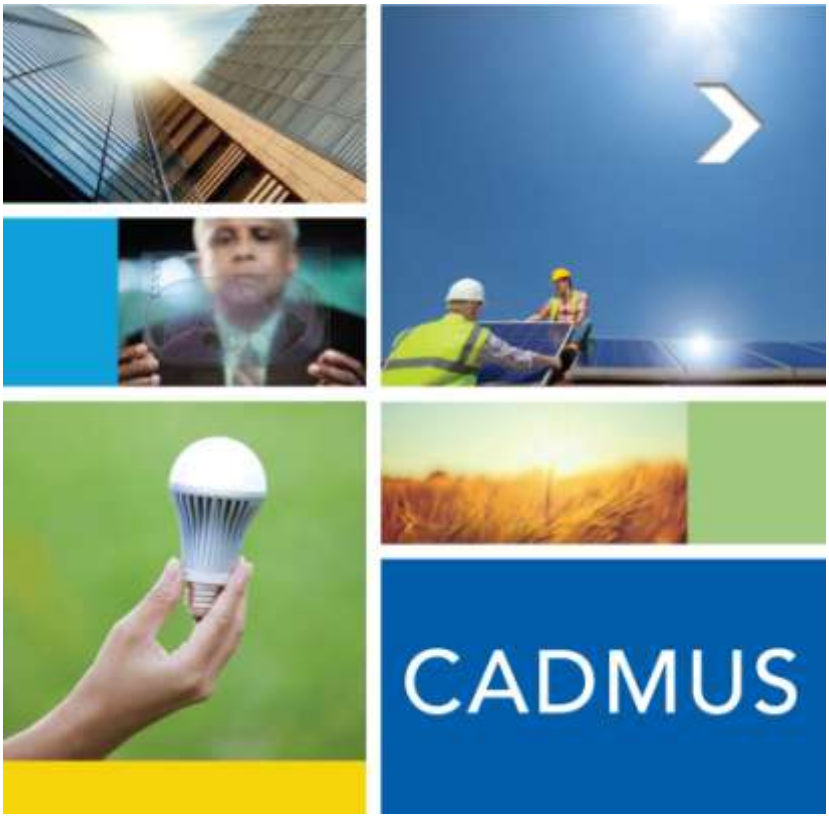

REVIEW DRAFT

Impact Evaluation: Home Energy Services – Income-Eligible and Home Energy Services Programs: Volume 1 (R16)

March 31, 2014

Connecticut Energy Efficiency Fund

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Glossary of Terms

Adjusted Gross Realization Rate

The adjusted gross realization rate is calculated by comparing the adjusted gross model savings estimate to the average per-participant *ex ante* savings for the participants included in the billing analysis sample.

Adjusted Gross Savings

Adjusted gross savings are model savings estimates that account for the differences in consumption changes between the participant group and comparison group model savings from the billing analyses.

Billing Analysis

A billing analysis is a statistical regression analysis of utility billing consumption data used to quantify gross and adjusted gross energy savings.

Evaluated Adjusted Gross Savings

Evaluated adjusted gross savings are calculated by applying the adjusted gross realization rate (derived from the billing analysis models compared to *ex ante* savings) to the reported gross savings by utility program (from the 2013–2015 Electric and Natural Gas Conservation and Load Management Plan).

***Ex Ante* Savings**

Ex ante savings represent those savings that provide the utility tracking data for the HES and HES-IE programs, which can include total per-participant savings or savings by specific measures.

Model Savings

Model savings represent average per-participant estimates of savings, estimated through the regression analysis, based on an analysis sample. Model savings estimates for the participant analysis sample are referred to as participant savings or gross savings. Model savings estimates for the comparison group sample are referred to as comparison group or nonparticipant savings. Model savings estimates that account for the differences between participant and comparison group changes are referred to as adjusted gross savings.

PRENAC and POSTNAC

In the regression analysis, weather-normalized annual consumption (NAC) estimates for the pre- and post-periods are called PRENAC and POSTNAC.

Relative Precision at 90% Confidence

The Evaluation Team calculated relative precision estimates to assess the level of uncertainty for results of distinct billing analysis models (Model Savings) and overall evaluated adjusted gross savings (reported at the program level). These values represent the uncertainty of the modeled results and variation in the observed impact on energy consumption. The Evaluation Team estimated precision at 90% confidence,

meaning one could be 90% confident the true impact falls within an interval that is equal to the estimated impact plus/minus the precision.

Reported Gross Savings

Reported gross savings represent savings reported in the 2013–2015 Electric and Natural Gas Conservation and Load Management Plan.

Executive Summary

The Connecticut Energy Efficiency Board (EEB) requires an impact evaluation of the Home Energy Services (HES) and Home Energy Services-Income Eligible (HES-IE) programs offered by these Connecticut utilities: Connecticut Light & Power (CL&P), The United Illuminating Company (UI), Connecticut Natural Gas (CNG), Southern Connecticut Gas (SCG), and Yankee Gas Services Company (YGS). The objective is to provide evaluated estimates of the energy and demand savings associated with measures installed through these programs. The NMR Group and its subcontractor, Cadmus (collectively known as the Evaluation Team) was selected to conduct this assignment.

This report describes the impact evaluation findings for the program year 2011 HES and HES-IE programs. Volume 1 of this document provides the results of a whole-house billing analysis to estimate average participant (household-level) electric and natural gas impacts. Volume 2 includes a measure-level impact evaluation, providing estimates of per-unit savings for measures offered through the HES and HES-IE programs, using an array of evaluation tasks, such as billing analysis, calibrated simulation modeling, and engineering analyses.

Program Overview

Through the HES program, the majority of homes received a set of core measures installed at the time of an in-home audit, including compact fluorescent light bulbs (CFLs), hot-water savings measures (e.g., faucet aerators, low-flow showerheads), and air and duct sealing. After this initial audit, participants had the option of installing other measures with HES rebates, including insulation and equipment replacements (including appliances and HVAC). While the 2011 HES participants received high installation rates of these core measures, low rates of insulation, HVAC upgrades, and appliance replacements occurred.

The HES-IE program has a similar structure, with the majority of homes receiving a similar set of core measures. A key distinction is that the add-on measures (identified as audit recommendations) are installed in HES-IE homes at no cost to the participant (although landlords often are subject to co-pays). Along with these core measures, 2011 HES-IE participants also received higher rates of insulation and heating system upgrades (e.g., ductless heat pumps) than in the HES program.

Methodology

A statistical billing analysis was performed, using fixed-effects regression models to estimate actual changes in electric and gas consumption in participating homes in the HES and HES-IE programs for 2011. The billing analysis is based on historical billing data, which covered up to a year before and after participation. This study focused on 2011 because (1) the analysis needed a complete 12-month period of post-participation billing data, and (2) at the time of evaluating planning, billing data for a complete 2013 period was not available. Weather-normalized models were used to screen for data quality and compare the final fixed-effects model results. Additionally, a comparison group was drawn from a

sample of post-2011 program participants to control for macroeconomic factors and other exogenous effects that may have affected energy consumption during the analysis period.

The tables that follow present the results of the analysis as "Total Evaluated Adjusted Gross Savings." This reflects the difference in energy use for the program participants (throughout the report, referred to as "model savings"), adjusted by the difference in energy use observed for the comparison group. The adjusted gross realization rates are the ratio of the adjusted gross savings calculated through the different billing analysis models to the average reported *ex ante* savings as recorded in the program tracking system for all of the participants in the analysis sample. The adjusted gross realization rates (specific to utility program and type of energy) were applied to the 2011 energy savings reported in the 2013–2015 Electric and Natural Gas Conservation and Load Management Plan (the Plan) to obtain the overall evaluated savings for 2011.[1]

Due to data limitations, it was not possible to directly evaluate oil and propane impacts using billing analysis; however, evaluated gas model impacts from the billing analysis were extrapolated to the participant population with oil/propane heating and water heating.

Demand impacts were calculated from the 2011 demand savings reported in the Plan using the adjusted gross realization rates for energy savings calculated from the billing analysis models.

Results

Table 1 through Table 4 present the evaluated adjusted gross electric and gas energy savings for each utility's HES and HES-IE programs for 2011.[2] [3]

For the HES program electric savings overall, the evaluated adjusted gross savings were slightly higher than the reported savings, with an adjusted gross realization rate of 117% (see Table 1). For the HES program gas savings overall, the evaluated adjusted gross savings were somewhat lower than the reported savings, with an adjusted gross realization rate of 58% (see Table 2).

[1] CL&P, UI, YGS, CNG, SCG Utilities. *2013–2015 Electric and Natural Gas Conservation and Load Management Plan*. 2012. http://energizect.com/sites/default/files/2013_2015_CLM%20PLAN_11_01_12_FINAL.pdf

[2] Totals may not add up to the sum of individual values due to rounding.

[3] Realization rates for "Program Overall" are calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.

Table 1. Total 2011 Evaluated HES Electric Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CL&P	15,886	16,190	18,730	116%	±4%
UI	5,329	3,541	4,454	126%	±8%
Program Overall	**21,215**	**19,731**	**23,184**	**117%**	**±4%**

Table 2. Total 2011 Evaluated HES Gas Savings, by Utility and Overall Program

Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjusted Savings (000s CCF)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CNG	1,895	196	132	67%	±17%
SCG	2,369	243	110	45%	±27%
YGS	1,811	172	112	65%	±16%
Program Overall	**6,075**	**611**	**354**	**58%**	**±12%**

For the HES-IE program electric savings overall, the evaluated adjusted gross savings were slightly lower than the reported savings, with an adjusted gross realization rate of 82% (see Table 3). For the HES-IE program gas savings overall, the evaluated adjusted gross savings were somewhat lower than the reported savings, with an adjusted gross realization rate of 50% (see Table 4).

The HES-IE program for CL&P is offered through four subprograms (SPs). Two of the subprograms (SP1 and SP4) have been handled differently in this report due to issues related to the way that data are tracked. For this report, the analysis of CL&P's HES-IE focused on SP2 and SP3. These analysis findings have been applied to SP1, and SP4 has been removed from the reported savings and the adjusted gross savings. This is true for both the electric and gas savings.

Table 3. Total 2011 Evaluated HES-IE Electric Savings, by Utility and Overall Program

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CL&P	10,685*	13,291*	9,882	74%**	±5%
UI	5,612	4,710	4,930	105%	±6%
Program Overall	**16,297**	**18,001**	**14,812**	**82%**	**±4%**

* These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (27%).

** The realization rate from the single-family electric savings model (105%) has been applied to the percentage of CL&P HES-IE savings attributed to SP1 (12%), to reflect similar program populations by building type.

Table 4. Total 2011 Evaluated HES-IE Gas Savings, by Utility and Overall Program

Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjusted Gross Savings (000s CCF)	Adjusted Gross Realization Rate	Relative Precision at 90% Confidence
CNG	1,610	198*	87	44%**	±25%
SCG	3,268	361	206	57%	±23%
YGS	1,961	300*	140	47%**	±25%
Program Overall	**6,839**	**859**	**433**	**50%**	**±12%**

* These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (6% CNG, 16% YGS). Since gas utilities territories are composed of both CL&P and UI electric customers, and the subprogram construct is specific to CL&P HES-IE delivery, the Evaluation Team used the proportion of gas savings for CL&P and UI from the program tracking data to differentiate the portion of reported HES-IE gas savings for CNG and YGS associated with SP4.

** The realization rates from the utility-specific gas savings models (44% CNG, 47% YGS) have been applied to the percentage of CL&P HES-IE savings attributed to SP1.

Benchmarking

To provide context for the program's savings estimates, the HES and HES-IE results were compared to other similar energy-efficiency programs.

Regarding electric impacts, HES demonstrated higher savings than in comparable programs, both in terms of absolute kWh savings per participant and when comparing savings as a percentage of pre-period usage. HES-IE program electric impacts are higher than similar programs when considering savings as a percentage of pre-period usage, but reveled lower absolute savings compared to other programs, likely due to lower saturations of electric heat.

A comparison of gas impacts revealed that HES and HES-IE program savings are lower in absolute and percentage terms relative to similar programs. Comparatively, many of these other programs had higher

frequencies of installing insulation and heating equipment upgrades, which likely contributed to higher savings. While HES and HES-IE demonstrated higher levels of air and duct sealing (included in the core measures offered at the time of audit), lower levels of other high-savings gas measures, such as insulation, characterized these programs.

