Central Air Conditioning Impact and Process Evaluation

Final Report

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Submitted to:

Connecticut Energy Efficiency Board

Submitted by:

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Executive Summary

The Connecticut Energy Efficiency Board (EEB) requested that the evaluation team comprising NMR Group, Inc., and DNV GL perform a comprehensive central air conditioning (CAC)[1] impact evaluation as well as market research to identify methods to better induce early replacement of CAC units among program participants. This report describes the objectives of the study, the methods and analysis procedures used, and the study findings.

Findings

The section below presents the impact and market research results. Each section begins with an overview of the objectives, the methods employed, and the findings.

Impact Evaluation

The primary goal of the impact evaluation was to determine the program electric energy savings as well as summer on-peak and seasonal peak demand savings. In addition, the EEB, Connecticut Light and Power (CL&P), and the United Illuminating Company (UI, the latter two collectively referred to as the Companies) were interested in the provision of information on the performance and conditions observed around the installed CAC units, including load shapes; a characterization of CAC units as installed (including size, airflow, and rated efficiency); and a determination of whether new replacement units are properly sized for the homes in which they were installed. The CAC units of interest are those installed using rebates provided by the Connecticut Energy Efficiency Fund, both those that went through the Home Energy Solutions (HES) program and those that did not.

To achieve these research goals, the evaluation team performed sampling and selection of 92 on-site visits, including long-term post-installation monitoring during the cooling seasons of 2012 and 2013. The visits included data collection on the areas served in order to support Manual J calculations, when appropriate, as well as true flow diagnostic testing. Regression modeling was applied to the field-collected data to project measure savings, determine peak period impacts, and develop measure load shapes. The final estimates of savings are derived from the on-site data, including the observed EER,[2] SEER,[3] capacity (tons), and metering.

The energy and peak demand impact portion of this study was designed to provide program savings estimates through the use of an M&V data-driven per-unit savings estimate. It was also

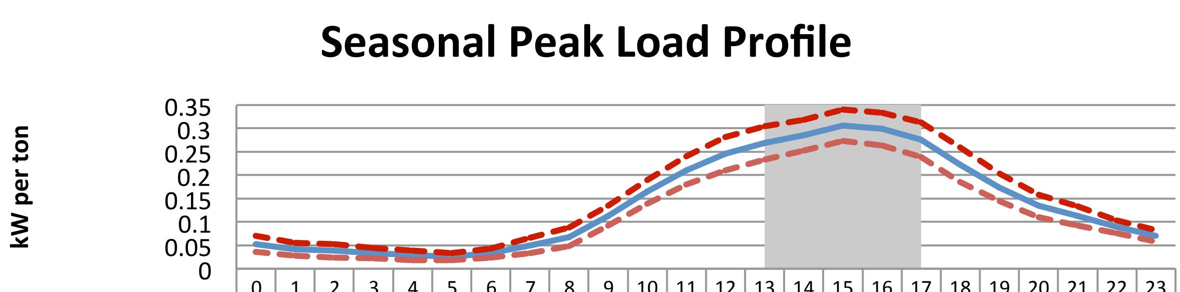
[1] All units explored in this study were ducted energy-efficient central air conditioning (AC) systems.

[2] Energy Efficiency Ratio (EER) is the measure of the instantaneous energy efficiency of room air conditioners: the cooling capacity in Btu/hr divided by the watts of power consumed at a specific outdoor temperature (usually 95 degrees Fahrenheit). http://energy.gov/eere

[3] Seasonal Energy Efficiency Ratio (SEER) is a measure of seasonal or annual efficiency of a central air conditioner or air conditioning heat pump. It takes into account the variations in temperature that can occur within a season and is the average number of Btu of cooling delivered for every watt-hour of electricity used by the heat pump over a cooling season. http://energy.gov/eere

designed to help the Companies and EEB improve on forward-looking calculations through recommendations to the Program Savings Document. The bullets below capture our conclusions and recommendations in this regard.

- The overall statewide Annual Savings factor (ASF[4]), which is an input to the calculation of savings in the PSD, is 362.0 kWh/ton, with an accompanying precision of ±11% at the 90% confidence interval. This value is based upon the calculation of energy savings using EER and is statistically the same as the current Program Savings Document Assumption of 357.6 kWh/ton. The calculated ASF using SEER results is 362.0 kWh/ton and is also statistically the same as the PSD assumption.
- The seasonal and on-peak Demand Savings Factors (DSFs), also PSD formula inputs, are 0.45 kW/ton and 0.24 kW/ton, respectively, each with precisions better than ±7% at the 80% confidence interval. The study's seasonal DSF estimate of 0.45 is statistically lower than the current PSD assumption of 0.591. (The PSD does not contain an on-peak DSF.)
- The overall statewide per-unit average annual savings estimate is 178.7 kWh/unit. The statewide per-unit average annual savings estimates for lost opportunity and retrofit events are 148.3 kWh/unit and 390.7 kWh/unit, respectively. The overall statewide per-unit average summer seasonal peak demand savings estimate is 0.22 kW/unit. The statewide per-unit average summer seasonal peak demand savings estimate for lost opportunity and retrofit events are 0.21 kW/unit and 0.34 kW/unit, respectively.
- The figure below shows the average daily profile for the seasonal peak period. The peak hours are shaded in grey, the mean load is depicted by the solid blue line, and the dotted red lines show the lower and upper 80% confidence interval. The seasonal peak load is actual consumption per ton that occurs between 3:00 and 4:00 P.M., which is different from the DSF (which is the seasonal demand savings factor and is calculated based on the equation given in section 4.1). The mean value is 0.31 kW/ton.



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Onpeak														1	1	1	1	1						
TM3 Load	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.07	0.11	0.16	0.21	0.25	0.27	0.29	0.31	0.30	0.28	0.22	0.17	0.13	0.11	0.09	0.07
Lower 80% CL	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.09	0.14	0.18	0.21	0.23	0.25	0.27	0.26	0.24	0.18	0.14	0.11	0.09	0.08	0.06
Upper 80% CL	0.07	0.05	0.05	0.04	0.04	0.03	0.04	0.07	0.09	0.13	0.19	0.24	0.28	0.30	0.32	0.34	0.33	0.31	0.26	0.20	0.16	0.13	0.10	0.08

[4] ASF is an Annual Savings Factor that is used in the 2012-2014 PSD, but not the 2011 PSD. This factor is the kWh per ton that is used in the savings calculation (along with efficiency and capacity) and is considered a reflection more of unit usage than savings.

- Overall, the incentives provided for CAC installations appear to be generating significant levels of savings. This study estimates 1,147 MWh of energy savings associated with 2011 and 2012 CAC installations, with a realization rate of 98.2% when compared to the raw tracking data. We estimate 1.405 MW of summer seasonal demand savings with a realization rate of 85.9%. Using the PSD assumed free ridership rates of 26% for UI and 42% for CL&P and no spillover savings, the overall net energy savings impact estimate is 725.4 MWh, and the overall net seasonal peak demand savings estimate is 0.877 MW.
- There was inconsistent adherence to the PSD in the tracking systems. When compared to the revised tracking data (tracking that has been corrected to better reflect PSD formulas), the realization rates for kWh and summer peak demand are 124.3% and 77.1%, respectively. For Lost Opportunity, the realization rates are 95.0% for kWh and 79.9% for seasonal peak demand. For Retrofit, the realization rates are 129.5% for kWh and 69.0% for seasonal peak demand. The energy realization rate is moderately high for energy savings due to higher usage than assumed in the PSD, generally higher unit sizes observed on-site than captured in the tracking system, and the application of incorrect baselines in some tracking estimates. The realization rate around the summer seasonal result is lower, primarily due to a reduction in the seasonal demand factor as compared to the PSD.
- The team found that 11% of inspected installed CAC systems were either oversized (4%) or undersized (7%) when compared to Manual J. Although the sample of units assessed in this manner was a subset of overall installations visited, we consider these results to be reasonable since there is some contractor judgment in determining the final unit size based on the nature of the ductwork observed, home shading, and home tightness, among other factors. Although we note that roughly three in ten units in the sizing assessment had ratios of calculated load to installed capacity of between 125% and 150%, overall, we conclude that equipment sizing is a low-level issue and does not cause substantial inefficiencies in the central air conditioning systems replaced under the Connecticut programs.
- Based upon our site work, unit efficiencies appear to be consistently tracked and accurate in the tracking system. Unit sizes, however, were noted not to be accurately tracked in a consistent manner.
- The assessment of unit air flow resulted in 49% of units having air flow at or below 350 CFM/ton. However, due to some uncertainty over whether all measurements were taken with blowers at full speed, the team believes that these lower measurements are not likely to significantly affect the efficiency of the program-installed units.

Market Research

The study team also conducted market research among program participants in order to identify methods to better induce early replacement of CAC units among program participants.[5] Note that the evaluation team was told that the Companies follow a rule of thumb that any CAC more than 10 years old that is still functioning qualifies as an early replacement.

To achieve this objective, the study explored a variety of questions in an effort to understand what factors customers consider when deciding to replace their CAC, with particular emphasis on the role of standard and early replacement rebates, energy efficiency, information provided by HES vendors, and the advice of installation contractors. The team also included questions about Quality Installation, as this approach provides additional opportunities for rebates among households replacing CAC.

The survey focused on three groups of PY2011 HES participants: those who were recommended CAC replacement as part of the HES audit and

1. Obtained only a standard, $250 CAC rebate (n=70)
2. Obtained a $500 rebate ($250 standard CAC rebate plus $250 "Early Replacement" rebate) (n=70)
3. Were recommended CAC but did not obtain a rebate (n=100, of which 27 replaced CAC without a rebate and 73 did not replace their CAC)

The market research yielded the following key findings:

- Despite the fact that the Companies offer substantial rebates meant to induce early replacement, having an inefficient but working CAC unit is a substantial barrier to replacement, particularly considering the cost of replacement, even with substantial rebates. About one-fifth of participants who replaced their CAC with an early replacement rebate reported that their "old unit broke down." If these units were truly not functioning, then the HES program did not actually achieve any early savings from the replacement.
- The rebate was not one of the primary factors considered in the decision to replace a CAC (only about 5% of respondents volunteered it as a factor that was considered), but rebates were important in the decision to replace an existing CAC system *with a high efficiency ENERGY STAR®-qualified model* (76% of rebate users said it was somewhat or very important). The rebates played a more important role in decision making for early replacement rebate users than for standard rebate users.

[5] The original scope of work for this study included focus groups to explore decision making regarding early CAC replacement in more detail. However, neither the Companies nor their HES implementation vendors regularly tracked households that were offered CAC rebates but did not use them. The EEB evaluation consultant and the evaluation team determined that the expense of finding and recruiting HES participants who were offered early replacement but did not use it would not be a cost-effective evaluation strategy.

- Only 15 respondents used program-supported low-interest financing to replace their CAC, but 13 of them said the loan was somewhat or very important to their decision to replace the CAC unit.
- Participants who obtained an early replacement rebate were much more likely than other participant groups—especially those who did not replace their CAC—to say that they were aware they could receive a rebate before the audit or before the survey call. However, they were no more likely than those who received a standard rebate to say that they had had plans to replace their CAC equipment before the audit.
- Participants rely more strongly on the advice and opinions of installation contractors than on those of HES vendors when deciding whether to replace the CAC and with which equipment.
- Of those who did not replace their CAC despite the recommendation, one-quarter plan to do so within the next five years.
- The data suggest that as much as four-fifths of participants who did not replace their CAC might have qualified for an early replacement rebate had they replaced their CAC.
- Participants who did not use the rebate to replace a CAC suggested that the HES vendors provide more information that explains the benefits of early replacement and perform follow-up calls to encourage following through with audit recommendations.
- There is opportunity to increase participant awareness and use of Quality Installation & Verification.

Recommendations

Based on the impact findings, the Companies or EEB may wish to do the following:

- Consider the use of SEER in the PSD to calculate energy savings for this measure, but continue to use EER for peak demand savings. SEER better reflects the average of the EER over the range of operating conditions that would be seen over the course of a year, while EER is more representative of performance at the peak condition being estimated.
- Consider the use of the seasonal peak DSF from this study (0.45) in lieu of the PSD assumption of 0.59.
- Re-examine the manner in which tracking savings are calculated to ensure adherence to the PSD. Notable items in this regard include ensuring use of the proper baseline when calculating tracking savings, ensuring proper crediting of all savings associated with retrofit events, and not dividing lifetime savings by measure life to estimate annual savings.
- Re-examine the method being used to gather and input CAC unit sizes (tons) and EERs in the tracking system to ensure accuracy and comprehensiveness. One idea in this regard might be to accompany each rebate application with model specification sheets from the AHRI database to ensure proper coding and backup.

- Consider changing the term Annual Savings Factor (ASF) in the current PSD to reflect the fact that it is more of a Usage Factor. This term will make it more consistent with how it is used in the savings formula.

Based on the market research findings, in planning for future program marketing and encouraging early replacement of CAC, the Companies or EEB may wish to do the following:

- Better emphasize, and effectively communicate, the size and types of CAC rebates available to HES participants. As one participant noted, "[They] should say up front about [the] $500 rebate."
- In program-related communications, emphasize the benefits of replacing systems before they break down, even if the system does not appear to be that old.
- Consider the means through which the program is marketed and how the program could bring CAC replacement rebates to the attention of participants earlier in the process. Currently, participants are most likely to learn about CAC replacement rebates from the HES vendor, followed by the utility website and a contractor. In order to reach the target audience with rebate information sooner in the program process, thus improving the likelihood of early CAC replacement, the Companies or EEB may wish to consider exploring other approaches for getting the word out about the availability of substantial rebates for CAC replacement and other residential measures earlier in the participation process. For example, immediately upon receiving an application, prior to approving it, the Companies could automatically send the applicant an eye-catching email or hardcopy mailing with information about the benefits of early CAC replacement and quality installation. There could be a "countdown" of periodic emails or mailings about the program from the point of application to the actual visit.
- While the energy auditor clearly plays an important role in participant decision making, most participants reported that the installation contractor was even more important. The Companies or EEB may want to help foster closer relationships between HES vendors and CAC installation contractors to increase the likelihood that customers who obtain an audit will follow through with replacing their CAC with high efficiency equipment.
- Continue to make financing available for CAC replacement. While only 16% of participants took advantage of financing, its availability mattered a great deal to the majority of these customers.
- Although measuring free ridership was not an objective of this study, the findings suggest that users of the early replacement rebate were more likely to have been aware of the rebate prior to their HES audit—pointing to free ridership. However, users of the early replacement rebate were no more likely than standard rebate users to report having prior plans to install CAC equipment—suggesting free ridership is not higher among this group. It may be worthwhile for the EEB to take these factors into consideration when measuring CAC free ridership for early replacement rebate users in the future.

- In light of the findings in this report and the recent Massachusetts Cool Smart evaluation, the Companies may wish to reconsider the decision to discontinue the early replacement rebate. If the Companies decide to reinstate the early retirement rebate, it may be worthwhile to have vendors explore the condition of the unit replaced. This information would enable the Companies to develop an algorithm to better categorize respondents regarding early replacement versus replacement on breakdown, understand the differences in their thinking and decision making, and avoid the potential for free ridership.
- The Companies may wish to consider some of the recommendations made by participants to encourage other customers to replace their CAC equipment. For example, given the customer bias against replacing equipment that still functions, the utilities could find ways to ensure that when HES vendors recommend replacing CAC, they always provide information on costs and savings and the logic of replacing older but still-functioning units with new units of higher efficiency. Another option is that they follow up with participants after the audit to encourage them to pursue recommended measures.
- The Quality Installation option could be better supported. HES participant awareness of this option was low. The anecdotal evidence offered by participants in open-ended questions suggests that there are substantial challenges to the implementation of the Quality Installation option, not the least of which is a shortage of qualified technicians. If the Companies wish to garner additional CAC savings by increasing the rate of Quality Installation of CAC in their service territories, they may first need to assess how to increase the number of qualified technicians in their service territories.

1 Introduction

The Connecticut Energy Efficiency Board (EEB) requested that the evaluation team comprising NMR Group, Inc., and DNV GL perform a comprehensive central air conditioning (CAC) impact evaluation and conduct market research to identify methods to better induce early replacement of CAC units among program participants. The team worked with the EEB evaluation consultant to determine the objectives and methods for this study in 2012 and engaged in data collection and analysis activities in both 2012 (impact) and 2013 (impact and market research). This report describes the objectives of the study, the methods and analysis procedures used, and the study findings.

1.1 Research Objectives

1.1.1 Impact Evaluation

The primary goal of the impact evaluation was to provide the EEB as well as Connecticut Light and Power (CL&P) and The United Illuminating Company (UI, the latter two collectively referred to as the Companies) with the information necessary to determine energy and demand savings for CAC installed using rebates provided by the Connecticut Energy Efficiency Fund. This effort comprised 92 on-sites, with metering and field confirmation of EER and capacity. Based on this information, we provide an independent estimate of per-unit and program savings in addition to a comparison of key assumed PSD values and those observed in this study. Households may have used these rebates through the Home Energy Solutions (HES) program or independently of the program. The market research described below addresses the rebate program.

The impact evaluation had the following two core objectives:

- To determine the program electric energy savings targeted to achieve ±10 precision at the 90% level of confidence
- To estimate program electric energy demand savings coincident with summer on-peak and seasonal peak periods targeted to achieve ±10 precision at the 80% level of confidence

In addition, the EEB and the Companies were interested in the provision of information on the performance and conditions observed around the installed CAC units. There were three objectives related to this goal:

- The provision of CAC load shapes
- A characterization of CAC units as installed (including size, airflow, and rated efficiency)
- A determination of whether new replacement units are properly sized for the homes in which they were installed

1.1.2 Market Research

The main objective of the market research was to identify methods to better induce early replacement of CAC units among program participants.[6]

To achieve this objective, the study explored a variety of questions. These included:

- What factors do customers consider when deciding to replace their CAC?
- What role does energy efficiency play in the decision to replace a CAC?
- What role do rebates for energy-efficient CAC play in the decision to replace a CAC?
- Why do some customers decide to use the rebate and others do not?

For these and related questions, the study explores how the responses compare between those who received recommendations for early replacement of a CAC and those who received recommendations to exchange one near the end of its useful life. The study also addresses the barriers and drivers to early replacement of CAC.

[6] The original scope of work for this study included focus groups to explore decision making regarding early CAC replacement in more detail. However, neither the Companies nor their HES implementation vendors regularly tracked households who were offered CAC rebates but did not use them. The EEB evaluation consultant and the evaluation team determined that the expense of finding and recruiting HES participants who were offered early replacement but did not use it would not be a cost-effective evaluation strategy.

2 Program Description

This description focuses on the Home Energy Solutions (HES) program for the period addressed by this research (2011, 2012, and 2013).[7] It is based on the Companies' 2011 and 2012 Electric and Natural Gas Conservation and Load Management Plans.[8][9] Established in the form described here in 2006, the program serves electric and natural gas customers in existing residential structures, including single- and multifamily properties. Among the many offerings under the HES umbrella are rebates for high efficiency replacement CAC units and HVAC Quality Installation and Verification (QIV) rebates.

"Core" or "In-Home Services" comprise the largest component of HES. Their purpose is "to identify comprehensive cost effective energy conservation opportunities in single family homes and educate and communicate these opportunities to the homeowner." The HES program accomplishes this through home audits and the following other measures:

- Blower door-guided air sealing
- Duct sealing
- Installation of CFL bulbs per HES guidelines and approved by customer
- Installation of water measures (low-flow showerheads and aerators)
- Installation of pipe insulation for hot water piping
- A "Kitchen Table Wrap-up," during which participants receive educational materials and the technician tells them about the opportunities for savings beyond HES Core Services. This includes information about savings opportunities identified by the audit and rebates for relevant add-on measures such as HVAC and appliance replacement, insulation, and window upgrades. Technicians use the Home Energy Yardstick (HEY) tool to show payback and investment information to customers to help them make decisions on purchasing and implementing additional energy efficiency and conservation measures.

Encouraging customers to retire older, inefficient equipment is a key market strategy. In addition to the $250 rebate for replacing inefficient CAC systems with qualified ENERGY STAR CAC systems, at the time addressed by this study the Companies offered an additional $250 rebate for early replacement of operable systems, as shown in Table 2-1. The Companies ended the early replacement rebate for CAC after the period addressed by this study. Note that in the Plans examined, this rebate is referred to as both "early retirement" and "early replacement." We use these terms interchangeably in this report.

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[7] The Home Energy Solution – Income Eligible (HES-IE) program does not offer CAC rebates or provide them free of charge to participants.

[8] The Connecticut Light and Power Company, the United Illuminating Company, Yankee Gas Services Company, Connecticut Natural Gas Corporation, and Southern Connecticut Gas Company. 2010. Docket Nos. 10-10-03 and 10-10-04. October 1.

[9] The Connecticut Light and Power Company, the United Illuminating Company, Yankee Gas Services Company, Connecticut Natural Gas Corporation, and Southern Connecticut Gas Company. 2011. Docket No. 11-10-03, September 30.

Residential Quality Installation Verification (QIV) is required for HES financing of HVAC measures to ensure proper design and installation of HVAC systems. QIV is a commissioning process that begins with system design verification and ends when installed systems are tested and verified to match provided HVAC system plans. This process includes Manual J calculations to assess unit sizing needs. To obtain this rebate, customers must supply the program with "the passing QIV certificate, all records pertaining to the HVAC system installation, operation and maintenance records, 'as-built' documents, manufacturers' technical documents and warranties."[10] The companies also provide contractors with training and site assistance for performing QIV and list the contractors on the companies' websites.

HES provides third-party financing for energy improvement projects recommended or offered through HES. The financing is offered at subsidized rates and includes on-bill repayment. Table 2-1 shows the CAC-related rebates offered to eligible customers at the time of this research. Note that, with the possible exception of QIV, these rebates can also be obtained by customers without participating in the program. For information about other program offerings, see the Companies' 2012 Electric and Natural Gas Conservation and Load Management Plan.

Table 2-1: CAC-Related Rebates as of 2012

Measure	Rebate Amount
ENERGY STAR Central Air Conditioner (14.5 SEER, 12 EER for split systems; 14 SEER, 11 EER for single packaged systems)	$250 per system; can be doubled to $500 through early retirement/replacement for operable systems
ENERGY STAR QIV Incentive	$500 per Home for AC or Heat Pump
ENERGY STAR Ductless AC (14.5 SEER, 12 EER)	$500 per ton capped at $1,500
Package Terminal AC (10 EER to 12.5 EER)	$150/system

[10] Ibid.

3 Methods and Analysis

3.1 Impact Methods and Analysis

Table 3-1 presents the core impact study objectives and the methods employed to inform each. To achieve these research goals, the evaluation team first developed and deployed a robust sampling methodology using Model-Based Statistical Sampling (MBSS) techniques. Measurement and verification (M&V) activities, including long-term post-installation monitoring during the cooling seasons of 2012 and 2013, were then performed on a sample of 92 program-rebated CAC units selected using these MBSS methods. The data collected at these sites included information to characterize CAC installations and perform Manual J calculations, where appropriate. Finally, regression modeling was applied to the field-collected data to project measure savings, determine peak period impacts, and develop measure load shapes. These are discussed in more detail following the table.

