efficiency programs to remain engaged with the residential lighting market. While there are differences in the findings of the two studies, they reach similar conclusions. The differences in findings can be explained by differences in methodology. The analysis for this study (R154) covers currently installed bulbs, whereas the NEEP estimates cover bulbs available for purchase (and not sales-weighted). Finally, we also analyzed the bulbs covered by EISA to determine what proportion are already compliant. In total 62% of bulbs covered by EISA are already EISA compliant—60% are efficient bulbs (CFLs or LEDS) and 2% are EISA-complaint halogen bulbs. Additional details on this analysis, including additional discussion of methodological differences, can be found in Section 6.

Figure 24: Bulbs by EISA Category



Remaining Potential Energy Savings

One of the main goals of this study was to update the residential energy potential for energy-efficient lighting in Connecticut. Using saturation figures from this study and hours of use (HOU) values from a study completed in 2014, we found that, while inefficient bulb types fill fewer than one-half of the sockets in Connecticut homes (44%), they are responsible for two-thirds (67%) of the energy used for lighting in these homes.

To help illustrate remaining potential energy savings in the residential lighting market, we calculated potential savings for five scenarios, including if all sockets currently filled with inefficient bulb types were replaced with CFLs (CFL-land) or LEDs (LED-land) and annual household energy usage if all currently installed non-EISA-compliant General Service bulbs covered by EISA were replaced with a minimum EISA-compliant bulb (EISA-land).

To calculate potential savings, we compared estimated average energy usage from CFL- and LED-land to current estimated energy usage minus expected additional savings due to EISA (EISA-land). Note that because only 56% of the of the bulbs found in Connecticut households are covered by EISA and 62% of those bulbs are already EISA complaint, additional savings due to EISA are only a small portion of remaining savings potential.

Not including additional EISA savings, remaining energy savings potential in LED-land is equal to 86% of the savings that have already been achieved 25). To help put estimated lighting energy use in context, according to data provided by Eversource, households in Connecticut served by Eversource used an average of 8,395 kWh in 2014. This means that current estimated lighting electric usage represents nearly one-quarter (24%) of average annual electric usage. Details for this analysis and additional findings can be found in Section 7.

Figure 25: Potential Electric Usage

Recommendations and Considerations

Recommendation 1: The PAs should continue with existing plans to educate consumers about and provide incentives for LED bulbs in future program cycles.
Rationale: While consumers are adopting LEDs in non-program states, they appear to be adopting them at a greater pace in program states.

Recommendation 2: The PAs should carefully observe and assimilate information coming from ongoing and planned saturation studies in the Northeast.
Rationale: The residential lighting market is in a period of rapid change, which creates opportunities to see significant changes in saturation across even partial years.

Recommendation 3: When updating the program savings document, the PAs should consider findings from this study regarding in-service rates. Based on bulbs found in storage and installed, we calculate a first-year in-service rate of 95% for LEDs and 76% for CFLs.
Rationale: While the in-service rate figures are based on self-reported purchases, any bias in the responses are likely to apply equally to both installed and stored bulbs.

Consideration 1: The PAs should consider plans for future primary residential lighting research in Connecticut to supplement and supplant information gathered in other areas in the Northeast.
Rationale: Given the rapid state of change in the market, it is likely that the market will change enough over the next 12 months to merit further study. Firsthand research in Connecticut may offer great insight. Specifically, the PAs should consider a low- income-specific study that investigates trends among low-income households.

Consideration 2: The PAs should carefully consider future support for standard CFLs. While CFL saturation growth appears to have slowed or plateaued, avoiding backsliding is an important consideration.
Rationale: Evidence from the New York comparison area suggests that CFL saturation has receded in the absence of programs, while halogen saturation has increased. This is an indication of potential backsliding in the absence of program support for CFLs and LEDs.
Consideration 3: The PAs should carefully consider whether or not they should use delta watt findings from this study when updating the program savings document or instead explore the possibility of updating delta watts through a market adoption model approach.