Recommendations

The Evaluation Team has developed several preliminary recommendations for improvement, which are specific to the research and evaluation findings presented in Volume 1. Additional detailed measure-level analysis will be presented in Volume 2.

The key recommendations presented in Volume 1 are specific to data challenges. The following recommendations are based the whole-building analysis included in Volume 1 and relate to the data quality issues discussed in the Data Challenges section of the report. The Evaluation Team believes that these suggestions will not only benefit the evaluation but will provide valuable data to inform delivery for these programs into the future.

- Identify changes to utility tracking system to ensure consistent and comprehensive tracking of electric and gas account numbers, or some other unique identifier, for program participants;
- Develop a data dictionary clearly documenting tracking data;
- Standardize program tracking data extracts, including consistent use of naming conventions (e.g., measure names or descriptions), and provide comprehensive data fields for key program information, including unique identifiers, *ex ante* fuel savings, subprogram or other categorical participation designation (e.g., HES tier 1 versus tier 2), participant contact information, building and fuel characteristics, and measure details; and
- Standardize queries or take steps (1) to eliminate errors in development of data extracts and (2) to reduce the time and burden associated with common data requests.

An exploration of the drivers of the program realization rates through the measure-level analysis will be presented in Volume 2. Additionally, the Evaluation Team will further explore issues regarding data quality and availability, barriers to measure installations, and potential behavioral changes (e.g., energy education, participant take-back) in the forthcoming process evaluation.

Introduction

This report summarizes the impact evaluation findings of the Home Energy Services (HES) and Home Energy Services – Income-Eligible (HES-IE) programs. Connecticut's Energy Efficiency Board (EEB) contracted the Evaluation Team (Cadmus and NMR) to perform an impact evaluation of the HES and HES-IE programs, which are provided by Connecticut electric and gas utilities: Connecticut Light and Power (CL&P), United Illuminating Company (UI), Southern Connecticut Gas (SCG), Connecticut Natural Gas (CNG), and Yankee Gas (Yankee).

This report consists of two volumes: Volume 1 provides methodology and results of performing a whole-house billing analysis of the HES and HES-IE programs; Volume 2, which will be submitted in May 2014, provides methodology and results of performing a measure-level analysis of these programs, using an evaluation approach that combines billing and engineering analyses. Note that the EEB Evaluation Consultant and Evaluation Team are also engaged in planning additional evaluation studies focused on program process, effective useful life, net-to-gross, and non-energy impacts for both HES and HES-IE programs.

Program Overview

The HES and HES-IE programs target residential customers living in single-family houses or multifamily buildings (for HES, limited to one to four units). The program offers home energy audits to participating customers, regardless of their heating fuel type. Currently, the HES program requires participants to pay $75 for the initial energy audit. In the past, oil- and propane-heat (delivered fuels) customers had to pay larger co-pays, but American Recovery and Reinvestment Act (ARRA) funds, and more recently other Connecticut Energy-Efficiency Fund (CEEF) funds, have allowed the utilities to offer the $75 co-pay to delivered-fuel households as well. Audits are typically provided at no cost to participants of the HES-IE program (although property owners often are subject to co-pays).

Through these audits, technicians identify opportunities for the customers to save energy through a variety of home improvements, as shown in Table 5.

Table 5. Overview of HES and HES-IE Measure Offerings

Measure Type	Measure
Core measures (installed on site during audit)	CFL bulbs
	Low-flow showerheads
	Low-flow faucet aerators
	Air and duct sealing
Additional measures (recommended based on audit results)	**Appliance replacement** (including refrigerators, freezers, clothes washers [HES only], dehumidifiers [HES only], room AC units [HES-IE only])
	Shell measures (including attic and wall, window replacement)
	HVAC equipment (including central AC units, heat pumps, ductless mini-splits)
	Water heater replacement (e.g., heat pump water heaters [HES only])

The HES-IE program offered by CL&P has four components or subprograms (SPs), as outlined in Table 6. The HES-IE program offered by UI also collaborates with the Weatherization Assistance Program (WAP), similar to SP1 for CL&P, but UI does not have the same subprogram structure as CL&P.

Table 6. Overview of CL&P HES-IE Subprograms

HES-IE Component	Description
SP1: Weatherization Projects / DOE Approved Jobs*	Utility-leveraged weatherization projects implemented by agency networks that deliver the federally funded Weatherization Assistance Program
SP2: Individual Customer Work Orders	Comprehensive audit and delivery of energy-efficiency and weatherization services
SP3: Multifamily Comprehensive Projects	Comprehensive audit and delivery of energy-efficiency and weatherization services specific to multi-family buildings in which 75% of residents meet income qualifications
SP4: Neighborhood Canvassing	Neighborhoods with anticipated income-eligible customers receive door-to-door HES-IE marketing and direct-installation measures, feeding into participation in SP2.

* Currently administered by the CT Department of Energy & Environmental Protection (DEEP) but was previously under the jurisdiction of the CT Department of Social Services.

Report Organization

The remainder of this report presents the following sections:

- ***Methodology***, which explains the impact-evaluation tasks, data sources, and analytical approach;
- ***Findings***, which details the key impact results from the evaluation activities for both the HES and HES-IE program, benchmarking results, and associated recommendations; and
- ***Appendices***, which provide supplemental details regarding the impact evaluation methods.

Methodology

Volume 1 of this report provides the detailed methodology associated with performing billing analyses to estimate program-level impacts of the 2011 HES and HES-IE programs. Using this approach, electric and gas energy savings were estimated for each program overall and for each utility. Electric demand and oil/propane impacts were also estimated based on the evaluated energy savings.

Modeling Approach: Electric and Natural Gas Impacts

To estimate actual changes in energy consumption within participating homes, the Evaluation Team used fixed-effects regression models to perform a statistical billing analysis.[4] Using historical billing data from up to a year before and after participation, program-level impacts associated with the HES and HES-IE measure installations were analyzed to estimate electric and gas savings. Weather-normalized models were used to screen the data and to provide a comparison against the final fixed-effects model results. The analysis also included the use of a comparison group based on program participants after 2011. The comparison group is used to control for macroeconomic factors and other exogenous effects that may have affected energy consumption during the timeframe that energy usage was analyzed.

For the model specifications, see Appendix A. Billing Analysis Fixed-Effects Model Specifications.

Data Sources

The following data sources were used in performing the billing analysis:

- ***Program Tracking Data*** for HES and HES-IE programs, provided by CL&P and UI, for all electric and gas participants from January 2011 to October 2013.
  These data included participant names, contact information (e.g., address), unique customer identifiers (e.g., utility account numbers), participation dates, building and fuel usage characteristics (e.g., conditioned square feet, heating and water heating fuel types), and total participant *ex ante* savings estimates. The utilities also provided detailed measure data, which included measure name or description, *ex ante* per-unit measure savings, and measure-specific details used as inputs to the Connecticut Program Savings Documentation (PSD) savings algorithms, such as quantities and efficiency levels.
- ***Billing Data*** for HES and HES-IE participants, provided by CL&P and UI, for all electric and gas participant monthly usage history.
  These data included meter-read dates and all kWh and CCF consumption, by participant account, between January 2010 and October 2013. Usage was allocated to calendar months to account for differences in customer meter-reading cycles.

4 Performing fixed-effects regression models with panel data is consistent with UMP protocols for evaluating whole-building retrofit. Source: UMP Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. https://www1.eere.energy.gov/wip/pdfs/53827-8.pdf

- ***Connecticut Weather Data***, including daily average temperatures from January 2010 through October 2013 for 12 weather stations, corresponding to the nearest monitoring station locations associated with HES and HES-IE participants.
  ZIP codes were used to match daily heating degree-days (HDDs) and cooling degree-days (CDDs) to respective monthly billing data read dates. TMY3 (typical meteorological year) 15-year normal weather averages from 1991–2005 were obtained from the National Oceanic and Atmospheric Administration (NOAA) to assess energy usage under normal weather conditions.
- ***Indicators of "Other" Energy-***Efficiency ***Program Participation Data,*** composed of program tracking data for non-HES/HES-IE program participation. These data contained program name, dates of participation, and measure installation information. These non-HES/HES-IE programs included other energy-efficiency rebate programs and the Home Energy Reports (HER) behavioral program.
  These data were used to identify HES participants who may have received recommendations during their audits but installed the measures through another program. Understanding whether these energy-efficiency improvements happened outside of HES or HES-IE was important for the model to be able to estimate savings accurately for these programs and to avoid attributing savings from other programs to HES or HES-IE.
  HER is a program that focuses on reducing energy consumption through education by increasing customers' awareness of their energy usage relative to their neighbors'. Because HER prompts behavior changes, participation in this program could be partially responsible for changes in the energy consumption observed in homes that also participated in HES and HES-IE. To control for the potential influence of HER, and ensure that any energy savings associated with that program were not attributed to HES/HES-IE, the Evaluation Team flagged all customers who participated by matching the customer account numbers between the two programs' participation tracking databases.
  Rather than excluding HER participants from the HES/HES-IE analysis, the HER participation flag was used as a dummy variable when specifying both the natural gas and electric billing analysis models. This controlled for the impact of the customers' behavior in HER and ensured that HER participation did not bias changes in energy consumption determined for HES and HES-IE.
- ***Connecticut Program Savings Documentation (PSD)***, which is a technical reference manual providing detailed documentation of energy and demand savings calculations, associated with Energy Efficiency Fund programs for specific energy-savings measures. Connecticut utilities offering the HES and HES-IE programs estimate *ex ante* measure savings for these programs based on savings calculations contained in this manual.[5]
- ***Connecticut 2013–2015 Electric and Natural Gas Conservation and Load Management Plan*** (the Plan), providing reported 2011 electric and gas savings by utility that were the basis for calculating total evaluated savings.

[5] http://www.ctenergyinfo.com/sites/default/files/2012%20CT%20Program%20Savings%20Documentation%20FINAL.pdf

- ***Indicators of non-utility funded HES-IE projects,*** flagging those projects which leveraged state or federal funding and may not comprehensively track household-specific installations and associated energy savings.
  A CL&P HES-IE subprogram, SP1, identifies all potential program participants that leverage non-utility funding. SP2, SP3, and SP4 receive complete funding through the utility. UI provided separate data files and merged them to participant data, flagging projects that leveraged either Department of Energy (DOE) or American Recovery and Reinvestment Act (ARRA) funding for HES-IE installations.

Data Challenges

The Evaluation Team addressed several issues with the participation, measure, and billing data, including:

- Delays in receipt of data;
- Lack of a data dictionary;
- Multifamily participant match to billing data;
- Receipt of data files with incorrect unique identifiers;
- Cumbersome formats and organization;
- Inconsistent information provided in repeat requests; and
- Error in mapping fields between billing and participant data files.

One utility provided electric and gas-billing data at the unit level for the majority of multifamily participants, which provided a straightforward mapping between the unit level measure data with the billing data; however, another provided billing data at the facility level. This was particularly significant in the multifamily/HES-IE SP3. In this subprogram, the *ex ante* savings estimates were aggregated to the facility level. To normalize the large usages across the complexes, the number of units needed to be determined.

To do this, the Evaluation Team checked the number of unique sequence numbers and the number of building units based on the measure data, along with Google lookups of the multifamily addresses. The usage per unit was calculated, as well as the *ex ante* estimate per unit. Then, the respective per-unit usages for these HES-IE SP3 customers and *ex ante* estimates were weighted by the number of units in the facility. Thus, a per-unit usage estimate for a 100-unit complex has more weight than a per-unit usage estimate for a 10-unit multifamily complex. This process ensured that all participant and nonparticipant data were analyzed at the unit level.

Challenges were also encountered in attempting to use unique identifiers to map participant data files to the associated billing data. One utility indicated their data management system is unable to assign unique identifiers that can map energy-efficiency projects at the customer level to billing data across different fuels savings. For example, unless program vendors collect account numbers separately for electric and gas, energy-efficiency programs can be assigned only a single fuel-specific account number,

resulting in a potential disconnect between that customer ID and associated billing data. This issue contributed to high attrition in the gas participant samples due to missing and unmatched gas account numbers.

Additional explorations in data quality and availability will be conducted in the Volume 2 report and in the forthcoming process evaluation.

