

CONNECTICUT ENERGY EFFICIENCY BOARD

Evaluation Studies and Results Abstracts, 2017

***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
Diane Duva
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PREFACE FROM THE EVALUATION ADMINISTRATORS --- OVERVIEW AND VERIFICATION OF THE 2017 EVALUATION OF CONNECTICUT'S ENERGY EFFICIENCY FUND ACTIVITIES

The evaluation efforts conducted in 2017 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 2017 add to the evaluation evidence of accomplishments from the use of Connecticut's Energy Efficiency Fund (EEF).

The Evaluation Consultant Team² verified that the 2017 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 Prah 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.

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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 the EEB 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; 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. These studies include:

- 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.

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 programs 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 calendar year 2017. 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 abstracts of descriptions, costs and summary results from commercial and residential studies in in draft final report stage.

The following table, Figure 1, summarizes the completed and in-progress and 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 2017 Legislative Report (by category)

(R=Residential; C=Comm'l / Industrial)

COMPLETE 2017 (Chapter 2)	Report Status
R1606. Eversource Behavior Program Persistence Evaluation	Complete
R1615. Light Emitting Diode (LED) Net-to-Gross Evaluation	Complete
R1602. Residential New Construction Program Baseline Study	Complete
R152. Impact of Connecticut Clean Energy Communities Program on HES Participation and Measure Uptake	Complete
C1639. Impact Evaluation of the Connecticut Small Business Energy Advantage Program	Complete
C1639. Process Evaluation of the Small Business Energy Advantage (SBEA) Program	Complete
IN PROGRESS (Chapter 3)	Report Status
R1614/R1613. CT HVAC and Water Heater Process and Impact Evaluation Report and CT Heat Pump Water Heater Impact Evaluation Report (abstract)	Draft
C1630. Largest Savers Evaluation (abstract)	Draft

This EM&V project list is an abbreviated list from the adopted 3-year plan. The legislative budget sweep led to cancellation or deferral of several high-priority, approved, EM&V projects, and these are not included in the list of completed or “under way” projects, leading to gaps in guidance to the PSD and to program design, development, and evaluation.

2. COMPLETED STUDIES

2.1 Residential

R1606 Eversource Behavior Program Persistence Evaluation

This project (R1606) estimates energy savings and the persistence of savings from Eversource Energy’s Home Energy Reports (HERs) program. The study provides results for four years following cession of reports and accumulates the results from previous studies to provide a complete accounting program savings. In addition, this project calculates the cost effectiveness of the program and suggests optimal program delivery scenarios. This report updates the results of three previous studies estimating energy savings, and tracks changes in savings in successive years for households that stopped receiving energy reports. The program induced statistically significant savings during the treatment period and for two to three years post-treatment. First-year savings after energy report discontinuation for the high-use customer groups are consistent with those found in the literature (1.6-3.6%, depending on cohort). The measured savings from all discontinued groups decreased over time. This study finds the average decrease in kWh savings over time is about 12-26% per year, averaged across the three years after treatment. Savings do not continue for a fourth year for any group. The implied “measure lifetime” estimated for this behavioral program is approximately three years (2.7 years – 3.3 years, depending on the assumptions made). The study finds that cycling report delivery across households offers a cost effective alternative program delivery model that yields comparable or better savings than continual report delivery. Figure 2 summarizes the accumulated results from the four studies of the HERs Pilot Program.