Table 3-1: Relationship of Impact Objectives to Methods

Objective	Research Questions	Methodology
To determine the program electric energy savings targeted to achieve ±10 precision at the 90% level of confidence at the state level	What are the annual electric savings of rebated CAC units?	Addressed through the performance of on-sites with post M&V, with one-half performed in the summer of 2012 and the remainder in the summer of 2013. Savings dependent on the development of individual regression equations.
To estimate the program electric energy demand savings coincident with summer On-Peak[11] and Seasonal Peak[12] periods targeted to achieve ±10 precision at the 80% level of confidence at the state level	What are the annual seasonal and On-Peak demand savings of the program?	Addressed through the performance of on-sites with post M&V, with one-half performed in the summer of 2012 and the remainder in the summer of 2013. Coincident demand savings derived from load shapes established from the individual regression equations cited above.
To provide CAC load shapes	How do the load shapes of the installed CAC units behave? What do they look like?	Addressed through the aggregation of the individual load shapes above.
To characterize CAC units as installed	What are the key characteristics of the installed units (airflow, efficiency, size)?	Primarily addressed through the on-site work. As part of our audit of the installed CAC units, the team performed air flow testing and gathered information on the installed unit.
To determine whether new replacement units are properly sized for the homes in which they were installed	Are installed CAC units properly sized?	Assessed through site-specific Manual J calculations, based on data collected during the field site visits and compared to the sizing of the unit installed at that site.

3.1.1 Sampling

For the impact evaluation, the Companies provided data on all households that received rebated CACs installed in 2011 and 2012, whether or not through HES in-home services. Table 3-2 presents the final program population data. According to the records, a total of 6,557 rebates were provided across the two years. Based on these records, it appears that approximately 73% of statewide activity during this time comprised participation through CL&P (4,773), with the remainder comprising participation through UI (1,784).

[11] Summer On-Peak Hours occur weekdays from 1-5 P.M. throughout June, July, and August.
[12] Seasonal Peak Hours occur when Real Time load is equal to or greater than 90% of the 50/50 Seasonal Peak load forecast during Summer (June – August).

Table 3-2: Original 2011 and 2012 Program Year Rebates by Utility

Utility	Total	% of Population
Program Year 2011		
CL&P	2,765	76.0%
UI	873	24.0%
2011 Total	3,638	**100.0%**
Program Year 2012		
CL&P	2,008	68.8%
UI	911	31.2%
2012 Total	**2,919**	**100.0%**
Total		
CL&P	4,773	72.8%
UI	1,784	27.2%
Grand Total	**6,557**	**N/A**

Sample Design and Selection

To sample across two summers, the team created a sample design that would achieve the overall objective of ±10% relative precision at the 80% confidence interval for summer peak and seasonal demand impacts[13] and ±10% relative precision at the 90% confidence interval for energy use, each at the state level. In our design, each unit that received a rebate was considered a sample unit (i.e., each CAC condenser unit was a single sample point). The team's understanding of the Independent Service Operator of New England's (ISO-NE) Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (M-MVDR) is that both CL&P and UI can use an overall state-level peak demand result since Connecticut is a single load zone, and they both implement and calculate program savings in a similar manner.

Central to the sample design was the assumed coefficient of variation (c.v.). In this study, the team assumed a c.v. of 0.75 to estimate the sample size needed for the coincident demand estimate and a c.v. of 0.8 for the energy savings estimate. These assumptions were based upon our past experience with CAC sample design work in California, a regional 2009 ADM study,[14] and the ISO-NE's M-MVDR.

Table 3-3 below presents the estimated sample sizes calculated to achieve ±10% relative precision at the 90% confidence interval for energy and ±10% relative precision at the 80% confidence interval for coincident demand. This table was based on the 2012 population (known at the time of sampling) and also shows the Z value[15] necessary to calculate sample size. As a result of the prohibitively large sample size needed to achieve the energy savings at the desired

[13] The calculation of precision for summer peak demand impacts at the ±10% relative precision at the 80% confidence interval is consistent with ISO-NE FCM standards.
[14] Residential Central AC Regional Evaluation, ADM Associates, Inc., November 2009.
[15] A constant based on the desired level of confidence—e.g., 1.645 for the 90% level of confidence.

level of precision and the importance of summer peak and seasonal demand impacts for this measure, the EEB evaluation consultant along with the team decided to perform 91 visits overall, which is sufficient to achieve ±10% relative precision at the 80% confidence interval for peak demand savings.

Table 3-3: Sample Design

Coefficient of Variation (c.v.)	Population (N)	Z-value	Relative Precision	Sample (n)
80% Confidence (Coincident Demand)				
0.75	3,638	1.282	10%	91
90% Confidence (Energy)				
0.8	3,638	1.645	10%	166

The team ended up performing 92 site visits due to an added site recruited in the 2012 summer sample. They metered 46 randomly selected sites in the summer of 2012 and another 46 in the summer of 2013. Breaking up the metering over two summers helped ensure that a full range of weather conditions would be available for the regression analysis work.

Table 3-4 presents the final disposition of the recruitment calls made for the 92 on-site visits based on the disposition codes provided in the American Association for Public Opinion Research's (AAPOR) Standard Definitions.[16] Based on the AAPOR algorithms, the response rate was 20.7% with a 36.4% refusal rate across both program years.

Table 3-4: Final On-site Recruitment Disposition

Disposition Code	Disposition Description	2011 PY Participants	2012 PY Participants	Total
1.1	Completion	46	46	92
2.11	Household-Level Refusal	65	97	162
2.21	Respondent Never Available	91	60	151
4.32	Disconnected Number	13	7	20
4.41	Number Changed	5	14	19
4.54	Person Not Household Resident	1	0	1
	Total Customers Called	221	224	445
	Response Rate[a]	20.8%	20.5%	20.7%
	Refusal Rate[b]	29.4%	43.3%	36.4%
	Cooperation Rate[c]	41.4%	32.2%	36.2%

[a] Response Rate is the number of completions (1.1) by total customers called.
[b] Refusal Rate is the number of household-level refusals (2.11) by total customers called.
[c] Cooperation Rate is the number of household-level refusals and completes (1.1 and 2.11) by total completes (1.1).

16 http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions2&Template=/CM/ContentDisplay.cfm&ContentID=3156

Final Sample Characteristics

The tables below present a comparison of the final primary sample and population characteristics based on utility, program channel, location, and unit efficiency and capacity. During the process of recruitment and site work, we realized that several heat pumps were included in the original sample frame. The tables below reflect the new population with these units removed. While the team did not establish quotas for these dimensions, it did track them during recruitment to ensure that the final sample would be representative of the population on these parameters. The final sample is reasonably close in representing the population for all four of these criteria.

Table 3-5: Overall Sample versus Population by Utility

Utility	Population		Sample	
	N	%	n	%
CL&P	4,772	77.1%	71	77.2%
UI	1,414	22.9%	21	22.8%
Total	6,186	100.0%	92	100.0%

Table 3-6: Overall Sample versus Population by Program Channel

Channel[17]	Population		Sample	
	N	%	n	%
Lost Opportunity[18]	5,240	84.7%	79	85.9%
Retrofit	946	15.3%	13	14.1%
Total	6,186	100.0%	92	100.0%

Table 3-7: Overall Sample versus Population by Location

Location	Population		Sample	
	N	%	n	%
Inland	4,338	70.1%	64	69.6%
Shoreline[19]	1,848	29.9%	28	30.4%
Total	6,186	100.0%	92	100.0%

[17] For CL&P, units installed through the HES Program were considered to be retrofit units, while units that were rebated outside of HES were considered to be lost opportunity units.

[18] Lost Opportunity savings are calculated from a baseline or standard (i.e., they are regarded as replace on burnout and therefore assume a code baseline). Retrofit assumes a baseline based on the existing pre-program unit.

[19] Shoreline towns were defined as those adjacent to the shore and were assigned to the Bridgeport weather station in our savings analysis.

Table 3-8: Overall Sample versus Population by Unit Efficiency

Efficiency	Population		Sample	
	N	%	n	%
Energy Efficiency Ratio (EER[a])				
11.5-12.4	1,542	24.9%	19	20.7%
12.5-13.4	4,192	67.8%	64	69.6%
13.5-14.4	434	7.0%	9	9.8%
>14.4	18	0.3%	0	0.0%
Total	**6,186**	**100.0%**	**92**	**100.0%**
Average EER[c]	**12.7**		**12.8**	
Seasonal Energy Efficiency Ratio (SEER[b])				
13.0-14.9	1,649	26.7%	22	23.9%
15.0-16.9	3,958	64.0%	64	69.6%
17.0-18.9	503	8.1%	6	6.5%
>18.9	76	1.2%	0	0.0%
Total	**6,186**	**100.0%**	**92**	**100.0%**
Average SEER[c]	**15.6**		**15.6**	

[a] Energy Efficiency Ratio
[b] Seasonal Energy Efficiency Ratio
[c] EER and SEER averages are capacity weighted

3.1.2 Data Collection and Metering

Detailed M&V activities were conducted at a sample of 92 program participant sites selected using the aforementioned methods. The research goals of this study aligned with a clearly defined set of on-site activities. Determining demand savings during the coincident peak demand period necessitated equipment monitoring throughout the summer. Savings load shape development required continuous equipment monitoring over a period including both summer and shoulder months. Lastly, characterizing equipment required collection of nameplate information, performance test data, and contextual data. The overlapping requirements of the three primary research goals allowed for the development of a streamlined on-site approach that simultaneously addressed the needs of each study objective. The on-site activities implemented for this project were divided into distinct two components: equipment characteristics data collection and HVAC unit monitoring.

Equipment Characteristics Data Collection. Determination of installed equipment characteristics was a goal of the study on its own, but it was also a prerequisite for load shape development and coincident peak demand savings determination. During each initial site visit, the following data were collected from the newly installed equipment:

Table 3-9: Information Gathered from Newly Installed Equipment

Outdoor Unit	Indoor Unit
• Model and Serial Number	• Model and Serial Number
• Size (tons)	• Fan HP
• Refrigeration type	• Coiling Coil Model Number (if accessible
• Compressor HP & RLA	
• Condenser Fan HP	
• Manufacturing Date (Month/Year)	

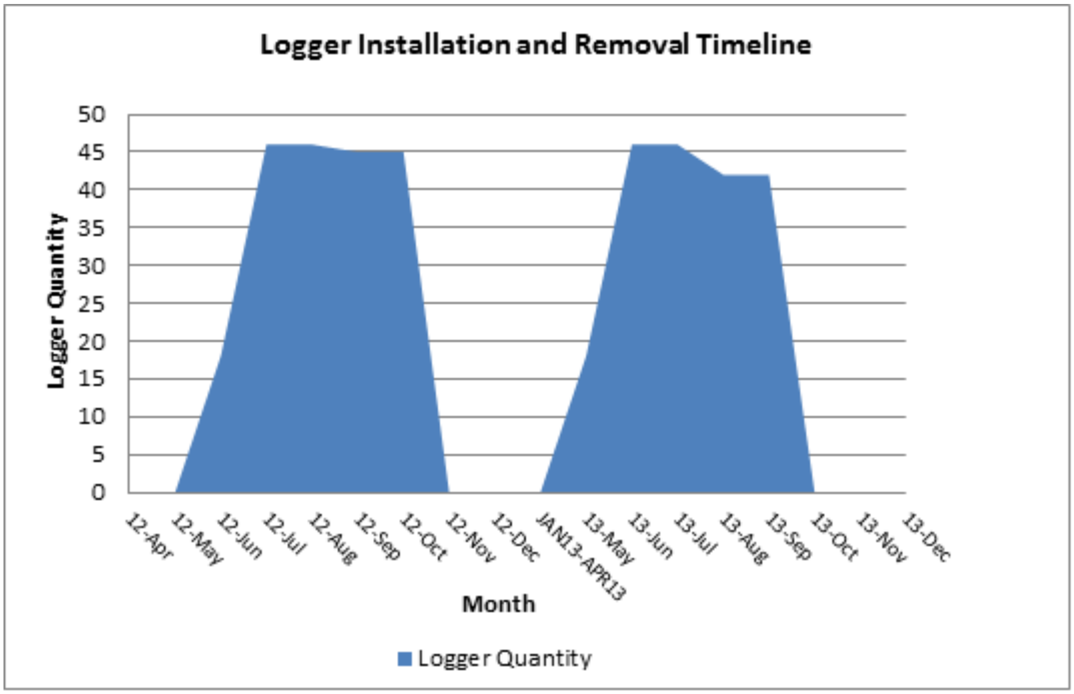
Equipment characteristic data collection also included an airflow testing component. The airflow rates of all sampled units were tested using an Energy Conservatory TrueFlow Grid (a differential pressure air flow meter that temporarily replaces the system's air filter during testing).

Unit operations data were also collected while on site to increase the number of potential regression model drives in the site-level analysis. Homeowners were asked if they operated their CAC system continuously, turned it on and off manually as needed, or followed programmed thermostat schedules. The primary cooling set point was also recorded in all cases. Typical daytime and nighttime home occupancy schedules were also surveyed.

HVAC Unit Monitoring. The team metered the same number of units (46) during the 2012 and 2013 cooling seasons. Condensing units were monitored with true power loggers whenever possible, while air handling units (AHU) were monitored with amperage loggers. True power logging was reserved for condensing units because they are more susceptible to power factor fluctuations than AHUs. In instances where it was not safe to install a true power logger because of space constraints, an amperage logger was used instead. Of the 46 units in the 2012 summer sample, seven condenser units were monitored with amperage loggers; five units in the 2013 summer sample were monitored with amperage loggers. More details on the metering equipment used and their specifications are contained in Appendix B.

Figure 3-1 presents an overview of the number of CAC units logged by month during each summer. Nearly all loggers were in place during the summer months of June, July, and August, which is particularly important for purposes of assessing performance during seasonal peak periods that might occur at any time during the summer months.

Figure 3-1: Logger Installation Overview



Off-Site Data Collection. Hourly temperature readings spanning the entirety of the two summer monitoring periods were collected from two nearby weather stations in Bridgeport and Hartford.[20] In the subsequent regression analysis, these data were matched to specific sites (Bridgeport to towns adjacent to the shoreline and Hartford to all others) and used to model the power/temperature response of each central air conditioner.

3.1.3 Sample Attrition in Analysis and Data Cleaning

As is expected in any data collection exercise, the team witnessed some loss of data. Every effort was made to use the available data without significantly affecting the quality of the analysis. Air Handling Unit (AHU) power data could not be collected for 8 out of the total 92 sites that were sampled (three sites from 2013 and five sites from 2012) due to failure of the logging equipment. The AHU site spot readings were used for these sites as a proxy. Since AHU power is a small contributor to the overall cooling power used by an air conditioner, this approximation did not impact the analysis significantly. Unfortunately, there were four sites (three from 2013 and one from 2012) for which problems with the logging equipment meant that the team had no condenser data or had partial/corrupt condenser data. The team decided to exclude these sites from the final analysis because it had no way to salvage these sites without significantly impacting the quality of the analysis. The analysis was therefore performed on M&V data for 88 out of the total 92 sites (4.4%). We regard this level of data loss/attrition to be reasonable for studies of this nature. For example, in a C&I HVAC load shape study recently performed for the

[20] Unfortunately, there are not very many smaller local weather stations in CT available that have high quality data.

Northeast Energy Efficiency Partnership,[21] we experienced a 4% loss of sample due to metering/ deployment failure.

3.1.4 Analysis

Determining CAC coincident peak load reductions required development of savings load shapes. CAC unit power regression profiles developed from monitoring data formed the foundation of these load shapes.

Developing regression models for all units in the evaluation sample first required pre-processing and resampling trend data. For each unit, AHU amperage data readings were multiplied by spot-measured voltage and power factor values to create an AHU power profile. The team employed a similar process for condensing units subject to amperage logging. The condenser and AHU power profiles were then synchronized and added to develop a total CAC unit power profile. The team only included power data from the AHU profile in the total power profile during periods when the condensing unit was on. As a result, the total power profile for each unit captured only energy use corresponding to cooling operation and ignored ventilation operation. The power profiles for all units were next resampled from their original five-minute format to an hourly format to prepare the data for regression modeling.

The team tested many regression model formulations in SAS to identify the model that best fit the available data. These tests used a variety of terms, including a temperature and humidity index, to account for outdoor temperature, weekday, time of day, consecutive hot days, occupancy patterns, and indoor temperature. Models were compared on the basis of average coefficient of determination (R^2) across the entire evaluation sample. The team selected the model that yielded the highest R^2 and applied the model to all units. For this study, we decided to use R-squared because it provides an overall measure of the success of a regression in predicting dependent variables from independent variables. If a model gives an average R-squared value greater than 0.5 across all the sites, generally speaking, it can be said that the model fits well for the majority of the data.

The model that best fit the metered data included a variable base cooling-degree hour (CDH) term, a term specific to each weekday hour, a preceding 48-hour mean temperature term, and two sequential hot day terms.

The final model was specified as,

$$kW_{dh} = \alpha_{dh} + \beta_{CDH-dh} CDH(\tau) + \beta_{2D} H_{2D} + \beta_{3D} H_{3D} + \beta_{T48} T_{48}$$

Where, for a particular unit,

kW_{dh} = CAC power draw for weekday *d* during hour *h*

α_{dh} = Weekday *d* and hour *h* specific constant accounting for time-dependent load variability

[21] C&I HVAC C&I Unitary HVAC Load Shape Study, Final Report, June 10, 2011. P 37.

$CDH(\tau)$ = cooling degree-hours, base τ

H_{2D} = 0/1 dummy indicating that a day is the second hot day in a row

H_{3D} = 0/1 dummy indicating that a day is the third or more hot day in a row

T_{48} = Mean temperature for the preceding 48 hours

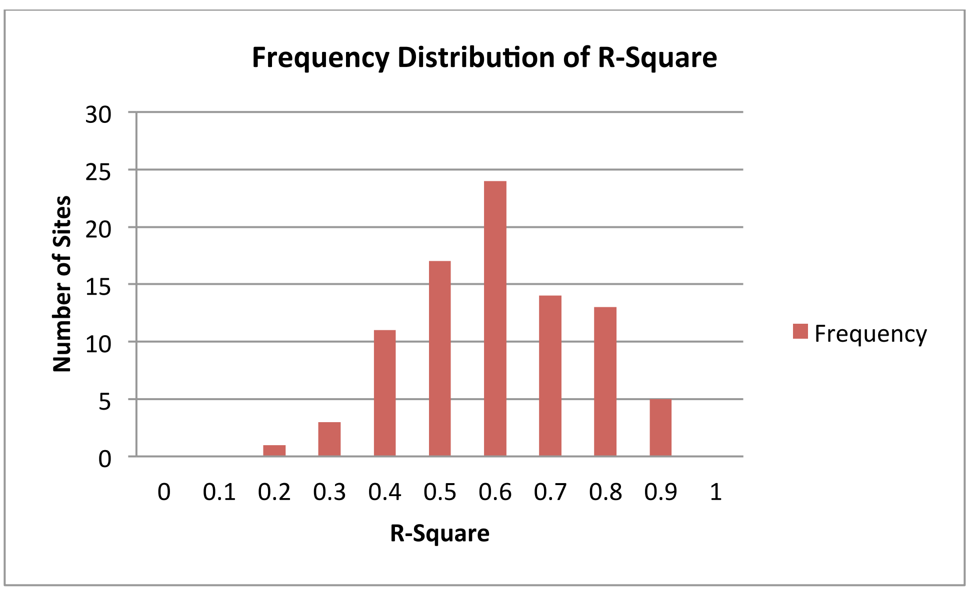
β_{CDH-dh}, β_{2D}, β_{3D}, β_{T48} = coefficients determined by the regression

Note that in the above formulation, all coefficients with a subscript of *dh* took on different values for each unique combination of weekday *d* and hour *h*.

Each individual term played a key role in modeling unit performance. The CDH variable accounted for the direct impact of current ambient temperature on cooling load. Estimation of unit-specific values of the degree day base (τ) was particularly important because residential HVAC units experience a wide range of occupant behaviors (set points, tolerance for hot temperatures, etc.), solar gains, and internal loads. Using a variable degree day base made the model flexible to these behaviors. The sequential hot day and preceding 48-hour mean temperature terms accounted for the impact of thermal inertia on both cooling load and occupant behavior. Lastly, the weekday- and hour-specific constant, α_{dh}, accounted for time-dependent load drivers such as occupancy. In summation, the model definition recognized the impact of present temperature, thermal inertia, and occupant behavior on CAC energy use.

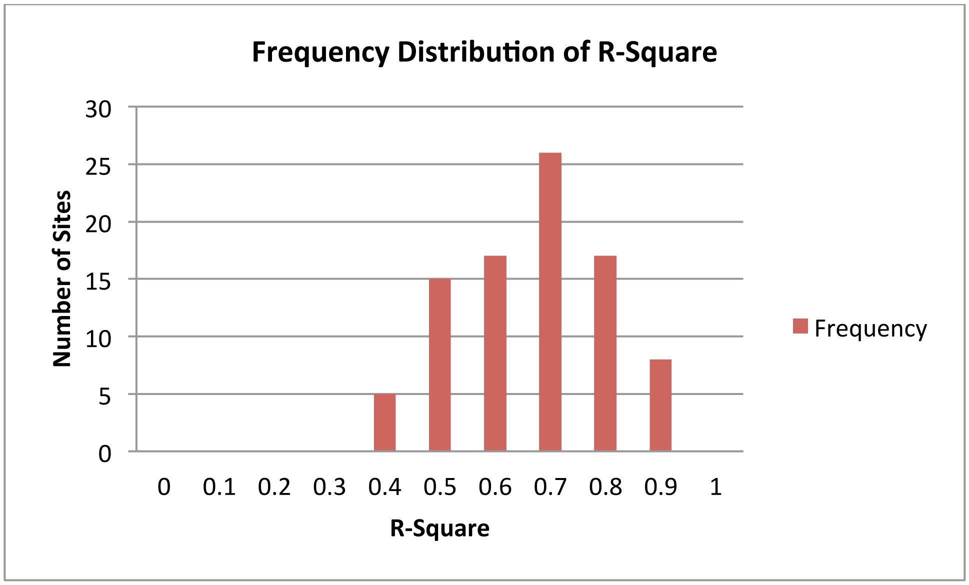
The team applied many model definitions in an effort to reduce error for problematic sites. After investigating several models, the team selected the one with the tightest distribution of individual R^2 values and higher mean R^2. The application of this model definition to the population of sites yielded an average R^2 value of 0.554 and the distribution of unit-specific R^2 values indicated in Figure 3-2 below.

Figure 3-2: Distribution of R-Square for the Model Using All Data



The team also checked the robustness of the model by including only the period when the unit was in the cooling mode. This exercise was performed to confirm the relationship between the operations of the unit with the outside temperature. The average R^2 turned out to be 0.615. The distribution of unit-specific R^2 values is depicted in Figure 3-3 below.