Participant Group

For the impact analysis, data were gathered from a participant (treatment) group composed of HES and HES-IE participants from the 2011 calendar year. Measure installations for these program participants occurred between January 1, 2011, and December 31, 2011. This study focused on the 2011 program year because (1) the analysis needed a complete 12-month period of post-participation billing data, and (2) at the time of evaluating planning, billing data for a complete 2013 period was not available. Because of this timeline, billing data from a complete year before and after program participation was available for 2011.

The population of participants included in the analysis was maximized by using rolling specifications for assigning pre- and post-installation periods. First, the Evaluation Team identified a specific range of months during which measures were installed through the program. Then pre- and post-periods were assigned for the 12 months before and after the installation period. For the entire participant treatment group, the average pre-period of billing data ranged from June 2010 to June 2011, and the average post-period ranged from September 2011 to September 2012.

Starting with a census of participation from this period, a final participant group was identified for the analysis after screening for several criteria. The billing analysis was conducted using participants who had not moved since participating and had at least 10 months of pre-period and post-period billing data. Account-level reviews of all individual participant pre- and post-period consumption were performed to identify anomalies (e.g., periods of unoccupied units) that could bias the results. Additional screening criteria were also applied, which are described in detail in the Data Screening section.

HES-IE Subprogram Participation

Differences in measure offerings, delivery, and data collection across and within the HES-IE program (and subprogram) components posed some challenges in applying the proposed impact methodology uniformly. Two subprograms of CL&P's program posed these issues:

- ***SP1*** uses different funding sources to install measures, leveraging ratepayer funds against non-utility weatherization funding (often from state or federal sources). Utility data tracking did not always clearly delineate measures funded by the utilities' HES-IE program compared to non-utility funding.
- ***SP4*** is a neighborhood canvassing delivery model that focuses primarily on direct-install measures and serves as a mechanism to enroll customers in SP2.

While UI's program did not apply the same subprogram structure and definitions as CL&P's, a percentage of their HES-IE projects in 2011 also received measures installed with non-utility funding (e.g., DOE, ARRA).

For efficiency, data preparation was conducted simultaneously for the measure-level and whole building impact evaluations. The scope for performing measure-level analysis proposed removing the specific participant subpopulations that either (1) were anomalous to the standard program delivery/design, or (2) received non-utility funding (where a complete assessment of measure installations was not tracked). The entire participant analysis sample, which was cleaned and combined with billing data for the measure-specific billing analysis, was used to estimate impacts through the whole-building analysis (excluding CL&P SP1 and SP4 and UI DOE/ARRA projects).

Volume 1 provides preliminary evaluation results for the whole-building impact analysis. Volume 2 explores measure-specific analysis, and estimates whole-building models specifically for CL&P HES-IE SP4 participants.

Program-level adjusted gross realization rates used in this report, generated through the billing analysis, will be applied to the reported *ex ante* savings for all HES and HES-IE program components (including CL&P SP1 and UI DOE/ARRA-leveraged projects) with the exception of CL&P's SP4. The percentage of SP4 savings (calculated based on the *ex ante* savings provided in the utility program tracking data) are used to scale down the HES-IE total reported savings from the Plan. By removing the associated SP4 reported savings, the Evaluation Team has applied the adjusted gross realization rates to calculate evaluated savings for HES-IE SP1, SP2, and SP3. The Savings Calculation section of this report provides more details about this approach.

Control for Non-HES/HES-IE Program Effects

In an effort to isolate the program effect specifically on the measures installed through HES and HES-IE, several steps were taken to control for non-program energy-efficiency installations. This accounted for (1) overlapping HER program participation; (2) non-utility funded installations occurring under HES-IE (e.g., DOE); and (3) overlapping participation in other energy-efficiency programs aside from HES and HES-IE.

In regard to overlapping participation, only about 0.2% of the gas participant population for HES and HES-IE were participating in some other energy-efficiency program during the pre- to post-period of this analysis. For the electric participants, 4% participated in other programs, and 3% participated in HER.

Final Participant Group Analysis Samples

Application of these various filters reduced the size of the participant group available for the billing analysis, for which Table 7 shows final sample sizes. Additional details specific to the screening process are provided in the Data Screening section.

Table 7. Billing Analysis Participant Groups, by Program and Fuel

Participant Group	Electric	Natural Gas
HES	11,110	1,862
HES-IE	5,481	1,250

Comparison Group

As an important aspect of the billing analysis quasi-experimental design, the analysis used a comparison group of "nonparticipants" to account for exogenous factors that may have occurred simultaneous to program activity. These factors can include macroeconomic effects, increases or decreases in energy rates, or other interactions that may have affected energy consumption outside of the program influence. For both HES and HES-IE programs, comparison groups were identified using samples of future program participants who participated after the analysis period, for HES and HES-IE respectively. For this analysis, the comparison group was selected from program participants between approximately October 2012 and September 2013. This group is referred to as nonparticipants or the comparison group.

Using future participants as a comparison group for similar analyses has several advantages, compared to selecting randomly from the customer population. First, the future participants are more representative of the participant treatment group than a random sample of residential customers because they are more likely to closely resemble participants from previous years in terms of energy awareness and pre-program building characteristics. Second, because this population has received program measures, the Evaluation Team was able to control and isolate the installation period of the comparison group to ensure that no program impacts would influence the analysis period.

To maximize the available comparison group sample and to maintain complete separation from the treatment group of 2011 participants, this sample was selected from customers that participated from October 2012 through September 2013. The approach ensured that the comparison group had sufficient billing data (using two complete years for comparison occurring before actual participation) and with both the pre- and post-periods consistent with the average participant pre- and post-participation periods. The comparison group pre-period of billing data ranged from June 2010 to June 2011, and the post-period ranged from September 2011 to September 2012, each period reflecting the average participant ranges.

Final Comparison Group Analysis Samples

The comparison group was similar to the participant group in that the application of several data screens reduced the size of the group that was available for the billing analysis. Table 8 shows the final sample sizes. The Data Screening section provides more details specific to the screening process.

Table 8. Billing Analysis Comparison Group, by Program and Fuel

Comparison Group	Electric	Natural Gas
HES	8,547	1,192
HES-IE	5,430	644

Savings Calculation

The Evaluation Team is reporting adjusted gross savings as the final estimate of program impacts. Adjusted gross savings is derived from "adjusting" evaluated participant savings based on changes in energy usage of a comparison group. Since savings are being adjusted based on a comparison group and not a true control group (i.e., randomized controlled trial experimental design), the adjusted gross savings is expected to account for some freeridership and spillover, but likely does not fully account for them. If freeridership and spillover were fully accounted for, then final estimates could be labeled net savings rather than adjusted gross savings. [6] For these reasons, these savings are defined as *adjusted gross savings* for this analysis.[7]

Model-Specific (Average Participant) Evaluated Savings

Since comparison group pre-period usage may not be identical to the participant pre-usage, a "percent of pre" approach was used to obtain the adjusted gross participant savings. The following formula depicts this specific calculation for adjusted gross participant savings:

$$Adj.\,Gross\,Savings = (Pre\,Part\,Usage)\left(\frac{Part\,Change\,In\,Usage}{Pre\,Part\,Usage} - \frac{NonPart\,Change\,In\,Usage}{Pre\,NonPart\,Usage}\right)$$

Through this process, instead of taking the difference between the participant savings delta and the nonparticipant savings delta (i.e., a difference-of-differences approach), the percentage reduction of both the participant and the nonparticipant groups (specifically, savings as a percentage of weather-normalized pre-period energy consumption) were obtained. The percentage reduction representative of adjusted gross savings is the participant percentage-change reduction minus the nonparticipant percentage reduction. This adjusted gross percentage reduction can then be multiplied by the participant pre-period usage to obtain the adjusted gross participant savings, thus effectively accounting for the differences in pre-period usage between participants and nonparticipants.

[6] UMP Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. https://www1.eere.energy.gov/wip/pdfs/53827-8.pdf

[7] As noted, the EEB Evaluation Consultant and Evaluation Team are engaged in planning an additional evaluation study focused on net-to-gross for these programs, primarily for HES. It is common best practice within the energy efficiency EM&V community to assume that the NTG ratio for low-income programs is 1.0, since these participants are unlikely to install these measures on their own due to significant affordability barriers.

Overall Program-Year Evaluated Savings

Given discrepancies between the total savings in the program-tracking data received compared to those savings reported in the Plan, the Evaluation Team relied on the adjust gross realization rates that were calculated via billing analysis (for specific analysis samples) to calculate evaluated total program-year savings. First, estimates of adjust gross savings were developed through the billing analysis and compared these average model savings estimates to average *ex ante* participant savings (reported in the utility tracking data) to calculate the adjusted gross realization rate. Then these adjusted gross savings realization rates, by utility program and fuel, were applied to the overall 2011 program-year reported savings from the Plan to derive the evaluated adjusted gross savings for the 2011 program year.

As noted in the Participant Group section, neither CL&P's HES-IE SP1 nor SP4 were included in the analysis sample used in the billing analysis for this evaluation. A separate tailored approach was developed for treating each of these subprograms in estimating overall program-year evaluated savings.

Since CL&P's HES-IE SP1 participants received non-utility funded installations, the billing analysis was restricted to SP2 and SP3 participants to assess an unadulterated utility-program effect; by allowing SP1 participants into the analysis, a portion of the modeled energy savings would be attributed to non-utility funded measures, further influencing the calculation of the adjusted gross realization rate. Given similarities between the type and distribution of energy-efficiency installations delivered through CL&P's HES-IE SP1 and SP2, realization rates calculated from the SP2 billing analysis were applied to the portion of reported savings associated with SP1 (i.e., applied to only with those measures paid for by the utility).

Regarding SP4, the Evaluation Team removed the portion of savings attributed to this subprogram from overall CL&P HES-IE savings from the Plan for the Volume 1 report. Given the distinct nature of delivery and measures, none of the realization rates calculated through billing analysis models of other subprograms were appropriate proxies to apply in the interim. A billing analysis of this specific subprogram is performed in the Volume 2 report to assign evaluated savings.

Table 9 provides the percentage assumptions used for disaggregating reported HES-IE savings reported in the Plan. These percentages were calculated based on the participant tracking data provided by the utilities.

Table 9. Percentage of HES-IE Savings Attributed to Subprograms or DOE/ARRA Projects

Fuel	Utility	Percentage of HES-IE Savings		
		SP1	SP4	DOE/ARRA Projects
Electric	CL&P	12%	27%	n/a
	UI	n/a	n/a	1%
Gas	CNG	11%	6%	n/a
	SCG	n/a	n/a	5%
	YGS	5%	16%	n/a

* Since gas utilities territories are composed of both CL&P and UI electric customers, and the subprogram construct is specific to CL&P HES-IE delivery, the proportion of gas savings for CL&P and UI from the program tracking data was used to differentiate the portion of reported HES-IE gas savings for CNG and YGS associated with specific subprograms.

Demand Impact Approach

The study's primary focus is evaluating energy savings through billing analysis; program-level demand impacts is also provided by applying the realization rates based on the energy impact analysis to the 2011 demand savings reported in the Plan.[8] Estimation of demand impacts using PSD coincidence factors will be conducted in the Volume 2 analysis.

Estimating Oil/Propane Impacts

Because oil and propane are not metered, and the fuel sales data are often difficult to access, are not always reliable, or are not available in electronic format, a direct calibrated analysis of oil and propane households was not performed. Instead, to develop an estimate of oil and propane savings based on the program-level billing analysis, conversion factors were used to extrapolate impacts in relation to those savings occurring in natural-gas homes. This approach assumes that homes using propane or oil heat have similar construction features and base loads as those heated with natural gas.

The conversion factors and equations provided in the PSD were used for these conversions. For thermal enclosure, duct sealing, and water-consumption savings measures, the PSD provided the following general equation for fuel savings conversion:

$$Fuel\ Savings = \frac{Btu\ Savings}{System\ Efficiency \times Fuel\ Conversion}$$

[8] As a supplemental analysis, the Evaluation Team has proposed performing a more detailed demand-impact modeling approach for evaluating demand savings. This approach would use end-use load shapes and several peak period definitions (seasonal versus on peak) to estimate demand associated with program measure activity for a specific program period.