Figure 2. Summary of Accumulated Findings Across Four Studies

		High-Use Households					Average-Use Households	High-Use Households	Average-Use Households
		Monthly Discontinued n=1,507	Qtly Discontinued n=9,374	Persistence discontinued n=3,796	Discontinued overall n=14,733	Monthly Continued Extension n=7,211	Monthly contined expansion n=8,966	High-use control n=8,779	Average-use control n=9,963
	Participation Dates	1/11-4/12	1/11-4/12	1/11-8/11	Varied	1/11-12/16	7/12-12/16	N/A	N/A
	Report Frequency	Monthly	Quarterly	Monthly	Varied	Monthly	Monthly	N/A	N/A
Monthly kWh usage	pre-program	1,611	1,601	1,595	1,576	1,606	712	1,599	721
	4 yr pre-end	N/A	N/A	N/A	N/A	1,407		1,432	
	3 yr pre-END	N/A	N/A	N/A	N/A	1,462	720	1,479	689
	2 yr pre-END	N/A	N/A	N/A	N/A	1,519	678	1,555	691
	1 YR pre-end	1,478	1,488	1,489	1,481	1,434	671	1,517	730
	TREATMENT	1,482	1,489	1,490	1,485	1,487	675		691
	1 yr post	1,427	1,505	1,506	1,493	N/A	N/A	1,517	N/A
	2 yrs post	1,519	1,545	1,546	1,540	N/A	N/A	1,555	N/A
	3 yrs post	1,441	1,479	1,481	1,475	N/A	N/A	1,479	N/A
	4 yrs post (not a full 12 months)	1,334	1,357	1,353	1,352	N/A	N/A	1,432	N/A

		High-Use Households				Average-Use Households	High-Use Households	Average-Use Households
Avg. Daily kWh savings	4 yr pre-end	N/A	N/A	N/A	N/A	438	N/A	
	3 yr pre-END	N/A	N/A	N/A	N/A	434	95	
	2 yr pre-END	N/A	N/A	N/A	N/A	445	102	
	1 YR pre-end	639	314	277	332	442	131	
	TREATMENT	639	314	277	332	442	131	
	1 yr post	544	303	274	321	N/A	N/A	
	2 yrs post	-	223	-	175	N/A	N/A	
	3 yrs post	-	-	-	-	N/A	N/A	
	4 yrs post (not a full 12 months)	-	-	-	-	N/A	N/A	
Degradation Rate	1 yr post	18%	32%	36%	21%			
	2 yrs post	5%	12%	14%	12%			
	3 yrs post	No Savings	28%	No Savings	34%			
Smoothed Degradation	Avg. yearly rate	12%	24%	25%	21%			
Estimated	Based on Stat. Sig. Findings	2.00	2.50	2.10	2.70			
	Calculated based on decay and attrition	2.28	3.80	2.70	3.30			

R1615 Light Emitting Diode (LED) Net-to- Gross Evaluation

The R1615 Light Emitting Diode (LED) Net-to-Gross (NTG) Study estimated NTG ratios for LEDs in 2015 and predicted prospective ratios through 2020 for the Retail Products Program. It also characterized the market to lay the groundwork for the R1616/R1708 Residential Lighting Impact Saturation Study to be conducted in 2017 and 2018. Lighting is part of the Retail Products Program and has historically been the largest savings contributor for the residential sector. The NTG ratios are a key element of the PSD used to estimate and assess program savings for program planning and evaluation. Updated NTG values are needed to reflect fast-moving market changes in this end-use and assure Connecticut program dollars are well-spent.

The study's recommendations were based on three primary research activities (sales data and demand elasticity modeling and supplier interviews) and the responses of a consensus panel.³ The key findings of the study include the following:

- LED NTG ratios have fallen since the completion of the 2014/2015 R86 Lighting NTG Study and are expected to continue falling through 2021.
- The lighting market remains volatile and marked by considerable uncertainty. Some of the factors that contribute to this situation include the following:
 - o If and when LEDs will overtake halogens as the dominant standard light bulb in the market
 - o If the current federal administration will rollback or fail to enforce higher lighting efficiency standards set to take effect in January 2020

³ The study was led by NMR with its subcontractors DNV GL and Cadmus.

- o Whether the market momentum for LEDs is sufficient to overcome federal action (or inaction) on lighting standards
- o Role played by non-ENERGY STAR-qualified LEDs in the market, and their impact on consumer acceptance and program sales of ENERGY STAR-qualified models
- Despite the uncertainty, the study recommends the following LED NTG ratios for 2018 to 2020 to be used in PSD updates for 2018 and program planning for 2019 and 2020:
 - o Standard and specialty LEDs: 40% for 2018, 36% for 2019, and 33% for 2020.
 - o Standard and specialty LEDs sold through hard-to-reach (HTR) channels: 60% for 2018, 56% for 2019, and 53% for 2020.

