

CONNECTICUT ENERGY EFFICIENCY BOARD

***Evaluation Studies Completed and
Underway in 2019***

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



Connecticut Energy Efficiency Board Evaluation Committee
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Draft Report

PREFACE FROM THE EEB EVALUATION COMMITTEE

The Energy Efficiency Board (EEB) Evaluation Committee is pleased 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.

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

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

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PREFACE FROM THE EVALUATION ADMINISTRATORS --- OVERVIEW AND VERIFICATION OF THE 2019 EVALUATION OF CONNECTICUT'S ENERGY EFFICIENCY FUND ACTIVITIES

The evaluation efforts conducted in 2019 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 2019 add to the evaluation evidence of accomplishments from the use of Connecticut's Energy Efficiency Fund (EEF).

The Evaluation Consultant Team² verified that the 2019 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.

SERA Evaluation Administration Team

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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 2019, is a team of experienced independent evaluators led by Skumatz Economic Research Associates (SERA) and includes Ralph Prah and Associates, Wirtshafter Associates, BuildingMetrics, and Left Fork Energy. Each consultant on the team has between 20 and 40 years of experience in the field and has conducted work nationwide. The offices of these firms are located in Colorado, Florida, Massachusetts, and New York.

LEGISLATIVE REPORT ON 2019 EVALUATION PROJECTS

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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 2019-2021 C&LM Plan budget is \$751 million. The accompanying three-year evaluation budget is \$7.9 million for all evaluation and related research studies, with the first year reflecting the last year of a short-term budget reduction from the Legislature. This represents an evaluation percent of 1.05%, reflecting a decrease compared to figures of 1.4% in 2018, 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 and summary results from completed studies that were filed in calendar year 2019. 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 brief descriptions of study background and key outputs expected from each residential, commercial, and cross-cutting study that was underway – but not completed – in 2019.

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 2019 Legislative Report (by category)

(R=Residential; C=Comm'l / Industrial, X=All/Both Sectors)

Studies Completed in 2019 (Summaries included in Chapter 2)	Report Status
R1603 HES Impact Evaluation	Complete 2019
R1617 Connecticut Residential Ductless Heat Pumps Market Characterization Study	Complete 2019
R1705 R1609 Multifamily Baseline and Weatherization Opportunity Study	Complete 2019
R1706 Residential Appliance Saturation Survey & R1616/R1708 Residential Lighting Impact Saturation Studies	Complete 2019
C1644 EO Net-to-Gross Study	Complete 2019
Studies underway in 2019 (Summaries included in Chapter 3)	
X1931 - In-depth review of the Connecticut Program Savings Document (PSD).	In progress 2019
X1941 Multi-Family Impact Evaluation	In progress 2019
X1939 Early Retirement Program Evaluation.	In progress 2019
C1635 – Energy Opportunities (EO) Impact Evaluation.	In progress 2019
C1901 – C&I Sector Wide Process Evaluation.	In progress 2019
C1906 – Strategic Energy Management (SEM) Program Evaluation.	In progress 2019
C1634 – Energy Conscious Blueprint (ECB) Impact Evaluation.	In progress 2019
R1973 - Retail Non-Lighting Evaluation.	In progress 2019
R1959 Single-Family Renovation and Addition Potential Analysis.	In progress 2019
R1963 - Short-Term Residential Lighting Analysis.	In progress 2019
R1965 HP/HPWH Baseline and Potential Assessment.	In progress 2019
R1982 HVAC / DHW Performance & Potential Evaluation	In progress 2019

This EM&V project list represents a portion of the projects from the adopted 3-year plan. The legislative budget sweep led to a reduction in funding for the first year of the EM&V Evaluation Plan for 2019-21. This leads to delays in addressing gaps in the PSD and to program design, development, and evaluation that will need to be made up over time.

2. PROJECTS COMPLETED IN 2019

R1603 HES Impact Evaluation

This report presents the results of a billing analysis conducted to evaluate the impact of the Home Energy Solutions (HES) and Home Energy Solutions-Income Eligible (HES-IE) programs during 2015 and 2016.

The HES and HES-IE programs are Connecticut's largest residential energy efficiency programs, serving tens of thousands of customers per year with audits, direct installations, and rebates for a variety of energy-saving measures. The measures installed through the HES program range from easy-to-install measures, such as domestic hot water (DHW) pipe insulation, light bulbs, and faucet aerators, to larger, more technical measures, including insulation and heating, ventilation or air conditioning (HVAC) equipment replacements.

Unless stated otherwise, all savings values in this report represent gross savings. The evaluation found that, on average, utility customers saved about 11% of natural gas consumption and 6% of electricity consumption by participating in either the HES or HES-IE programs, a level of savings well within the range seen across similar residential programs in the Northeast.

While these savings are substantial, they are somewhat less than reported during the 2015-2016 evaluation period. The overall gross-savings realization rates for the combined HES and HES-IE programs, were 74% and 48% for natural gas and electricity, respectively, also well within the range seen for similar programs. For natural gas measures, the main contributors to the overall realization rate were insulation and air sealing measures. For electric measures, lighting measures were the primary determinant of the realization rate.