In this equation, Btu Savings refers to the reduced amount of heat transfer from the improvement in envelop or duct measures, or the reduced amount of heated water used at the faucet or showerhead. The following fuel conversions, provided in the PSD, were used as inputs into this equation for fuel conversion:

- Natural gas: 100,000 Btu/therm
- Natural gas: 102,900 Btu/CCF
- Oil: 138,690 Btu/gallon
- Propane: 91,330 Btu/gallon

The assumed system efficiencies in the PSD are equivalent for each fuel type for the thermal enclosure, duct sealing, and water-consumption reduction measures. This simplifies the savings conversion from natural gas to oil or propane, as shown in the following equation:

$$Fuel\ Savings\ (Gallons) = \frac{Natural\ Gas\ Fuel\ Savings\ (CCF) \times 102{,}900\ (\frac{Btu}{CCF})}{Fuel\ Conversion\ (\frac{Btu}{Gallon})}$$

Specifically, the following conversion factors are used:

- CCF to gallons of oil: 0.7419
- CCF to gallons of propane: 1.1267

To ensure that savings are comparable, the measure distribution of gas-savings homes from the analysis sample was compared to the measure distribution of oil- and propane-heated households.

The Volume 1 analysis is based on the associated impacts for program participants included in the gas billing analysis, assuming that the savings associated with a typical mix of measures that drive gas impacts can be extrapolated to the population of oil- and propane-savings participants. Volume 2 of this analysis will explore the impacts of oil and propane associated with the specific participant population and the energy-savings measures for which they occur.

Data Screening

General Screens

The following screens removed anomalies, incomplete records, and outlier accounts that could have biased savings estimations:

- Inability to merge the participant and measure data with the billing data, including instances of customers for which different addresses are listed between the participant data, measure data, and billing data files;
- Insufficient billing data for accounts with fewer than nine months (270 days) of billing data in the pre- or post-period;

- Accounts that change electric or gas usage from the pre- or post- period by more than 70%;[9]
- Accounts with low annual usage in the pre- or post-period (e.g., less than 1,000 kWh for electric, or less than 200 CCF for gas); [10]
- Customers for which the *ex ante* savings estimate exceeds the pre-period usage, or where the *ex ante* savings estimate is less than 1% of the pre-period usage;[11]
- For the comparison group, any nonparticipants with higher per-unit usage compared to the maximum participant per-unit usage; [12] and
- Other extreme values, including vacancies in the billing data (outliers); heating or cooling system changes (e.g., adding or removing heating or cooling loads); base-load equipment changes; or changes in occupancy. [13]

Weather Normalization Model Screens

The primary models used for obtaining energy savings were pooled fixed-effects models; additional models were run for initial data processing, additional screening, and comparison to the final energy model savings. Specifically, models similar to Princeton Scorekeeping Method (PRISM) were used to weather-normalize pre- and post-billing data for each account, and to provide an alternate check on measure savings obtained from the pooled fixed-effects model.

For each participant home, three models in both the pre- and post-periods were run to weather-normalize the raw billing data:

- Heating and cooling
- Heating only
- Cooling only

See Appendix B. PRISM Model Specifications for more detail.

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9 Changes in usage of this magnitude are probably due to vacancies, home remodeling or addition, seasonal occupation, or fuel switching. Changes of usage over a certain threshold are not anticipated to be attributed to program effects and can confound the analysis of consumption for this purpose.

10 As a reference point, the average CL&P household uses approximately 800 kWh each *month*; therefore, *annual* usage less than 1,000 is very low for residential households in Connecticut.

11 That is, if the program estimated that the household would save more energy than it actually used in the first place. If the *ex ante* savings exceed the pre-period usage, a high probability exists of either vacancies in the pre-period or potential inconsistencies in matching measure and billing data. In instances where *ex ante* savings are less than 1% of the pre-period usage, the impact will be too insignificant to capture through a billing analysis.

12 Nonparticipants with larger usage than the maximum participant usage are removed to ensure that the comparison group more closely resembles the participant group in terms of energy consumption.

13 Base-load changes could include adding or removing appliances (such as a refrigerator or water heater) or changes in occupancy; in either case, this may convolute the analysis for distinguishing program effects.

Through this process, the Evaluation Team dropped gas customers from the analysis in cases where the model heating parameters were negative, indicating an inconsistency in heating energy-usage trends that corresponded to increases or decreases in HDDs. Specifically for the electric billing analyses, customers were dropped for which all models (heating and cooling, heating only, cooling only) yielded negative heating, cooling, and base-load parameters.

Model Attrition

Application of these screens resulted in final cleaned, matched analytic HES samples consisting of 11,110 participants and 8,547 nonparticipants in the electric analysis, and 1,862 participants and 1,192 nonparticipants in the gas analysis.

For more detail on HES model attrition, reference Appendix C. Model Attrition.

Main sources of attrition in the HES participant electric models included insufficient pre- and post-period months of billing data and outlier removal, for which the latter involved detailed review of individual participant pre- and post-period consumption. Due to level of rigor involved in the outlier review process, this review was performed only on the participant groups for both gas and electric analyses.

The primary driver of attrition in the HES gas models was the inability to match the program tracking data (including participant and measure data files) to the billing data. As mentioned in the Data Challenges section, a key contributor to this issue is that the utility customer data-tracking system has limited ability to assign unique identifiers that can map energy-efficiency projects to billing data across different fuels' saving participants.

Application of these screens resulted in overall cleaned, matched HES-IE samples consisting of 5,481 participants and 5,430 nonparticipants in the electric analysis, and 1,250 participants and 644 nonparticipants in the gas analysis.

Similar to HES, the main sources of attrition in the HES-IE participant electric models included insufficient pre- and post-period months of billing data and outlier removal. Challenges for HES-IE gas participants are comparable to those for HES, with attrition in the HES-IE gas models primarily driven by the inability to match the program tracking data (including participant and measure data files) to the billing data.

For more detail on HES-IE model attrition, reference Appendix C. Model Attrition.

HES Findings

Overall Results

This section presents evaluated savings estimates for the HES program, covering electric, natural gas, and oil/propane fuel types. The results are grouped by fuel savings. Specific to the electric and gas findings, several detailed tables are presented to help contextualize the evaluated impacts as a result of the billing analysis, including measure distributions and findings specific to distinct analysis samples included through modeling (e.g., by utility, by building type).

Weather-normalized annual consumption in the pre-program period (PRENAC) is included in these results to characterize the average energy consumption of the participant and comparison groups prior to any program treatment. Additionally, consideration of program impacts in terms of savings as a percentage of pre-period usage (i.e., PRENAC) is a helpful metric for comparison purposes and for assessing the magnitude of program impacts, since this ratio normalized these savings relative to consumption levels.

Electric Savings

Billing Analysis Results

Table 10 compares changes in energy consumption from the pre- to post-program periods for the participant and comparison groups. Estimated adjusted gross savings are included, calculated based on the "percent of pre" approach discussed in the Savings Calculation section of the methodology.

Table 10. HES Electric Billing Analysis: Savings Summary, Overall

Group	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Participant	11,110	11,278	1,096	10%	±2%	1,071	1,122
Comparison	8,547	10,666	28	0%	±112%	-3	60
Adjusted gross	11,110	11,278	1,067	9%	±4%	1,026	1,107

Participants achieved estimated gross energy savings of 1,096 kWh. A slight decrease in electric usage detected in the comparison group resulted in an adjusted gross savings estimate of 1,067 kWh.

Table 11 shows additional utility-specific models, which disaggregate the overall HES program results shown above for the participant, comparison group, and adjusted gross savings estimates.

Table 11. HES Electric Billing Analysis: Savings Summary, by Utility

Group	Utility	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participant	CL&P	8,695	11,878	1,146	10%	±3%
	UI	2,415	9,159	972	11%	±5%
	Overall	**11,110**	**11,278**	**1,096**	**10%**	**±2%**
Comparison	CL&P	7,043	11,061	59	1%	±61%
	UI	1,504	8,896	-79	-1%	±85%
	Overall	**8,547**	**10,666**	**28**	**0%**	**±112%**
Adjusted gross	CL&P	8,695	11,878	1,082	9%	±4%
	UI	2,415	9,159	1,053	12%	±8%
	Overall	**11,110**	**11,278**	**1,067**	**9%**	**±4%**

Savings as a percentage of pre-usage are quite similar among HES participants across utilities. CL&P participants demonstrate slightly higher electric savings, though higher pre-period usage results in percentage savings approximately 1% less than that of UI participants.

Changes in comparison group usage reveal slight increases in consumption for UI nonparticipants, while CL&P nonparticipants are showing minor decreases in consumption. These effects result in nearly equivalent adjusted gross electric savings across the utility programs: approximately 1,082 kWh for CL&P and 1,053 kWh for UI.

Table 12 shows the frequency distribution of measure installations occurring in the analysis sample of participants, by electric utility, along with the average reported savings per measure type. The Evaluation Team stresses that the measures did not serve as model inputs. Instead, the listing of measures and their *ex ante* per-unit savings estimates provides context for understanding the model results.

Table 12. HES Electric Analysis: Measure Distribution of Final Model Sample

Category	Measure	Percentage of Sample		Average *Ex Ante* Savings by Measure (kWh per Participant)	
		CL&P	UI	CL&P	UI
Lighting	Lighting	97%	97%	661	622
Water heat	DWH bundle*	12%	9%	546	479
	Pipe insulation	9%	<1%	101	95
	Heat pump water heater	<1%	<1%	1,762	1,762
Shell	Air sealing	76%	67%	163	117
	Attic insulation	n/a	<1%	n/a	110
	Wall insulation	n/a	<1%	n/a	90
	Windows	<1%	n/a	482	n/a
	Insulation other **	4%	n/a	368	n/a
HVAC	Duct sealing	15%	30%	310	292
	Central AC	1%	4%	230	173
	Heating system replacement	<1%	<1%	288	293
	Heat pump	<1%	<1%	1,136	728
	Ductless heat pump	<1%	<1%	2,969	2,152
	Ground-source heat pump	<1%	n/a	2,630	n/a
Appliance	Refrigerator	<1%	1%	247	234
	Dehumidifier	<1%	<1%	398	172
	Clothes washer	<1%	<1%	364	102
	Freezer	<1%	n/a	638	n/a
Other	Other	n/a	<1%	n/a	259
Sample (n)		**8,695**	**2,415**		

* Contains a mix of low-flow showerheads and faucet aerators

** Projects consist of insulation installations without location description

In general, installation activity for both utility HES programs (and the associated electric impacts) is characterized by high frequencies of energy-efficient lighting (97% for CL&P, 97% for UI) and air sealing (76%, 67%), along with duct sealing (15%, 30%) and hot-water savings measures (12%, 9%). This mix of measures composes the "core" installations that occur during the initial in-home visit, in which an HES program technician performs an audit to assess home energy performance. Based on the recommendations for deeper energy-saving measures, participants can opt to use HES-specific rebates for subsequent measure installations such as insulation or replacement of appliance or HVAC systems.

Installations for the participant analysis sample reveal lower levels of these "add-on" rebated measure options. In part, this may be due to higher saturations of non-electric heating or water, which would

mean that the measures such as insulation would result in natural gas, fuel oil, or propane savings, not electric savings.[14] However, appliance installations are also infrequent relative to the total participant sample (for most, occurring in less than 1% of the participants).

The majority of average per-participant *ex ante* measure savings estimates are similar across utility program participants. The only exceptions occur for heat pumps, dehumidifiers, and clothes washers, where CL&P average per-unit savings is noticeably higher than the UI estimates. Given such low frequencies of these measure installations, deviations in these *ex ante* savings are unlikely to produce a significant effect in consideration of realized savings. A further review of these measure-specific differences is presented in Volume 2 of this evaluation report.

A key implication of this measure mix—which despite being skewed towards small measures rather than big savings ones is still producing reliable electricity savings—is that these impacts will primarily affect electric base load, with slight effects on heating and cooling.

To provide some additional context around the program-specific impacts, Table 13 and Table 14 show the HES adjusted gross energy savings by heating type (electric versus non-electric) and building type (single family versus multifamily).

Table 13 provides transparency around the larger absolute energy savings that are associated with electrically heated homes, over 70% higher than non-electrically heated homes. Yet, the electric heat homes are a small part of the sample, which is why overall savings, percent savings, and precision more closely resemble non-electric homes than electric ones. Consideration of savings as a percentage of PRENAC indicates that these are relatively similar and consistent with the overall model results.

Table 13. HES Electric Billing Analysis: Savings Summary, by Participant Heating Fuel (Adjusted Gross)

Participant Heating Type	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Electric	1,042	17,642	1,720	10%	±10%
Non-electric	10,068	10,621	999	9%	±4%
Overall	**11,110**	**11,278**	**1,067**	**9%**	**±4%**

Table 14 shows that the bulk of HES electric-savings participants occur in single-family homes, demonstrating slightly higher savings than in multifamily units. However, it is important to note that while there is a savings discrepancy of about 300 kWh on average between these participant types, lower pre-period usage for multifamily participants results in a higher savings as a percentage of PRENAC.