Other study recommendations include the following:

- The program should continue to support LEDs through 2018 as planned, but the EEB should monitor federal and state policy decisions and market trends to determine whether to fund an upstream lighting program in the 2019 to 2021 cycle.
- Further targeting HTR channels has the potential to increase the program’s cost effectiveness, particularly by focusing incentives on lower-priced ENERGY STAR- qualified LEDs.
- Improving the level of detail in the tracking of in-store merchandising displays (ideally product model number or brand and bulb type) would increase the likelihood of identifying the impact this program component has on program sales.

R1602 Residential New Construction Program Baseline Study

This report describes a single-family, residential new construction (RNC) baseline study conducted in Connecticut for Eversource and United Illuminating (UI) Company (“the Companies”). The study was designed to assess (1) how the market has changed over time and (2) what changes in building practices have occurred since the previous baseline study. The study also updated the User Defined Reference Home (UDRH), the baseline used to calculate savings for the Companies’ RNC program. The UDRH is described in Appendix F. Appendix G of this report describes the results of a billing analysis designed to assess the accuracy of REM/Rate model estimates of energy use. The baseline study and billing analysis, along with a process evaluation, are collectively referred to as the R1602 study; the process evaluation stands as a separate report. The Connecticut Energy Efficiency Board (EEB) has also planned a 2017 net-to- gross study of the RNC program (R1707).

This baseline study included site visits to 70 new, non-program single-family homes in Connecticut that were built under the 2009 International Energy Conservation Code (IECC). Data collection covered all aspects of energy performance, including building envelope, mechanical systems, lighting, appliances, and air infiltration. Home Energy Rating System (HERS) ratings were performed at all homes.

Comparisons between program data and the non-program on-site inspections revealed that program homes outperform non-program homes on every analyzed measure. These measures range from shell measures, to mechanical equipment, to overall HERS Index values. According to the analysis, program homes have an average HERS Index value of 48, which is much better than the average score for non-program homes of 70. Interestingly, the non-program average HERS Index of 70 meets the HERS Index requirement of the lowest RNC program tier.

Homes in this study have improved substantially from those in the previous Connecticut baseline study, conducted in 2011 (2006 IECC homes).⁴ HERS Index values improved from 84, on average, to 70. Average R-values improved for every shell measure, as did heating and cooling system efficiencies. Efficient lighting use increased tremendously – 62% of homes use efficient lighting in the majority of their permanent sockets, compared to only 4% in the 2011 study. Duct leakage to the outside improved dramatically, a 65% improvement from the 2011 baseline, and air infiltration improved by 16%.

The billing analysis found that single-family program homes use about 8% more electricity (n=157) and 4% less natural gas (n=23) than estimated by program REM/Rate models. The study also found that non-program single-family homes used about 5% less electricity than estimated by their REM/Rate models; results for natural gas homes were inconclusive.

2.2 Commercial

C1639: Impact Evaluation of the Connecticut Small Business Energy Advantage Program

This report presents the findings of an impact evaluation of the Connecticut Small Business Energy Advantage Program (SBEA, or “the program”), which offers a free energy assessment, monetary incentives, zero-interest financing, and other services to encourage small businesses in Connecticut to invest in energy-efficient upgrades. The SBEA program is one of several programs and initiatives that the Connecticut Energy Efficiency Fund (CEEF) supports to advance energy efficiency throughout the state. Connecticut Light & Power, doing business as Eversource Energy (Eversource), and United Illuminating (UI) administer the programs on their own behalf and that of Connecticut Natural Gas and Southern Connecticut Gas.

Study Methods

ERS determined evaluation results through engineering assessment of 99 statistically sampled SBEA projects completed between 2013 and 2015. Although the program savings occur predominantly from lighting measures, the sample design segmented the population into other measure categories—non-lighting electric, space heating only gas, space heating and DHW gas, and other gas— to develop representative conclusions for non-lighting measures as well. This study marks the first time that SBEA natural gas savings have been evaluated at the same engineering and statistical rigor as electric savings.