Figure 3-3: Distribution of R-Square for the Model Using Values in Cooling Mode



Normalizing and Extrapolating to a Full Year Shape. The unit-specific regression model results provided a basis for normalizing observed demand to typical weather conditions and extending the logging period data to a full year load shape. The regression models were applied to a single 8,760-hour Typical Meteorological Year (TMY3[22]) weather file in the regression analysis. This blended file was developed by weighting Bridgeport and Hartford weather station data. In this way, the energy use profiles observed during the logging periods were extrapolated to typical year load shapes.

The weather stations used in this analysis, located at Bradley Airport (Hartford) and Bridgeport, were assigned to sites based on their proximity to the coast. Using the same base weather stations for regression modeling and 8,760-hour extrapolation properly normalized the models consistently. This principle is best explained by way of counterexample: Imagine that a model was built using weather station logger data gathered locally at a site, and then applied to a weather file developed from a government weather station 20 miles away. If, on average, the temperature at the site were five degrees Fahrenheit hotter than the temperature at the government weather station at any time, then the model would consistently under-predict cooling load when applied to the weather file.

[22] Typical meteorological year 3 (TMY3) data sets are derived from the 1991-2005 National Solar Radiation Data Base (NSRDB) update. The TMY3 data sets hold hourly values of solar radiation and meteorological elements for a one-year period. (http://www.nrel.gov/docs/fy08osti/43156.pdf)

Site-Level Savings Load Shape Development. Using the unit-specific 8,760-hour load shapes developed from the preceding step, site-level energy savings were determined as follows:

$$Savings_{kWh} = \sum_{i=1}^{8760} kWh_i \left(1 - \frac{SEER_{installed}}{SEER_{baseline}}\right)$$

where

kWh_i = Energy use in hour *i* predicted from the unit regression model using TMY weather

$SEER_{installed}$ = Nominal installed equipment SEER (kBtu/kWh)

$SEER_{baseline}$ = Nominal baseline SEER (kBtu/kWh)

This savings calculation approach yielded an estimate of gross annual savings and an hourly savings load shape for each metered unit. Additionally, the savings load shapes provided a basis for determining anticipated average load reductions during the on-peak[23] and seasonal peak[24] demand periods of interest. More information on how seasonal peak hours were determined for this study is provided in Appendix C. Seasonal and on-peak demand savings factors (DSFs) were calculated from each unit-level load shape for both peak definitions and were then used to estimate peak demand savings according to the formula below.

$$SKW_c = DSF \times CAP_i \times (1 - \frac{EER_i}{EER_b})$$

where

DSF = Seasonal demand savings factor (kW/ton)

CAP_i = Installed capacity (ton)

EER_i = Nominal installed equipment EER (kBtu/kWh)

EER_b =Nominal baseline EER (8 for retrofit, 11 for lost opportunity [kBtu/kWh])

Note that, in our savings approach, we used SEER to calculate energy impacts, but in our peak demand savings approach we used EER. The reason why we did this is because SEER better reflects the average of the EER over the range of operating conditions that would be seen over the course of a year. EER is generally calculated using 95° outside air temperature, which we consider to be representative of the peak condition being estimated.

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23 On-Peak: Summer 1-5 P.M., non-holiday, weekdays in June, July, and August;

24 Seasonal Peak: non-holiday weekdays when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the summer season.

3.1.5 Manual J

The team also collected data to perform Manual J calculations to help determine whether Connecticut residential HVAC contractors consistently right-size new units. This work was an add-on to the original core project budget, and the analyses proceeded with a limited budget. As such, the team performed Manual J analysis only on houses that had an easily determined zonal boundary for the installed system (i.e., 55 out of 92 sites had a separated and defined zone for the installed CAC unit). Homes not included in the analysis were those with multiple systems in which zonal boundaries were not easily determined and included an interaction of these multiple systems.

To calculate Manual J load requirements, the team used Wrightsoft Right-Suite Universal software. Wrightsoft is the original software program for Manual J calculations approved by the Air Conditioning Contractors of America (ACCA) and has been a technical partner with ACCA since 1986. Wrightsoft is considered the industry-leading load calculation program. The analysis relied on the current eighth edition of the ACCA Manual. The program was used to develop Block (whole house) calculations without the assessment of room-by-room calculations, which would be done for actual ductwork installation specifications. Outdoor weather conditions were calculated by the software using historical recorded weather data from either the Hartford Bradley National Weather Station or the Bridgeport Sikorsky National Weather Station, depending on the location of the sample site. The mean indoor temperature was set to remain consistent at 68 degrees heating, 72 degrees cooling, and 50% indoor relative humidity for all sites. Block appliance calculations were used to estimate average household appliances and the effect of residual heat on cooling loads, and bedroom counts were used to estimate the number of occupants for each site calculation.

3.2 Market Research Methods and Analysis

The evaluation team gathered data for the market research via a telephone survey of a subset of participants in the HES Program. Because the primary goal of the market research portion of the study was to identify methods to better induce early replacement of CAC among program participants, the survey sample frame comprised HES program participants who were recommended CAC replacement as a result of the HES audit. These households participated primarily in PY2011. The reason for focusing on PY2011 participants was to allow for enough time between the HES audit and the survey so that the households would have completed any action taken in response to the recommendation to replace their CAC.[25] The survey identified eligible participants through program records supplemented by questions to confirm the

[25] The survey focused primarily on PY2011 participants. Because the evaluation team found it impossible to meet quotas with PY2011 participants, we added PY2012 and a small number of PY2010 participants to the study sample frame. The majority of respondents (87%) were PY2011 participants. The team excluded HES-Income Eligible participants from the study because they did not receive CAC rebates through the program. Because the Newtown, CT school shooting occurred shortly before the survey was fielded, the team excluded from the study customers with the Newtown zip code and adjacent zip codes.

information in the records. Note that this is a different sample frame from that of the impact portion of the study. Some issues with program recordkeeping resulted in the Companies' sample frames differing somewhat. These issues are described in Appendix E.

The participants in the sample were offered either a standard $250 rebate or a $500 early replacement rebate ($250 standard plus $250 additional for early replacement), as best as we could identify from the program data we received from the Companies. Only households that took part in the HES program were eligible for the $500 early replacement rebates. Only customers who already had CAC at the time of the HES audit were eligible for the study (i.e., they had to be in the position of replacing a unit, not installing a system in a home that did not already have one). Participants were randomly selected to be included in the survey. Table 3-10 displays the sample design, describing each stratum, completed sample sizes, and the final sampling errors (calculated at the 90% confidence level with a 50/50 break in responses).

Table 3-10: Participant Survey Sample Design

Strata	Sample Size	Sampling Error
Obtained $250 rebate	70	9.8%
Obtained $500 rebate	70	9.8%
Recommended CAC rebate but did not use it	100	8.2%
Did not replace CAC	*73*	*n/a*
Replaced CAC but did not use rebate	*27*	*n/a*

Braun Research conducted the data collection using Computer-Assisted Telephone Interviewing (CATI) surveys in January 2013. Out of a sample of 4,373 HES participants, Braun Research attempted to contact 4,188 randomly selected participants who appeared to meet the study criteria based on the sample data. Of these, 1,592 were usable numbers for households found to be qualified for the study. Braun Research completed telephone interviews with 240 households, for a response rate of 15%. A certain amount of time needed to have passed between the time of the audit and the survey in order for households to have installed CAC after the audit. However, in the case of some households contacted, as many as two years had passed between the time of the audit and the survey. To minimize recall problems, only households who said that they remembered the audit were included in the study.

The evaluation team weighted the survey data proportionally to the percentage of 2011 HES participants for each utility.[26] The tables in which the market research results are reported note all significant differences between subgroups at the 90% confidence level.

The team performed the analysis using the Statistical Package for Social Sciences (SPSS), supplemented by Excel. The majority of analyses involved calculating averages and describing the proportions of respondents providing particular answers to survey questions.

[26] Per the 2013-15 Electric and Natural Gas Conservation and Load Management Plan, this was 75% CL&P and 25% UI.

4 Key Findings

4.1 Impact Findings

To begin our assessment of program impacts, the team reviewed the annual electric energy savings calculation methodology from the Connecticut Program Savings Documentation (PSD; 2012). This review was performed to fully understand the manner in which the PSD requires calculating savings, including all inputs and assumptions. For savings due to retrofit, it is necessary to add the savings from the retrofit gross savings formula and the lost opportunity gross savings formula together to get the full program credit for the early retirement of a working unit where it would have been installed until failure. The equations are shown below.

- Retrofit Gross Energy Savings – Electric
  - $AKWH_c = ASF \text{ x } CAP_i \text{ x } (1-\frac{EER_e}{EER_b})$
- Retrofit Gross Peak Demand Savings
  - $SKW_c = DSF \text{ x } CAP_i \text{ x } (1-\frac{EER_e}{EER_b})$
- Lost Opportunity Gross Energy Savings
  - $AKWH_c = ASF \text{ x } CAP_i \text{ x } (\frac{EER_i}{EER_b} - 1)$
- Lost Opportunity Gross Peak Demand Savings
  - $SKW_c = DSF \text{ x } CAP_i \text{ x } (\frac{EER_i}{EER_b} - 1)$

Where

Symbol	Description	Units	Values
$AKWH_c$	Annual electric energy savings – cooling	kWh	
ASF	Annual savings factor	kWh/ton	357.6*
CAP_i	Installed cooling capacity	Tons	Input
DSF	Seasonal demand savings factor	kW/ton	0.591*
SKW_c	Summer seasonal demand savings – cooling	kW	
EER_e	Existing EER	Btu/Watt-hr	8
EER_b	Baseline EER	Btu/Watt-hr	11
EER_i	Installed EER	Btu/Watt-hr	Input

* These values were calculated based on "Residential Central AC Regional Evaluation," a study by ADM Associates, Inc., in November 2009.

Although there were no CAC lifetime savings in the PSD in place at the time of the installations examined in this study, the current PSD has a retrofit lifetime savings calculation. This calculation adds the product of the retrofit annual savings and remaining useful life assumption for retrofit events (5 years) to the product of the lost opportunity annual savings and effective useful life of a lost opportunity event (25 years). This approach allows the use of two baselines in the calculated lifetime savings by virtue of ratcheting up of the baseline after 5 years in retrofit events. Lifetime savings were not addressed in this study.

The tracking systems provided by CL&P and UI for this study contained a lot of information on installed units, including energy and peak summer savings. Table 4-1 below presents the raw savings as provided in the tracking databases. Given the importance of the circumstances around the installed unit, the table summarizes these savings according to whether the CAC unit installed was classified as a lost opportunity or a retrofit. CL&P activity represents just over 77% of all energy savings. Statewide, 84.4% of rebates were issued for lost opportunity installations, with an accompanying 82.5% of statewide energy savings. UI has a more equal split of activity between lost opportunity and retrofit events when compared to CL&P. Overall, CL&P and UI tracked savings of 1,168 MWh from CAC program installs in 2011 and 2012.

Table 4-1: 2011 and 2012 CAC Raw Tracking Savings Summary

Sponsor	Population				
		Annual Energy Savings		Summer Seasonal Demand Savings	
	N	kWh	Percent	SkW	Percent
Lost Opportunity[a]					
CL&P	4,518	824,987	85.6%	1,004.6	78.9%
UI	722	139,024	14.4%	269.1	21.1%
Total	5,240	964,011	100.0%	1,273.7	100.0%
Retrofit					
CL&P	254	75,555	37.1%	122.8	33.9%
UI	692	128,095	62.9%	239.4	66.1%
Total	946	203,650	100.0%	362.2	100.0%
Overall					
CL&P	4,772	900,542	77.1%	1,127.4	68.9%
UI	1,437	267,119	22.9%	508.5	31.1%
Total	6,209	1,167,661	100.0%	1,635.8	100.0%

[a] For UI, units designated as new installations in the *inst_desc* field from the tracking system were classified as lost opportunity units. CL&P's assumption that all units that were rebated are lost opportunity units was followed.

As part of understanding the results from this study, we reviewed the CAC tracking data and the manner in which those savings were being calculated. The following tables summarize the findings from our comparison of all tracking system annual kWh savings estimates for each CAC unit in the population to the savings calculated using the formulas provided in the Program Savings Documentation (PSD) for each year.

Table 4-2 below shows a comparison of the per-unit UI tracking data to our calculation of savings using PSD formulas. There are two primary discrepancies of interest in this table. The first is the application of the PSD baseline. It is important to note that, between 2011 and 2012, the PSD went from an assumed retrofit baseline of "using 8 if existing EER is not known" in

2011 to an assumed EER of 8 for all retrofit units in 2012.[27] The majority of the 2012 discrepancy noted in the retrofit "incorrect PSD Baseline application" row is due to the use of the tracking system baseline EER of 11 as opposed to the PSD baseline of 8. The other significant discrepancy also occurred in the 2012 retrofit bin. In these instances, UI appears to have calculated lifetime savings per the PSD, then divided those savings by total measure life to estimate annual savings.

Table 4-2: UI Comparison of Tracking to PSD Annual Savings Estimates

Comparison of tracking kWh savings to PSD	**Program Channel/Year**						Total (N= 1,414)
	Lost Opportunity			**Retrofit**			
	2011 (N=457)	2012 (N=265)	Total (N=722)	2011 (N=416)	2012 (N=276)	Total (N=692)	
No Discrepancy*	98.5%	100.0%	99.1%	93.3%	6.9%	58.9%	79.4%
Discrepancy (detail below)	1.5%	0.0%	0.9%	6.7%	93.1%	41.1%	20.6%
Discrepancy Cause							
Incorrect PSD baseline application	0.7%	0.0%	0.4%	6.3%	72.5%	32.7%	16.2%
Calculation inconsistent with PSD	0.0%	0.0%	0.0%	0.0%	20.7%	8.2%	4.0%
Data entry error	0.7%	0.0%	0.4%	0.5%	0.0%	0.3%	0.4%
Tracking claimed no savings	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%

* Includes some very minor (<0.1%) differences in savings, presumably due to rounding.

Table 4-3 below shows a comparison of the per-unit CL&P tracking data to our calculation of savings using PSD formulas. There are two primary discrepancies of interest in this table. The first is the use of an incorrect PSD formula in 2011. Essentially, these entries used the older 2010 PSD formula and not the revised 2011 formula. The majority of the 2011 discrepancy noted in the "calculation incorrect with PSD" is due to CL&P not correctly crediting its tracking savings with the retrofit portion of the PSD calculation. We do note that the 2012 PSD more explicitly points out the use of components in the calculation of retrofit CAC savings.

Table 4-3: CL&P Comparison of Tracking to PSD Annual Savings Estimates

Comparison of tracking kWh savings to PSD	Program Channel/Year						Total (N= 4,772)
	Lost Opportunity			Retrofit			
	2011 (N=2,654)	2012 (N=1,864)	Total (N=4,518)	2011 (N=110)	2012 (N=144)	Total (N=254)	
No discrepancy	62.8%	99.9%	78.2%	0.9%	88.9%	50.8%	76.7%
Discrepancy	37.2%	0.1%	21.8%	99.1%	11.1%	49.2%	23.3%
Discrepancy Cause							
Used incorrect PSD formula	37.0%	0.0%	21.8%	4.5%	0.0%	2.0%	20.7%
Calculation inconsistent with PSD	0.0%	0.0%	0.0%	94.5%	11.1%	47.2%	2.5%
Data entry error	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%

Table 4-4 shows the revised population savings by event and utility after correcting for the above cited discrepancies. As part of the process of reviewing the application of the PSD, 23 entries originally thought to be CAC units were actually heat pumps and were removed from the

[27] Note that the 2013 PSD returns to the use of a baseline EER of 8 only if the existing EER is not known.

population. Overall, after adjusting the tracking savings to be more consistent with the PSD, the overall estimate of annual energy savings decreased by 7%, while the summer kW savings increased by 11%. Our overall estimate of impacts after making revisions to the tracking savings based on PSD calculations is 1,103 MWh of energy savings and 1.823 MW of summer seasonal peak demand savings.

Table 4-4: 2011 and 2012 CAC Revised Tracking Savings Summary

Sponsor	Population				
		Annual Energy Savings		Summer Seasonal Demand Savings	
	N	kWh	Percent	SkW	Percent
Lost Opportunity[a]					
CL&P	4,518	711,620	87.0%	1,176.1	87.0%
UI	722	106,170	12.9%	175.5	12.9%
Total	5,240	817,790	100.0%	1,351.6	100.0%
Retrofit					
CL&P	254	108,738	38.1%	179.7	38.1%
UI	692	176,694	61.9%	292.0	61.9%
Total	946	285,432	100.0%	471.7	100.0%
Overall					
CL&P	4,772	820,358	74.3%	1,356	74.4%
UI	1,414	282,864	25.7%	467.5	25.6%
Total	6,186	1,103,222	100.0%	1,823.3	100.0%

[a] For UI, units designated as new installations in the *inst_desc* field from the tracking system were classified as lost opportunity units. CL&P's assumption that all units that were rebated are lost opportunity units was followed.

Discrepancies between equipment specifications reported in the tracking data and those that were recorded during field site visits are summarized in Table 4-5. During site visits, the condenser unit's model and serial numbers were recorded from the manufacturer name plate. Referencing the manufacturer's specifications for the model, the unit's output capacity in tons was determined. The name plate also contains the Energy Efficiency Ratio (EER) of the unit.

Of the 88 units in the sample, the EER reported in the tracking data matched that of the field verification on 77 of the units. In the tracking data, there were 10 units in which the EER was not reported. The one EER discrepancy that was found reported the EER of the unit in the tracking data as 13.25 EER, while it was verified in the field as 12 EER. The average EER of the units observed on-site was 12.8, which is the same average as that from the tracking system for all sample units where EER was tracked.

When comparing the tracking data for unit capacity in tons to the field verification, greater discrepancies were found. Of the 88 units in the sample, the tracking data unit capacity and field verifications matched on 46 units. Of the remaining 42, one unit in the tracking data did not report the capacity, 27 units were found to be a higher capacity in tons than in the tracking data, and 14 units were found to have a lower capacity in tons. This level of discrepancy for unit capacity in tons, at 48%, results in some question of how this data is being reported and quality controlled in the tracking system.

Upon further examining these 42 discrepancies, it was found that 55% were misreported by .5 tons, 28% were misreported by 1.0 tons, and the remaining 17% were misreported by > 1.0 ton. Despite there being observations of more higher capacity than lower capacity discrepancies in the field as compared to the tracking data, the average capacity changed very little overall, decreasing slightly from 2.8 in the tracking system to 2.7 in our on-site observations. This discrepancy might be the result of inattention by contractors to this important tracking item or a signal that final entered capacities could use better oversight. Regardless of the ultimate cause of this discrepancy, later in this report we recommend that specification sheets accompany applications to help ensure proper tracking of this important field.

Table 4-5: Discrepancies Between Tracking and On-site Summary

Sponsor	N	EER				Capacity (Tons)			
		Same	Higher	Lower	Not in Tracking	Same	Higher	Lower	Not in Tracking
Lost Opportunity									
CL&P	66	56	0	1	9	31	21	14	0
UI	11	11	0	0	0	9	2	0	0
Total	77	67	0	1	9	40	23	14	0
Retrofit									
CL&P	2	1	0	0	1	0	1	0	1
UI	9	9	0	0	0	6	3	0	0
Total	11	10	0	0	1	6	4	0	1
Overall									
CL&P	68	57	0	1	10	31	22	14	1
UI	20	20	0	0	0	15	5	0	0
Total	88	77	0	1	10	46	27	14	1

Table 4-6 presents key results for the PSD formula based upon the findings from this M&V-based study. It includes the Annual Savings Factor (ASF; kWh/ton), seasonal and on-peak Demand Savings Factors (DSFs; kW/ton), and mean savings values. The table provides this information for lost opportunity and retrofit demand savings events, with the baseline for these being 11 or 8 EER, respectively. For the energy savings estimates, we used baselines of 10 and 13 SEER, respectively. Although not part of our sample, we believe the ASF and DSF values from this study are transferable to central heat pumps operating in cooling mode. Precisions associated with each result are also provided at the 90% confidence interval for the ASF and the 80% confidence interval for the two DSFs, with the latter conforming to the requirements of the ISO-NE.

The overall statewide ASF (based on SEER) is 362.0 kW/ton,[28] with an accompanying precision of ±11% at the 90% confidence interval. The ASF is used to reflect usage per ton in the PSD and used with capacity and delta efficiency to calculate annual energy savings. The seasonal and on-peak DSFs are 0.45 and 0.24, respectively, each with precisions of better than ±7% at the 80% confidence interval. For an average unit size of 2.8 tons and installed SEER of 15.6, the overall statewide per-unit average annual savings estimate is 208.4 kWh, with an accompanying precision of ±25% at the 90% confidence interval. The overall statewide per-unit seasonal and on-peak savings are 0.22 and 0.12, respectively, each with precisions of better than ±14% at the 80% confidence interval. Poor precisions associated with the retrofit results are largely due to smaller sample sizes among that subset.

[28] The Statewide ASF based on EER is 368.41 kWh/ton.