Rationale: A market adoption model would describe likely lighting market changes and responses to federal lighting standards and program activity, drawing on the most recent market assessment data available. The model would provide information on market-level bulb sales by technology, program-induced sales, and changes in delta watts. In the model, users can manipulate assumptions about program activity to see the likely impact of various scenarios on expected sales and other outcomes.

R157- Multifamily Initiative Process Evaluation

This report presents the results of a process evaluation of the Multifamily (MF) Initiative. The Connecticut Energy Efficiency Board (EEB) contracted NMR Group, Inc., to conduct a retrospective study, the primary objectives of which are to understand whether the initiative is functioning as designed, to assess participant satisfaction, and to identify opportunities for program improvement.

The MF Initiative is designed to provide a customized approach to serving multifamily property owners and managers and their tenants. Measures in the multifamily sector are common to both residential single-family homes and commercial buildings. As a result, the MF Initiative leverages measures from residential retrofit programs—Home Energy Solutions (HES) and Home Energy Solutions-Income Eligible (HES-IE)—for in-unit measures, and as applicable additionally coordinates with commercial programs such as C&I Retrofit and Small Business Energy Advantage to address common-area measures. If a property is eligible to receive common-area upgrades and on a residential revenue code, Program Administrators (PAs) use C&I savings methodologies, but apply residential program guidelines and funding. From the property owner's perspective, the upgrades are intended to be offered seamlessly as a single package that puts them on a pathway to increase the efficiency of their property.

The objective of this process evaluation is to provide the EEB and Connecticut PAs with actionable recommendations about how to improve the design, delivery, and administration of the MF Initiative. The evaluation consisted of a review of program documentation and tracking databases; a series of in-depth telephone interviews with program staff, participating vendors, and landlords/property managers who participated in HES-IE; and an in-person focus group with landlords/property managers who participated in HES. Table 17 below lists the evaluation data collection tasks and associated sample sizes.

Table 17: Evaluation Tasks

Task	n
In-depth interviews with program staff	3
In-depth interviews with program vendors	15
Focus group with HES landlords / property managers	9
In-depth interviews with HES-IE landlords / property managers	30

Note: Data collection for these different tasks was closely coordinated with other research efforts, including R4 HES/HES-IE Process Evaluation and R151 Air Sealing, Duct Sealing, and Insulation Practices Evaluation.

Because the MF Initiative is promoted as an offering within the HES and HES-IE programs, which are explained in more detail later, and evaluation participants specifically referenced their involvement in the MF Initiative through these programs, this evaluation accordingly reports on their respective experiences with these programs. When referring to issues that are not specific to either program, the evaluation refers to the MF Initiative as a whole.

Key Findings
The key findings from this evaluation are summarized below. The main body of the report explores these findings in more detail.

Goals and Objectives
The MF Initiative encompasses the HES and HES-IE programs as well as commercial programs such as C&I Retrofit and Small Business Energy Advantage. The MF Initiative seeks to provide multifamily property owners with a customized approach to adopting energy-efficient measures and equipment. According to program staff, the MF Initiative is primarily designed to reduce energy consumption and related costs in multifamily buildings, for both residential units and common areas.

Market Barriers
The primary market barrier that the MF Initiative intends to address is the cost of energy- efficient upgrades. Other significant market barriers include split incentives, limited customer knowledge of incentives and financing opportunities, lack of trust in contractors, and widespread health and safety hazards, all of which prevent the installation of many efficient upgrades.

Marketing and Outreach
Program staff use a variety of approaches for marketing and outreach. These different methods work together to engage customers in different ways. In addition, vendors use both formal and informal strategies to reach customers and generate leads.

Participation Patterns
Program data for July 2013 through April 2015 show that nearly 48,000 multifamily units were treated by HES (14,334 units) and HES-IE (33,564 units). These multifamily units represent just over one-half of all units served through both programs combined (34% through HES and 74% through HES-IE).