Electric Savings

The evaluators determined an annual electric energy savings gross RR of 102.6%, at a relative precision of $\pm 8.0\%$ at the 90% confidence interval. The program is saving higher levels of kWh than anticipated.

Natural Gas Savings

The evaluators determined a gross RR of 76.6%, at a relative precision of $\pm 17.4\%$ at the 90% confidence interval, for annual natural gas savings. These findings indicate that the program is saving lower levels of natural gas than anticipated, by 23%, and the higher-than-anticipated relative precision value also illustrates higher variability in results than anticipated by the evaluators.

⁴ https://www.energizect.com/sites/default/files/ConnecticutNewResidentialConstructionBaseline-10-1-12_0.pdf.

Conclusions and Recommendations

The evaluation team identified nine major conclusions and forward-looking recommendations to improve program effectiveness and savings estimation.

Conclusion 1 – The evaluators determined 23% lower natural gas savings and 28% lower non-lighting electric savings than reported.

Conclusion 2 – The Connecticut PSD provides reliable and cost-effective savings estimates for many measures offered by the SBEA, including lighting, refrigeration, packaged HVAC, boiler, and DHW measures.

Conclusion 3 – ERS observed variation in the estimates of lighting fixture wattages among the SBEA contractors.

Recommendation 1 – The Connecticut PSD should be enhanced to include a Connecticut-specific fixture wattage table that encompasses all lighting technologies typically installed or removed through program activity.

Conclusion 4 – ERS examined changes in the PSD from 2013 to the present and found that only three measures have undergone changes that affect the forward-looking RR (FRR) for natural gas, increasing the gas FRR by 1% compared to the evaluation RR. The evaluators found no changes for electric measures.

Recommendation 2 – For electric projects, the evaluation results and RRs are directly applicable to SBEA participants moving forward. For natural gas projects, the program should apply a 78% RR, not a 77% RR, to projects moving forward.

Conclusion 5 – The evaluators found that non-lighting measures saved 28% and 23% less electric energy and natural gas, respectively, than anticipated by the program with energy management systems (EMSs), vending machine controls and condensing boilers having particular performance issues.

Recommendation 3 – The SBEA should invest in contractor training and increased oversight of program activities to appropriately identify non-lighting measures, educate customers on their operation, and inform those customers of the benefits of high-efficiency equipment when maintained.

Conclusion 6 – The evaluators could not obtain gas billing data for 41% of program participants over the evaluation time frame. This unfulfilled request led the evaluators to forgo a planned program-wide billing analysis approach for all program participants, not just those in the sample. In addition the lack of billing data for 10 sampled projects led the evaluators to employ alternative analysis approaches, often at lower evaluation rigor.

Recommendation 4 – The program should better associate utility account numbers and archive utility billing data for participating SBEA customers, starting at least a year prior to the program application date.

Conclusion 7 – For an estimated 30% of sampled projects, the evaluators had difficulties in obtaining sufficient project files from the utilities, resulting in complications in M&V planning, analysis, and reporting phases. The evaluators often could not pinpoint the specific contributors to project-level RRs.

Recommendation 5 – The utilities should adopt a more comprehensive method to digitally archive any relevant project files, such as pre- and post-installation inspection reports, particularly for non-lighting measures.

Conclusion 8 –SBEA claimed HVAC interactive savings were often less than found by evaluators but in other cases claimed HVAC interactive savings for lighting fixtures found by the evaluators in spaces not mechanically cooled, such as basements and mechanical rooms. Overall, these two effects led to a 3% reduction in kWh RR for lighting measures.

Recommendation 6 – The program’s administrators and implementers should uniformly assess each lighting measure for potential HVAC interactivity and, through improved screening and inspection protocols, only claim interactive HVAC savings for fixtures installed in conditioned spaces.