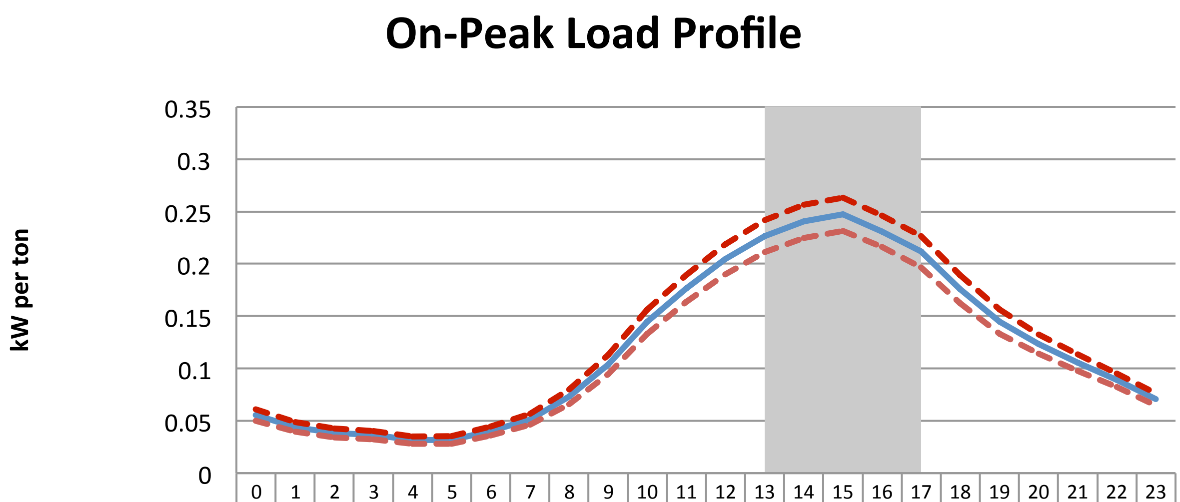
Table 4-6: Energy and Summer Demand Results by Savings Event

Factors	Mean	Confidence Limit		Precision
		Lower	Upper	
Lost Opportunity (n=77)				
Annual Savings Factor (ASF)(kWh/ton)	359.5	319.2	399.9	11%
Seasonal Demand Savings Factor (DSF)(kW/ton)*	0.45	0.42	0.48	6%
On-Peak Demand Savings Factor (DSF)(kW/ton)*	0.24	0.22	0.26	7%
Per-Unit Annual Energy Savings (A kWh)	148.3	131.4	165.4	11%
Per-Unit Summer Seasonal Savings (S kW)*	0.21	0.19	0.22	8%
Per-Unit Summer On-peak Savings (O kW)*	0.11	0.10	0.12	9%
Retrofit (n=11)				
Annual Savings Factor (ASF)(kWh/ton)	379.5	220.6	538.4	42%
Seasonal Demand Savings Factor (DSF)(kW/ton)*	0.43	0.33	0.53	23%
On-Peak Demand Savings Factor (DSF)(kW/ton)*	0.21	0.17	0.26	22%
Per-Unit Annual Energy Savings (A kWh)	390.7	47.9	733.4	88%
Per-Unit Summer Seasonal Savings (S kW)*	0.34	0.18	0.50	46%
Per-Unit Summer On-peak Savings (O kW)*	0.20	0.09	0.31	55%
Overall (n=88)				
Annual Savings Factor (ASF)(kWh/ton)	362.0	321.5	402.6	11%
Seasonal Demand Savings Factor (DSF)(kW/ton)*	0.45	0.42	0.47	6%
On-Peak Demand Savings Factor (DSF)(kW/ton)*	0.24	0.22	0.25	7%
Per-Unit Annual Energy Savings (A kWh)	178.7	131.1	116.2	27%
Per-Unit Summer Seasonal Savings (S kW)*	0.22	0.20	0.25	11%
Per-Unit Summer On-peak Savings (O kW)*	0.12	0.11	0.14	14%

*Calculated at the 80% confidence interval

The team also developed daily profile plots from the metered data for each of the coincident peak definitions. Figure 4-1 shows the average daily profile for the on-peak period—that is, non-holiday weekdays 1:00 to 5:00 P.M. from June through August. The peak hours are shaded in grey. The mean load is depicted by the solid blue line and the dotted red lines show the lower and upper 80% confidence interval. The peak load occurs around 3:00 P.M. (i.e., the 15th hour), and the mean value is 0.25 kW/ton.

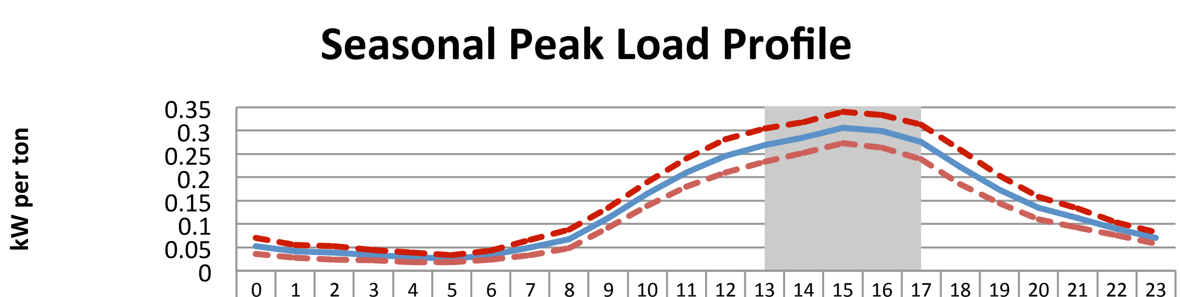
Figure 4-1: Average Daily Load Profile for On-Peak Days



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Onpeak														1	1	1	1	1						
TMY3 Load	0.06	0.04	0.04	0.04	0.03	0.03	0.04	0.05	0.07	0.1	0.14	0.18	0.2	0.23	0.24	0.25	0.23	0.21	0.18	0.14	0.12	0.11	0.09	0.07
Lower 80% CL	0.05	0.04	0.03	0.03	0.03	0.03	0.04	0.05	0.07	0.09	0.13	0.16	0.19	0.21	0.22	0.23	0.22	0.2	0.16	0.13	0.11	0.1	0.08	0.06
Upper 80% CL	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.06	0.08	0.11	0.16	0.19	0.22	0.24	0.26	0.26	0.25	0.23	0.19	0.16	0.13	0.11	0.1	0.08

Figure 4-2 shows the average daily profile for the seasonal peak period. The peak hours are shaded in grey. As before, the mean load is depicted by the solid blue line and the dotted red lines show the lower and upper 80% confidence interval. The seasonal peak load occurs between 3:00 and 4:00 P.M., and the mean value is 0.31 kW/ton.

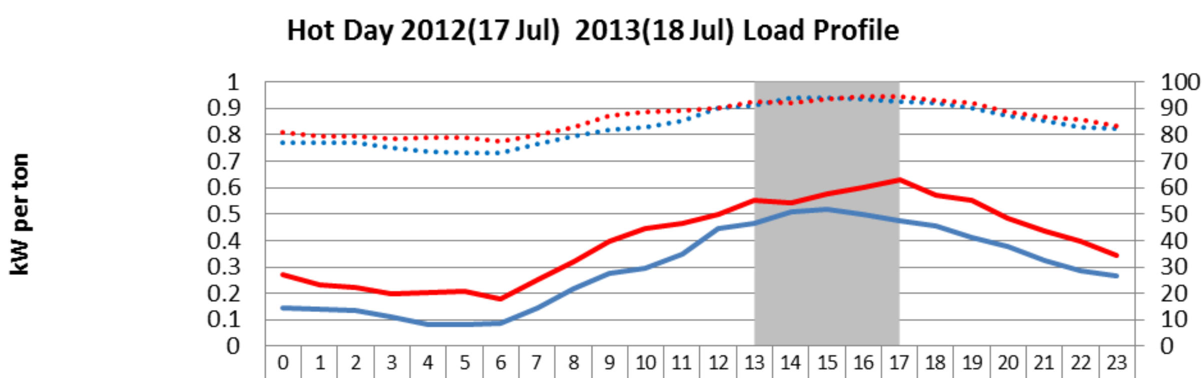
Figure 4-2: Average Daily Load Profile for Seasonal Peak Days



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Onpeak														1	1	1	1	1						
TM3 Load	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.07	0.11	0.16	0.21	0.25	0.27	0.29	0.31	0.30	0.28	0.22	0.17	0.13	0.11	0.09	0.07
Lower 80% CL	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.09	0.14	0.18	0.21	0.23	0.25	0.27	0.26	0.24	0.18	0.14	0.11	0.09	0.08	0.06
Upper 80% CL	0.07	0.05	0.05	0.04	0.04	0.03	0.04	0.07	0.09	0.13	0.19	0.24	0.28	0.30	0.32	0.34	0.33	0.31	0.26	0.20	0.16	0.13	0.10	0.08

Figure 4-3 shows the profile for one hot day each in 2012 and 2013 along with the temperature profiles for both years. A hot day is defined as the day for which the mean temperature was greater than 80° Fahrenheit. The peak hours are shaded in grey. The load curves seem to follow the temperature profile fairly closely. Load values for 2013 are higher because the corresponding temperatures were higher than in 2012.[29] The team looked at the mean temperatures for summer 2012 vs. 2013, and the trend indicates that the summer of 2013 was hotter than that of 2012 overall. The peak occurs at 5:00 P.M. for 2013 with the value of 0.64 kW/ton, aligning well with the corresponding temperature peak, which occurs between 4:00 and 5:00 P.M. For 2012, the peak occurs between 2:00 and 3:00 P.M., and the value is 0.51 kW/ton. This aligns well with the temperature peak for that year, which occurs at 3:00 P.M.

Figure 4-3: Hot Day Profile for 2012 and 2013



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Onpeak														1	1	1	1	1						
Actual Load 2012	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2
Actual Load 2013	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3
temperature 2012	77	77	77	75	73	73	73	76	79	82	83	85	90	91	94	94	93	93	92	90	87	85	83	82
temperature 2013	81	80	80	79	79	79	77	80	83	87	89	89	90	93	92	93	94	94	93	92	88	86	85	83

Table 4-7 shows the current assumed ASF and DSF values from the PSD along with those calculated from this study. When we calculate an ASF based upon the use of EER, our estimate of 368.4 is statistically the same as that currently assumed in the PSD (357.6). Later in this report, we recommend that energy savings be calculated based upon unit SEER. We recalculated the ASF using SEER to determine whether the use of SEER would result in the need for a different ASF assumption. The ASF based on the use of SEER is 362.0, which is also statistically the same as that assumed in the current PSD. The study's seasonal DSF estimate of 0.45 is statistically lower than the current PSD assumption of 0.591. The estimated on-peak DSF from this study is 0.24; the PSD did not list an on-peak DSF.

[29] That is, while each year exhibited similar daily peak temperatures, the overnight and morning temperatures in 2013 exceeded those compared to 2012.

Table 4-7: PSD Input Assumptions Versus Study Findings

Symbol	Description (units)	PSD Value	Verified Values	CI Lower	CI Upper
ASF	Annual Savings factor (kWh/ton)	357.6	368.4 (based on EER)	326.7	410.1
ASF	Annual Savings factor (kWh/ton)	N/A	362.0 (based on SEER)	321.5	402.6
DSF	Seasonal demand savings factor (kW/ton)*	.591	0.45	0.42	0.47
DSF	On-Peak demand savings factor (kW/ton)*	N/A	0.24	0.22	0.25

*Calculated at the 80% confidence interval

Table 4-8 presents the 2011 and 2012 program-verified gross energy and summer seasonal demand savings. This table shows these impacts by lost opportunity versus retrofit savings activity along with realization rates when compared to the *raw* tracking savings estimates. Overall, the study estimates 1,371 MWh of energy savings and 1.405 MW of summer seasonal demand savings. We note that the retrofit sample is small and, as such, has poor precisions associated with it. Overall, the higher ASF and general increases in capacity between the studies' on-site work and tracking system are causing energy savings results to go up, while the decrease in demand savings factors are causing the seasonal demand estimate to go down.

Table 4-8: 2011/2012 CAC Raw Tracking and Verified Savings with Realization Rate

Sponsor	Population						
	N	Annual Energy Savings			Summer Seasonal Demand Savings		
		Tracking	Verified Gross	RR	Tracking	Verified Gross	RR
Lost Opportunity (n=77)							
CL&P	4,518	824,987	670,019	81.2%	1,004.60	930.57	92.6%
UI	722	139,024	107,073	77.0%	269.1	148.71	55.3%
Total	5,240	964,011	777,092	80.6%	1,273.70	1,079.28	84.7%
Retrofit (n=11)							
CL&P	254	75,555	99,238	131.3%	122.8	87.44	71.2%
UI	692	128,095	270,364	211.1%	239.4	238.21	99.5%
Total	946	203,650	369,602	181.5%	362.20	325.64	89.9%
Overall (n=88)							
CL&P	4,772	900,542	769,257	85.4%	1,127.40	1,018.00	90.3%
UI	1,414	267,119	377,437	141.3%	508.50	386.92	76.1%
Total	6,186	1,167,661	1,146,694	98.2%	1,635.90	1,404.92	85.9%

Table 4-9 presents the 2011 and 2012 program-verified gross energy and summer seasonal demand savings. This table shows these impacts by lost opportunity versus retrofit savings activity, along with realization rates when compared to the *revised* tracking savings estimates. Since the number of units tracked and the gross savings per unit calculated did not change between the raw and revised tracking estimates, the overall study estimate of impacts is the same between Table 4-8 and Table 4-9. However, since the revised tracked energy savings decreased from the tracked raw savings, the energy impact realization rate improved to nearly 118% overall. One of the primary drivers of the realization rate in both tables is the high realization rate for UI, which is due to the incorrect use of baselines in some tracking estimates that resulted in the underestimation of savings in the retrofit program. Since the revised tracked summer seasonal demand savings increased from the tracked raw savings, that realization rate went down.

Table 4-9: 2011/2012 CAC Revised Tracking and Verified Savings with Realization Rate

Sponsor	Population						
	N	Annual Energy Savings			Summer Seasonal Demand Savings		
		Tracking	Verified Gross	RR	Tracking	Verified Gross	RR
Lost Opportunity (n=77)							
CL&P	4,518	711,620	670,019	94.2%	1,176.1	930.6	79.1%
UI	722	106,170	107,073	100.9%	175.5	148.7	84.7%
Total	5,240	817,790	777,092	95.0%	1,351.6	1,079.3	79.9%
Retrofit (n=11)							
CL&P	254	108,738	99,238	91.3%	179.7	87.44	48.7%
UI	692	176,694	270,364	153.0%	292.0	238.21	81.6%
Total	946	285,432	369,602	129.5%	471.7	325.64	69.0%
Overall (n=88)							
CL&P	4,772	820,358	769,257	93.8%	1,355.8	1,018.0	75.1%
UI	1,414	282,864	377,437	133.4%	467.5	386.9	82.8%
Total	6,186	1,103,222	1,146,694	103.9%	1,823.3	1,404.9	77.1%

4.1.1 Characterization of Installed Units

A core objective of this study was to characterize program-installed CAC units, including by size, airflow, and rated efficiency. The team gathered the data to perform this as part of our on-site work. During the on-site visits, all units installed under the program were identified by manufacturer and model number to determine appropriate sizing and rated efficiency. Additionally, all installed CAC units and systems were tested during the on-site visit for airflow by performing a TrueFlow diagnostic test.

Rated Efficiency. In terms of the EER, all program-installed units had efficiencies of 11.5 or greater. Nearly seven in ten participating customers installed units in the 12.5-13.4 EER range, with another quarter installing units with an EER between 11.5 and 12.4. The capacity weighted average EER among the sample is 12.8.

Table 4-10: Efficiency of Installed Units Observed On-site (EER)

EER Range	11.5-12.4	12.5-13.4	13.5-14.4	>14.4	Average
Population (N=6,186)	24.9%	67.8%	7.0%	0.3%	12.7
Sample (n=92)	20.7%	69.6%	9.8%	0.0%	12.8

Air-Flow. Air flow is also a very important aspect of overall CAC efficiency, along with the manufactured EER and the appropriate sizing of the unit. To characterize system air flow among sampled sites, diagnostic testing was performed using a TrueFlow plate and manometer. During this test, the cubic feet per minute (CFM) of air flow as well as the air pressure within the ductwork are measured as the return air reenters the air exchanger in the air handler system. The plate is installed to replace the air filter during the diagnostic testing, and the CFM and TrueFlow operating pressures are recorded with the system in full operation mode. A second reading for air pressure was taken after this test with the filter back in place. This reading is taken to determine the normal standard operating pressure (NSOP). The team performed this second reading as a second check on the TrueFlow reading because they should vary slightly but not have an unusually high differential. In this way, the team was able to determine whether the system had an acceptable CFM flow and a reasonable difference between TrueFlow operating pressure and NSOP.

Table 4-11 reflects percentages of TrueFlow results within ranges of CFM per ton. Sources at both Lawrence Berkeley National Laboratory (LBL)[30] and the Building Performance Institute (BPI)[31] indicate that air handler air flow in CAC systems should be at or above 350 CFM/ton. BPI suggests that CFM rates lower than this can result in lower system efficiency and can suggest improperly installed flexible ducting, undersized ducts, and dirty filters or coils. Note that systems in the study included single-speed, multiple-speed, and variable-speed blower motors. The CFM testing was done after trying to get each system into steady state operation for at least ten minutes. However, due to differentials between set temperatures and outside air temperatures, it was often difficult to know whether flow readings were taken on blowers operating at full speed. Since this uncertainty may account for some of the low readings observed, the team regards the 49% of units tested at below 350 CFM/ton as not impacting the efficiency of the units as much as might be expected. No systems tested at below 250 CFM/ton.

Table 4-11: TrueFlow CFM/Ton Readings

CFM/Ton Range	Number	Percent
Range 250-300	15	20.5%
Range 300-350	20	27.4%
Range 350-400	16	21.9%
Range 400-450	8	11.0%
Range 450-500	6	8.2%
Range 500-550	6	8.2%
Range >500	2	2.7%
Total	73	100.0%

Table 4-12 presents the air flow results by capacity, which suggests that smaller systems tend to be more prone to surplus airflow than larger systems. This may be the result of larger systems having larger and more complex duct systems, which might cause lower flow rates.

Table 4-12: CFM/Ton by Capacity

Size (Tons)	Number	Average CFM/Ton
2	13	498.8
2.5	15	405.8
3	25	367.3
3.5	7	325.8
4+	12	326.0
Total	72	389.7

[30] http://ducts.lbl.gov/hvacretrofitguide.html
[31] http://www.bpi.org/Web%20Download/BPI%20Standards/Air%20Conditioning%20and%20Heat%20Pump%20Professional%20Final%202003.pdf

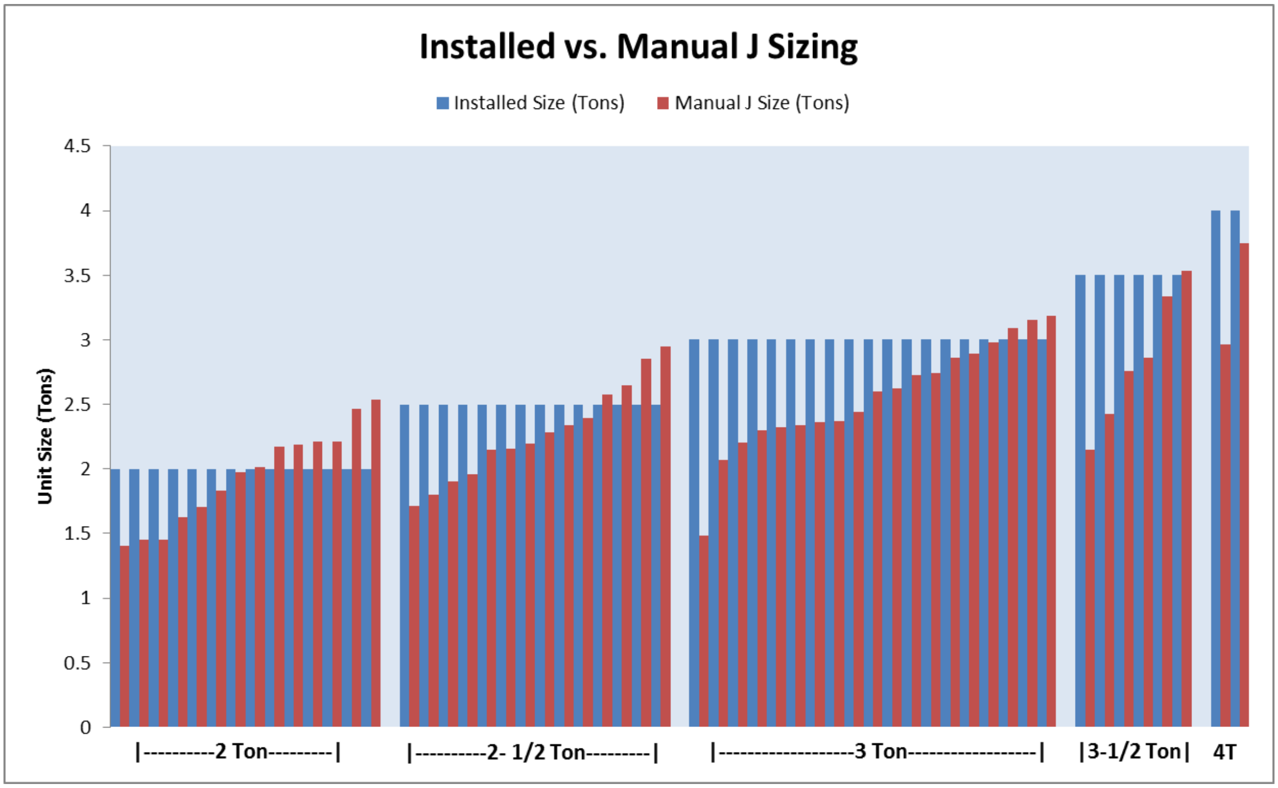
System Sizing and Manual J Results

Determining the appropriate size equipment for the space it serves is crucial to achieving both effective and efficient central air conditioning. Whether the equipment is a replacement unit utilizing preexisting distribution ductwork or a newly installed system, system sizing is performed using formulas developed by the ACCA, referred to as Manual J calculations. The sponsors of this study agreed that checking the proper sizing of the installed equipment was a determining factor for system efficiency and that Manual J calculations should be performed on all installed units. The exceptions to this were units that could not be easily distinguished from the space they serve. Large homes with multiple systems and systems that interact with each other were not included in the calculations because the system boundaries could not be accurately determined without ductwork schematics.

The HVAC installation contractor typically decides the final sizing of an installed unit. A common industry practice is to oversize the unit a reasonable amount to assure that the system is meeting the cooling demand that the customer expects. With models sized to 0.5 ton loads, it is therefore acceptable to have a unit oversized by up to 0.5 tons because the installing contractor would need to round up to the next available size model. If the contractor believes this amount of oversizing is not needed, a slight undersize of the unit may be acceptable under circumstances such as installations with short, straight, and effective ductworks where professional judgment suggests that a slightly undersized unit is sufficient. The 2012 and 2013 average ratios are 1.03 and 1.19, respectively. Overall, the average oversizing across both samples is 0.3 tons. The results generally suggest that equipment sizing is a low-level issue that does not cause substantial inefficiencies in the central air conditioning systems replaced under the Connecticut programs.

Figure 4-4 graphically presents the results of the Manual J load analysis (brown bars) against installed capacity for each unit (blue bars). Looking at the data in this way suggests that the nominal capacity of the majority of installations are within one-half ton of what Manual J suggests is needed.

Figure 4-4: Installed vs. Manual J Sizing



To summarize these results further, the team divided the installed units into five categories based on the ratio of calculated load to installed Btuh capacity of the unit. These categories are based on a determination of whether a unit is appropriately sized or not. For this purpose, the team considered a unit between the ratios of 1.0 to 1.25 to be appropriately sized and between the ratios of 1.25 to 1.5 and 0.9 to 1.0 to be appropriately over- and undersized, respectively. These categories of sizing allow for some discretion on the part of the installation contractor, such as when a Manual J result is on the margin of the next size necessary but the contractor decides to install a unit that is actually a half-ton higher. Units that are below the 0.9 ratio and above the 1.5 ratio can be considered undersized or oversized, respectively.[32]

[32] Although the team notes that, in some instances, the contractor may have determined a unique need for a unit to be oversized or undersized. For example, a retrofit into a house with a poor ductwork design may lead to considering additional capacity and, likewise, a house with a conditioned basement that remains relatively cool during the heating season may allow for more undersizing than a Manual J calculation would consider.

Table 4-13 presents these five categories in terms of total number and percent of the 55 units included in the Manual J calculations. The Manual J analysis determined that approximately 38% of the installed units were sized appropriately, that another 51% were acceptably over- or undersized, and that 11% of the total units installed fell below or above the acceptable range.