[14] Approximately 9% of the HES participant sample in the electric models was identified as electrically heated.

Table 14. HES Electric Billing Analysis: Savings Summary, by Building Type (Adjusted Gross)

Participant Heating Type	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Single family	10,589	11,552	1,084	9%	±4%
Multifamily	521	6,177	761	12%	±16%
Overall	**11,110**	**11,278**	**1,067**	**9%**	**±4%**

Realization Rate

Table 15 provides realization rates based on the participant gross and adjusted gross savings for the billing analysis sample.

Table 15. HES Electric Billing Analysis: Realization Rate Summary

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CL&P	1,146	936	122%	10%	8%
	UI	972	837	116%	11%	9%
	Overall	**1,096**	**914**	**120%**	**10%**	**8%**
Adjusted gross savings	CL&P	1,082	936	116%	9%	8%
	UI	1,053	837	126%	12%	9%
	Overall	**1,067**	**914**	**117%**	**9%**	**8%**

Participants of both CL&P and UI programs are observing realization rates higher than 100%. Average *ex ante* savings for participants are similar across utility-programs (these vary by approximately 100 kWh). For each utility program, evaluated per participant savings estimated through the billing analysis are higher than the *ex ante* estimates. Even accounting for the nonparticipant adjustment, realization rates for both HES electric impacts are over 100%, averaging approximately 117% for the program statewide.

Overall HES Electric Program Results

Table 16 provides overall 2011 HES electric energy savings, by utility and overall. In this table, realization rates based on the specific billing-analysis model groups by utility are applied to the 2011 *ex ante* savings as reported in the Plan.

Table 16. Total 2011 Evaluated HES Electric Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate
CL&P	15,886	16,190	18,730	116%
UI	5,329	3,541	4,454	126%
Program Overall**	**21,215**	**19,731**	**23,184**	**117%**

* Totals may not add up to the sum of individual values due to rounding.

** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.

Demand Savings

Table 17 provides evaluated adjustments to the reported demand impacts from the Plan. Realization rates developed through the electric HES billing analysis were applied to reported demand savings by utility.

Table 17. Total 2011 Evaluated HES Demand Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Demand Savings (kW)	Evaluated Adjusted Gross Demand Savings (kW)	Adjusted Gross Realization Rate
CL&P	15,886	2,521	2,917	116%
UI	5,329	714	898	126%
Program overall**	**21,215**	**3,235**	**3,815**	**118%**

* Totals may not add up to the sum of individual values due to rounding.

** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.

Natural Gas Savings

Billing Analysis Results

Table 18 compares changes in energy consumption from the pre- to post-program periods for the participant and comparison groups. Estimated adjusted gross savings are included, calculated based on the “percent of pre” approach discussed in the Savings Calculation section of the methodology

Table 18. HES Natural Gas Billing Analysis: Savings Summary, Overall

Group	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (CCF)	Savings Upper 90% (CCF)
Participants	1,862	1,051	72	7%	±6%	68	76
Comparison	1,192	999	17	2%	±25%	12	21
Adjusted gross	1,862	1,051	55	5%	±12%	48	61

Participants achieved estimated gross energy savings of 72 CCF. A slight decrease in gas usage detected in the comparison group resulted in an adjusted gross savings estimate of 55 CCF.

Table 19 presents additional utility-specific models that disaggregate the overall HES program results shown above for the participant, comparison group, and adjusted gross savings estimates.

Table 19. HES Natural Gas Billing Analysis: Savings Summary, by Utility

Group	Utility	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participants	CNG	649	1,160	76	7%	±10%
	SCG	461	1,053	61	6%	±13%
	YGS	752	957	76	8%	±8%
	Overall	**1,862**	**1,051**	**72**	**7%**	**±6%**
Comparison	CNG	508	1,041	15	1%	±43%
	SCG	243	1,052	14	1%	±68%
	YGS	441	922	19	2%	±33%
	Overall	**1,192**	**999**	**17**	**2%**	**±25%**
Adjusted gross	CNG	649	1,160	59	5%	±17%
	SCG	461	1,053	46	4%	±27%
	YGS	752	957	55	6%	±16%
	Overall	**1,862**	**1,051**	**55**	**5%**	**±12%**

Average participant savings for CNG and YGS appear to be similar, at 76 CCF each, while average gross participant savings for SCG are approximately 20% lower (61 CCF). Comparison groups for each gas utility are saving a roughly consistent amount of energy during the analysis period (1 to 2% of PRENAC). Adjusted gross savings by utility program are similar in proportion to the participant gross savings, with comparable gas savings between CNG and YGS, and slightly lower SCG impacts.

Table 20 shows the frequency distribution of measure installations occurring in the analysis sample of participants, along with the average reported savings per measure type. Upon review of the utility program tracking data, the Evaluation Team determined UI insulation formulas are based on changes in

R-value and are not constant *ex ante* savings per square foot (like CL&P). For SCG, the median wall R-value is 0, for which 0.28 CCF per square foot is assigned; the median attic R-value is 19, for which 0.047 CCF per square foot is assigned. This infers that average SCG participant homes have higher levels of baseline insulation in attics, resulting in larger incremental savings for wall insulation projects (most often relative to no pre-existing levels of insulation).

Table 20. HES Natural Gas Analysis: Measure Distribution of Final Model Sample

Category	Measure	Percentage of Sample			Average *Ex Ante* Savings by Measure (CCF per Participant)		
		CNG	SCG	YGS	CNG	SCG	YGS
Shell	Air sealing	90%	97%	91%	62	64	61
	Attic insulation	n/a	3%	n/a	n/a	114	n/a
	Wall insulation	n/a	1%	n/a	n/a	287	n/a
	Insulation other	<1%	n/a	<1%	228	n/a	69
	Windows	n/a	n/a	<1%	n/a	n/a	19
Water heating	DWH bundle*	67%	75%	63%	32	27	29
	Pipe insulation	50%	6%	48%	6	6	5
HVAC	Duct sealing	12%	26%	15%	42	48	53
	Heating system replacement	<1%	<1%	<1%	304	282	171
Appliance	Clothes washer	n/a	<1%	n/a	n/a	8	n/a
Sample (n)		**649**	**461**	**752**			

* Contains a mix of low-flow showerheads and faucet aerators

In general, installation activity for each of the utility HES programs (and the associated gas impacts) is characterized by high frequencies of air sealing (90% for CNG, 97% for SCG, and 91% for YGS), hot-water savings measures (67%, 75%, 63%), and pipe insulation for CNG (50%) and YGS (48%). In addition to air sealing, duct sealing represents another high gas-saving measure, occurring for 12% of CNG, 26% of SCG, and 15% of YGS participants.

As discussed in the Data Challenges section, high attrition of gas participants occurred due to lack of available account numbers and ability to merge these customers with billing data. As a result, frequencies of certain measures may be underrepresented in cases where higher proportions of accounts that received these measures are screened out of the analysis. For example, CL&P provided a dataset of nearly 400 participants receiving various types of insulation; only seven of these participants had gas account numbers listed, which are requisite for matching to billing data for performing this analysis. While these accounts represent only approximately 8% of the total HES gas accounts prior to

screening, it is not possible to be certain that the attrition is entirely random and the results are not biased, since they are based on data where the billing records could be matched.

Table 21 shows that the majority of HES gas-savings participants occur in single-family homes, which is consistent with the HES electric participant distribution.

Table 21. HES Natural Gas Billing Analysis: Savings Summary, by Building Type (Adjusted Gross)

Participant Heating Type	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Single family	1,784	1,063	56	5%	±10%
Multifamily	78	786	21	3%	±128%
Overall	**1,862**	**1,051**	**55**	**5%**	**±12%**

Realization Rate

Table 22 provides realization rates based on the participant gross and adjusted gross savings for the billing analysis sample.

Table 22. HES Natural Gas Billing Analysis: Realization Rate Summary

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CNG	76	88	86%	7%	8%
	SCG	61	103	59%	6%	10%
	YGS	76	85	89%	8%	9%
	Overall	**72**	**91**	**80%**	**7%**	**9%**
Adjusted gross savings	CNG	59	88	67%	5%	8%
	SCG	46	103	45%	4%	10%
	YGS	55	85	65%	6%	9%
	Overall	**55**	**91**	**60%**	**5%**	**9%**

Average expected gas savings for HES participants are higher in each case than savings estimated through the model. In accounting for the nonparticipant savings, adjusted gross realization rates are reduced slightly from those reported for gross savings.

Overall HES Gas Program Results

Table 23 provides overall 2011 HES gas energy savings, by utility and overall. In this table, realization rates based on the specific billing-analysis model groups by utility are applied to the 2011 *ex ante* savings as reported in the Plan.

Table 23. Total 2011 Evaluated HES Gas Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjust Gross Savings (000s CCF)	Adjusted Gross Realization Rate
CNG	1,895	196	132	67%
SCG	2,369	243	110	45%
YGS	1,811	172	112	65%
Program overall**	**6,075**	**611**	**354**	**58%**

* Totals may not add up to the sum of individual values due to rounding.

** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.

The Evaluation Team will explore the discrepancies driving the differences in realization for specific measures in Volume 2. A thorough understanding of *ex ante* calculations and the high-frequency measures that characterize program savings will be important in assessing whether measure-specific *ex ante* assumptions may deviate from the actual population, or whether other impacts to consumption (e.g., take-back, behavior change) or installation are driving these differences in savings from the planning estimates.

Oil/Propane Savings

Table 24 provides extrapolated oil and propane savings based on: (1) the participant population reporting oil/propane savings tracked in the utility data, (2) the distribution of these participants by heating and water heating types, and (3) the application of evaluated adjusted gross savings from the gas billing analysis models.

Table 24. HES Total Evaluated Oil and Propane Savings, by Heating and Water Heating Fuel Type

Fuel Type	Configuration	n	Gas Model Savings (CCF per participant)	Conversion Factor (gallons/CCF)	Converted Oil/Propane Savings (gallons per participant)	Total Oil/Propane Savings (gallons)
Oil	Heating Only	3,693	41	0.7419	30	112,506
	Water Heating Only	187	14	0.7419	10	1,899
	Combo	8,196	55	0.7419	41	332,918
	Overall	**12,076**	**n/a**	**n/a**	**n/a**	**447,323**
Propane	Heating Only	238	41	1.1267	46	11,011
	Water Heating Only	166	14	1.1267	15	2,560
	Combo	365	55	1.1267	62	22,516
	Overall	**769**	**n/a**	**n/a**	**n/a**	**36,087**

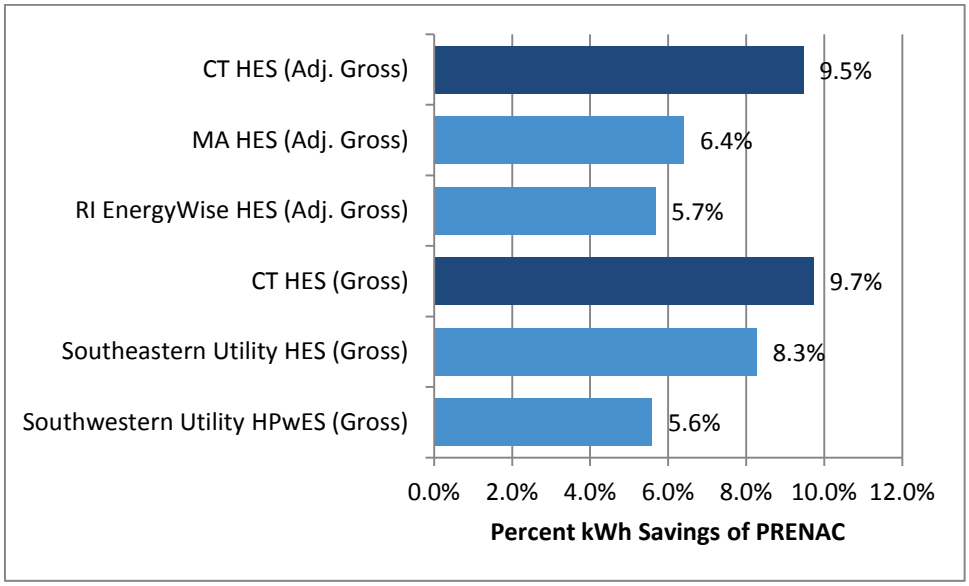
Benchmarking

Benchmarking: HES Electric

To provide context for the program's savings estimates, Figure 1 compares results from other similar energy-efficiency programs that offered an initial home audit with direct-installation and options for add-on measures (e.g., equipment, insulation).[15] The first three bars compare programs with evaluated adjusted gross savings, while the remaining bars compare only gross estimates of savings (i.e., no adjustment for nonparticipants).