Conclusion 9 – The evaluators found three instances of unrealistically high savings percentages claimed by reported measures.

Recommendation 7 – For high-savings projects and/or those with complex measures such as EMSs, the SBEA program administrators and implementers should cross- reference at least the most recent year of monthly utility bill data to “sanity check” savings before reporting.

C1639: Small Business Energy Advantage (SBEA) Process Evaluation

This report presents the findings of a process evaluation of the Connecticut Small Business Energy Advantage (SBEA) program, which offers a free energy assessment, monetary incentives, zero-interest financing, and other services to encourage small businesses in Connecticut to invest in energy efficient equipment replacements or upgrades (hereafter collectively referred to as “upgrades”). The SBEA program is one of several programs and initiatives that the Connecticut Energy Efficiency Fund (CEEF) supports to advance energy efficiency. Connecticut Light & Power, doing business as Eversource Energy (Eversource), and United Illuminating (UI) administer the programs on their own behalf and that of Connecticut Natural Gas and Southern Connecticut Gas. This process evaluation was done in concert with an impact evaluation conducted by ERS staff.

Evaluation Activities

The evaluation team, in coordination with the CT EEB Evaluation Administrator Team, carried out the following research activities:

- Feedback from 21 program stakeholders involved in the development, administration, or oversight of the SBEA.
- Interviews with 16 of the 24 active contractors who market and deliver the SBEA program.
- A phone survey of 125 randomly selected program participants.
- An onsite survey of 51 participants.
- A phone survey of 27 nonparticipating SBEA-eligible utility customers.

Key Findings

As program stakeholders noted, lighting dominates SBEA projects, with about three-quarters of projects having only lighting measures. Key findings include:

- Contractors’ overall success rate was positively related to their reported success at identifying the correct decision-makers but it was unrelated to other contractor characteristics or indices of success.

- All interviewed contractors were program-approved SBEA contractors and served as the lead contractor on all their projects, but they differed in the range of in-house energy-related capabilities they offered, and their ability to sell non-lighting projects was positively related to having a greater range of in-house energy-related capabilities.
- Customer concerns about upgrade costs and length of payback are particular barriers to non-lighting upgrades among tenants, who appear to be under-represented in the program population⁵.
- In general, contractors' ability to sell non-lighting projects was unrelated to the strategies they reported for getting deeper savings.
- Contractor responses suggested that the current maximum 48-month loan term and the current \$100,000 loan cap may prevent some higher-cost, longer-payback projects.
- Contractors universally agree that zero-percent financing is a key piece of the program that should not change.
- Half of the participants with non-lighting projects identified non-energy benefits as benefits of their new equipment, but they were not included in contractors' reported strategies for selling upgrades.

Conclusions and Recommendations

The above key findings suggest the following conclusions and recommendations.

Conclusion 1: Contractors often deal with tenants who are not responsible for non-lighting equipment or may have a lease that is not long enough to make non-lighting upgrades economically feasible.

Recommendation 1: The utilities should consider developing strategies for outreach to building owners.

Conclusion 2: The higher percentage of projects that have non-lighting measures is related to the number of staff that contractors have doing SBEA-related work and to the contractors' range of in-house energy-related capabilities.

Recommendation 2a: The utilities should continue to try to recruit contractors with the ability to do a broad range of project types.

Recommendation 2b: The utilities, together with the CT EEB, should consider increasing the incentives for non-lighting measures.

Conclusion 3: The non-energy benefits of upgraded equipment are important to program participants, yet contractors appear to focus on energy savings.

Recommendation 3: The utilities should include training to contractors on how to talk about the value of non-energy benefits with customers to get more non-lighting projects.

Conclusion 4: Some customers, particularly building owners, may do more extensive upgrades if they can extend the loan length or increase the loan amount.

Recommendation 4a: The utilities might consider offering alternative loan terms for building owners or tenants with long-term leases

Recommendation 4b: The utilities should continue to investigate how third-party financing, including Commercial Property Assessed Clean Energy (C-PACE) financing.