Table 4-13: Unit Sizing Summary

Unit Sizing by Ratio	Number of Sites	Percent of Total
Appropriately Sized units (1.0-1.25)	23	41.82%
Acceptable Undersized Units (0.9-1.0)	9	16.36%
Acceptable Oversized Units (1.25-1.5)	17	30.9%
Oversized Units (>1.5)	2	3.6%
Undersized Units (<0.9)	4	7.3%
Total	55	100.0%

Although software tools such as Wrightsoft can make sizing and Manual J calculations far easier in determining capacity of equipment, the fact that equipment is manufactured only in set intervals, and that the contractor may see something site-specific to influence his or her final decision, still makes HVAC equipment sizing an imperfect science. We do not consider these results to be a strong indicator of installed unit sizing problems. In examining several of these over- and undersized units, it was apparent that some contractor judgment was used in determining the final unit size needed based on the nature of the ductwork observed, home shading, and home tightness, among other factors.

4.2 Market Research Findings

The market research was especially concerned with understanding the factors that households consider when deciding whether to replace their CAC, with particular emphasis on why more households were not using the early replacement rebate. This section seeks to provide some insight into the factors that participants consider regarding CAC replacement. As mentioned in the Methods section, significant differences are noted using the letter (in superscript) corresponding with the subgroup with which a significant difference was detected. Subgroup letters are displayed in the table headings.[33]

4.2.1 Factors (Including Efficiency) Customers Consider for CAC Replacement

If it ain't broke, don't fix it. When considering whether to replace a still-working CAC, HES participants subscribed to the adage, "If it ain't broke, don't fix it." Specifically, having a newer, working CAC unit was a substantial barrier to replacement, particularly given the cost of replacement.

[33] For example, in Table 4-17, a superscript *b* next to a result signifies that the result differs significantly from the similar one for the group in the second column with the heading "B. Replaced CAC with CAC+Early Replacement Rebate ($500)."

As Table 4-14 shows, about one-third (34%, or 25 total) of the 73 participants who were recommended CAC replacement but did not replace their CAC had considered replacing their unit after the HES vendor[34] recommended it. When asked what kept them from replacing their CAC, the impediment these 25 participants most commonly cited was cost (76%), followed by the fact that the unit was still working (20%).

The 46 participants who did not consider replacing their CAC after the vendor recommended it[35] were asked why not. This group most commonly responded that the unit was still working (59%), followed by cost (39%). As one such participant explained, "The unit worked fine and was still new." Four respondents to this question added qualitative responses suggesting that another reason was that the CAC was not used much, so the energy savings would be of minor importance. As one noted, "We don't use the central air that often." In the words of another, "In the scheme of things, the [CAC] is not the worst loss of energy."

[34] The survey instrument used the term *energy auditor* to refer to the vendor staff person who conducted the audit, as participants are more likely to think of auditors than vendors.

[35] Auditors followed a rule of thumb in recommending CAC for early retirement. In general, auditors were expected to recommend early replacement when they found a functioning CAC that appeared to be more than 10 years old. However, in cases in which customers requested an earlier replacement or the vendor suggested an earlier replacement, the CAC unit would nevertheless qualify as early replacement.

Table 4-14: Why Participants Did Not Replace CAC

(Base: Varies by question)

What kept you from replacing it? (multiple response*)	**Considered Replacing CAC**
Sample Size	*25*
Cost/too expensive	76%
Current unit was still working	20%
Had other financial priorities (refrigerator, roof, etc.)	8%
Just bought the house	4%
Installed geothermal heating	4%
No immediate need for CAC during wintertime	4%
Too busy	4%
Why didn't you consider replacing your Central Air Conditioning unit after the recommendation? (multiple response*)	**Did Not Consider Replacing CAC**
Sample Size	*46*
Current unit was still working	59%
Cost/too expensive	39%
I don't remember them recommending it	11%
Not enough rebate or savings	4%
Don't use CAC often	4%
Hassle of installation	2%
Forgot about it and missed rebate deadline	2%
Current unit only 2 years old	2%
Had other efficiency priorities with higher energy savings potential than CAC	2%
No immediate need for CAC during wintertime	2%

*Multiple response results are reported with a percentage sign (%) following each value. Only the first value is followed by a percentage sign for questions that are not multiple response.

The survey asked participants who did not replace their CAC after the audit what else the program could have done that might have made them decide to replace their CAC. It also asked participants who had replaced their CAC what else the program could have done to encourage customers like themselves to replace their CAC. More than one-third (36%) of participants who had not replaced their CAC said that the program could not have done anything else that would have made them decide to replace their CAC. Twelve percent suggested a larger rebate and 10% suggested low- or no-interest financing. Note that the program already offers financing, but these respondents were not aware of it.

About one-fifth (21%) of participants who replaced their CAC suggested providing information on costs and savings or on the efficiency of old versus new units. Presumably, auditors are meant to do this already, but this may not be carried out as consistently or thoroughly as it could be. This was followed by more advertising (16%) and continuing to offer the rebate (14%).

If it is broken, replace it. In contrast, the fact that a CAC was older or broken served as the major reason for replacing a unit, either with or without a rebate (Table 4-15). This open-ended question allowed individuals to name multiple factors they considered when replacing their CAC, and nearly all of the respondents cited the age of a unit and its working (or non-working) condition as one of the reasons to replace it. That is, participants wanted to replace their CAC because the unit was approaching—or they thought it had reached—the end of its useful life. The fact that respondents wanted to replace their unit because of its age also likely underlies the fact that three out of five respondents who received a rebate said that they had had plans to replace the CAC equipment prior to having the HES audit (Table 4-16).[36] (The survey was not designed to measure free ridership and did not ask these respondents whether their plans included replacement with standard or high efficiency equipment.)

More than one-fifth of participants who obtained the early replacement rebate (21%) stated that the old unit having broken down was an important factor in their decision to replace it. Nearly the same percentage of participants who replaced their CAC *without* a rebate (19%) stated this.[37] These open-ended responses were not clear enough to determine whether the CAC systems in question were functioning at the time of the audit, so it is not possible to draw any conclusions regarding either free ridership or spillover from these results. Regardless, at the time of this study the Companies did not have a set definition of *early replacement*. By contrast, the Massachusetts Cool Smart program defines equipment qualifying for early replacement as equipment with "4 or more years of remaining life."[38] The program should consider setting more stringent criteria for determining early replacement or risk paying greater incentives than needed.

Energy efficiency paled in comparison to the desire to replace an aging unit when considering factors motivating CAC replacement. In fact, only 29% of respondents named energy efficiency or lower energy bills as factors they had considered when deciding to replace a CAC. Interestingly, respondents who received the standard $250 rebate more frequently cited energy efficiency or lowering bills as a factor than did the respondents receiving the early replacement rebate or those who did not use a rebate.

Finally, participants rarely volunteered the rebate as a factor in their decision to replace a CAC in response to this open-ended question—a topic explored in more detail below. Only five percent of respondents volunteered the rebate as a factor they had considered, while another three

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[36] Note that the survey did not explore how *firm* these plans were. Respondents' plans likely varied in their specificity and the degree to which households were ready to act on the knowledge that their unit probably should be replaced soon.

[37] This was asked as an open-ended question and coded by the interviewer. "The old unit broke down" was among the pre-coded answers available. It is possible that some of the broken units may have been repaired and functioning by the time of the audit.

[38] The Cadmus Group. 2013. "2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing Final Report." June. Accessed August 9, 2014, from http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2013/Residential%20Program%20Studies/Residential%20Yr.%202012%20Heating%20Water%20Heating%20&%20Cooling%20Equipment%20Evaluation%20Vol%20I%20&%20II%20Final%20Report%20June%202013.pdf

percent mentioned the loan. Importantly, however, 11% of respondents who made use of the $500 early replacement rebate cited the rebate as a factor in their decision; although not a large percentage, only two percent of households receiving the standard rebate named it as a factor in deciding to replace their CAC.

Table 4-15: Factors Participants Considered when Replacing CAC

(Base: Respondents within group, open-ended, multiple response)

What factors helped you decide to replace your Central Air Conditioning unit?	**A. Replaced CAC with CAC Rebate only ($250)**	**B. Replaced CAC with CAC+Early Retirement Rebate ($500)**	**C. Replaced CAC Without Rebate**	**Total**
Sample Size	*70*	*70*	*27*	*167*
Unit Getting Old or Not Working Well				
The old unit wasn't working well	36%[c]	29%[c]	56%	36%
Unit was getting old	30[c]	26[c]	59	33
The old unit broke down	8[b]	21	19	15
The old unit required too many repairs	10	7	11	9
Did not want old unit to break down at a bad time	12[b]	4	11	9
Contractor convinced me old unit needed to be replaced	8	7	11	8
Had home inspected and inspector recommended replacing old unit	0	4[c]	0	2
Save Energy, Lower Electric Bill				
Save energy/energy efficiency concerns	22	15	15	18
Lowering electric bills	16[b]	7	7	11
Rebate or Financing[*]				
The rebate	2[b]	11[c]	0	5
The loan	4[c]	2	0	3
Other Factors				
Replaced furnace at same time	6	5	4	5
We were doing extensive remodeling and needed to replace equipment	3	7[c]	0	4
Wanted Central Air Conditioning	4[c]	5[c]	0	4
Comfort	2	1	7	3
Cost of unit	1	5[c]	0	2
Other[**]	10[c]	4[c]	0	6
Refused	2	0	0	1

[a,b,c] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

[*] Respondents answered these questions via "open response," meaning that they volunteered answers and were not asked to select among pre-coded, read responses. In Section 4.2.2, the team explores the role of rebates and

financing in more detail through a series of questions designed to elicit more specific information on those program offerings.
** Other responses addressed issues such as warranties, indoor air quality, and numerous additional topics.

Table 4-16: Prior Plans to Replace CAC Equipment

(Base: Respondents within group)

Did you have specific plans to install any of this efficient air conditioning equipment before you talked with anyone about the Home Energy Solutions Program?	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Retirement Rebate ($500)	Total
Sample Size	*70*	*70*	*140*
Yes	64%	60%	62%
No	33	37	35
Don't know/don't remember	3	3	3

Opinions of Installation Contractors Matter. The team also explored the role that HES vendors and installation contractors played in CAC replacement decisions. The results suggest that respondents tended to rely more on the opinions of installation contractors than those of HES vendors when deciding whether to replace the CAC and deciding which unit to install (Table 4-17).

Of the three groups of participants who replaced their CAC, 77% (54 out of 70) of participants who obtained the early replacement rebate, 88% (24 out of 27) of participants who did not obtain a rebate but did replace their CAC, and 94% (66 out of 70) of participants who obtained the standard rebate used a firm other than the HES vendor to install the replacement CAC. This is to be expected, given that firms that conduct HES audits would not necessarily qualify to install replacement CAC units.

In general, participants who replaced a CAC unit were more likely to rate the firm that did the installation, rather than the HES vendor, as "very important" to the decision to replace the CAC. The same was true for the decision of which CAC unit to install in its stead. The one exception was the decision to replace the CAC by participants who received an early replacement rebate. These participants were more likely than participants who received a standard rebate to say that the HES vendor's firm was "very important" to this decision (38% versus 20%), suggesting that the HES vendors are offering convincing reasons for early CAC replacement.

Table 4-17: Importance of Firms to Decision Making

(Base: All respondents unless otherwise noted)

	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Replacement Rebate ($500)	C. Replaced CAC Without Rebate	Total
How important was advice from the firm that conducted the energy audit to your decision to replace the unit?				
Sample Size	*70*	*70*	*27*	*167*
Very important	20%[b]	38%	33%	30%
Somewhat important	26	18	30	23
Slightly important	14	9	19	13
Not at all important	35[c]	35[c]	19	32
Don't know/don't remember	2	0	0	1
Refused	2	0	0	1
How important was advice from the firm that installed your replacement Central Air Unit to your decision to replace the unit?				
Sample Size[*]	*66*	*54*	*24*	*144*
Very important	47%	49%	38%	46%
Somewhat important	22	14[c]	33	21
Slightly important	11	9	21	12
Not at all important	18	21	8	18
Don't know/don't remember	0	4	0	2
Refused	0	3	0	2
How important was advice from the firm that conducted the energy audit to your decision of which Central Air Conditioning unit to install?				
Sample Size	*70*	*70*	*27*	*167*
Very important	9%[bc]	19%	26%	16%
Somewhat important	13	17	19	15
Slightly important	14	12	7	12
Not at all important	60	48	44	53
Don't know	4	4	4	4
How important was advice from the firm that installed your replacement Central Air Unit to your decision of which Central Air Unit to install?				
Sample Size[*]	*66*	*54*	*24*	*144*
Very important	58%	55%	54%	56%
Somewhat important	23	19	29	22
Slightly important	4	4	8	4
Not at all important	11	22[c]	8	15
Don't know	5[c]	1	0	2

[a,b,c] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

[*]Sixty-six of the 70 respondents who obtained a $250 rebate used a firm other than the audit firm to install the replacement CAC. Fifty-four of the 70 respondents who obtained a $500 rebate used a firm other than the audit firm

to install the replacement CAC. Twenty-four of the 27 respondents who replaced their CAC without a rebate used a firm other than the audit firm to install the replacement CAC.

Plans to Install CAC in the Future. Of those who did not replace their CAC despite the recommendation, more than two-fifths (44%) said that they will replace the unit when it breaks down (Table 4-18). About one-quarter (27%, or 20 participants) reported that they planned to replace it at a future date. Some of the reasons these participants offered for delaying replacement included "I'm not going to replace something when it is working at 100%," and "That whole Yankee thing—if it is not broke down [sic], do not fix it."

Of the 20 participants who planned to replace their CAC at a future date (rather than when it breaks down), 90% said they would do so within the next five years. The primary reasons offered for the delay were cost (55%) and that the current unit still worked (30%).

Table 4-18: Expectations about Future CAC Replacement

(Base: Varies by question)

Have you decided to delay the replacement of your Central Air Conditioning unit to a future date, to delay it to when the unit breaks down, or something else?	**Did Not Replace CAC**
Sample Size	*73*
Replace when unit breaks down	44%
Delay to a future date	27
No[39]	14
Something else	10
Undecided	3
Don't know/Refused	2
When do you expect to replace the unit?	
Sample Size	*20*
1-3 years	45%
4-5 years	25
Within 1 year/next spring or summer	20
Don't know	10
Why did you decide to delay replacement of your Central Air Conditioning unit to a future date? (multiple response)	
Sample Size	*20*
Cannot afford it right now/Costs too much	55%
Current one still works	30%
Don't use CAC often	10%
Not a priority right now	5%
Just installed energy-efficient windows	5%
Current one is under warranty, covering all repairs	5%
Other	5%

4.2.2 Role of Rebates in Decision to Replace CAC

The telephone survey explored in some detail the role of rebates in decision making around CAC replacement. Many of the questions focused on the early replacement rebate, but the team also examined the standard CAC rebate as well as low-interest financing.

Awareness of Rebates. The survey asked respondents who used either the standard or early replacement rebates if they had known about the rebates before the HES audit; similarly, the survey asked respondents who did not use a rebate if they had been aware of CAC rebates before the survey call. Responses to these questions suggest that the majority of respondents who replaced CAC systems—whether they used the rebate or not—knew about the availability of rebates prior to the HES audit or the survey call (Table 4-19). Respondents who made use of the

[39] A response of "no" indicates that the respondent had not consciously made a decision about whether or when to replace the unit.

early retirement rebate (84%) were significantly more likely to have prior awareness of the rebate than those who used the standard rebate (67%) or did not use a rebate (63%).[40] In contrast, less than one-half (47%) of respondents who did not replace their CAC had prior knowledge of the rebate. Thus, it appears that knowledge of rebates closely correlates with decisions to replace CAC, even when the participant decides not to use the rebate.

Table 4-19: Awareness of CAC Replacement Rebate

(Base: All respondents)

Before the energy audit/this call today, were you aware that you could receive a rebate for replacing your Central Air Conditioning equipment?	**A. Replaced CAC with CAC Rebate only ($250)**	**B. Replaced CAC with CAC+Early Replacement Rebate ($500)**	**C. Replaced CAC Without Rebate**	**D. Did Not Replace CAC**
Sample Size	*70*	*70*	*27*	*73*
Yes	67%[bd]	84%[cd]	63%	47%
No	19[d]	13[cd]	33	48
Don't know/don't remember	14[bcd]	3	4	5

[b,c,d] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

[40] At first blush, this finding might suggest a higher level of free ridership among early replacement rebate users, but Table 4-16 shows that such rebate users were not significantly more likely than other respondents to have had prior plans to replace CAC.

In an open-ended question, the survey asked participants who did not receive a rebate but were aware of it how they had learned about the rebate. Participants most frequently cited the energy auditor (39%), followed by an online source such as their utility website (18%), a contractor who gave them a quote for a replacement (16%), and the contractor who installed their replacement CAC (10%) (Table 4-20). That 10% of this group of respondents did not use the rebate, even though they learned about it from the contractor who installed their replacement CAC, suggests the possibility of spillover.

Table 4-20: Sources of Rebate Awareness of Participants Who Did Not Obtain Rebate

(Base: Respondents who did not use rebate but were aware of it)

How did you learn about the rebate?	**Replaced CAC Without Rebate or Did Not Replace CAC, and Aware of Rebate**
Sample Size	*51*
Energy auditor	39%
Online/Utility website	18
Contractor who gave them quote	16
Contractor that installed new CAC	10
Accountant/Tax research	6
Rebate application packet	4
I work in the industry	4
Newspaper	2
Other	6
Refused	2

Overall Important of Rebates and Financing. As the findings on prior knowledge of rebates hint, further inquiries confirm that rebates continue to be an important program tool for CAC replacement, especially for encouraging early replacement. Moreover, the results continue to suggest that the rebates were more important to respondents who used early replacement rebates than to those who relied on a standard rebate alone.

The survey asked participants who remembered obtaining a rebate about the importance of the rebate in their decision to replace their CAC with a high efficiency ENERGY STAR unit. Participants who received an early replacement rebate were significantly more likely than participants who received the standard rebate to say that the rebate was "very important" to their decision to replace their unit (50% versus 35%) (Table 4-21). This finding also points to the possibility of low free ridership.

Table 4-21: Importance of CAC Replacement Rebate in Decision to Replace CAC with High Efficiency Unit

(Base: Respondents who recalled using rebate)

How important was the rebate to your decision to replace your Central Air Conditioning with a high efficiency ENERGY STAR unit?	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Retirement Rebate ($500)	Total
Sample Size	*64*	*63*	*127*
Very important	35%[b]	50%	43%
Somewhat important	38	27	33
Slightly important	21	16	19
Not at all important	5	7	6

[b] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

Similarly, ten of the 15 respondents who also made use of low-interest financing said that the financing was "very important" in their decision to replace the CAC unit (Table 4-22). Each of the six early replacement respondents who also used financing reported that the financing was "somewhat important" or "very important" to their decision to replace the CAC.

Table 4-22: Importance of Loan in Decision to Replace CAC

(Base: Respondents who used low-interest financing)

How important was the loan to your decision to replace your Central Air Conditioning unit?*	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Retirement Rebate ($500)	Total
Sample Size	*9*	*6*	*15*
Very important	6	4	10
Somewhat important	1	2	3
Slightly important	1	0	1
Not at all important	1	0	1

*Results are reported as unweighted counts where sample size is less than 20.

Early Replacement Rebate. When the EEB Evaluation Consultant first approached the team about market research related to the CAC rebate program, the team was asked to focus on the decision making regarding the early replacement rebate.[41] Therefore, the team asked a number of detailed questions regarding the early replacement rebate. In their efforts to explore this question, the team discovered that there appeared to be no formal criteria for defining *early replacement* for CAC. The evaluation team was informed that the Companies follow a rule of thumb that any CAC more than 10 years old that is *still functioning* qualifies as an early replacement. The team used that definition when discussing early retirement with the respondents.

More than one-third of participants (36%) who did not replace their CAC reported that they were told by the auditor that, because of their unit's age, they could obtain an additional $250 rebate for replacing their CAC (Table 4-23). It is also worth noting that 81% of households not replacing their CAC reported that the units in their home are more than 10 years old, meaning that they met the "rule of thumb" criteria for eligibility for an early replacement rebate. As noted in Table 4-14, those households that decided not to replace a CAC most often did so because of the cost or because their unit was still operating. Unfortunately, the data collected by the program did not allow the evaluation team to calculate the rate at which early replacement opportunities went unrealized among the sample.[42]

Table 4-23: Auditor Informed Participant of Additional Early Retirement Rebate

(Base: Respondents who did not use rebate)

Did the energy auditor tell you that there could be an additional $250 rebate for replacing your Central Air Conditioning unit because of its age?	C. Replaced CAC Without Rebate	D. Did Not Replace CAC	Total
Sample Size	*27*	*73*	*100*
No	37%	36%	36%
Yes	26	36	33
Don't know/don't remember	37	29	31

[41] Ideally, the HES vendor would record the year of manufacture of the CAC unit during the audit—which would help assess the rate of units eligible for early replacement—but the vendors do not record this information. Moreover, HES vendors do not consistently note which participants receive offers of rebates for CAC, be they standard or early retirement rebates. Without these two pieces of information, the team cannot provide an estimate of the percentage of HES participants who could have used the early retirement rebate and actually did so. When deciding which questions to ask, the team relied on survey respondents' own recollection of the age of their unit and whether the HES vendor had recommended they replace their CAC.

[42] The team does not present findings on the 27 households that the data tracking systems suggest replaced a CAC without a rebate because 10 of these 27 households actually thought they had used a rebate, and another ten did not know the rebate existed. Thus, only seven respondents provided any information on why they had not used the rebate, and this small number of responses cannot be generalized to all participants.

The survey asked respondents who used either the standard rebate or the early replacement rebate to rate the importance of the rebate in choosing to replace their CAC unit while it was still functioning. The results indicate that the majority of respondents in both rebate groups rated the rebates as "somewhat" or "very" important in deciding to replace a still functioning unit. Importantly, respondents who used early replacement rebates were significantly more likely to say the rebate was "very important" to their decision making regarding CAC replacement.

Table 4-24: Importance of CAC Replacement Rebate in Decision to Replace CAC with High Efficiency Unit

(Base: Respondents who recalled obtaining reports; respondents who recalled replacing a still functioning unit)

How important was the rebate to your decision to replace your Central Air Conditioning unit while it was still functioning?	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Replacement Rebate ($500)	Total
Sample Size	*55*[*]	*63*	*118*
Very important	31%[b]	50%	42%
Somewhat important	31	11	20
Slightly important	19	16	17
Not at all important	15	22	19
Don't know/don't remember	3	1	2

[b] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

[*]Fifty-five of the 64 respondents who remembered obtaining a $250 rebate said that their CAC was working at the time of the audit.