Recommended Changes to PSD

Figures R1603-1 and R1603-2 summarize the realization rates (RR's) by measure group to be applied on a prospective basis. The RR's account for changes between the 2016 and 2019 Program Savings Document (PSD). The natural gas RR's should be applied to other fossil heating fuels (oil and propane). The average program reported savings for insulation were different for the Eversource and SCG/CNG, although the evaluated savings were the same. Consequently, the realization rates are different. The realization rates for air sealing and duct sealing are reported the same because the models could not separate out the individual effects.

Figure R1603-1: Overview of Evaluated Gross Energy Savings per Household (1-4 unit buildings) by Program and Fuel Type

	Natural Gas		Electricity ¹	
	HES	HES-IE	HES	HES-IE
Number of Homes in the Billing Models	3,647	2,215	14,894	8,368
Mean Pre-Install Usage ²	102.5 Mcf	103.4 Mcf	9,767 kWh	8,071 kWh
Mean Program Reported Gross Savings ³	12.4 Mcf	20.6 Mcf	1,254 kWh	1,183 kWh
Program Reported Gross Savings as Percent of Pre-Use	12%	20%	13%	15%
Mean Evaluated Gross Savings ⁴	9.8 Mcf (+/- 0.3 Mcf)	10.4 Mcf (+/- 0.5 Mcf)	683 (±23 kWh)	430 (±30 kWh)
Evaluated Gross Savings as Percent of Pre-Use	10%	10%	7%	5%
Realization Rate	79% (+/- 3%)	50% (+/- 2%)	56% (+/-2%)	36% (+/- 2%)

¹ Most homes with electric measures were heated by natural gas or delivered fuels (such as fuel oil or propane). In the program records, about 12% of participants were identified as having electric space heat, and about 55% of these homes in the regression model had electric use patterns consistent with electric space heat. The savings from heating measures were estimated separately for homes with and without a pattern of use consistent with electric space heating.

² For all homes in final regression model (n=5,862 for natural gas; n=23,201 for electricity). See Section 3.2 for model inclusion criteria.

³ For all single family 2015-2016 program participants (N=8,298 for natural gas, N=39,932 for electricity). Section 3.2 explains rationale for excluding multifamily participants. Averages are computed from gross and adjusted gross values reported by utilities. ⁴ A small proportion of the program reported savings could not be evaluated. The realization rate for these measures was assumed to be 100%. See Section 4.

Figure R1603-2: Realization Rates for HES Natural Gas Measures

Measure Group	Mean Reported Mcf ¹	Mean Evaluated Mcf ¹	Realization Rate	Source/ Comments
DHW Conservation	1.6	N/A	100%	Billing analysis estimate has poor precision; no basis for adjustment
Insulation	Eversource	15.4	124%	Billing analysis included separate estimates by program component (HES and HES-IE); utilities have different program reported savings per home
	SCG & CNG		95%	
Air Sealing	9.2	6.4	70%	Billing analysis included separate estimates by program component
Duct Sealing	5.1	N/A	70%	Savings could not be independently modeled due to overlap with air sealing

https://www.energizect.com/sites/default/files/R1603_HES%20Impact%20Evaluation_Final%20Report_10.22.19.pdf

R1617 Connecticut Residential Ductless Heat Pumps Market Characterization Study

The R1617 Ductless Heat Pump (DHP) study examines the installation circumstances, impacts, and estimated adoption rate of program DHPs installed in Connecticut. The study (1) systematically determined the savings baseline from rebated DHP units in 2015 and 2016, (2) determined the electric and fossil fuel impacts of those units under each baseline condition, (3) explored the DHP marketplace from the contractor perspective, (4) developed a tool to estimate market adoption rates under various rebate and fuel cost levels, and (5) provided guidance for documenting DHP impacts in the CT Program Savings Document (PSD).

Using a survey of 90 participating customers, 23 contractors, and secondary meter data, and the support of a working group³, this study found that DHPs present a unique opportunity to pursue a wide variety of energy outcomes in Connecticut depending on the circumstances in which they are installed. The baselines from DHPs observed in this study produced a very diverse set of energy impacts among multiple fuels, including the possibility of electric load building. The mix of baselines observed in this study, however, produce an average reduction in MMBtu per home.

A significant finding in the adoption model is that single family customers with fossil fuel who use the DHP units for heating and cooling were the most likely customer segment to participate when program rebate levels or the price of alternative fuel increased. These customers have an average impact that includes load building accompanied by significant therm savings and carbon reductions.

The current Program Savings Document (PSD) only credits electric savings to DHP installations. This savings approach is due to standing EEB policy that ratepayer funds not support fuel switching (and by extension not receive therm impact credit for such events). The baseline assumptions in the current PSD approach overstates true electric impacts as it does not include instances of load building. DHPs can be a valuable part of an efficiency portfolio, a vehicle to carbon reduction, and/or a means to induce strategic electrification. A threshold issue lies in the program determining its desired outcomes.

This study has five core recommendations:

1. The study recommends three paths to calculate claimed impacts from DHPs. Path selection depends on what is known about a given installation and whether fuel switching is allowed. These paths are: (1) a blended approach that weights the baseline conditions observed in this study, (2) a series of impacts based on defined baselines (e.g., natural gas furnace, electric resistance, etc.) that are dependent on a handful of easily identifiable characteristics of the project, or (3) a custom baseline determined on a case-by-case basis (akin to this study).
2. The study recommends program implementers consider rebating units only where the baseline can be understood as part of an audit, an online questionnaire, contractor assessment, or as the observation of load patterns indicate to help ensure DHP installations produce fuel impacts aligned with CT program goals.
3. The study recommends the DHP Planning Tool be used to understand how incentive levels and alternative fuel prices affect outcomes credited to the program and help guide the design and

³ These key stages of working group input included the baseline approach, adoption modelling work and impact estimates.

implementation of the future DHP program⁴.