[15] The comparables are Massachusetts HES, Rhode Island EnergyWise HES, and two similar utility programs from the Southeast and Southwest.

Figure 1. Evaluated HES Electric Impact Comparison: Savings Percentage of Pre-Installation Period Consumption



As shown in the figure, the Connecticut HES program's electric savings percentages were slightly higher than the range of estimates observed through other programs. However, to provide a meaningful comparison, it is important to consider the primary electric-savings measures that drive the impacts of each of these programs.

The CT HES electric impacts were characterized primarily by installations of CFLs, hot-water savings measures, and air sealing, but the mix of measures varied in the other programs. These programs' savings were composed primarily of the following measures:

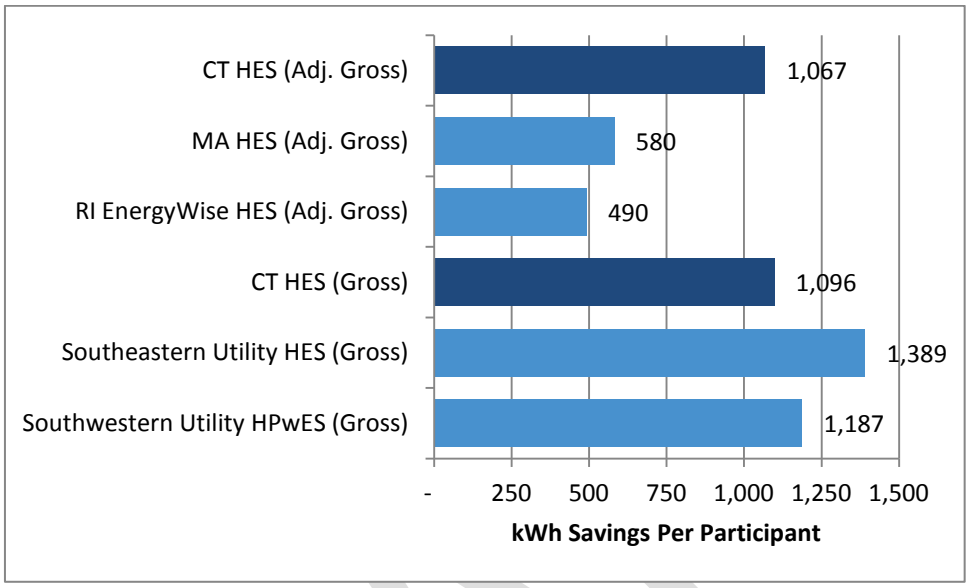
- CT HES: lighting (97%), air sealing (74%), duct sealing (19%), hot-water saving (12%)
- MA HES: lighting (99%), refrigerators (5%), fan savings (32%), (only base-load measures; did not include electric heating participants or shell measures)
- RI EnergyWise HES: lighting (96%), with low frequencies of appliances (e.g., 3% refrigerators), not water heating
- Southeastern utility HES: attic insulation (95%), HVAC (10%), air sealing (10%), lighting (2%)
- Southwestern utility HPwES: lighting (92%), insulation and duct sealing (42%), hot-water saving (53%)

Despite variation in the types of electric-saving measures installed through these programs, Connecticut's HES program savings of approximately 9.5 to 9.7% of pre-installation period usage appeared relatively high by comparison.

Absolute estimates of savings should also be considered. The Evaluation Team normalized the percentage comparison to average the level of pre-installation period consumption, which accounted

for the variation in participation across different geographies, climates, and levels of electric heating and cooling saturations. Figure 2 compares average per-participant kWh savings from the comparable studies.

Figure 2. Evaluated HES Electric Impact Comparison: Average Per-Participant Savings



As shown, average kWh for Connecticut's HES program participants was less than the average for several other programs; compared to approximately 11,278 kWh in Connecticut, the average participants' pre-installation period consumption of these other programs ranged between 16,000 kWh and 22,000 kWh. In the higher kWh-saving programs, more electric heating (and cooling) and more installations of shell measures (e.g., insulation) appeared to drive these differences. Compared to the Massachusetts HES, higher installations of air sealing, duct sealing, and hot-water savings probably contributed to increased electric savings in Connecticut.

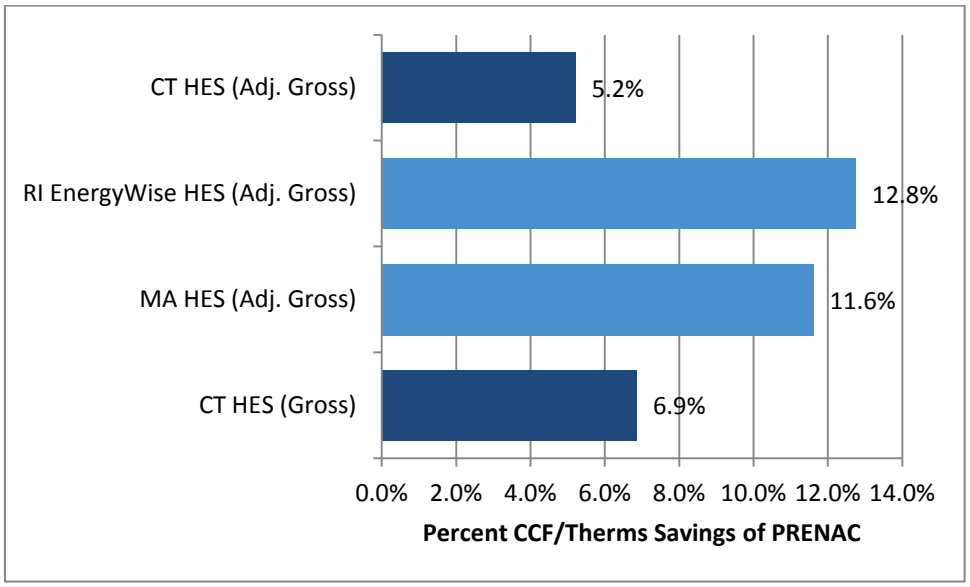
A comparison of total 2011 program expenditures to the total reported savings (from the Plan) reveals an expected $/kWh ranging from $0.93 per kWh to $0.96 per kWh across the Connecticut HES electric utility programs. These metrics provide some context around the anticipated program cost-effectiveness associated with *ex ante* savings and costs associated with the measure mix, delivery, and program administration. To contract the Connecticut programs, similar electric-savings HES programs for four Massachusetts utilities showed a range between $1.25 per kWh to $1.44 per kWh for 2011 program activity, reflecting a higher expected program cost relative to reported savings.[16]

[16] Massachusetts Utility Mid-Term Modifications to Three-Year Plans for 2011 (Exhibit G (08-50 Tables)). Massachusetts Energy Efficiency Advisory Council. http://www.ma-eeac.org/Mid-Term%20Modifications.html

Benchmarking: HES Gas

To provide context for the program's savings estimates, Figure 3 compares results from other similar energy-efficiency programs that offered an initial home audit with direct-installation and options for add-on measures (e.g., equipment, insulation).[17] The first three bars compare programs with evaluated adjusted gross savings, while the remaining bar provides the Connecticut HES gross estimates of savings (i.e., no adjustment for nonparticipants).

Figure 3. Evaluated HES Gas Impact Comparison: Savings Percentage of Pre-Period Consumption



As shown in the figure, the Connecticut HES program's gas savings percentages were below the range of estimates observed in similar programs. It seems likely this disparity was attributed to the primary gas-savings measure mix driving each of these programs' impacts. While the CT HES gas impacts were characterized primarily by projects receiving air sealing, duct sealing, and hot-water savings measures, each of the other programs had higher installations of shell measures, such as attic, wall, and floor insulation.

Under Connecticut's HES program, insulation and equipment replacements are part of the add-on measures recommended through the audit, which the participant decides whether to install, and appeared to differ from comparable programs.

The comparable programs' savings primarily comprised the following mixture of measures:

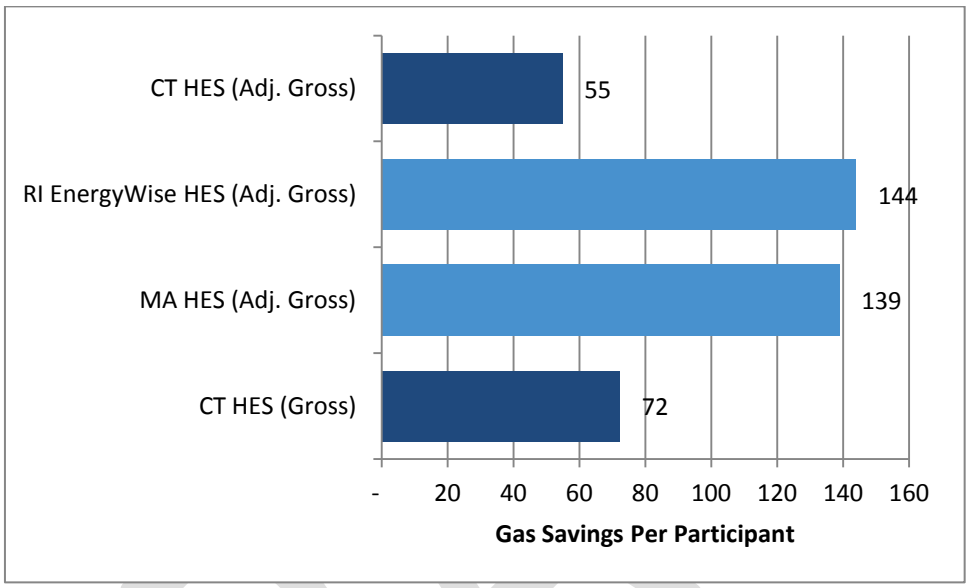
- CT HES: air sealing (92%), hot-water saving (67%), pipe insulation (39%), duct sealing (17%)
- RI EnergyWise HES: air sealing (55%), attic/wall/floor insulation (47%, 23%, 20%), showerheads (17%)

[17] The comparables are Massachusetts HES and Rhode Island EnergyWise HES.

- MA HES: air sealing (80%), attic/wall/floor insulation (36%, 20%, 12%), some water-savings measures

A comparison of absolute estimates of savings presented a similar story. While Figure 4 shows average gas savings (including CCF and therms), regardless of the normalized pre-installation period consumption, Connecticut's HES program showed lower estimates of savings by comparison.

Figure 4. Evaluated HES Gas Impact Comparison: Average Per-Participant Savings



HES-IE Findings

Overall Results

This section presents evaluated savings estimates for the HES-IE program, covering electric, natural gas, and oil/propane fuel types. The results are grouped by fuel savings. Specific to the electric and gas findings, several detailed tables are presented to help contextualize the evaluated impacts as a result of the billing analysis, including measure distributions and findings specific to distinct analysis samples included through modeling (e.g., by utility, by building type).

Weather-normalized annual consumption in the pre-program period (PRENAC) is included in these results to characterize the average energy consumption of the participant and comparison groups prior to any program treatment. Additionally, consideration of program impacts in terms of savings as a percentage of pre-period usage (i.e., PRENAC) is a helpful metric for comparison purposes and for assessing the magnitude of program impacts, since this ratio normalized these savings relative to consumption levels.

As discussed under the Methodology section of this report, the CL&P HES-IE subprograms SP1 and SP4 have been excluded from the Volume 1 billing analysis. The subsequent findings derived through the billing analyses are based on analysis samples that exclude both SP1 and SP4 participants.

For the calculation of program-level evaluated savings, distinct approaches were used to account for each of these subprograms. For SP1, the Evaluation Team applied realization rates from the billing analysis models composed of SP2 and SP3 participants to the total reported HES-IE savings from the Plan. For SP4, the Evaluation Team removed the portion of total reported savings reflecting the percentage of SP4 savings estimated using the utility program tracking data.

Electric Savings

Billing Analysis Results

Table 25 compares changes in energy consumption from the pre- to post-program periods for the participant and comparison groups. Estimates of adjusted gross savings are included, calculated based on the "percent of pre" approach discussed in the Savings Calculation section of the methodology.