Participation Drivers
Program staff, vendors, and landlords/property managers all consistently stated that the primary motivation to participate in HES or HES-IE stemmed from a desire to save money on energy costs or conserve energy (on the both overall building and in-unit energy bills).

Participation Barriers
According to program staff and vendors, the main barriers to participation in HES and HES- IE include health and safety issues, and lack of access to units or equipment. The most common barrier to installing add-on measures, according to program staff and vendors, is the high upfront costs for such upgrades.

On the whole, landlords/property managers reported very few barriers to participation; the most common challenges that they cited were occupant buy-in, scheduling and timing of installations, measure quality, and communication issues with program and contractor staff.[47]

[47] The low incidence of reported barriers may be more of a reflection of the sample than a representation of all participants. That is, landlords/property managers who faced significant barriers to participation likely would not have accessed program services, and, therefore would not be included the sample for this evaluation.

Initiative Awareness and Satisfaction
Program vendors and landlords/property managers reported very little name recognition of the Multifamily Initiative. Roughly one-half of the vendors interviewed were aware of this initiative, and those who reported that they had heard of it expressed a limited knowledge of the effort.

- None of the HES landlords/property managers was initially familiar with the initiative, and only and after being read a description of the effort did three of the nine focus group attendees state that they had heard of it.[48]
- Although the MF Initiative had low name recognition, vendors as well as multifamily landlords/property managers reported relatively strong satisfaction with its residential component, the HES and HES-IE programs.
- Fourteen of the 15 vendors who were interviewed (93%) reported that they were satisfied with their experience in the program.
- The majority of multifamily landlords/property managers who participated in HES and HES-IE said that they were satisfied with their experience in the program.

Initiative Design and Implementation
The audit process for a multifamily property involves initial diagnostic testing (e.g., blower door testing, duct blasting) of 10% of the facility's units to identify opportunities for energy savings. During the initial visit (based on the unit's condition), residents can receive an assortment of direct-install measures such as air and duct sealing, energy-efficient light bulbs, domestic hot water measures, and pipe insulation.

Following the audit, vendors and program staff develop a proposal that includes a package of electric and natural gas measures that will help the landlord or property manager as well as the tenants reduce overall energy consumption. The proposal leverages measures and rebates from the other programs and is presented as a comprehensive offering for the landlord or property manager.

- Landlords/property managers reported that they generally were satisfied with the audit, including the installation of the core and add-on measures. However, they reported that they encountered challenges in a few areas:
- HES landlords/property managers cited difficulties with scheduling the vendors' visit for both core and add-on measures.
- HES-IE landlords/property managers also noted inadequate follow-up, particularly related to information on incentives and financing options.

Program Strengths
Program staff reported that the primary strength of the MF Initiative is that it provides multifamily owners and managers with a customized approach to adopting energy upgrades that helps building owners and occupants save energy and money and become more aware of energy-efficient practices.

- Vendors similarly cited benefits to customers, including improved energy efficiency, discounted upgrades, and increased awareness.
- HES landlords/property managers overwhelmingly reported that they were pleased with the energy savings that they experienced through the program.

[48] HES-IE landlords/property managers were not asked if they were aware of the MF Initiative.

Program Challenges

When citing program challenges, program staff discussed obstacles to effective implementation in the multifamily sector such as a limited pool of qualified vendors and the level of coordination that is needed with different people involved with the property. Staff also mentioned the pervasive problem of health and safety issues present in both the single-family and multifamily sectors for both market-rate and income-eligible programs.

- Vendors brought up various challenges related to coordinating with PAs, including high turnover, staff restructuring, slow response times, and lack of clarity on program procedures.
- HES-IE landlords/property managers voiced mixed perceptions regarding the accuracy of their energy savings estimates. Roughly one-third of HES-IE interviewees (10 out of 29 respondents) thought that the energy savings estimate from their audit was accurate, another one-third believed that it was inaccurate (nine overall, with six stating that it was overestimated), and the remainder said that they did not receive an estimate or that they
- "don't know" if the estimate was accurate.