The team asked those respondents who recalled receiving rebates to name the factors that were important to them in deciding whether to replace the CAC with a unit that would qualify for a rebate. In contrast to overall factors that led them to replace their CAC (Table 4-15), the majority of rebate users (60%) cited energy efficiency as the primary factor of importance when deciding to choose a rebate-qualified CAC unit. Other common factors include the cost to purchase (16%) or operate (14%) the unit, the reliability of the unit (11%), the age or condition of the older unit (10%), and the fact that the rebate existed (10%). Of these top answers, only the two types of rebate users displayed significant differences regarding operating cost (20% for standard rebate users vs. 8% for early replacement users).

Table 4-25: Factors Important to Decision to Replace CAC with Rebated Unit

(Base: Respondents who recalled obtaining rebate; multiple response)

What factors were important to you when deciding whether or not to replace your Central Air Conditioning unit with one that would qualify for a rebate?	A. Replaced CAC with CAC Rebate only ($250)	B. Replaced CAC with CAC+Early Retirement Rebate ($500)	Total
Sample Size	*64*	*63*	*127*
Save energy/Energy efficiency concerns	61%	58%	60%
Purchase cost of unit	19	14	16
Operating cost of unit	20[b]	8	14
Reliability	9	13	11
Existing CAC was old/damaged	12	8	10
The rebate	5[b]	15	10
Comfort	8	6	7
Installation cost of unit	9[b]	1	5
Better for environment	5	4	5
The loan	7	2	5
Speed of installation	0	3	2
Improving health and safety in home	2	2	2
Existing CAC wasn't working	4	1	2
Lowering electric bills	0	1	1
Reputation of contractor or brand of equipment	0	1	<1
Other	3	10	7
Don't know	2	2	2

[b] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

The team also asked both early retirement rebate users and households that replaced the CAC without a rebate to discuss the importance of the HES vendor and the installation contractor in their decision to replace a still functioning CAC unit (Table 4-26 and Table 4-27). Unexpectedly, respondents who did not use a rebate when replacing their still working CAC system placed more importance on both the advice from the HES vendor and their installation contractor than did those respondents who made use of the early replacement rebate. Nearly one-half (45%) of early replacement rebate users said the HES vendor's advice was "not that important" in the decision to replace a still functioning CAC, and 37% of the early replacement rebate users said that the installation contractor's advice was "not that important" to their decision. In contrast, only 22% of households who replaced CAC without a rebate responded similarly about HES vendors and 17% about installation contractors. Among those respondents who did find the HES vendors and contractors helpful, it seems that the most important pieces of advice included the increased efficiency of a new unit, information about the benefits of the new model, and the existence of the rebate.

Table 4-26: Importance of HES Vendor in Decision to Replace Unit Before Failure

(Base: Varies by question)

How important was advice from the firm that conducted the energy audit in your decision to replace the unit that was still functioning?	**B. Replaced CAC with CAC+Early Retirement Rebate ($500)**	**C. Replaced CAC Without Rebate**	**Total**
Sample Size	*70*	*27*	*97*
Very important	18%	26%	20%
Somewhat important	25	30	26
Slightly important	8	22	12
Not at all important	45[c]	22	39
Don't know/don't remember	4[c]	0	3
What did the firm do or say that was important to your decision?[*] (multiple response)			
Sample Size	*31*	*15*	*46*
Convinced me a new unit is more efficient	34%	4	32%
Told me it needed to be replaced	8%	4	14%
Demonstrated the cost benefit of replacing old system	17%	1	14%
Performed diagnostic tests on current system	10%	2	11%
Nothing in particular/had already decided to upgrade	14%	0	9%
Told me about the rebate	12%	0	8%
Provided information on new models	2%	1	3%
Reinforced my decision	2%	1	3%
Helped me get the best possible price	0%	1	2%
The firm has done work for me in the past	0%	1	2%
Their professionalism	2%	0	1%
Other	7%	0	5%
Don't remember	8%	1	8%

[c] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

[*]Results are reported as unweighted counts where sample size is less than 20.

Table 4-27: Importance of Installation Firm in Decision to Replace Unit before Failure

(Base: varies by question)

How important was advice from the firm that installed your replacement Central Air Unit in your decision to replace the unit that was still functioning?	**B. Replaced CAC with CAC+Early Retirement Rebate ($500)**	**C. Replaced CAC Without Rebate**	**Total**
Sample Size	*54*	*24*	*78*
Very important	38%	38%	38%
Somewhat important	17	29	20
Slightly important	6	13	8
Not at all important	37[c]	17	31
Don't know/don't remember	2	0	2
Refused	0	4	1
What did the firm do or say that was important to your decision?* **(multiple response)**			
Sample Size	*29*	*16*	*45*
Convinced me a new unit is more efficient	21%	3	20%
Provided information on new models	20%	3	20%
Demonstrated the cost benefit of replacing old system	17%	4	19%
Told me about the rebate	17%	1	13%
Offered competitive pricing	7%	2	9%
Told me it needed to be replaced	7%	2	9%
Nothing in particular/had already decided to upgrade	8%	0	5%
Firm is trustworthy	5%	1	5%
Reinforced my decision	2%	1	3%
Performed diagnostic tests on current system	5%	0	3%
Offered to service new equipment	5%	0	3%
Told me a new unit would function much better	0%	1	2%
Provided a detailed quote	2%	0	1%
Other	8%	2	10%
Don't remember	7%	1	6%

[c] Significant differences between subgroups at the 90% confidence level are noted in superscript letters corresponding to the subgroup against which a significant difference was detected. Subgroup letters are displayed in the table headings.

*Results are reported as unweighted counts where sample size is less than 20.

Implications for Free Ridership. According to Connecticut Program Savings Documents, the 2011 free ridership rates for CAC were 42% for Connecticut Light & Power Company and 26% for the United Illuminating Company.[43] Although not directly measured in the study, the findings for recipients of early replacement rebates have mixed implications for free ridership and for the

[43] The United Illuminating Company & Connecticut Light & Power Company. 2010. "UI and CL&P Program Savings Documentation for 2011 Program Year." September 21.

Companies' recent decision to discontinue the early replacement rebate. (This decision was made after the research for this study was completed.)

On one hand, higher free ridership—and support for the Companies' decision to discontinue the early replacement rebate—is suggested by some of the possible explanations for the following findings: (1) Participants who obtained an early replacement rebate were more likely to have been aware of the rebate before the audit than those who replaced their CAC either for the standard rebate or without a rebate, and (2) these participants were much more likely to have been aware than those who did not replace their CAC. On the other hand, other possible interpretations of these findings, coupled with (3) the finding that participants who received an early replacement rebate were no more likely than those who received the standard rebate to report having had plans to install efficient air conditioning equipment before talking with anyone about the HES Program, suggest lower free ridership.

Another finding that suggests lower free ridership for recipients of early replacement rebates is that, for participants who retired a system early, the rebate was more important to their decision making than for those who obtained a standard rebate. Indeed, the fact that 10% of respondents who did not get a rebate for replacing their CAC had heard of the rebate from the contractor who installed the replacement CAC suggests the possibility of spillover. Related to this, a recent evaluation of the Massachusetts Cool Smart residential CAC program found that 8% of program participants' CAC installations qualified as early retirement (i.e., equipment with four or more years of remaining life), potentially affecting net impacts.[44] In light of the evidence presented here for lower free ridership, the impact findings that suggest more substantial energy savings from retrofit than from lost opportunity events (roughly 3.5 times more), and the rate of early CAC retirement found for the Massachusetts Cool Smart evaluation, the Companies may wish to consider reinstating the early replacement rebate. If there is to be an early retirement rebate, the Companies should clarify what constitutes a qualified early CAC retirement in order to reduce the risk of paying incentives unnecessarily.

4.2.3 Quality Installation

Although not directly related to the main objectives of the market research, the team took the opportunity to ask survey respondents about their experiences with the Quality Installation certification process. This exploration concludes that the opportunity exists to increase participant awareness and use of Quality Installation.

Just three of the survey respondents obtained a rebate for Quality Installation. All three also obtained the early replacement rebate. More than three-quarters (76%) of participants who

[44] The Cadmus Group. 2013. "2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing Final Report." June. Accessed August 9, 2014, from http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2013/Residential%20Program%20Studies/Residential%20Yr.%202012%20Heating%20Water%20Heating%20&%20Cooling%20Equipment%20Evaluation%20Vol%20I%20&%20II%20Final%20Report%20June%202013.pdf.

obtained a rebate for replacing their CAC, but not for Quality Installation, were unaware before the survey that they could have been eligible to receive an additional $500 rebate if the CAC equipment installation had gone through the Quality Installation certification process (Table 4-28).

The survey asked participants who had obtained a rebate but did not go through Quality Installation if the auditor had recommended a Quality Installation. Only about 1 in 10 (13%) said the auditor had (Table 4-28). The survey also asked these participants why they did not obtain a Quality Installation. Three said that they did not qualify for the rebate (e.g., "I applied for it. They denied me"), and two said that their installation contractor does not offer Quality Installation (e.g., "The installation people were not qualified to fill out the paperwork").

The survey asked what else the HES program could do to encourage customers like themselves to replace their less efficient CAC units with more energy-efficient units. Two participants volunteered that the Quality Installation process should be streamlined. One suggested the following:

> *"[To] fix the Quality Installation program. The whole process was a nightmare. No one knew what they were doing. Streamline the process. They need more training. The guy didn't know which papers to fill out. The process took too long. I had to find out all the information on my own [and] it took over a year."*

Another respondent echoed similar concerns:

> *"[The] Quality Installation program is broken. The process does not work well for some customers. I knew I needed a new AC—it wasn't broken but [was] not running efficiently. [I] looked on the CL&P [web]site and learned about the rebates. I had the assessment to get the rebate. [The] installer was not a Quality Installation inspector. I helped him become one so I could qualify for the Quality Installation program. They wanted me to send the inspector's workbook. I couldn't do that. [It was] not relevant to the Quality Installation or my house. [I] sent it and was told [the] application was incomplete. I was counting on the Quality Installation rebate. [It was] misleading that I could get a rebate."*

Table 4-28: Awareness of Quality Installation Rebate – No Quality Installation Certification

	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Replacement Rebate ($500)	Total
Before this call today, were you aware that you could have been eligible to receive an additional $500 rebate if the Central Air Conditioning equipment installation went through the Quality Installation certification process?			
Sample Size	*70*	*67*	*137*
No	78%	73%	76%
Yes	13	27	20
Don't know	9	0	5
Another aspect of the Home Energy Solutions program is known as Quality Installation and Verification, or QIV. It ensures that your Central Air Conditioning has been installed for best performance and reliability, and carries with it an extra incentive. Did the energy auditor recommend Quality Installation and Verification for the replacement Central Air Conditioning?			
Sample Size	*70*	*67*	*137*
No	62%	49%	56%
Yes	9	17	13
Don't know	29	33	31
Refused	0	1	<1

5 Conclusions and Recommendations

The impact portion of this study was designed to provide program savings estimates through the use of an M&V data-driven per-unit savings estimate. It was also designed to help the Companies and the EEB improve on forward-looking calculations through recommendations to the Program Savings Document. The bullets below capture our conclusions and recommendations in this regard.

- Overall, the incentives provided for CAC installations appear to be generating significant levels of savings. Rebates and incentives provided for CAC units in 2011 and 2012 generated annual energy savings of 1,147 MWh and seasonal peak demand savings of 1.405 MW. This compares to the raw tracking savings estimates of 1,167 MWh of annual energy savings and 1.635 MW of seasonal peak demand savings, which result in realization rates of 98.2% and 85.9%, respectively. Using the PSD-assumed free ridership rates of 26% for UI and 42% for CL&P and no spillover savings, the overall net energy savings estimate is 725.5 MWh, and the overall net seasonal peak demand savings estimate is 0.877 MW. The realization rate is moderately high for energy savings due to higher usage than assumed in the PSD, generally higher unit sizes observed on-site than captured in the tracking system, and the application of incorrect baselines in some tracking estimates. The realization rate around the summer seasonal result is lower primarily due to a reduction in the seasonal demand factor as compared to the PSD.
- The overall statewide per-unit average annual savings estimate is 178.7 kWh/unit. The statewide per-unit average annual savings estimates for lost opportunity and retrofit events are 148.3 kWh/unit and 390.7 kWh/unit, respectively. The overall statewide per-unit average summer seasonal peak demand savings estimate is 0.22 kW/unit. The statewide per-unit average summer seasonal peak demand savings estimates for lost opportunity and retrofit events are 0.21 kW/unit and 0.34 kW/unit, respectively.
- When calculating ASF with EER and SEER, the current assumed ASF values from the PSD appear very reasonable in light of this study. Statistically, this study's EER-based ASF estimate of 368.4 kWh/ton and SEER-based ASF estimate of 362.0 kWh/ton are statistically the same as that currently assumed in the PSD (357.6).
- The study's seasonal DSF estimate of 0.45 is statistically lower than the current PSD assumption of 0.591. The estimated on-peak DSF from this study is 0.24; the PSD does not have an on-peak DSF.
- Although the magnitude of savings changes due to discrepancies between the tracking unit savings and the PSD unit savings was minor overall, there were many discrepancies noted.
- Based upon our site work, unit efficiencies appear to be consistently tracked and accurate in the tracking system. Unit sizes, however, were noted not to be accurately tracked in a consistent manner.

- In general, although the team found some systems outside the acceptable sizing range, we conclude that equipment sizing is a low-level issue and does not cause substantial inefficiencies in the central air conditioning systems replaced under the Connecticut programs.
- Our assessment of unit air flow resulted in 49% of units having air flow at or below 350 CFM/ton. However, due to not being able to consistently take measurements with blowers at full speed, the team believes that these lower measurements are not likely to significant affect the efficiency of the program-installed units.

Based on the impact findings, the Companies or EEB may wish to do the following:

- Consider using SEER in the PSD to calculate energy savings for this measure, but continue to use EER for peak demand savings. SEER better reflects the average of the EER over the range of operating conditions that would be seen over the course of a year, while EER is more representative of performance at the peak condition being estimated.
- Consider using the seasonal peak DSF from this study (0.45) in lieu of the PSD assumption of 0.591.
- Re-examine the manner in which tracking savings are calculated to ensure adherence to the PSD. Notable items in this regard include ensuring use of the proper baseline when calculating tracking savings, ensuring proper crediting of all savings associated with retrofit events, and not dividing lifetime savings by measure life to estimate annual savings.
- Re-examine the method being used to gather and input CAC unit sizes (tons) and EERs in the tracking system to ensure accuracy and comprehensiveness. One idea in this regard might be to accompany each rebate application with model specification sheets from the AHRI database to ensure proper coding and backup.
- Consider changing the term Annual Savings Factor (ASF) in the current PSD to reflect the fact that it is more of a Usage Factor. This term will make it more consistent with how it is used in the savings formula.

Based on the market research findings, in planning for future program marketing and encouraging early replacement of CAC, the Companies or EEB may wish to do the following:

- Better emphasize, and more clearly communicate, the sizes and types of CAC rebates available to HES participants. As one participant noted, "[They] should say up front about [the] $500 rebate."
- In program-related communications, emphasize the benefits of replacing systems before they break down, even if the system does not appear to be that old.
- Consider the means through which the program is marketed and how the program could bring CAC replacement rebates to the attention of participants earlier in the process. Currently, participants are most likely to learn about CAC replacement rebates from the HES vendor, followed by the utility website and a contractor. In order to reach the target

audience with rebate information sooner in the program process, thus improving the likelihood of early CAC replacement, the Companies or EEB may wish to consider exploring other approaches for getting the word out regarding the availability of substantial rebates for CAC replacement and other residential measures earlier in the participation process. For example, immediately upon receiving an application, prior to approving it, the Companies could automatically send the applicant an eye-catching email or hard-copy mailing with information about the benefits of early CAC replacement and quality installation. There could be a “countdown” of periodic emails or mailings about the program from the point of application to the actual visit.

- While the energy auditor clearly plays an important role in participant decision making, most participants reported that the installation contractor was even more important. The Companies or EEB may want to foster closer relationships between HES vendors and CAC installation contractors to increase the likelihood that customers who obtain an audit will follow through with replacing their CAC with high efficiency equipment.
- Continue to make financing available for CAC replacement. While only 16% of participants took advantage of financing, its availability mattered a great deal to the majority of these customers.
- Although measuring free ridership was not an objective of this study, the findings regarding prior knowledge of the rebate and prior plans to install new CAC provide contradictory information on this important topic for early replacement rebate users. Specifically, users of the early replacement rebate were more likely to have been aware of the rebate prior to their HES audit—pointing to free ridership. However, users of the early replacement rebate were no more likely than standard rebate users to report having prior plans to install CAC equipment—suggesting free ridership is not higher among this group.
- In light of the findings in this report and in the recent Massachusetts Cool Smart evaluation, the Companies may wish to reconsider the decision to discontinue the early replacement rebate. If the Companies decide to reinstate the early retirement rebate, it may be worthwhile for them to probe in more detail about the condition of the unit replaced. This could include questions exploring the degree of functioning of the unit, the type and cost of repairs that broken units may have needed, and the level of maintenance expenditures over the previous year. Additional data of this type would enable development of an algorithm to better categorize respondents as to early replacement versus replacement on breakdown and to understand the differences in their thinking and decision making and avoid the potential for free ridership. This level of examination would be facilitated by collecting more detailed data from auditors, as described in Appendix E.
- The Companies may wish to consider some of the recommendations made by participants to encourage other customers to replace their CAC equipment. In particular, they may want to ensure that, when HES vendors recommend replacing CAC, they always provide

information on costs and savings as well as the logic of replacing older but still-functioning units with new units of higher efficiency. While it is likely that the HES vendors already have such a discussion with customers, they may need to find a way to emphasize it or explain it more convincingly, given the customer bias against replacing equipment that still functions. Another promising participant suggestion was follow-up with participants after the audit to encourage them to pursue recommended measures.

- The Quality Installation option could be better supported. HES participant awareness of this option was low. The anecdotal evidence offered by participants in open-ended questions suggests that there are substantial challenges to the implementation of the Quality Installation option. However, opportunities appear to be limited by current availability of certified technicians. According to North American Technician Excellence (NATE), NATE certification is a requirement for Quality Installation. The NATE website lists contractors with NATE-certified technicians on staff to facilitate Quality Installation. It appears from this website that, as of March 2013, fewer than ten Connecticut-based HVAC contractors have NATE-certified technicians on staff.[45] If the Companies wish to garner additional CAC savings by increasing the rate of Quality Installation of CAC in their service territories, they may first need to assess how to increase the number of qualified technicians in their service territories.

[45] North American Technician Excellence. "HVAC Contractor Locator." Accessed March 11, 2013, from http://www.hvacradvice.com/maps/locator.aspx

Appendix A Market Research Telephone Survey Instrument

Central Air Conditioning (CAC) Study

Participant Telephone Survey for Market Research

Sample Groups & Subgroups	Population Size (N)	Sample Size (n)	Group		Source of Disposition	Margin of Error at 90% Confidence Level	Possible Paths	Question Series (in addition to G, which all receive)
Eligible participant* who took rebate	1,800**	70	A	$250 CAC rebate only	Program Records	9.70%	If financed replacement (from program records): gets question F1	C series (CAC replacement)
	1,800**	70	B	$500 combo rebate for CAC+Early Retirement	Program Records	9.70%	If obtained Quality Installation (from program records): gets Q series	C series (CAC replacement) E series (early replacement)
Eligible participant* who did not take rebate	3,000***	Up to 100	C	Early-retirement	S5=1 (CAC working at time of visit)	9.70%	**C1**. Replaced CAC after audit (S6=1) **[UP TO 30]**	C series (CAC replacement) Selected questions from E series (early replacement)
							C2. Did not replace CAC after audit (S6=2) **[QUOTA OF 70]**	N series (no replacement)

Introduction & Screening

[ALL] Hello, my name is _______________ and I am calling from ________________ on behalf of the Connecticut Energy Efficiency Fund with the cooperation of [READ FULL NAME OF UTILITY FROM PROGRAM RECORDS].

May I please speak to _________________________ [READ “FIRST_NAME LAST_NAME” FROM SAMPLE FILE]?

If contact person is not available:

We are conducting a survey to help the Connecticut Energy Efficiency Fund and your electric utility improve the Home Energy Solutions program. Our records show that your household participated in the Home Energy Solutions program in [MONTH, YEAR FROM PROGRAM RECORDS]. I would like to ask a few questions about your household’s experience with the Home Energy Solutions program. Would you be able to answer these questions for us? The survey should take about 15 minutes. I’m not selling anything.]

If contact person is available:

We are conducting a survey to help the Connecticut Energy Efficiency Fund and your electric utility improve the Home Energy Solutions program. Our records show that your household participated in the Home Energy Solutions program in [MONTH, YEAR FROM PROGRAM RECORDS]. I would like to ask you a few questions about your household’s experience with the Home Energy Solutions program. The survey should take about 15 minutes. I’m not selling anything.

[IF NECESSARY, READ: THE CONNECTICUT ENERGY EFFICIENCY FUND IS SPONSORING THIS PROGRAM AND STUDY. THE CEEF CONTACT PERSON IS

TIM COLE. IF YOU HAVE QUESTIONS, YOU CAN REACH HIM AT (860) 874-5813. IF YOU PREFER EMAIL, timothy.cole@ctenergyinfo.com.]

A1. **[ASK OF ALL]** Our records show that your home is located at [READ STREET ADDRESS, TOWN]. Is this correct?

1. Yes **[IF RESPONDENT VOLUNTEERS THAT THEY ARE THE LANDLORD FOR THE ADDRESS BUT DO NOT LIVE THERE, CHECK YES]**
2. No **[THANK AND TERMINATE]**
96. Don't know/refused **[THANK AND TERMINATE]**

Are you the best person in your household to talk with about the program? [IF YES GO TO S1. IF NO, ASK FOR THE BEST PERSON AND REPEAT "We are conducting a survey to help the Connecticut Energy Efficiency Fund and your electric utility improve the Home Energy Solutions program. Our records show that your household participated in the Home Energy Solutions program in [MONTH, YEAR FROM PROGRAM RECORDS]. I would like to ask you a few questions about your household's experience with the Home Energy Solutions program. The survey should take about 15 minutes. I'm not selling anything."]

S1. **[ASK OF ALL]** As part of the program, someone would have come to your home to assess the energy efficiency of your home, given you some free energy-saving devices like light bulbs, and might have recommended additional ways that you could save energy. Do you remember this visit?

1. Yes **[CONTINUE]**
2. No or Don't Know **[ASK IF ANYONE ELSE IN THE HOUSEHOLD MIGHT REMEMBER**
    - **i. IF SO, ASK THEM "**"We are conducting a survey to help the Connecticut Energy Efficiency Fund and your electric utility improve the Home Energy Solutions program. Our records show that your household participated in the Home Energy Solutions program in [MONTH, YEAR FROM PROGRAM RECORDS]. As part of the program, someone would have come to your home to assess the energy efficiency of your home, given you some free energy-saving devices like light bulbs, and might have recommended additional ways that you could save energy. Do you remember this visit?**" [IF YES, CONTINUE; IF NO, THANK AND TERMINATE]**
    - **ii. IF NOT, THANK AND TERMINATE]**
96. Refused **[THANK AND TERMINATE]**

S2. **[ASK OF ALL]** Were you directly involved in making decisions about the energy-efficiency assessment of your home, such as deciding whether to purchase and install any of the efficiency measures recommended by the energy auditor?