4. The study recommends that DHPs be monitored as part of the planned study (R1982) to update the PSD's equivalent full load hour (EFLH) factor.
5. The study recommends the continued use of contactors to perform outreach and targeting of installation baselines to produce the program's desired impacts.

https://www.energizect.com/sites/default/files/R1617_CT%20Residential%20DHP%20Market%20Characterization%20Study_Final%20Report_6.20.19.pdf

⁴ The current version of the DHP Planning Tool only measures participation and savings attributable to changes in program incentive levels and/or prices for alternative fuels. The impact on participation and savings from other program design features are not captured in the DHP Planning Tool. For midstream programs where the discounted equipment prices are passed to the contractors and then on to customers, the DHP Planning Tool can be used to quantify changes in participation and savings.

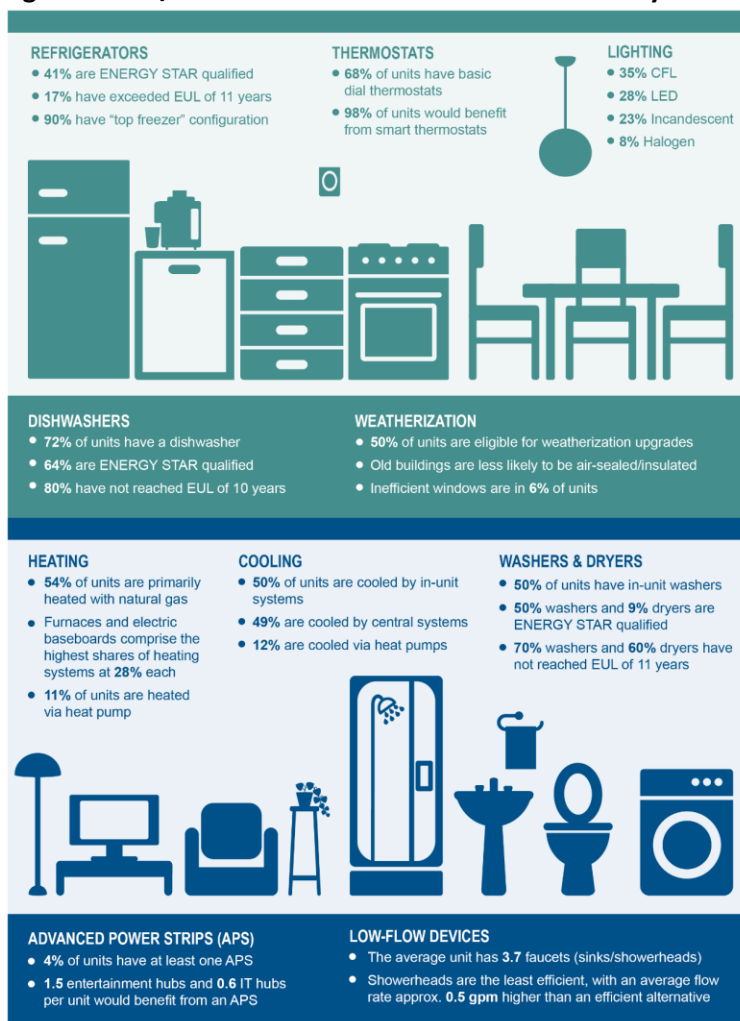
R1705 / R1609 Multifamily Baseline and Weatherization Opportunity Study

The Connecticut Energy Efficiency Board (EEB) commissioned ERS to conduct a baseline and weatherization study of multifamily (MF) units in Connecticut. This research informs the EEB's and utilities' strategies to achieve the Public Act 11-80 mandate to weatherize 80% of residential units in Connecticut by 2030, building on prior and concurrent baseline and weatherization research on single-family (SF) homes.

This study achieves three primary objectives: 1) estimate the quantity and key characteristics of MF units in Connecticut; 2) conduct on-site visits to validate tenant responses to the Residential Appliance Saturation Survey (RASS) and collect weatherization characteristics; and 3) estimate the statewide technical potential savings if all systems were converted to high-efficiency alternatives in MF units.

This study's field data collection focused on the apartments of 137 tenants who completed the RASS. While common area data collection was not a primary focus, ERS engineers collected key common area data when possible. After aggregating, cleaning, and reviewing unit-level data, in coordination with the concurrent SF study, ERS analysts developed tables and figures to characterize the typical apartment in CT by segments of interest (e.g., rent/own).