Conclusions and Recommendations

Initiative Design and Implementation: Landlords/property managers reported that, overall, they are highly satisfied with the MF initiative (referencing their experiences in the HES and HES-IE programs). Effective practices to engage participants and provide services should be maintained, and program staff may consider developing other strategies to further their goals with this sector, such as the following:

Explore strategies for addressing health and safety issues.[49] Vendors indicated that health and safety issues are prevalent in as many as 40% of all sites, with an average of roughly 25%. The HES and HES-IE programs should verify the extent to which this prevents multifamily properties from fully accessing program services and explore how similarly situated programs in other states address such concerns.

Continue to work with vendors to promote installations of add-on measures. These efforts could involve trainings that emphasize the importance of consistently offering recommendations for add-on measures through a comprehensive discussion following the audit. This review should also focus on approaches for informing participants about the opportunities for program financing and incentives.

Provide consistent QA/QC. The program currently undertakes great efforts to conduct rigorous QA/QC to ensure quality measure installation and there do not appear to be any major issues with the process. The program may nevertheless benefit from implementing a higher level of QA/QC with non-program-approved contractors as a number of HES landlords/property managers mentioned using non-program contractors who may not have the qualifications or meet the standards set for program-approved contractors.

Program coordination: Program staff and vendors indicated that there has been improved communication across agencies and organizations in recent years. Vendors noted areas for improvement specifically related to slow response times and lack of clarity on program procedures.

[49] The R4 HES/HES-IE Process Evaluation and R31 Real-time Research report, delivered under separate cover, offers a broader set of recommendations regarding health and safety issues for both single-family and multifamily projects.

Clarify multifamily guidelines and procedures. Developing a separate document from the HES/HES-IE Implementation Manual that outlines guidelines and procedures for multifamily projects would help define specific protocols for vendors and program staff and improve vendors' perceptions that the program is not well-defined.

Increase transparency in PAs roles and responsibilities. Vendors voiced confusion regarding appropriate program staff contacts. An organizational chart for each Company would likely assist vendors in making appropriate connections with staff.

Marketing and outreach: Program staff should consider additional approaches to marketing and outreach, including the following:

- Increase awareness of the MF Initiative. The program may wish to enhance its branding strategy, within existing budget allocations, to increase awareness of the MF Initiative.
- Promote non-energy benefits.
- While marketing and outreach materials should underscore energy savings, they should highlight non-energy benefits that will appeal to property managers (e.g., reduced tenant complaints, reduced water bills) if they are not already doing so.[50]
- Provide greater clarity regarding vendors' marketing responsibilities, including program processes for approving co-branded materials.

[50] For more information on the benefits of non-energy benefits (also referred to as non-energy impacts), see NMR Group, Inc. & Tetra Tech. 2011. Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for the Massachusetts Program Administrators.

2.2 Commercial

No commercial studies were completed in 2016.

3. STUDIES IN PROGRESS

The following commercial studies below were initiated in 2016. In-progress residential studies are omitted and will be included in next year's report.

C1630 - Largest Energy Savers Impact Evaluation

This study addresses the largest savings projects regardless of whether they are new construction or retrofits. Projects included in this study were completed under CT's Energy Conscious Blueprint and Energy Opportunities programs. The study is being undertaken to a) evaluate the energy and peak demand savings impacts for a census of the largest projects supported by the Energize CT initiative and b) assess the possible cost efficiencies and precision improvements offered by only conducting a combination of more frequent project impact evaluations and less frequent supplemental program impact evaluations instead of the more traditional standard program impact evaluations that CT has used in the past. This study was undertaken in two phases; throughout both phases, CT EEB worked with Nexant to collect and analyze utility data.