Table 25. HES-IE Electric Billing Analysis: Savings Summary, Overall

Group	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Participants	5,481	7,292	885	12%	±4%	848	922
Comparison	5,430	6,091	-100	-2%	±29%	-129	-72
Adjusted gross	5,481	7,292	1,005	14%	±5%	958	1,051

Participants achieved estimated gross energy savings of 885 kWh. A slight increase in electric usage detected in the comparison group resulted in an adjusted gross savings estimate of 1,005 kWh. Despite slightly lower adjusted gross savings when compared to the overall HES program (1,067 kWh), percentage savings are actually 5% higher in HES-IE due to lower pre-period participant consumption.

Table 26 presents additional utility-specific models that disaggregate the overall HES-IE program results shown above for the participant, comparison group, and adjusted gross savings estimates.

Table 26. HES-IE Electric Billing Analysis: Savings Summary, by Utility

Group	Utility	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participants	CL&P	3,196	7,408	917	12%	±6%
	UI	2,285	7,111	864	12%	±5%
	Overall	**5,481**	**7,292**	**885**	**12%**	**±4%**
Comparison	CL&P	4,016	6,367	-80	-1%	±43%
	UI	1,414	5,204	-108	-2%	±46%
	Overall	**5,430**	**6,091**	**-100**	**-2%**	**±29%**
Adjusted gross	CL&P	3,196	7,408	1,011	14%	±6%
	UI	2,285	7,111	1,011	14%	±6%
	Overall	**5,481**	**7,292**	**1,005**	**14%**	**±5%**

Both kWh savings and savings as a percentage of pre-usage are quite similar among HES-IE participants across utilities. While CL&P participants demonstrate slightly higher electric savings, higher pre-period usage results in percentage savings approximately identical to UI participants.

Both utility programs observe an increase in electric usage of the comparison group participants. These effects result in nearly equivalent adjusted gross electric savings across the utility programs: approximately 1,011 kWh for both CL&P and UI.

Table 27 shows the frequency distribution of measure installations occurring in the analysis sample of participants, by electric utility, along with the average reported savings per measure type. The Evaluation Team stresses that the measures did not serve as model inputs. Instead, the listing of measures and their *ex ante* savings estimates provides context for understanding the model results.

Table 27. HES-IE Electric Analysis: Measure Distribution of Final Model Sample

Category	Measure	Percentage of Sample		Average *Ex Ante* Savings by Measure (kWh per Participant)	
		CL&P	UI	CL&P	UI
Lighting	Lighting	84%	96%	503	419
Water heat	DWH bundle *	39%	21%	565	697
	Pipe insulation	6%	n/a	48	n/a
	Water heater replacement	3%	n/a	55	n/a
Shell	Air sealing	32%	53%	514	380
	Attic insulation	9%	2%	433	2,565
	Wall insulation	2%	<1%	1,493	1,440
	Insulation other **	2%	n/a	153	n/a
	Windows	2%	n/a	532	n/a
HVAC	Ductless heat pump	19%	7%	1,737	1,805
	Duct sealing	<1%	4%	284	255
	Window AC	4%	n/a	98	n/a
	Heat pump	2%	n/a	1,132	n/a
	Central AC	n/a	<1%	n/a	98
Appliance	Refrigerator	26%	n/a	758	n/a
	Appliance other ***	n/a	13%	n/a	353
	Freezer	3%	n/a	733	n/a
Other	Other	<1%	n/a	637	n/a
Sample (n)		**3,196**	**2,285**		

* Contains a mix of low-flow showerheads and faucet aerators

** Projects that consist of insulation installations without available detail on location

*** Projects composed of appliance installations with specific category details

In general, installation activity for both utility HES-IE programs (and the associated electric impacts) is characterized by high frequencies of energy-efficient lighting (84% for CL&P, 96% for UI), air sealing (32%, 53%), hot-water savings measures (39%, 21%), along with ductless heat pumps (19%, 7%) and appliances (29%, 13%). Many of these measures compose a similar mix of HES "core" installations (i.e., CFLs, air sealing, water-saving measures), though certainly higher frequencies of appliance, insulation, and HVAC equipment installations are occurring under HES-IE. Similar to HES, the HES-IE program technician performs a home energy assessment to identify deeper energy-savings measures for installation; the key difference is that these "add-on" measures are usually free of charge to HES-IE participants (although landlords often are subject to co-pays), contingent only upon whether they are eligible for efficiency upgrade or replacement based on the audit. Thus, when comparing HES to HES-IE, one should keep in mind that a larger proportion of HES-IE households installed deep savings measures

because they received them for free; the fact that HES households need to buy these measures—even with sizable rebates and opportunities for financing—reduces the prevalence of their adoption.

Overall, a higher saturation of electric heating occurs for HES-IE participants compared to HES.[18] This would indicate a higher frequency of opportunities for measures that target electric heating loads.

The majority of average per-participant *ex ante* measure savings estimates are similar across utility program participants. The only noticeable exception occurs for attic insulation, where UI average per-unit savings is nearly six times higher than the CL&P estimate. Upon review of the utility program tracking data, CL&P applies a constant 1.3 kWh *ex ante* savings per square foot of insulation, while UI employs a formula that is dependent on R-value (ranging from 0.71 kWh per square foot to 8.25 kWh per square foot). Volume 2 of this evaluation report will present further review of these measure-specific differences.

To provide some additional context around the program-specific impacts, Table 28 and Table 29 show the HES-IE adjusted gross energy savings by heating type (electric versus non-electric) and building type (single family versus multifamily).

Nearly a third of the HES-IE participant sample homes are electrically heated, demonstrating approximately 36% higher kWh savings on average than non-electrically heated homes, as shown in Table 28. However, consideration of savings as a percentage of PRENAC indicates that these are relatively similar and consistent with the overall model results.

Table 28. HES-IE Electric Billing Analysis: Savings Summary, by Participant Heating Fuel (Adj. Gross)

Participant Heating Type	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Electric	1,741	8,918	1,231	14%	±8%
Non-electric	3,740	6,485	905	14%	±5%
Overall	**5,481**	**7,292**	**1,005**	**14%**	**±5%**

Table 29 shows that approximately 56% of HES-IE electric-savings participants occur in multifamily homes. While there is a savings discrepancy of about 312 kWh on average between these participant types, lower pre-period usage for multifamily participants results in a slightly higher savings as a percentage of PRENAC.

[18] Approximately 32% of the HES-IE participant sample in the electric models was identified as electrically heated, compare to only 9% for HES.

Table 29. HES-IE Electric Billing Analysis: Savings Summary, by Building Type (Adjusted Gross)

Participant Heating Type	n	PRENAC	Model Savings (kWh)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Single family	2,389	9,048	1,193	13%	±7%
Multifamily	3,092	6,143	880	14%	±7%
Overall	**5,481**	**7,292**	**1,005**	**14%**	**±5%**

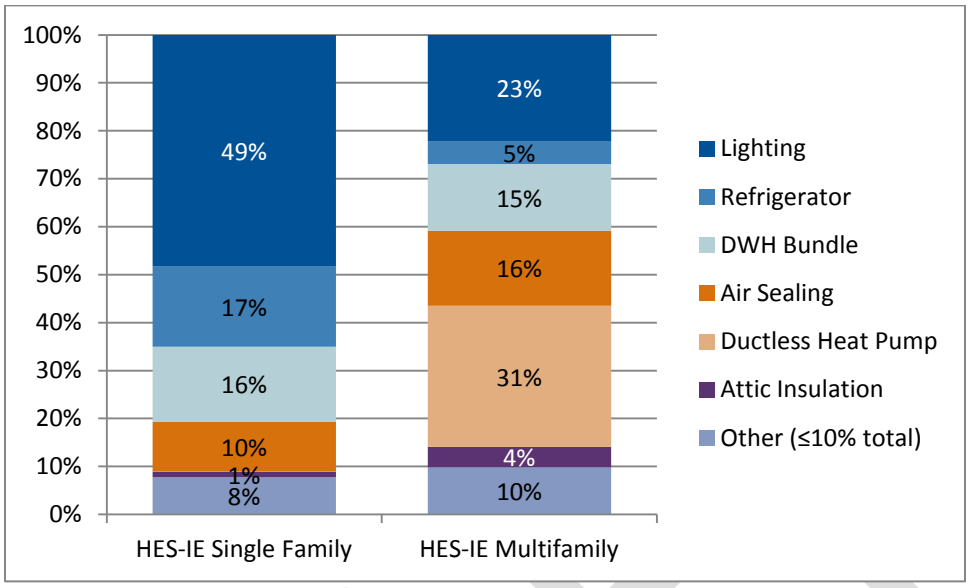
A deeper analysis of the distribution of HES-IE measure installations by building type and associated *ex ante* savings reveals some key distinctions; specifically:

- A higher frequency of ductless heat pump installations occurred in multifamily (24%) versus single-family participants (<1%) in the analysis sample.
- Average *ex ante* savings for ductless heat pumps represent the highest portion of expected electric savings for multifamily HES-IE participants (a function of the number installed and the average *ex ante* savings).
- Average *ex ante* ductless heat pumps savings represent a high percentage compared to average pre-period usage for the HES-IE analysis sample (approximately 15% of PRENAC for single family participants and 29% for multifamily).[19]

Related to the first and second point, Figure 5 illustrates the distribution of average *ex ante* savings for measures installed for the HES-IE participant analysis sample, taking into account the frequency of installation (installation rate) and average *ex ante* savings per measure; essentially, this depicts the expected savings by building type, weighted by the *ex ante* savings and frequency of installation. Measures accounting for less than 10% of these *ex ante* savings were combined into the category "Other."

[19] Averaged *ex ante* savings for ductless heat pumps also represents a high percentage savings for HES as well (savings of 25% of PRENAC for single-family participants; none were installed for multifamily participants).

Figure 5. Distribution of *Ex Ante* HES-IE Electric Savings, Weighted by Frequency of Installation and Average *Ex Ante* Measure Savings, by Building Type



Ductless heat pumps are the expected source of nearly a third of HES-IE multifamily participant savings. As shown above in Table 27, average expected savings for ductless heat pumps are among the largest per-unit kWh estimates under HES-IE (averaging 1,394 kWh for single family and 1,751 kWh for the analysis sample, across utilities). Given the higher frequency of these installations in multifamily buildings, it is likely that a large portion of the overall savings derived from installing ductless heat pumps will be attributable to multifamily homes rather than single-family homes.

In Table 30, this difference is apparent in comparing HES-IE realization rates by building type (based on adjusted gross savings compared to average *ex ante* savings for the analysis sample).

Table 30. HES-IE Electric Billing Analysis: Realization Rate by Building Type

Participant Heating Type	PRENAC	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Single family	9,048	1,193	1,138	105%	13%	13%
Multifamily	6,143	880	1,374	64%	14%	22%
Overall	**7,292**	**1,005**	**1,281**	**78%**	**14%**	**18%**

Despite similarities in percentage savings compared to pre-period usage, average expected participant *ex ante* savings is slightly higher for multifamily participants due in large part to the high frequency of ductless heat pumps. Accounting for pre-period usage, the estimate of expected savings for multifamily participants assumed savings of 22% of pre-period usage, approximately 7% higher than for single-family

homes. Given the measure mix by building type, the assumed savings appear more aggressive for multifamily participants compared to single family.

Furthermore, given the prevalence of ductless heat pumps for multifamily participants and the associated lower realization rate, there is a need to review the *ex ante* assumptions used in the savings calculation for this measure. For example, it is possible that the *ex ante* calculation did not account for pre-installation usage levels for this customer segment. In comparing average expected savings to analysis sample participants, approximately 29% of average multifamily participant usage would be saved through ductless heat pumps (while only 15% for single-family participants).

A recent study of ductless heat pump retrofits in multifamily buildings identified high levels of take back occurring for participants through an increase in average temperature settings during the heating season.[20] Take-back or rebound effects typically refer to the behavioral responses to the installation of new energy-efficiency technology, which may result in lower expected savings due to an increase in participant usage. For example, the installation of a new energy-efficient heating system may prompt a participant to increase the temperature settings, anticipating the increase in cost-savings for operating an efficient unit. Through an analysis of 12 submetered sites, the study identified increased output heat of participants receiving ductless heat pumps ranging from 39% (1,416 kWh) to 78% (2,603 kWh) relative to pre-installation usage.