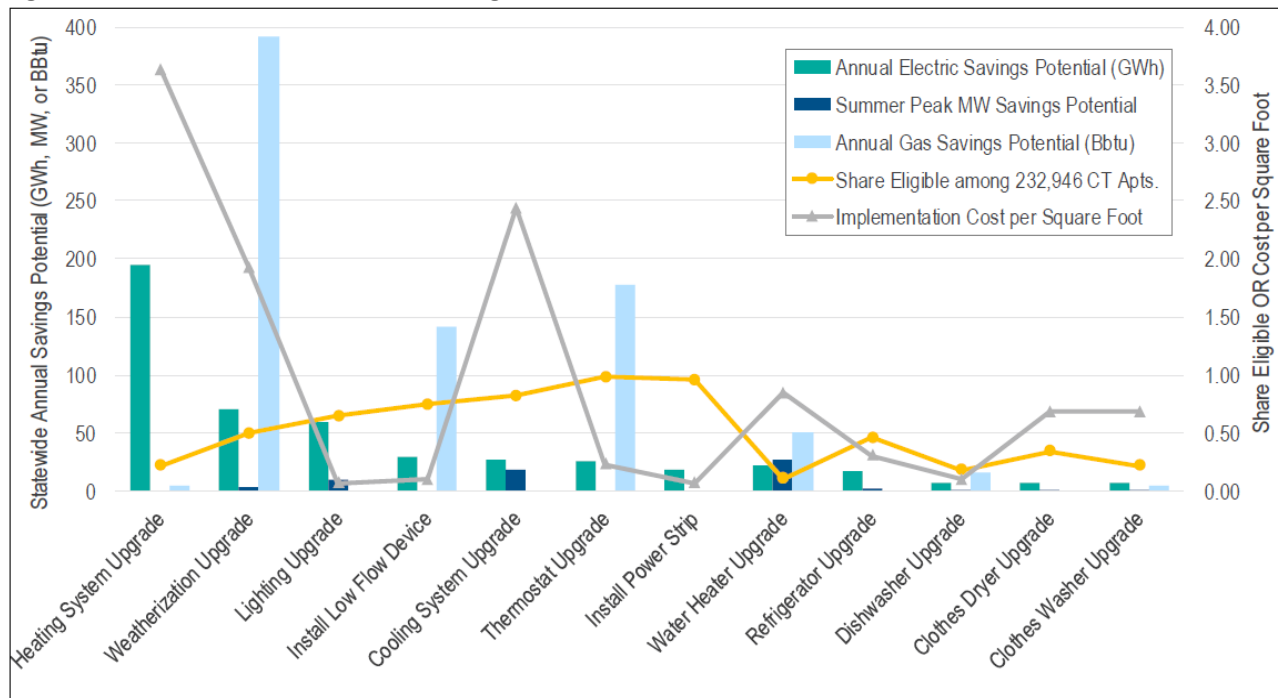
Figure R1705/R1609 - 1: Results of the unit-level analysis



This market data will be valuable for baseline assumptions in the PSD. Results of the unit-level analysis are summarized in graphic [F1].

Comparing existing conditions with high-efficiency alternatives for Connecticut's 232,946 occupied MF units shows significant technical savings potential statewide, as illustrated in the figure [2] below for electric (GWh) and gas (BBtu).

Figure R1705/R1609 - 2: Technical Savings Potential



KEY CONCLUSIONS

1. Conversion to air-source heat pumps (ASHPs) presents the most promising savings opportunity of any measure considered in this study. We found that 28% of MF units are heated by electric resistance baseboards while only 8% are heated via ASHP, indicating significant potential for higher electric efficiency. Using ASHPs to replace existing non-electric heating would also result in significant carbon savings from fuel switching.
2. 50% of the state’s MF units would benefit from at least one weatherization measure. This weatherized share is comparatively higher than that found in the 2014 SF study. Weatherization opportunities depend closely on building vintage for all measures studied, with older buildings offering greater savings potential.
3. There are significant savings opportunities from LED upgrades in tenant units. LEDs comprise only 27% of lighting sockets, while inefficient lighting (incandescent and halogen) comprise 31% of sockets and 53% of stored bulbs.
4. Smart thermostats and advanced power strips offer significant savings opportunity because nearly the entire statewide MF population is eligible for upgrade.

RECOMMENDATIONS

1. Pursue deeper penetration of low-cost measures that offer significant savings potential, including LED lighting, smart thermostats, low-flow devices, and advanced power strips.
2. Electric heating system upgrades and weatherization measures should be further assessed for feasibility, achievable savings, barriers, and contractor training needs in Connecticut.
3. As key common spaces such as basements and rooftops were not always accessible, we recommend that this study be supplemented with a similar baseline study with MF common areas as the focus.

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4. This study quantified technical savings potential, which does not consider measure cost-effectiveness, implementation barriers, or market adoption rates. We recommend that a follow-up global economic or achievable potential study be conducted, using this study's research as a starting point for the MF sector.
 5. Given Connecticut's focus on carbon emissions reduction as well as the preponderance of electric resistance and oil space-heating for MF units, we recommend that further research be conducted on strategic electrification opportunities.

https://www.energizect.com/sites/default/files/R1705-1609%20MF%20Baseline%20Weatherization%20Study_Final%20Report_10.10.19.pdf

R1706 Residential Appliance Saturation Survey & R1616/R1708 Residential Lighting Impact Saturation Studies

The *R1706 Residential Appliance Saturation Survey (RASS)* and *R1616/R1708 Lighting Impact Saturation* studies were based on web surveys with 2,426 Eversource and United Illuminating (the Companies) electric customers and follow-up on-site verification visits with 227 of those customers⁵. With the goal of developing an inventory of residential end uses and building characteristics, the study produced an Excel database that contains all primary research data and detailed analyses. Analyses include adjustment factors that were calculated based on differences between self-reported data and on-site observations (to correct for self-reported data errors). As summarized in this report, results often reinforced current program offerings and directions outlined in Connecticut's 2019 to 2021 Plan or implied additional tactics to save energy:

1. The Plan notes strategies for exploring and pursuing decarbonization through electrification in Connecticut. Findings underscore the relevance for programs to support near-term strategic electrification. Most customers rely on natural gas/propane (48%) or fuel oil (40%) as their primary heating fuel. Similarly, over two-fifths of customers rely on natural gas/propane (49%) or fuel oil (34%) for water heating. Heat pump water heaters were uncommon, but nearly one-half of single-family homes could technically accommodate them.
2. Results emphasize the value of the Companies' current support of ENERGY STAR®-qualified smart learning thermostats, which are less reliant on consumer knowledge and behavior. Their penetration is low (5%), and customers demonstrated a general lack of understanding of thermostats and programmable features on programmable models.
3. Supporting ENERGY STAR-qualified appliances is still relevant. ENERGY STAR saturation was low among appliances manufactured in 2013 or more recently.
4. Secondary refrigerators were present in one in five homes, which may indicate a need to explore the cost-effectiveness of appliance recycling programs.
5. The Companies' support of advanced power strips (APS) through its E-Commerce Platform is likely worthwhile. It may be beneficial to explore including APS as a direct install measure in Home Energy Solutions and Home Energy Solutions – Income Eligible programs. Despite ample opportunities for employing APS, relatively few customers (4%) had them. Nearly all homes had at least one set of electronics with peripherals devices based around a TV or PC, yet they were rarely plugged into an APS.
6. While LED saturation has increased substantially since 2012, the study reveals considerable opportunity for additional LED adoption: 43% of sockets have inefficient bulbs and 57% of bulbs in storage are inefficient. While these findings may indicate that continued promotion of ENERGY STAR LEDs is warranted, federal standards and naturally occurring market adoption may present risk to continued program interventions in the form of reduced baseline.

⁵ In partnership with the R1705/R1609 Multifamily Baseline and Weatherization Opportunity.

This study also examined weatherization in single-family homes, but complications in comparability between a 2011 study and these 2019 results implied the need to commission a more comprehensive weatherization study to accurately assess the current and changing state of single-family home weatherization in Connecticut.

https://www.energizect.com/sites/default/files/R1706%20and%20R1616R1708%20CT%20RASS%20Lighting_Final%20Report_10.1.19.pdf

C1644 EO Net-to-Gross Study

The CT EEB sought a robust and accurate evaluation of the net influence of the Energy Opportunities (EO) program on the market for energy efficiency retrofits to use for regulatory reporting (by updating Program Savings Document (PSD) NTG values) and future program planning. To accomplish their objectives, the EEB contracted with EMI Consulting (hereafter referred to as “the evaluation team”) to complete this evaluation.

The primary objective of the evaluation of the EO program was to estimate a net-to-gross (NTG) ratio by estimating free-ridership, like-spillover, and unlike-spillover from the custom and prescriptive components of the EO program, disaggregated for each of the nine electric and five gas measure categories in the EO program (Controls, Cooling, Custom, Heating, Lighting, Motors, Process, Refrigeration, and Other for electric; Controls, Custom, Heating/DHW, Process and Other for natural gas). The evaluation team also estimated a NTG ratio for the upstream lighting Initiative. This Initiative is separate from the EO program, but is included in the program’s reporting. These results presented in the form of end-use-level estimates of free-ridership and spillover, as well as NTG ratios.

To develop the NTG ratios, the evaluation team assessed the influence of the program on various market actors’ purchasing behaviors and quantified the proportion of gross program savings that are attributable to the program. To discern the influence of the EO program on purchase decisions and vendor business practices, the evaluation team relied on self-reported data from a variety of relevant market actors including end-users, contractors, and distributors. We collected the self-reported data by conducting telephone interviews with 80 EO program participants, representing 395 electric projects and 70 gas projects. In addition to conducting interviews with EO program participants, the evaluation team also conducted interviews with design professionals and vendors identified by customers as being influential. Finally, as part of this study, the evaluation team also conducted survey research to establish free-ridership and spillover estimates for the Energize CT upstream lighting initiative.

As part of this study, the evaluation team recommends that the EEB update the 2020 PSD with the NTG values found in this study as outlined in the tables below. This includes adding a separate NTG value for electric Controls and applying the program-level natural gas results to all-natural gas measures (as was done in 2011). This includes a NTG value of 83% for screw-based LEDs and 91% for linear LEDs as part of the upstream lighting program initiative.