⁵ A study by the National Federation of Independent Business (NFIB) found that building owners may make up just over half (57%) of all small businesses. NFIB Small Business Facts, Volume 6, Issue 3, 2006. ISSN 1534-8326. Available at: <http://www.411sbfacts.com/sbpoll-about.php?POLLID=0047>. Last accessed March 7, 2017.

3. STUDIES IN PROGRESS

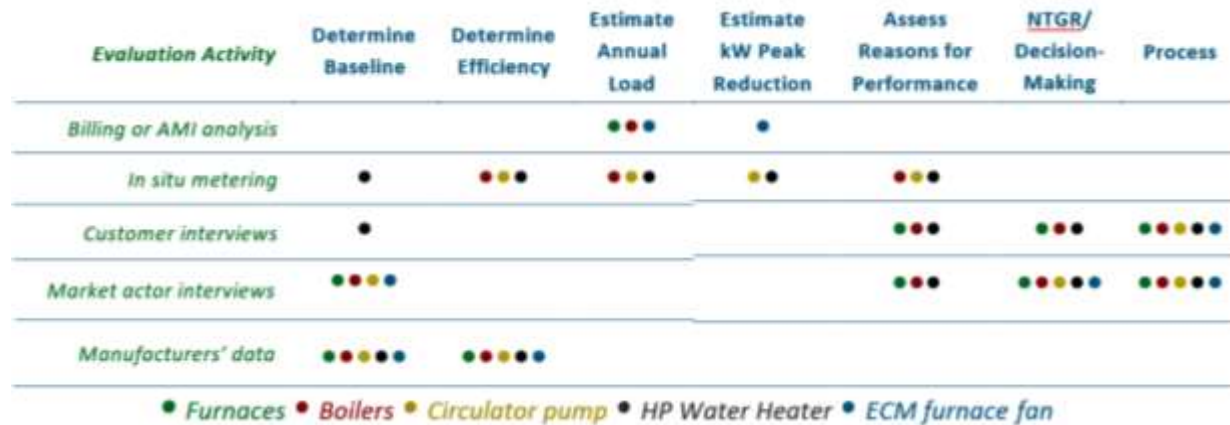
The following studies below were initiated in 2017 and are currently in the draft final report stage. Abstracts of those reports are below.

R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation Report and CT Heat Pump Water Heater Impact Evaluation Report

The report covers impact and process evaluation studies of the Connecticut Residential Upstream HVAC and Water Heating Program (“Upstream HVAC Program”) and the impact evaluation of Heat Pump Water Heater Program. The Upstream HVAC Program offers rebates to distributors to encourage the installation of high efficiency space and water heating equipment and the Heat Pump Water Heater Program offers rebates to distributors and retailers.

This evaluation covered full analysis of five of the eight program measures, which account about 70% or more of the program reported savings for natural gas and electric energy and winter peak savings, and about 25% of the summer peak savings. The evaluated measures are boilers, furnaces, electrically commutated motor (ECM) furnace fans, heat pump water heaters (HPWH’s), and boiler circulating pumps⁶. The analysis used several combinations of methods chosen to balance cost and accuracy. The analysis method and outcomes for each measure are presented in Figure 3.

Figure 3: Summary of Evaluation Activities



⁶ Ground source heat pumps, mini-splits, air source heat pumps, air conditioners and gas water heaters were not evaluated. In aggregate, these measures account for less than about 30% of the savings energy and winter peak savings, and over 70% of the summer peak savings. These measures were not prioritized as previous impact evaluations for ground source heat pumps and central air conditioners were completed in June of 2014 and October of 2014.

The net-to-gross ratios (NTGR) were estimated using the self-report method and incorporating an experimental component to address the causal mechanisms. An alternative experimental approach to estimating program influence, the Barriers Approach, was also tested. (See Appendix K.)

Figure 4 presents a summary of the evaluated gross and net savings by measure. Detailed recommendations for changes to the Program Savings Document are provided in the Executive Summary and in Section 8 of the full report.