Phase 1

Phase 1 involved reviewing program tracking data, selecting projects for analysis, developing an impact evaluation approach for each project in the sample, and developing the evaluation design and costs for achieving the project's second objective.

In Phase 1, a program tracking data request was submitted to two utilities: United Illuminated (UI) and Eversource. A project was defined as all measures installed at a single address as part of the Energize CT initiative between 2013 and 2015. To compare projects with different types of savings, all savings types were converted to avoided costs and summed at the project level. A second data request was submitted to the utilities for project files for the 60 projects with the largest total avoided cost. The key Phase 1 deliverable was the evaluation work plan, which included the Phase 2 budget, Project Summary, and timeline, as well as the evaluation plan and budget to meet the second research objective.

Phase 1 of the study was approved in February of 2016. Nexant received initial data from the utilities in March of 2016. Once the 60 largest savers projects were selected, additional data requests were issued in April of 2016. After project files from the utilities were received, Nexant began developing site specific measurement and verification plans (SSMVPs) for each of the top 30 projects; SSMVPs were completed in July of 2016.

Phase 2

In July of 2016, Phase 2 of the study was approved. Phase 2 includes the measurement, verification, and analysis of the top 30 projects to meet the second study objective.

The study will provide more immediate feedback to the programs on the effectiveness of their largest projects in delivering savings by calculating project specific realization rates.

In addition, it seeks to test a hypothesis that a C&I evaluation framework that studies the largest projects on a more frequent basis than program evaluations can lead to cost savings relative to the industry standard design where program-wide evaluations are conducted at regular intervals. Two hypothetical evaluation approaches shall be tested:

- Industry standard approach where program evaluations are conducted every three years. Large projects represent a stratum within the program (Industry Standard)
- Program evaluations every four years with Large projects evaluated every two years. (Alternative)

The analysis will focus on whether approach #2 results in lower costs to achieve the same level of accuracy and precision (or achieves improved precision given identical spending levels)" (Nexant, Evaluation Work Plan, July 2016).

By September of 2016, site specific measurement and verification plan template documents were finalized and onsite inspections were initiated. Nexant is working with Utility account managers to plan metering projects. 11 of 30 planned site visits and meter installations were completed in 2016. Data collection is anticipated to be complete by September 2017.

The expected outcome of the second objective is a report that informs a data-driven discussion regarding frequency of C&I evaluations in Connecticut. If the analysis finds that a framework where the largest projects are evaluated more frequently and the remaining population of projects is evaluated less frequently is more accurate, more precise, and/or less expensive than the industry standard, the report may include recommended changes to impact evaluation policy and planning.

The C1630 report is expected to be complete by November 2017.

C1639 - SBEA Impact & Process Evaluation

This study is being undertaken to evaluate the processes and impacts of the Small Business Efficiency Act (SBEA). The evaluation was divided into two phases; throughout both phases, CT EEB worked with Energy & Resources Solutions / Research into Action (ERS-RIA) to collect and analyze utility data.

The SBEA program provides small businesses (under 200kW peak demand) with opportunities to save energy. Participants receive a free energy assessment which provides them with a proposal that depicts all possible energy efficiency measures applicable to the site. The proposal includes all material and installation costs so the business owner can select which measures to complete. Incentives can cover up to 50% of the cost and the remaining costs can be covered through a zero-interest loan paid via the utility bill.

Phase 1

Phase 1 of the project was approved in February 2016. Phase 1 deliverables included an online survey of stakeholders, a webinar regarding the stakeholder survey, a process evaluation plan, M&V plans by site type, sample design, and a work plan presentation. The evaluation team interviewed Eversource and United Illuminating (UI) SBEA program participants to gather insights on: 1) experience with the SBEA program; 2) any dissatisfaction with the incentives, loan paperwork, and other elements of the program; 3) interest in non-lighting or deeper savings opportunities; and 4) barriers to taking larger loans and/or pursuing non-lighting projects.
In March 2016, ERS-RIA submitted a request for tracking data from the two utilities. Initial data was received in April, and the work for the stakeholder survey began. In July, the workplan scope was finalized and in August, planning for Phase 2 began.