1. Yes **[CONTINUE]**
2. No **[ASK** "May I please speak to the person in the household who made these decisions?**" IF THIS PERSON COMES TO THE LINE, SAY** "We are conducting a survey to help the Connecticut Energy Efficiency Fund and your electric utility improve the Home Energy Solutions program. Our records show that your household participated in the Home Energy Solutions program in [MONTH, YEAR FROM PROGRAM RECORDS]. I would like to ask you a few questions about your household's experience with the Home Energy Solutions program. The survey should take about 15 minutes. I'm not selling anything." **THEN CONTINUE TO S3; OTHERWISE, THANK AND TERMINATE]**

96. Don't know/refused **[THANK AND TERMINATE]**

[IF DISPOSITION=1, SKIP TO S6. IF DISPOSITION=2, SKIP TO G5.]

S3. Did the Home Energy Solutions visit occur at the home you live in, homes or apartments that you rent out, or some other location, such as the home of a family member? [**MARK ALL THAT APPLY**]

1. My own home **[SEE INSTRUCTIONS BELOW. IF CLARIFICATION NEEDED FOR LANDLORDS OR MULTIPLE HOMEOWNERS, THIS IS "THE HOME I LIVE IN MOST OF THE YEAR"**
2. A unit or building that I rent out **[SEE INSTRUCTION BELOW]**
3. Another location **[IF ALSO S2=1 OR 2 CONTINUE AS DIRECTED ABOVE, OTHERWISE THANK AND TERMINATE]**

96. Don't know/refused **[THANK AND TERMINATE]**

[IF S3=BOTH 1 AND 2, READ "FOR THE REST OF MY QUESTIONS, PLEASE ANSWER ONLY FOR THE HOME IN WHICH YOU LIVE" AND CONTINUE. IF S3=2 ONLY, AND RESPONDENT TELLS YOU THEY HAD A VISIT AT OTHER HOMES THEY OWN, OR S3=2 AND S3=3 READ "FOR THE REST OF MY QUESTIONS, PLEASE ANSWER ONLY FOR THE HOME LOCATED AT (READ STREET ADDRESS, TOWN FROM FILE)"]]

S3a According to our records, at the time of the visit your home had Central Air Conditioning. Is this correct?

1. Yes
2. No **[THANK AND TERMINATE]**

96. Don't know/don't remember **[THANK AND TERMINATE]**
97. Refused **[THANK AND TERMINATE]**

S4. **[ASK IF DISPOSITION=3]** Our records indicate that the energy auditor who came to your home for the Home Energy Solutions evaluation recommended that you replace your Central Air Conditioning unit; you might also have been offered a rebate or low-interest financing to help with the cost. Do you remember a Central Air Conditioning unit replacement being recommended for your home?

1. Yes [SKIP TO S6]
2. No [USE IF NO OTHER INFO VOLUNTEERED BY RESPONDENT] **[THANK AND TERMINATE]**
3. No/I don't remember [USE IF RESPONDENT VOLUNTEERS THEY DO NOT REMEMBER] **THANK AND TERMINATE]**
4. No/Recommendation was not made [USE IF RESPONDENT VOLUNTEERS THAT RECOMMENDATION WAS NOT MADE] **THANK AND TERMINATE]**

96. Don't know **[THANK AND TERMINATE]**
97. Refused **[THANK AND TERMINATE]**

S5. **[ASK DISPOSITION=4]** Did the energy auditor who came to your home for the Home Energy Solutions evaluation recommend that you replace your Central Air Conditioning unit?

3. Yes
4. No **[THANK AND TERMINATE]**

98. Don't know/don't remember **[THANK AND TERMINATE]**
99. Refused **[THANK AND TERMINATE]**

S6. Was your Central Air Conditioning unit working at the time of the audit?

1. Yes
2. No **[IF DISPOSITION=3 OR 4, THANK AND TERMINATE]**

96. Don't know/don't remember **[IF DISPOSITION=3 OR 4, THANK AND TERMINATE]**
97. Refused **[IF DISPOSITION=3 OR 4, THANK AND TERMINATE]**

[IF DISPOSITION= 1 OR 2, SKIP TO G5]

S7. Did you replace your Central Air Conditioning unit after the audit?

1. Yes [THIS IS GROUP C1]
2. No [THIS IS GROUP C2]

96. Don't know/don't remember **[THANK AND TERMINATE]**
97. Refused **[THANK AND TERMINATE]**

General Questions & Rebate Awareness

G1. **[IF S7=2]** To the best of your knowledge, how old is your current Central Air Conditioning unit? Is it . . .

1. Less than 10 years old, or
2. 10 years old or more?
96. Don't know/don't remember
97. Refused

G2. **[IF S7=1]** To the best of your knowledge, how old was the Central Air Conditioning unit you replaced? Was it . . .

1. Less than 10 years old, or
2. 10 years old or more?
96. Don't know/don't remember
97. Refused

G3. **[IF C1 OR C2]** Before this call today, were you aware that you could receive a rebate for replacing your Central Air Conditioning equipment?

1. Yes
2. No
96. Don't know/don't remember
97. Refused

G4. **[IF G3=1]** How did you learn about the rebate? [ASK OPEN ENDED. ACCEPT MULTIPLE REPSONSES. BELOW ARE SOME PRECODES FOR LIKELY RESPONSES. FOR ALL OTHERS, RECORD DESCRIPTION OFFERED BY RESPONDENT.]

1. Energy auditor
2. Rebate Application packet
3. Contractor who gave them quote
4. Some other way (RECORD DESCRIPTION)______________

G5. **[IF DISPOSITION=1 OR 2]** Before the energy audit, were you already aware that you could receive a rebate for replacing your Central Air Conditioning equipment?

1. Yes
2. No
96. Don't know/don't remember
97. Refused

G6. **[IF GROUP C1 OR C2]** Did you get an estimate from the energy auditor's company or another company to replace your Central Air Conditioning unit?

1. Yes
2. No
96. Don't know/don't remember
97. Refused

G7. **[IF G6=1]** Did any of the companies that gave you estimates recommend a high-efficiency unit that would qualify for a rebate?

1. Yes
2. No
96. Don't know/don't remember
97. Refused

Replacement with Rebate

R1. **[IF DISPOSITION=1 OR 2]** Our records show that you received a [IF DISPOSITION = 1 **READ** $250, IF DISPOSITION = 2 **READ** $500] rebate for replacing your Central Air Conditioning unit with a more efficient unit. Do you remember the rebate?

1. Yes
2. No
96. Don't know
97. Refused

R2. **[IF DISPOSITION=1 OR 2 AND R1=1]** How important was the rebate to your decision to replace your Central Air Conditioning with a high-efficiency ENERGY STAR unit? Would you say it was… (READ RESPONSES ALOUD)

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don't know/don't remember
97. Refused

R3. [(IF DISPOSITION=2 AND R1=1) OR (IF DISPOSITION=1 AND R1=1 AND S6=1)] How important was the rebate to your decision to replace your Central Air Conditioning unit *while it was still functioning*? Would you say it was… (READ RESPONSES ALOUD)

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don’t know/don’t remember
97. Refused

R4. **[IF DISPOSITION=1 OR 2 AND R1=1]** What factors were important to you when deciding whether or not to replace your Central Air Conditioning unit with one that would qualify for a rebate? (If respondent asks for clarification – “What kinds of things were important…)”

1. (Speed of installation)
2. (Purchase cost of unit)
3. (Installation cost of unit)
4. (Operating cost of unit)
5. (Reputation of contractor or brand of equipment)
6. (Reliability)
7. (Comfort)
8. (Improving health and safety in home)
9. (Save energy/Energy efficiency concerns)
10. (Better for environment)
11. (Other **[SPECIFY: ___________]**)
96. (Don't know)

R5. **[IF DISPOSITION=1 OR 2]** Did you have specific plans to install any of this efficient air conditioning equipment before you talked with anyone about the Home Energy Solutions Program?

1. Yes
2. No
96. Don’t know/don’t remember
97. Refused

R6. [IF DISPOSITION=1 OR 2 OR C1] Did the same firm that conducted your energy audit also install your replacement Central Air unit?

1. Yes
2. No
96. Don’t know/don’t remember
97. Refused

R7.[IF DISPOSITION=1 OR 2] How important was the information provided by the firm that conducted the energy audit to your decision to apply for a rebate for the unit? Was it… **(READ ALOUD)**

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?

96. Don't know
97. Refused

R8.[**IF DISPOSITION=1 OR 2 AND R6=2, 96 OR 97]** How important was the information provided by the firm that installed your replacement Central Air unit to your decision to apply for a rebate for the unit**?** Was it… **(READ ALOUD)**

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?

96. Don't know
97. Refused

R9. **[IF DISPOSITION=1 OR 2]** Did you consider any drawbacks before using the rebate?

1. Yes
2. No

96. Don't know
97. Refused

R10. **[IF R9=1]** What were the drawbacks? **(RECORD VERBATIM)**

Financing

F1. **[IF DISPOSITION=1 OR 2 AND IF FINANCING RECEIVED = Y]** Our records show that you obtained a loan through [utility name] to finance the replacement of your Central Air Conditioning. How important was the loan to your decision to replace your Central Air Conditioning unit? Was it . . . (READ RESPONSES ALOUD)

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?

96. Don't know/don't remember

97. Refused

Quality Installation

Q1. **[IF DISPOSITION=1 OR 2 AND QIV REBATED = N]** Before this call today, were you aware that you could have been eligible to receive an additional $500 rebate if the Central Air Conditioning equipment installation went through the "Quality Installation" certification process?

1. Yes
2. No

96. Don't know
97. Refused

Q2. **[IF Q1=1]** How did you learn about it? **[MULTIPLE RESPONSES ALLOWED** ASK OPEN ENDED. BELOW ARE SOME PRECODES FOR LIKELY RESPONSES. FOR ALL OTHERS, RECORD DESCRIPTION OFFERED BY RESPONDENT.]

1. energy auditor
2. contractor who gave quote for installation
3. financing requirement
4. Other (RECORD VERBATIM)

Q2a. **[IF IF DISPOSITION=1 OR 2 AND QIV REBATED = Y]** According to our records you received an additional $500 rebate because your Central Air Conditioning equipment installation went through the "Quality Installation" certification process. How did you learn about this additional rebate? **[MULTIPLE RESPONSES ALLOWED** ASK OPEN ENDED. BELOW ARE SOME PRECODES FOR LIKELY RESPONSES. FOR ALL OTHERS, RECORD DESCRIPTION OFFERED BY RESPONDENT.]

1. energy auditor
2. contractor who gave quote for installation
3. financing requirement
4. Other (RECORD VERBATIM)

Q3. **[IF DISPOSITION=1 OR 2 AND QIV REBATED = N]** Another aspect of the Home Energy Solutions program is known as "Quality Installation and Verification" or QIV. It ensures that your Central Air Conditioning has been installed for best performance and reliability, and carries with it an extra incentive. Did the energy auditor recommend Quality Installation and Verification for the replacement Central Air Conditioning?

1. Yes

2. No
96. Don't know
97. Refused

Q4. **[IF DISPOSITION=1 OR 2 AND Q3=1]** What made you decide not to obtain "Quality Installation" certification for your replacement Central Air Conditioning? (MULTIPLE RESPONSE) (RECORD VERBATIM)

Q5. **[IF DISPOSITION=1 OR 2 AND Q3=1]** Is there anything that would have made you more likely to obtain a certified Quality Installation?
1. Yes
2. No
96. Don't know/don't remember
97. Refused

Q6. **[IF Q5=1]** What would have made you more likely to obtain a certified Quality Installation? [RECORD VERBATIM]

CAC Replacement (Any Variety)

C1. **[IF DISPOSITION=1 OR 2 OR IF S7=1]** How important was advice from the **[IF R6=1 READ "firm that conducted the energy audit and installed your replacement Central Air Unit" IF R6=2, 96 OR 97 READ "firm that conducted the energy audit"]** to your decision to replace the unit? **Was it… (READ ALOUD)**
1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don't know/don't remember
97. Refused

C2. **[(IF DISPOSITION=1 OR 2 OR C1 AND IF R6=2, 96 OR 97)]** How important was advice from the firm that actually installed your replacement Central Air Unit to your decision to replace the unit?**) Was it… (READ ALOUD)**
1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don't know/don't remember

97. Refused

C3. **[IF DISPOSITION=1 OR 2 OR IF S7=1]** How important was advice from the **[IF R6=1 READ "firm that conducted the energy audit and installed your replacement Central Air Unit" IF R6=2, 96 OR 97 READ "firm that conducted the energy audit"]** to your decision of *which* Central Air Conditioning unit to install? **Was it… (READ ALOUD)**

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?

96. Don't know
97. Refused

C4. **[(IF DISPOSITION=1 OR 2 OR C1 AND IF R6=2, 96 OR 97)]** How important was advice from the firm that actually installed your replacement Central Air Unit to your decision of *which* Central Air Unit to install? **Was it… (READ ALOUD)**

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?

96. Don't know
97. Refused

C5. **[IF DISPOSITION=1 OR 2 OR IF S7=1]** What factors helped you decide to replace your Central Air Conditioning unit? (If respondent asks for clarification – "What kinds of things were important to your decision to replace the unit)" [DO NOT READ. ACCEPT MULTIPLE RESPONSES]

1. (The old unit broke down)
2. (The old unit wasn't working well)
3. (The old unit required too many repairs)
4. (We were selling home)
5. (Contractor said we should replace the old unit)
6. (Had home inspected and Inspector recommended replacing old unit)
7. (Contractor convinced me old unit needed to be replaced)
8. (Unit was getting old)
9. (Did not want old unit to break down at a bad time)
10. (We were doing extensive remodeling and needed to replace EQUIP)
11. (Other: [SPECIFY] _____________)

Early Replacement

E1. **[IF GROUP C1 OR C2]** Did the energy auditor tell you that there could be an additional $250 rebate for replacing your Central Air Conditioning unit, because of its age?

1. Yes
2. No
96. Don't know/ don't remember
97. Refused

E2 and E3 ask only (if DISPOSITION=2) OR (if S6=1 and S7=1)

E2. How important was advice from the **[IF R6=1 READ "firm that conducted the energy audit and installed your replacement Central Air Unit"] [IF R6=2, 96 OR 97 READ "firm that conducted the energy audit"]** in your decision to replace the *unit that was still functioning*? Were they… (READ ALOUD)

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don't know/don't remember
97. Refused

E2a. [IF E2=3 OR 4] What did the firm do or say that was important to your decision? (RECORD VERBATIM)

E3. **[IF R6=2, 96 OR 97]** How important was advice from the firm that actually installed your replacement Central Air Unit in your decision to replace the *unit that was still functioning*? Were they… (READ ALOUD)

1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important?
96. Don't know/don't remember
97. Refused

E4. **[IF E2a=3 OR 4]** What did the firm do or say that was important to your decision? (RECORD VERBATIM)

Replacement without Rebate

W1. **[IF S7=1]** Have you ever seen or heard of the ENERGY STAR label? This is a blue-and-white label that appears on some products and equipment to show that they use less energy than average.

1. Yes
2. No
96. DON'T KNOW
97. REFUSED

W2. **[IF W1=1]** To the best of your knowledge, does the replacement unit you installed carry the ENERGY STAR label, or is it ENERGY STAR-qualified?

1. Yes
2. No
96. Don't know/ don't remember
97. Refused

W3. **[IF W2=2]** What factors made the unit you installed preferable to an Energy Star unit? (If respondent asks for clarification – "What kinds of things made the unit you installed preferable)" (RECORD VERBATIM)

W4. **[IF W2=2]** What might have convinced you to install an efficient Central Air Conditioning unit that would qualify for a rebate? (RECORD VERBATIM)

W5. **[IF S7=1]** To your knowledge, did the unit you installed qualify for a rebate from [UTILITY]?

1. Yes
2. No
96. Don't know/ don't remember
97. Refused

W6. **[IF W5=1]** Why didn't you use the rebate when replacing your Central Air Conditioning unit? (RECORD VERBATIM)

W7. **[IF W5=1]** What factors did you consider when deciding whether or not to apply for the rebate? (MULTIPLE RESPONSE, DO NOT READ ALOUD)

1. (Time limit on use of rebate)
2. (Contractor I used was not associated with Home Energy Solutions program)
3. (I would have installed the unit without the rebate anyway)
4. (Rebate not large enough to be worth the trouble)

5. (Applied but was rejected [for example, model number not qualified]) RECORD VERBATIM
6. Other [RECORD VERBATIM]

No Replacement

N1. **[IF S7=2]** Did you consider replacing your Central Air Conditioning unit after the energy auditor recommended it?

1. Yes
2. No
96. Don't know/don't remember
97. Refused

N2. **[IF N1=1]** What kept you from replacing it? (MULTIPLE RESPONSE DO NOT READ ALOUD)

1. Cost/too expensive
2. Current unit was still working
3. Other (RECORD)
96. Don't know/don't remember
97. Refused

N3. **[IF N1=2]** Why didn't you consider replacing your Central Air Conditioning unit after the recommendation? (MULTIPLE RESPONSES ALLOWED)

1. Cost/too expensive
2. Current unit was still working
3. Hassle of installation
4. Other (RECORD)
96. Don't know/don't remember
97. Refused

N4. **[IF S7=2]** Have you decided to delay the replacement of your Central Air Conditioning unit to a *future date*, to delay it to when the unit *breaks down*, or something else?

1. Delay to future date
    a. When do you expect to replace the unit? [RECORD]
    b. Do you plan to replace the unit with a high-efficiency unit that would qualify for a rebate from [UTILITY NAME]?
        i. Yes
        ii. No
            1. Why . . .
2. Replace when unit breaks down
    a. When do you expect the unit to break down? [RECORD]
    b. Do you plan to replace the unit with a high-efficiency unit that would qualify for a rebate from [UTILITY NAME]?
        i. Yes
        ii. No
            1. Why . . .
3. No
4. Undecided
5. Something else [DESCRIBE]
96. Don't know
97. Refused

N5. **[IF N4=1, 2 OR 5] [IF N4=1 READ "**Why did you decide to delay replacement of your Central Air Conditioning unit to a future date?"] [**IF N4=2 READ** "Why did you decide to wait until the unit breaks down to replace it?"] [**IF N4=5 READ** "Why did you make that decision?"]?
1. (RECORD VERBATIM)
96. Don't know
97. Refused

N7. **[IF S7=2]** How important was the energy auditor or their firm to your decision making about your central air conditioning unit? Were they… (READ ALOUD)
1. Not at all important
2. Slightly important
3. Somewhat important, or
4. Very important
96. Don't know/ don't remember
97. Refused

N8. [IF N7=3 OR 4] In what way was the energy auditor or their firm important to your decision making? [RECORD VERBATIM]

Recommendations

REC1. **[IF S7=2]**Other than offering a rebate, what else could the Home Energy Solutions Program have done that might have made you decide to replace your Central Air Conditioning unit? [RECORD VERBATIM]

REC2. **[IF DISPOSITION=1 OR 2 OR IF S7=1]** In your opinion, what else could the Home Energy Solutions program do to encourage [UTILITY NAME] customers like yourself to replace their less efficient Central Air Conditioning units with more energy efficient units? (RECORD VERBATIM)

Demographic Characteristics [ASK OF ALL RESPONDENTS]

DEM1. Do you or members of your household own this home or do you rent?

1. Own/Buying
2. Rent/Lease
3. Occupied without Payment or Rent
4. OTHER (SPECIFY): __________

96. DON'T KNOW
97. REFUSED

DEM2. Approximately how many square feet is your home?

1. Less than 1,500
2. 1,500 – 1,999
3. 2,000 – 2,999
4. 3,000 – 3,999
5. 4,000 – 4,999
6. 5,000 – 5,999
7. 6,000 or more

96. DON'T KNOW
97. REFUSED

DEM3. How many rooms are in your home, not counting bathrooms?

1. 1
2. 2
3. 3
4. 4

5. 5
6. 6
7. 7
8. 8
9. 9
10. 10 or more
96. (Don't know/refused)

DEM4. How long have you lived in this home? [DO NOT READ. ASK FOR AN ESTIMATE IF DK]

1. One year or less
2. 1+ to 2 years
3. 2+ to 3 years
4. 3+ to 4 years
5. 4+ to 5 years
6. 5+ to 6 years
7. 6+ to 7 years
8. 7+ to 8 years
9. 8+ to 9 years
10. 9+ to 10 years
11. 10+ to 11 years
12. 11 to 15 years
13. 15+ to 20 years
14. More than 20 years
96. (Don't know)

DEM5. What is the highest level of education that you have completed? **[READ CATEGORIES]**

1. Less than high school
2. High school graduate
3. Technical or trade school graduate
4. Some college
5. College graduate
6. Some graduate school
7. Graduate degree
96. (Refused)

DEM6. How many people live in your home?

1. 1

2. 2
3. 3
4. 4
5. 5
6. 6 or more

96. (Refused)

DEM7. What is your age?

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over

96. (Refused)

DEM8. What category best describes your total household income in 2011, before taxes?

1. Less than $35,000
2. $35,000 to $49,999
3. $50,000 to $74,999
4. $75,000 to $99,999
5. $100,000 or more

96. (Refused)

DEM9. **[RECORD SEX]**

1. Male
2. Female

Recruit For Possible Focus Groups

We may be conducting focus groups in your area about the Home Energy Solutions program within the next few months. We would offer a $75 incentive to focus group participants to compensate them for their time. The focus group would take place during a weekday evening, in North Haven or Farmington. Would you be interested in being part of a focus group?

[IF NO: GO TO CLOSING]

[IF YES]

RE1. Is this the best number to reach you at to schedule a focus group? [RECORD BEST NUMBER]

RE2. Just in case we have trouble reaching you by phone, may we also contact you by email? **[IF YES]** What email address should we use? [RECORD EMAIL]

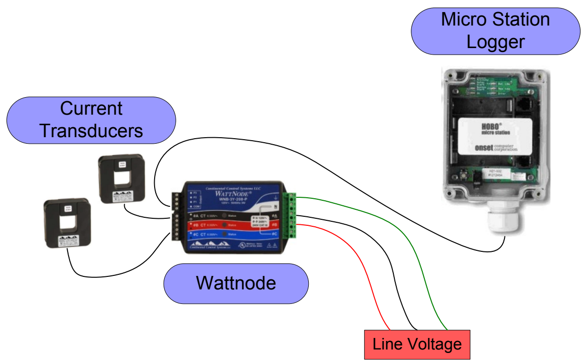
Closing

Thank you for taking the time to help improve the Home Energy Solutions Program.