Figure 1644-1: Energy Opportunities NTG Study Results by End-use and Fuel type - Electric

Sample Stratum Electric	Free-ridership	Like-spillover	Unlike Spillover	NTG Ratio	+/- Confidence Interval (90%)	+/- Confidence Interval (80%)
Controls	0.39	0.11	0.03	75%	N/A	35%
Cooling	0.12	0.05	0.00	93%	N/A	3%
Custom	0.23	0.00	0.00	77%	N/A	9%
Heating	0.14	0.07	0.00	93%	N/A	11%
Lighting	0.11	0.05	0.00	94%	4%	N/A
Motor	0.12	0.01	0.02	91%	N/A	6%
Other	0.00	0.00	0.00	100%	N/A	0%
Process	0.12	0.35	0.00	124%	N/A	7%
Refrigeration	0.13	0.00	0.00	88%	N/A	2%
Upstream Lighting (Screw-based Only)	0.40	0.23	N/A	83%	N/A	14%
Overall Electric	0.12	0.06	0.003	94%	3%	N/A

Figure 1644-2: Energy Opportunities NTG Study Results by End-use and Fuel type – Natural Gas

Sample Stratum Electric	Free-ridership	Like-spillover	Unlike Spillover	NTG Ratio	+/- Confidence Interval (90%)	+/- Confidence Interval (80%)
Controls	0.31	0.02	0.00	71%	N/A	28%
Custom	0.37	0.02	0.00	65%	N/A	12%
Heating / DHW	0.16	0.02	0.00	86%	N/A	5%
Other	0.00	0.00	0.00	100%	N/A	0%
Process	0.14	0.12	0.04	102%	N/A	13%
Overall Gas	0.19	0.06	0.02	89%	5%	N/A

https://www.energizect.com/sites/default/files/C1644%20%20EO%20NTG%20Final%20Report_9.25.19.pdf

3. STUDIES IN PROGRESS IN 2019

No additional studies that were underway in 2019 produced draft reports within calendar year 2019. The following studies had kick-offs in 2019 and are in progress. Note that study numbers beginning with C are commercial, R means residential, and X studies cross both residential and commercial sectors.

X1931 - In-depth review of the Connecticut Program Savings Document (PSD).

The CT Program Savings Document (PSD) is used in developing the C&LM Plan. The document is updated annually by utility staff to incorporate results from Connecticut residential and commercial evaluation projects and savings and the variety of other local, state, and federal measure, savings, and other values that comprise the PSD. However, there has not been an independent, in-depth PSD review in the recent past. This study undertakes a comprehensive, systematic, measure-by-measure, data-driven review of Connecticut's PSD against a variety of studies and regional PSDs to identify data gaps, recommend near-term updates, and prioritize future research and evaluation opportunities. This study is designed to address five main objectives: 1) Conduct a comprehensive, data-driven review of the entries in the PSD to identify gaps, validate values against best available data, and provide prioritized opportunities for primary research; 2) Complete research to fill in data gaps and to update content based on best available data, including secondary research; 3) Recommend near-term PSD updates and develop a prioritized list of gaps that should be filled by primary research (near- and longer-term); 4) conduct agreed-upon high priority primary research on PSD entries for CT and 5) Suggest PSD update protocols for the future based on best practices research from other jurisdictions. The outcome for this study will be specific values and entries to be incorporated into a revised PSD.

X1941 Multi-family Impact Evaluation.

The multifamily sector represents a large, relatively untapped opportunity for cost-effective energy savings. Historically, multifamily applications and projects have not been separately evaluated, but rather the results of residential and commercial evaluations have been applied to low-rise and high-rise multifamily, respectively. As the multifamily housing sector is growing in Connecticut and nationally, it is increasingly important to separately evaluate the impacts of energy efficiency measures in multifamily buildings. Connecticut is responding to identified gaps in realized savings that are ostensibly due to a misalignment between actual savings levels likely to occur in multifamily properties and savings levels identified for commercial and residential sectors in the PSD.

This multifamily impact evaluation includes a gap analysis based on a thorough review of the PSD and other similar resources from other states and an engineering review of the calculations and assumptions. Based on this information, the study will recommend modifications to the PSD and utilize site specific information and billing data for a sample of participants to validate the accuracy of the proposed revised estimates, as explained in the following sections. The study includes a comprehensive review and update of measures, with special attention to measure categories with high levels of savings and those with significant variance in savings. Priority measures will likely include boiler, domestic hot water (DHW), insulation, in-unit appliances and lighting replacements. The study will use on-site verification to field test and further improve the PSD savings estimates. The study will use billing data from a sample of surveyed sites to verify savings estimates at the site level and, to the extent it can be

correlated, to the measure-level. The study will then conduct analysis of the available site and utility data to identify whether billing data generally supports the revised PSD savings estimates. The study will compute a realization rate for the statewide multifamily program(s). Once all the data collection and analysis are complete, The study will provide recommendations for multifamily-specific saving methodologies to use in the PSD, along with program-level realization rates and program-level savings.

X1939 Early Retirement Program Evaluation.

Connecticut's 2019–2021 Conservation & Load Management Plan outlines several early retirement programs. The C&LMP includes plans for small targeted initiatives (storage water heaters and HVAC equipment), early retirement incentives for air-to-air heat pumps for central A/C, and for and natural gas high efficiency boilers and furnaces, and for the replacement of larger commercial or industrial equipment such as large chillers. The primary objectives for this impact evaluation are to provide feedback on these types of programs and verify the savings claimed by the pilot programs that are being released throughout 2020. In Phase I, ERS will conduct secondary research and interviews to provide recommendations about program design and implementation. In Phase II, ERS will estimate the adjusted gross energy savings (natural gas and electric) and demand (both summer and winter) for CT early retirement programs. Data collection for this evaluation primarily consists of project file review and interviews with participating customers. The project will: 1) Provide feedback on early retirement program design, including which gross and net parameters are relevant for these programs; 2) Ensure that CT programs are using correct measure type and baselines in the PSD; 3) Examine non-energy impacts NEIs appropriate to the programs; 4) Optimize the program's design and delivery of services for effectiveness and efficiency; 5) Assess the savings and realization rate performance of the program to provide improvements to the design of early retirement programs.