Phase 2

In September 2016, Phase 2 was approved and field work began. Phase 2 deliverables include process evaluation surveys, impact and process analysis, and the final study report.

Multiple data requests were submitted by ERS-RIA after approval; some data requests were not filled until December 2016. By the end of the year, on site investigation of 16 out of 25 sites were completed, though data issues persisted into the new year.
The final study report will include:

- Program-level savings estimates, realization rates and – where applicable – PSD recommendations for electric and natural gas energy and electric demand measures
- Adoption rates of non-lighting measures (both during the incentive eligibility time frame and beyond)
- Barriers to implementation of non-lighting projects
- Information regarding the decision-making processes across participants for adoption of multiple measures,
- Program design and implementation's ability to address process related issues.

The final report for this study is expected to be complete in Summer of 2017.

C1641 - BES & PRIME Impact Evaluation

This study is being undertaken to evaluate the impact of the Business Energy Sustainability (BES) suite of four programs: Retro-Commissioning (RetroCx), Operations & Maintenance (O&M), Business Sustainability Challenge (BSC). and Process Re-Engineering for Increased Manufacturing Efficiency (PRIME).

The primary objective of this impact evaluation is to verify the savings claimed by the BES suite of programs, reduce savings uncertainty and planning risk, and provide current information to assess needed changes to the Program Savings Document (PSD) that guides reported energy and demand savings" (ERS, Workplan, October 2016).

The project was approved in April of 2016, and CT EBB engaged ERS to work with utilities to learn about BES program participants.

The first data request was submitted in May of 2016. In June, sample design and site-specific measurement and verification planning got underway. Both the electric and gas sample designs covered projects completed in calendar year 2015 and were based on the tracking data provided by UI and Eversource. For the electric sample, evaluators identified 174 measure instances with non-zero electric savings from 104 projects completed during the evaluation time frame. For the gas sample, evaluators identified 63 measure instances with non-zero gas savings from 31 projects completed during the evaluation time frame.

The evaluation work plan was drafted in July and finalized in September. Summer metering was planned for 2017. The project experienced significant delays in response to data requests in fall of 2016: savings computations data that were requested in August were not provided in 2016. At the end of 2016, the ERS team had enough data from UI to start evaluation plan; however, no data from Eversource was available for impact evaluation for the project. Accordingly, the project report deliverable was pushed to October 2017.

C1663 - Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation

This study is being undertaken to evaluate the program processes associated with the non-SBEA commercial and industrial (C&I) energy efficiency programs in the EnergizeCT portfolio and to research issues that cross the C&I programs. These programs are: Energy Conscious Blueprint, Energy Opportunities, Business and Energy Sustainability, and Upstream Lighting.

In October of 2016, the project one-pager was approved by CT EEB. The prioritized outcomes for this study include:

- An overall evaluation of the processes and operation of the non-SBEA C&I programs.
- Identification of the various timeframes with which C&I customers make efficiency investments over time. Then comparing this to program offerings and ways in which the program may influence the long-term efficiency changes C&I customers undertake.
- Documentation of current technical assistance, outreach approach, and usage of financing options for each Energize CT commercial and industrial program. Assessment by the contractors and customers of need for increased technical assistance and financing options, and outreach support.
- Assess the ability of the programs to meet non-monetary barriers and risk concerns alongside monetary and outside financing barriers.
- Barriers to participation in Energize CT commercial and industrial programs from the perspective of contractors and participating and nonparticipating customers[51].

Contracting issues delayed the commencement of this project in 2016. It is expected to complete in 2017.

[51] CT EEB, C1663 One Pager, October 2016