Appendix B Metering Equipment, Specifications, and On-site Form

Whenever possible, condensing unit powers were monitored using ONSET Hobo Microstation data loggers configured to receive pulse outputs from Continental Control System Wattnode pulse meters. The Wattnode meters were connected to the condensing units via split-core current transducers and voltage taps connected to both split-phase legs and the ground terminal. Using the proposed setup, condensing unit energy usage was recorded in five-minute intervals for the duration of the summer monitoring period. Figure B-1 below provides a complete schematic of the condensing unit logging setup.

Figure B-1: Condensing Unit Logging Equipment



Air handler operating data were collected with Onset Microstation data loggers outfitted with TRMS modules and CCS split-core current transducers. Current logging was used instead of time-of-use logging because many residential air handlers have multiple speeds. Multiple speeds can be captured with a single-phase current logger, but not with a time-of-use logger. Current measurements were recorded in five-minute intervals. Figure B-2 below provides a schematic representation of the air handler logging setup. An identical amperage metering suite was utilized for condenser unit monitoring in instances where it was not possible to install the true power logging suite.

Figure B-2: Air Handler Logging Equipment

In addition to metering, spot power measurements of condensing unit and air handling unit power, power factor, voltage, and amperage were taken whenever possible. Condensing unit spot measurements were taken to QC the magnitude of the logged values and supplement amperage data when true power logging was not possible. Air handler unit spot measurements were taken to determine the voltage and power factor levels corresponding to AHU operation. These data were then used in conjunction with logged amperage to estimate AHU power for each logging interval.

Meter Compliance—ISO Requirements

All metering equipment used to conduct the monitoring in this study on newly installed CAC equipment met or exceeded specifications of the ISO New England Measurement and Verification Equipment Requirements. The relevant requirements include the following:

- All equipment used for monitoring and data recording shall meet or exceed the relevant standards set by the American National Standard Institute (ANSI) or equivalent standard for the equipment.
- Data recorders that are recording pulses from measurement and monitoring devices must utilize a pulse rate within the resolution capabilities of the recorder.
- All equipment installed on electric circuits with significant harmonics shall meet or exceed the relevant standards provided by the Institute of Electrical and Electronics Engineers (IEEE).
- Any equipment that directly measures electrical demand shall be a true RMS (Root Mean Square) measurement device with an accuracy of no less than ± 2%.
- Any monitoring equipment of current (amps) and nominal voltage used to calculate electrical demand must include the power factor of the end-uses in the demand (kW) calculations.
- The Project Sponsor must maintain documentation on all measurement monitoring and data recording equipment maintenance and calibration activities.
- Interval metering devices shall collect electricity usage data at a frequency of 15 minutes or less.

The table below shows all metering equipment used and their rated accuracy, among other information. We also footnote the specification documents below.

Table B-1: Primary Meters and Logging Equipment

Equipment Monitored	Function/Data Point to Measure	Equipment Brand/Model	Rated Full-Scale Accuracy	Duration of Metering	Metering Interval	Meets Standards
Condenser	Power Meter	Wattnode Power Meter-240v[46]	± 0.5%	10+ Weeks	5 Min	ANSI 12.20
Condenser	Power Logger	Onset HOBO Micro Station[47]	± 1.0%	10+ Weeks	5 Min	ANSI 12.1
Air Handler	Power Logger	Onset HOBO H22[48]	± 1.0%	10+ Weeks	5 Min	ANSI 12.1
Condenser and Air Handler	Current Transducer	Magnelab Split-Core AC CT[49]	± 1.0%	10+ Weeks	5 Min	ANSI 12.1
Spot Measurements	Power Measurements	Extech Power Clamp Meter[50]	± 1.5%	Spot Measurements	Spot Measurements	IEC 1010 Category III

Meter Calibration and Inventory

Prior to the commencement of field data collection activities, a comprehensive metering calibration check was performed on all meters to verify accuracy and functionality.

1. All metering equipment was inventoried and serial numbers recorded. All meters received new batteries and visual inspections of wiring and connections.
2. Power Meters: The Continental Control System Wattnode pulse meters were tested for accuracy using a 240-volt circuit with a known power draw and recorded data over a set duration of time. Pulse counts were verified as recorded on the HOBO micro-station logger and calculated to that of the test load. Any combination of Wattnode and micro-station that was not recording within ± 2.0% of the known test load was eliminated from use.
3. Amp Meters: The HOBO H22s and HOBO micro-stations that were used to record run-time and amp usage by the HVAC equipment were tested using a similar method. Meters were connected to the wiring of a known power draw, and recorded data was compared for accuracy with the test load. Any meter that was not recording within ± 2.0% of the known test load was eliminated from use.

[46] http://www.ccontrolsys.com/w/Advanced_Pulse_WattNode_-_Specifications
[47] http://www.onsetcomp.com/files/manual_pdfs/7645-K-MAN-H21-002.pdf
[48] http://www.onsetcomp.com/files/manual_pdfs/9857-E-MAN-H22.pdf
[49] http://www.ccontrolsys.com/ww/images/8/8a/Data_Sheet_CT_Splitcore.pdf
[50] http://www.extech.com/instruments/resources/manuals/380940_um.pdf

4. Meters were preset for launch in the field with recording intervals of 5 minutes. All Wattnode meters/micro-stations tested in pairs were kept together as a set for deployment in the field. Meter numbers were recorded on the field data collection forms at each site as the meters were assigned to a particular field site.

The form below was utilized at all sites visited.

ONSITE VERIFICATION FORM - *CT Central Air Conditioning Study - version 2*							
SITE ID #			CONTACT NAME:				
ADDRESS 1:						PHONE 1:	
CITY:				ZIP:		PHONE 2:	
STATE:	CT	DATE:	/ /	VISIT TIME:		UTILITY NAME:	
AUDITOR 1:			# of CAC UNITS:			# of ZONES:	
AUDITOR 2:			TOTAL Sq Ft:			VOLUME:	
SITE NOTES:							
OPERATIONAL & BEHAVIORAL USE QUESTIONS							
TYPE OF T-STAT	MANUAL ☐		PROGRAMMABLE ☐		PREFERRED TEMP		
# OF OCCUPANTS DAY			# OF OCCUPANTS NIGHT				SUMMER ______ F
OPERATIONAL USE		CONTINUOUS ☐		PROGRAMMED ☐		MANUAL W/ SET BACKS ☐	
COOLING SCHEDULE							
CONTROL TYPE		WHAT MONTHS ARE AC USED		MAR APRIL MAY JUNE JULY AUG SEP OCT			
COOLING	SUN	MON	TUE	WED	THU	FRI	SAT
TIME SET TO TEMP1							
TIME SET TO TEMP2							
TIME SET TO TEMP3							
TIME OFF							
#1 OUTDOOR CONDENSOR UNIT NAMEPLATE INFO							
CONDENSOR			MOD #			SERIAL #	
CAPACITY (Tons)		MFG DATE (Mo/Year)	/	Rated Efficiency		SEER/EER (circle one)	
REFRIGERANT	☐ TXV ☐ NON-TXV		☐ R-22 ☐ R-410a				
FAN HP		COND. HP		COND. RLA			
NOTES:							

#1 INDOOR AIR HANDLER UNIT NAMEPLATE INFO						
UNIT #		ZONE #		SET POINT		
TYPE OF UNIT	PACKAGED ☐		SPLIT ☐		AC ONLY ☐	
HEAT FUEL TYPE	GAS ☐	ELECTRIC ☐	PROPANE ☐	HP ☐	OIL ☐	SQ FT:
MFG					VOLUME:	
MODEL #				SERIAL #		
DISPOSITION	REPLACEMENT ☐		RETROFIT ☐		EXISTING ☐	
HEATING			HEATING EFF		AFUE ☐	HSPF ☐
COIL MODEL #				SERIAL #		
FAN HP			# of SPEEDS			
NOTES:						

#2 OUTDOOR CONDENSOR UNIT NAMEPLATE INFO							
CONDENSOR MFG			MOD #			SERIAL #	
CAPACITY (Tons)		MFG DATE (Mo/Year)	/	Rated Efficiency		SEER/EER (circle one)	
REFRIGERANT	☐ TXV	☐ NON-	☐ R-22	☐ R-410a			
FAN HP		COND. HP		COND. RLA			

#2 INDOOR AIR HANDLER UNIT NAMEPLATE INFO						
UNIT #		ZONE #				
TYPE OF UNIT	PACKAGED ☐		SPLIT ☐		AC ONLY ☐	
HEAT FUEL TYPE	GAS ☐	ELECTRIC ☐	PROPANE ☐	HP ☐	SQ FT:	
MFG					VOLUME:	
MODEL #				SERIAL #		
DISPOSITION	REPLACEMENT ☐		RETROFIT ☐		EXISTING ☐	
HEATING			HEATING EFF		AFUE ☐	HSPF ☐
COIL MODEL #				SERIAL #		
FAN HP			# of SPEEDS			
NOTES:						

TRUEFLOW VOLUMETRIC AIRFLOW TEST						
ARRAY	SIZE (circle one)	Normal Static Pressure (NSOP)	Trueflow Static Press (TFSOP)	Plate Pressure (Pa)	Flow Grid CFM	COMMENTS
	#14					
	#20	*Filter in place*	*Flow array in filter rack*			

LOGGER DATA			
LOGGER	SERIAL NUMBER	LOGGER TYPE	LOCATION
1			
2			
3			
4			
5			
6			
7			
8			

SPOT MEASUREMENTS				
Unit in Cooling Mode (wet coils)				
	VOLTS	AMPS	WATTS	COMMENTS
COND 1				
COND 2				
COND 3				
AVERAGE	#DIV/0!	#DIV/0!	#DIV/0!	
AHU 1				
AHU 2				
AHU 3				
AVERAGE	#DIV/0!	#DIV/0!	#DIV/0!	

PREVIOUS SYSTEM INFORMATION
NOTES:

Appendix C Seasonal Peak Calculation Approach

The calculation of the summer Seasonal Peak demand reduction was based on the performance hours that were used to evaluate the Demand Reduction Values (DRV). Seasonal demand performance hours for ISO-NE FCM are defined as hours when the real-time ISO-NE system load meets or exceeds 90% of the predicted Seasonal Peak from the most recent Capacity, Electricity, Load and Transmission (CELT) report. The peak load forecast for the summer of 2013 season was 27,840 kW, 90% of which is 25,056 kW. There were 43 hours during the summer 2013 season when the load exceeded 25,056 kW. The evaluation used a blend of both Hartford and Bridgeport real-weather data for the summer of 2013 to calculate the weighted average Total Heat Index (THI) of 79.3 for Connecticut during these hours. The Total Heat Index is a forecast variable used by ISO-NE and it is calculated as follows.

$THI = 0.5 \times DBT + 0.3 \times DPT + 15$ Where

THI = Total Heat Index

DBT = Dry Bulb Temperature (°F)

DPT = Dew Point Temperature (°F)

ISO-NE also uses a variable called a Weighted Heat Index (WHI), which is a three-day weighted average of the THI, and it is calculated as follows.

$WHI = 0.59 \times THI_{di\ hi} + 0.29 \times THI_{d(i-1)\ hi} + 0.12 \times THI_{d(i-2)\ hi}$ Where

WHI = Weighted Heat Index

$THI_{di\ hi}$= Total Heat Index for the current day and hour

$THI_{d(i-1)\ hi}$= Total Heat Index for previous day and same hour

$THI_{d(i-2)\ hi}$= Total Heat Index for two days prior and same hour

Table C-1 provides the summer 2013 Seasonal Peak hours along with the system load, percent of CELT forecast peak, the THI, and the WHI based on Connecticut weather.

Table C-1: 2013 Summer Seasonal Peak Hours and System Load

Date	Hour	System Load (kW)	Percent of Peak	THI	WHI	Date	Hour	System Load (kW)	Percent of Peak	THI	WHI
6/24/2013	16	25,071	90%	78.9	77.7	7/18/2013	12	25,842	93%	78.4	77.6
6/24/2013	17	25,129	90%	77.9	76.9	7/18/2013	13	26,339	95%	79.4	78.8
7/15/2013	13	25,344	91%	77.9	76.4	7/18/2013	14	26,747	96%	79.4	78.8
7/15/2013	14	25,779	93%	77.6	76.5	7/18/2013	15	26,867	97%	79.6	79.0
7/15/2013	15	25,972	93%	78.8	77.4	7/18/2013	16	26,840	96%	80.6	79.9
7/15/2013	16	26,066	94%	78.1	76.8	7/18/2013	17	26,680	96%	79.8	79.3
7/15/2013	17	26,089	94%	78.5	77.3	7/18/2013	18	26,306	94%	80.7	80.0
7/15/2013	18	25,917	93%	77.7	77.0	7/18/2013	19	25,617	92%	80.5	79.8
7/15/2013	19	25,418	91%	79.1	77.7	7/19/2013	11	25,436	91%	79.3	78.6
7/16/2013	13	25,328	91%	77.7	77.7	7/19/2013	12	26,457	95%	79.8	79.0
7/16/2013	14	25,900	93%	77.7	77.6	7/19/2013	13	27,015	97%	80.2	79.7
7/16/2013	15	26,088	94%	77.9	78.1	7/19/2013	14	27,347	98%	81.0	80.2
7/16/2013	16	26,160	94%	78.4	78.1	7/19/2013	15	27,353	98%	81.4	80.5
7/16/2013	17	26,226	94%	78.4	78.3	7/19/2013	16	27,350	98%	81.7	81.1
7/16/2013	18	26,040	94%	78.2	78.0	7/19/2013	17	27,360	98%	82.0	81.0
7/16/2013	19	25,422	91%	78.0	78.2	7/19/2013	18	27,066	97%	81.3	80.9
7/17/2013	13	25,487	92%	78.0	77.9	7/19/2013	19	26,305	94%	81.2	80.8
7/17/2013	14	26,064	94%	78.2	78.0	7/19/2013	20	25,483	92%	80.5	79.9
7/17/2013	15	26,351	95%	78.4	78.3	7/19/2013	21	25,154	90%	80.3	79.1
7/17/2013	16	26,522	95%	79.1	78.8						
7/17/2013	17	26,622	96%	78.7	78.6						
7/17/2013	18	26,494	95%	79.4	78.8						
7/17/2013	19	25,890	93%	79.2	78.8						
7/17/2013	20	25,089	90%	79.3	78.6						

The peak load data and the weighted THI and WHI data for 2013 were used to create linear regressions of peak system load as a function of THI and WHI. The analysis focused on non-holiday weekdays from June through July during hours ending 11 through 21. Evaluators used the time window of hours ending 11 to 21 because of the abovementioned observed peaks in the 2013 season that occurred outside of the 1 P.M. to 5 P.M. daily peak period.

The following THI and WHI cutoff points were the result of the regression analyses. These represent the selection points that both the THI and WHI from a blended Connecticut TMY3 weather file must be greater than in order to trigger a summer seasonal peak hour.

THI Cutoff Point: 79.8

WHI Cutoff Point: 79.1

Table C-2 provides a summary of the THI, WHI, and number of summer seasonal hours for the blended Connecticut TMY3 weather file used in the analysis by month and for the summer season. These are the total number of TMY3 hours applied to the evaluation year that meet the above criteria for being selected as a summer seasonal peak hour.

Table C-2: Summary of Summer Seasonal Hours for Blended TMY3 Weather

Month	Mean THI	Mean WHI	# of Hours
June	80.1	79.2	6
July	81.1	79.7	38
August	80.9	80.4	9
Summer	**80.9**	**79.7**	**53**

Appendix D Demographic Characteristics of Survey Respondents

Because the primary purpose of the study was to understand participants, the evaluation team compared participants' responses to demographic characteristics questions with each other rather than with the state population. The tables below show the characteristics across respondent groups and overall.

Table D-1: Home Ownership

Do you or members of your household own this home or do you rent?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
Own	98%	100%	100%	100%	99%
Rent	2	0	0	0	1

Table D-2: Home Square Footage

Approximately how many square feet is your home?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
Less than 1,500	19%	22%	11%	22%	20%
1,500 to less than 2,000	24	29	11	18	22
2,000 to less than 3,000	41	23	52	29	33
3,000 to less than 4,000	13	12	11	11	12
4,000 to less than 5,000	0	5	7	11	6
5,000 to less than 6,000	1	2	4	3	2
6,000 or more	0	1	0	3	1
Don't know	3	4	4	4	4

Table D-3: Number of Rooms in Home

How many rooms are in your home, not counting bathrooms?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
2	0%	0%	0%	4%	1%
3	1	1	0	1	1
4	4	16	4	7	9
5	9	9	7	12	10
6	20	14	11	18	17
7	14	16	22	11	14
8	29	15	30	11	19
9	7	15	4	14	11
10 or more	14	10	19	18	14
Don't know/refused	3	4	4	4	4

Table D-4: How Long Participants Have Lived in Home

How long have you lived in this home?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
1+ to 2 years	14%	2%	0	4%	6%
2+ to 3 years	5	13	7	14	10
3+ to 4 years	4	4	0	7	5
4+ to 5 years	3	3	4	3	3
5+ to 6 years	1	1	0	1	1
6+ to 7 years	7	8	4	8	7
7+ to 8 years	3	5	4	4	4
8+ to 9 years	4	2	0	10	5
9+ to 10 years	4	5	0	3	3
10+ to 11 years	4	7	15	7	7
11 to 15 years	9	12	22	14	13
15+ to 20 years	13	9	15	4	9
More than 20 years	25	26	26	21	24
Don't know	3	3	4	1	3

Table D-5: Educational Attainment

What is the highest level of education that you have completed?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
Less than high school	0%	%	4%	0%	<1%
High school graduate	8	7	4	5	7
Technical or trade school graduate	3	0	0	3	2
Some college	13	12	19	8	12
College graduate	42	44	41	32	39
Some graduate school	0	3	0	3	2
Graduate degree	33	33	33	45	37
Refused	1	0	0	4	2

Table D-6: Household Size

How many people live in your home?	Replaced CAC with CAC Rebate only ($250)	Replaced CAC with CAC+Early Retirement Rebate ($500)	Replaced CAC Without Rebate	Did not Replace CAC	Total
Sample Size	*70*	*70*	*27*	*73*	*240*
1	9%	14%	11%	14%	12%
2	43	43	44	32	40
3	25	16	22	14	19
4	11	18	11	21	16
5	10	4	7	14	9
6 or more	0	4	0	3	2
Refused	1	1	4	4	2

Table D-7: Age

What is your age?	**Replaced CAC with CAC Rebate only ($250)**	**Replaced CAC with CAC+Early Retirement Rebate ($500)**	**Replaced CAC Without Rebate**	**Did not Replace CAC**	**Total**
Sample Size	*70*	*70*	*27*	*73*	*240*
25 to 34	8%	4%	4%	8%	6%
35 to 44	14	12	11	22	16
45 to 54	24	20	26	23	23
55 to 64	30	32	19	21	26
65 or over	22	30	33	16	24
Refused	2	2	7	10	5

Table D-8: Income

	Replaced CAC with CAC Rebate only ($250)	**Replaced CAC with CAC+Early Retirement Rebate ($500)**	**Replaced CAC Without Rebate**	**Did not Replace CAC**	**Total**
Sample Size	*70*	*70*	*27*	*73*	*240*
Less than $35,000	1%	4%	7%	5%	4%
$35,000 to less than $50,000	2	9	4	5	5
$50,000 to less than $75,000	16	6	0	11	10
$75,000 to less than $100,000	22	21	15	15	19
$100,000 or more	39	48	48	48	45
Refused	21	13	26	15	17

Table D-9: Gender

Gender	**A. Replaced CAC with CAC Rebate only ($250)**	**B. Replaced CAC with CAC+Early Retirement Rebate ($500)**	**C. Replaced CAC Without Rebate**	**D. Did not Replace CAC**	**Total**
Sample Size	*70*	*70*	*27*	*73*	*240*
Male	55%	71%	59%	62%	62%
Female	45	29	41	38	38

Appendix E Research Issues

E.1 Program Recordkeeping

The evaluation team found the participant data supplied by the Companies for the market research portion of this study to be of varying quality.

Mid-year in PY2011, CL&P began collecting data on the measures recommended by auditors as part of the HES program. As a result, data became available for a substantial number of CL&P participants indicating whether an HVAC measure of any kind had been recommended. While this helped to reduce the number of CL&P participants we had to contact to find those for whom CAC replacement was recommended, having data at an even more detailed level—specifically, whether CAC replacement had been recommended—would have been much more effective in reducing the number of calls that had to be made to find participants qualified for the survey. Nonetheless, HVAC recommendation data did help to keep survey costs down, as participants with this variable responded to the survey at higher rates than did participants without it.

The research team found that UI did not collect any data on the recommendations made by auditors as part of the HES program during either PY2011 or PY2012. As a result, the survey data included very few UI participants who did not take advantage of a CAC rebate. In addition, UI does not have a codebook for the program tracking data. The lack of a codebook slowed down the process of developing the sample frame for the study, and the lack of recommendation recordkeeping resulted in higher survey research costs than necessary; the more calls that must be made to reach target quotas, the higher the costs. The lack of information about program recommendations made to participants also presents a substantial barrier to understanding why participants do not follow through with recommendations.

The auditor does not record the year of manufacture of the CAC unit during the audit. Obtaining this information from the auditor would be much more reliable than participants' retrospective estimates of their CAC unit age at the time of the audit and would help in assessing the rate of units eligible for early replacement.

Including the kinds of information described above in program recordkeeping would improve future evaluations of HES CAC efforts.

E.2 Evaluation Design and Planning

Of the 27 respondents in the stratum of participants who reported replacing their CAC without a rebate, ten later stated during the survey that they did in fact use a rebate. The evaluation team does not know if this is an issue of incorrect data from the Companies, or if the respondents confused the CAC rebate either with other rebates they may have obtained through the program or with federal tax credits.

Evaluating the program closer in time to the audit would yield more reliable results at lower cost. The original plan was to collect the PY2011 data in the summer of 2012. This would have allowed participants who were audited late in 2011 enough time to follow through with CAC replacement, while also increasing the likelihood that the survey would be fielded during warm weather—i.e., when CAC would be a salient topic for the participants. Due to a variety of factors beyond the team's control, the research was delayed until Fall 2012, and the telephone survey was carried out in mid-winter. In future, a better approach to studying CAC replacement would be to field a survey multiple times over the study period. For example, fielding the survey in two waves over the course of a program year would make it possible to ask questions of all participants within 6 to 12 months of the audit, at the very latest. By contrast, participants who were audited in the winter of 2011 were asked questions nearly two years after their audits. To save on costs with this approach, the evaluation team could report on the results annually or even every other year, thus reusing the analysis programming and keeping interim reporting brief.

Appendix F Manual J Site Results

The following tables indicate the results of the Manual J load calculations for the installed units. For each sample point, we divided the Manual J load calculation by the rated capacity of the installed unit in tons ("Manual J Calculation Per Unit Ton" field). This field represents the BTUh cooling load needed per ton installed. The final field in the table (ratio) captures the relationship between the Manual J calculation per ton and the cooling capacity of a ton (12,000 BTUh). This field is provided to simplify the comparison of calculated load vs. installed load. A perfectly sized unit would have a ratio of 1.0 and each ratio less than or greater than that would be undersized or oversized, according to the Manual J calculations.