C1635 – Energy Opportunities (EO) Impact Evaluation.

This study is an impact evaluation of the EO program, including gas and electric installations. The study's objectives are to evaluate program-level energy and demand savings estimates and realization rates for electric and natural gas measures; evaluate the LED component of the upstream lighting program to provide savings parameter assumptions (i.e., reduction in watts, hours of use) to inform/refine future savings estimates; and provide PSD savings parameters including realization rates and Program Savings Document (PSD) updates where available. The last comprehensive impact evaluation for this program was for 2011 and more current results are needed to accurately estimate savings and performance. This impact evaluation includes 149 C&I gas and electric downstream sites, and 95 upstream lighting sites, for a total of 244. Field work should be completed on the last dozen sites this spring. The deliverables are a report that provides realization rates for electric and gas end for the program by utility, and a lighting hours of use study that supports updates to the PSD.

C1901 – C&I Sector Wide Process Evaluation.

This study is designed to understand how the portfolio of large C&I programs (Energy Opportunities, Energy Conscious Blueprint, Business and Energy Solutions) work together to deliver savings to the targeted sector. The key areas of interest are cost effectiveness, program optimization, market penetration, depth of savings, and customer equity. The study will use a consistent approach to investigate these issues, analyze the data for cross-program and cross-Company comparisons, and assess opportunities for closer synergies between programs. This comprehensive approach offers

advantages over evaluations of individual programs where interactions between programs serving the same market can be less visible to the investigator. The approach also supports economies of scale where the sample sizes and number of interviews are smaller than for individual programs. The deliverable is a report with findings and recommendations for the key areas of interest.

C1906 – Strategic Energy Management (SEM) Program Evaluation.

The SEM program is a new program offering that targets the commercial and industrial (C&I) markets. SEM is a customer engagement approach that focuses on setting goals, tracking processes, and reporting results. Major SEM objectives include establishing long-term relationships with energy users and targeting persistent energy savings through a combination of capital, behavioral and operations improvement measures. Since SEM is a behavioral and organization-based practice, the energy savings are complex to estimate. The primary objectives for this study are to identify best practices for estimating energy savings and documenting program activities, provide evaluation methodologies based on these best practices, and to perform process and impact evaluations on the SEM program. Since the SEM program is in the beginning stage of deployment, this study presents a unique opportunity to define data needs and data collection strategies from the program onset; thus, providing the information needed to conduct a robust and defensible evaluation of the program. Deliverables from the study include best practice evaluation methods, data collection protocols, an impact evaluation providing energy savings estimates and realization rates, and a process evaluation identifying improvements to program design and implementation.

C1634 – Energy Conscious Blueprint (ECB) Impact Evaluation.

The ECB program is one of the major efficiency programs in the CT portfolio, focusing on new construction, major renovation, and end-of-life replacement projects in the commercial and industrial sectors. The ECB program accounts for 18% of the electricity and 20% of the gas savings in the CT portfolio. The study includes an impact evaluation and a new construction baseline study. The impact evaluation collected primary data from a statistically valid representative sample of ECB program participants and conducted Measurement and Verification (M&V) data on installed measures. The sample consisted of 275 unique energy efficiency measures (219 electric, 56 gas). While most customers were only sampled for a specific measure, some customers were selected that have multiple primary measures. About 190 unique sites were visited. The deliverables are a report that provides realization rates for five electric and three gas end use groups, develops program demand savings for reporting to the ISO New England Forward Capacity Market (FCM) and develops data that will support updates to the Program Savings Document (PSD). The new construction baseline study consisted of in-depth telephone interviews with architects, engineers and contractors active in the CT new construction market. A separate memo report will be delivered outlining the results of the new construction baseline study.

R1973 - Retail Non-Lighting Evaluation.

Eversource and United Illuminating run the ENERGY STAR Retail Products Platform (ESRPP) and the utilities' E-commerce platforms. United Illuminating launched their E-commerce platform in 2019, and Eversource is planning to launch their platform in 2020. Both utilities have been participating in the ESRPP program since 2018. These programs are part of the Connecticut program administrators (PAs) efforts to provide additional energy efficiency opportunities to residential customers in the face of declining savings opportunities from lighting. Under the program, participating retailers per-unit

incentives that increase with efficiency levels for every program-qualified unit that they sell in targeted product categories (e.g., clothes dryers, sound bars) during the program period. Utilities partner with participating retailers to increase the sales of energy-efficient models over less efficient models, and generate energy and demand savings for utility customers in the short-, mid-, and long-term, and also transform the overall market towards higher efficiency in the long-term. The E-commerce platforms provide an additional path for residential energy efficiency savings by providing a centralized location for customers to purchase energy efficient products. The objective of this study is to develop improved impact parameters for the programs and provide recommendations on improvements to program design and implementation. The study will include a review of the Connecticut PSD's unit energy savings and unit demand reduction values, assess increases in shelf assortment of qualified products at participating retail locations, estimate the increases in sales of qualified products due to the program, and conduct a comparative EM&V best practices review.