Figure 4: Summary of per unit PSD and Evaluated Savings by Measure

Measure	2017 PSD Gross Savings	Evaluated Gross Savings	Realization Rate	Evaluate Net Savings
High Efficiency Furnace	14.1 MMBtu/year	10.4 MMBtu/year	74%	4.7 MMBtu/year
High Efficiency Boiler	11.5 MMBtu/year	7.6 MMBtu/year	66%	3.0 MMBtu/year
ECM Boiler Circulating Pumps	285 kWh/year	68 kWh/year	24%	58 kWh/year
	0.056 Winter kW	0.015 Winter kW	20%	0.013 Winter kW
Furnace Fan	293 kWh/year	321 kWh/year	110%	128 kWh/year
	0.090 Winter kW	0.064 Winter kW	67%	0.026 Winter kW
	0.072 Summer kW	0.032 Summer kW	43%	0.013 Summer kW
Heat Pump Water Heater	1,675 kWh/year	1,070 kWh/year ¹	64%	621 kWh/year
	0.201 Winter kW	0.015 Winter kW	5%	0.009 Winter kW
	0.171 Summer kW	0.021 Summer kW	12%	0.012 Summer kW
	0 MMBtu/year	4.3 MMBtu/year ¹	N/A	2.5 MMBtu/year

¹ These savings reflect a blended baseline, accounting for replacements of electric and fossil fuel water heaters. Although the electric savings are lower, substantial fossil fuel MMBtu savings were added.

Recommendations

Improve Program Tracking: Issues with the data quality had substantial effects on the evaluation. In addition, it is critical to maintain a connection between the rebate and the location of the installation to allow for verification. Quality control procedures need to be strengthened to check the integrity of data required for verification and evaluation.

Improve Communication about Rebate Processing: The satisfaction rating for distributors was substantially affected by low ratings for rebate processing, long lag time to receive the rebate and communication from the utilities. Program managers can improve communication to establish clear expectations with distributors around rebate requirements and timelines.

Expand Contractor Training: Contractors expressed an interest in attending trainings offered by the utilities or third parties that increase their employees' technical knowledge of efficient products and familiarize them with program processes and requirements.

Encourage Distributors to Stock Replacement Parts: Contractors expressed concerns about equipment issues with the efficient equipment, such as problems finding replacement parts. Program staff can work with distributors to stock replacement parts and increase training to contractors on installation and maintenance concerns.

C1630 Largest Savers Evaluation

This study, completed in Q1 2018, includes an impact evaluation of the largest commercial and industrial (C&I) projects for program years 2013 - 2015 and discusses observed trends and their potential impact on future evaluation planning. The study population included participants from both the C&I Energy Conservation Blueprint (ECB) and Energy Opportunities (EO) Programs.

This study found that realization rates (RR), including high and low rigor measures, were as follows:

- ECB electric energy RR: 90%
- ECB summer demand RR: 92%
- ECB gas RR: 92%
- EO electric energy RR: 76%
- ECB summer demand RR: 96%
- ECB gas RR: 76%

Because the sample size is small, inference from the results should be done with caution. The study also found that realization rates and coefficients of variation continue to be good for lighting measures with more variance and generally lower RRs for non-lighting measures. The study also found that the relatively high coefficients of variation found in prior studies persists, indicating that reducing sample sizes for C&I Impact Evaluations going forward is not recommended until the programs implement processes that result in lower variances that are proven out in future evaluations.

Recommendations regarding program delivery include:

- Improve tracking and file management by utilities to reduce effort required to obtain the data necessary to support evaluation
- Ensure executable energy modeling files are obtained and retained by the utilities when the programs fund energy modeling to assess efficiency opportunities (typically in ECB true new construction projects)

In addition, this study found that custom analyses appear to be developed for each project by a variety of vendors. The Programs should consider streamlining this by developing and distributing a standardized analysis tool for each measure type which could reduce program delivery costs and increase consistency in measure analyses. However, the development of these tools requires significant investment which is unlikely to be viable under the current constrained budgets.

No recommendations were made regarding changes to the PSD in this study.