R1959 Single-Family Renovation and Addition Potential Analysis.

Renovations and additions to homes may represent a larger opportunity for energy savings than new construction, but neither the current RNC or retrofit program in Connecticut is set up to address the needs of renovations and additions. It is unclear how large the market is, how much of the work has the potential for improvements in energy efficiency, nor how equipped current home repair contractors are to deliver energy efficiency. This study is designed to 1) estimate the size of the market using permit data, 2) characterize the scope of renovation and addition projects, 3) gain insight on standard practices used in these projects to inform future baseline efforts, 4) estimate the energy saving potential that currently exists in this sector, 5) identify key barriers in this market, 6) make recommendations for program planning and updates to the Connecticut Program Savings Document (PSD) and 7) provide a limited process evaluation of the RA program in Connecticut and compare with other programs nationally/regionally to identify best practice improvements. The study will use a specialized calculation algorithm to estimate market size using Census data, information from contractor and homeowner surveys and other data to characterize the scope of renovation and addition projects. Resulting energy simulation models will estimate the potential savings for the variety of renovation and addition scenarios, and the savings will be scaled up to estimate the potential savings for the entire state. The study will also gather baseline information on market effects indicators so that market effects can be measured and tracked in future evaluations.

R1963 - Short-Term Residential Lighting Analysis.

The residential lighting market is at a turning point; over the past decade, it has experienced rapid changes and uncertainty stemming from federal legislation and rulemakings that increased lighting efficiency standards and redefined what constitutes a *general service lamp*, the introduction of new technologies to the market, and changes in ENERGY STAR® specifications. The future of residential lighting remains unclear; while the market seems poised for LEDs to dominate, there are lingering questions regarding when and how the next phase of federal standards will be implemented. In addition, some states have begun to pursue local state efficiency standards, further complicating any predictions. This leaves Connecticut, with a conundrum, determining if, when, and how to exit the residential lighting market. The study uses both quantitative and qualitative sources to characterize the retail lighting market and predict its future. Quantitative resources (e.g., sales data, web scraping, and program tracking data) provide historic and recent information on product availability, sales, and characteristics. These sources are being coupled with evaluation reports, regulatory documents, media

reports, and in-depth interviews to add depth to our understanding and extrapolate to the future. The goals of the R1963 study are to: 1) analyze legislative updates regarding the Energy Independence and Security Act (EISA) to identify the legislative and regulatory landscape regarding lighting, 2) Examine third-party lighting sales data to assess market share in Connecticut, nearby states, the US, and program and non-program states; 3) Examine program tracking data to assess sales by product category and characteristics; 4) Gather shelf stocking information to analyze market changes, 5) Obtain predicted market share and product trends through 2021 (from lighting experts); 6) Document program design and exit strategies (suggested by lighting experts), and 7) Communicate overall findings on market characteristics, trends, and implications for program design -- and potential indicators, exit timing and if appropriate, exit strategies.

R1965 HP/HPWH Baseline and Potential Assessment.

With the Connecticut Utilities considering a shift in the residential market toward efficient heat pump systems, it is critical to gain a full understanding of these markets in terms of their size, the key market actors, and the drivers and barriers that affect adoption. How many of these systems are sold, and into what supply chain channels? Do market actors see a value proposition for these products? Is the air source heat pump (ASHP) market trending toward ductless mini-splits, or is there increasing interest in less-visible distribution systems that use ducts or in-ceiling cassette blowers? Will the efficiency of heat pump water heaters (HPWHs) compensate for their complex installation requirements? Do mini-split ASHPs and ground source heat pumps (GSHPs) meet the needs of the retrofit market? The study will incorporate multiple primary and secondary data sources to estimate the size of the market in Connecticut. Secondary sources include previous baseline studies, purchased sales data, as well as shipment data. Primary data collection work will solicit feedback from manufacturers, distributors, and installers through interviews and interactive surveys to better understand the future of the market for heat pumps, as well as system configurations that are dominating the market. The project will provide results from cost effectiveness testing at the measure level, focusing on particular system configurations of interest to identify the most cost-effective systems and system installation configurations for the Utilities to consider in order to meet the C&LM goals for heat pumps. This study will take an in-depth dive into the state of the Connecticut market for heat pumps and heat pump water heaters, investigating the size and state of the market, what market actors think about these technologies, real-world factors affecting heat pump installations in homes, and how the Utilities can best promote cost-effective heat pump programs, given the rapid change in heat pump technologies.

R1982 HVAC / DHW Performance & Potential Evaluation

This project is focused on getting up-to-date performance measurements for two emerging technologies: mini-split heat pumps and heat pump water heaters. This project will install metering equipment in 150 homes in Connecticut to provide detailed energy use and load shapes for prevalent HVAC and DHW equipment types. This data will update the PSD values for efficiency, annual use, seasonal peak and off-peak loads.

The project will install end-use metering equipment on major energy-consuming equipment in 150 single-family homes across Connecticut. Emphasis will be on selecting homes with heat pumps or heat pump water heaters, though the sampling plan includes homes that have furnaces, boilers, or other types of water heaters. Meters will remain in place for at least one year so that data from summer and winter periods will be collected. When possible, other large electric equipment will be metered.

Together this project will update baseline and efficiency assumptions in the PSD. It will also provide better load shape data for use in demand-response studies and as inputs to the New England ISO.