The Evaluation Team will seek to further explore the potential for participant take-back effects through the process evaluation effort.

Realization Rate

Table 31 provides realization rates based on the participant gross and adjusted gross savings for the billing analysis sample.

[20] Larson, et al. *Ductless Heat Pump Retrofits in Multifamily and Small Commercial Buildings: A Report of BPA Energy Efficiency's Emerging Technologies Initiative.* 2012. http://www.bpa.gov/energy/n/emerging_technology/pdf/DHPx_Multifamily%20_Small_Commercial_Report_02-08-13.pdf

Table 31. HES-IE Electric Billing Analysis: Realization Rate Summary

Group	Utility	Model Savings (kWh)	Reported *Ex Ante* Savings (kWh)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CL&P	917	1,481	62%	12%	20%
	UI	864	966	89%	12%	14%
	Overall	**885**	**1,281**	**69%**	**12%**	**18%**
Adjusted gross savings	CL&P	1,011	1,481	68%	14%	20%
	UI	1,011	966	105%	14%	14%
	Overall	**1,005**	**1,281**	**78%**	**14%**	**18%**

Averaged expected electric savings for UI and CL&P participants vary by approximately 515 kWh, each of which are lower than the evaluated gross savings estimated through the billing analysis. When accounting for the nonparticipant adjustment, both realization rates increase from the gross estimate, with UI achieving 105% and CL&P achieving 68%.

Overall HES-IE Electric Program Results

Table 32 provides overall 2011 HES-IE electric energy savings, by utility and overall. In this table, realization rates based on the specific billing-analysis model groups by utility are applied to the 2011 *ex ante* savings as reported in the Plan.

Table 32. Total 2011 Evaluated HES-IE Electric Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Savings (MWh)	Evaluated Adjusted Gross Savings (MWh)	Adjusted Gross Realization Rate
CL&P	10,685***	13,291***	9,882	74%****
UI	5,612	4,710	4,930	105%
Program Overall**	**16,297**	**18,001**	**14,812**	**82%**

* Totals may not add up to the sum of individual values due to rounding.
** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.
*** These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (27%).
**** The realization rate from the single-family electric savings model (105%) has been applied to the percentage of CL&P HES-IE savings attributed to SP1 (12%), to reflect similar program populations by building type.

Demand Savings

Table 33 provides evaluated adjustments to the reported demand impacts from the Plan. Realization rates developed through the electric HES-IE billing analysis were applied to reported demand savings by utility.

Table 33. Total 2011 Evaluated HES-IE Demand Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Demand Savings (kW)	Evaluated Adjusted Gross Demand Savings (kW)	Adjusted Gross Realization Rate
CL&P	10,685***	728***	542	74%
UI	5,612	263	275	105%
Program Overall**	**16,297**	**991**	**817**	**82%**

* These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (27%).
** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.
*** These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (27%).

Natural Gas Savings

Billing Analysis Results

Table 34 compares changes in energy consumption from the pre- to post-program periods for the participant and comparison groups. Estimated adjusted gross savings are included, calculated based on the "percent of pre" approach discussed in the Savings Calculation section of the methodology.

Table 34. HES-IE Natural Gas Billing Analysis: Savings Summary, Overall

Group	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%	Savings Lower 90% (CCF)	Savings Upper 90% (CCF)
Participant	1,250	840	85	10%	±10%	77	94
Comparison	644	873	13	1%	±62%	5	21
Adjusted gross	1,250	840	73	9%	±16%	61	84

Participants achieved estimated gross energy savings of 85 CCF. A slight reduction in gas usage detected in the comparison group resulted in an adjusted gross savings estimate of 73 CCF, approximately 15% of gross participant savings.

Table 35 presents additional utility-specific models that disaggregate the overall HES program results shown above for the participant, comparison group, and adjust gross savings estimates.

Table 35. HES-IE Natural Gas Billing Analysis: Savings Summary, by Utility

Group	Utility	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Participant	CNG	460	976	90	9%	±10%
	SCG	340	903	68	7%	±17%
	YGS	450	713	92	13%	±14%
	Overall	**1,250**	**840**	**85**	**10%**	**±10%**
Comparison	CNG	223	981	23	2%	±62%
	SCG	233	928	-3	0%	±366%
	YGS	188	756	18	2%	±76%
	Overall	**644**	**873**	**13**	**1%**	**±62%**
Adjusted gross	CNG	460	976	67	7%	±25%
	SCG	340	903	71	8%	±23%
	YGS	450	713	75	11%	±25%
	Overall	**1,250**	**840**	**73**	**9%**	**±16%**

Average participant savings for CNG and YGS appear fairly similar, at 90 CCF and 92 CCF respectively. While SCG average gross participant savings are lower, the comparison-group adjustment results in an increase in adjusted gross savings, while CNG and YGS each decrease. Adjusted gross impact estimates are ultimately quite similar across gas utilities; however, lower pre-period usage for YGS reflects a higher savings percent (11%) than either CNG or SCG (at 7% and 8%, respectively).

Table 36 shows the frequency distribution of measure installations that occur in the analysis sample of participants, along with the average reported savings per measure type.

Table 36. HES-IE Natural Gas Analysis: Measure Distribution of Final Model Sample

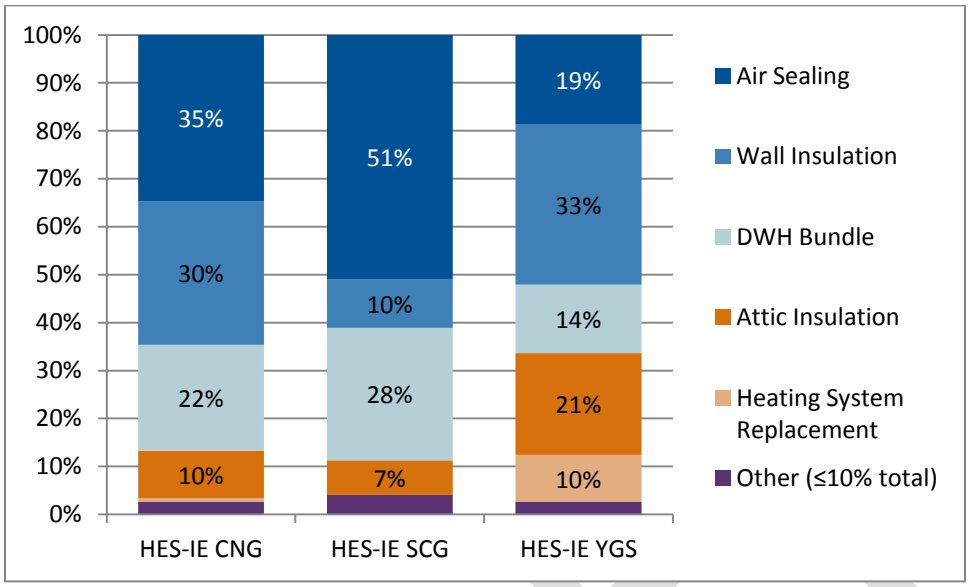
Category	Measure	Percentage of Sample			Average *Ex Ante* Savings by Measure (CCF per Participant)		
		CNG	SCG	YGS	CNG	SCG	YGS
Shell	Air sealing	77%	96%	68%	69	66	45
	Attic insulation	5%	4%	26%	287	204	135
	Wall insulation	12%	3%	22%	373	477	251
	Windows	2%	n/a	5%	4	n/a	63
Water heating	DWH bundle*	80%	90%	61%	42	38	38
	Pipe insulation	34%	<1%	11%	5	5	5
	Water heater replacement	32%	<1%	5%	6	6	6
HVAC	Duct sealing	n/a	10%	<1%	n/a	49	29
	Heating system replacement	<1%	n/a	12%	267	n/a	127
Appliance	Appliance other	n/a	1%	n/a	n/a	8	n/a
Other	Other	<1%	n/a	1%	130	n/a	8
Sample (n)		**460**	**340**	**450**			

* Contains a mix of low-flow showerheads and faucet aerators

In general, installation activity for each of the HES-IE utility programs (and associated gas impacts) is characterized by high frequencies of air sealing (77% for CNG, 96% for SCG, 68% for YGS) and hot-water savings measures (80%, 90%, 61%). Attic and wall insulation are each installed at a lower frequency of participant homes; however, the average *ex ante* savings are among the higher gas-savings measures, in addition to heating system replacements.

To characterize the weight of the expected energy savings relative to the frequency of installation, Figure 6 provides a summary by utility program that shows the measures that account for over 90% of the expected savings. Measures accounting for less than 10% of these *ex ante* savings were combined into the category "Other."

Figure 6. Distribution of *Ex Ante* HES-IE Gas Savings, Weighted by Frequency of Installation and Average *Ex Ante* Measure Savings, by Utility



The summary of weighted expected savings by frequency of installation helps to illustrate how certain measures characterize and differentiate the program delivery across utility programs. The measure mix and associated savings for each of these participant analysis samples provides perspective on how utility-specific evaluated savings may differ. For example, heating system replacements occurred only under the YGS program. Additionally, slightly higher participant model savings occurred under the CNG and YGS programs (90 and 92 CCF, respectively, compared to 68 CCF for SCG), which each have a higher portion of expected savings derived from attic and wall insulation.

Table 37 provides a comparison of HES-IE adjusted gross gas savings by building type.

Table 37. HES-IE Natural Gas Billing Analysis: Savings Summary, by Building Type (Adjusted Gross)

Participant Heating Type	n	PRENAC	Model Savings (CCF)	Savings as Percentage of Pre-Usage	Relative Precision at 90%
Single family	594	995	54	5%	±21%
Multifamily	656	735	85	12%	±19%
Overall	**1,250**	**840**	**73**	**9%**	**±16%**

Similar to HES-IE electric, over half of HES-IE gas savings participants are occurring within multifamily homes.

Realization Rate

Table 38 provides overall 2011 HES-IE gas energy savings, by utility and overall. In this table, realization rates based on the specific billing-analysis model groups by utility are applied to the 2011 *ex ante* savings as reported in the Plan.

Table 38. HES-IE Natural Gas Billing Analysis: Realization Rate Summary

Group	Utility	Model Savings (CCF)	Reported *Ex Ante* Savings (CCF)	Realization Rate	Model Savings as Percentage of Pre-Usage	Reported *Ex Ante* Savings as Percentage of Pre-Usage
Gross savings	CNG	90	152	59%	9%	16%
	SCG	68	124	55%	7%	14%
	YGS	92	161	57%	13%	23%
	Overall	**85**	**149**	**57%**	**10%**	**18%**
Adjusted gross savings	CNG	67	152	44%	7%	16%
	SCG	71	124	57%	8%	14%
	YGS	75	161	47%	11%	23%
	Overall	**73**	**149**	**49%**	**9%**	**18%**

Overall HES-IE Gas Program Results

Table 39 provides overall 2011 HES-IE gas energy savings, by utility and overall. In this table, realization rates based on the specific billing-analysis model groups by utility are applied to the 2011 *ex ante* savings as reported in the Plan.

Table 39. Total 2011 Evaluated HES-IE Gas Savings, by Utility and Overall Program*

Utility	Reported Participation	Reported Savings (000s CCF)	Evaluated Adjusted Gross Savings (000s CCF)	Adjusted Gross Realization Rate
CNG	1,610***	198***	87	44%****
SCG	3,268	361	206	57%
YGS	1,961***	300***	140	47%****
Program Overall**	**6,839**	**859**	**433**	**50%**

* Totals may not add up to the sum of individual values due to rounding.

** The realization rate for "Program Overall" is calculated by taking the difference between the sum of each utility's reported savings and the sum of each utility's evaluated adjusted gross savings totals.

*** These totals have been reduced from the reported Plan values by the percentage of total CL&P HES-IE *ex ante* savings associated with SP4 (6% CNG, 16% YGS). Since gas utilities' territories are composed of both CL&P and UI electric customers, and the subprogram construct is specific to CL&P HES-IE delivery, the Evaluation Team used the proportion of gas savings for CL&P and UI from the program tracking data to differentiate the portion of reported HES-IE gas savings for CNG and YGS associated with SP4.

**** Realization rates from the utility-specific gas savings models (44% CNG, 47% YGS) were applied to the percentage of CL&P HES-IE savings attributed to SP1.

Energy Savings: Oil/Propane

Table 40 provides extrapolated oil and propane savings based on: (1) the participant population reporting oil/propane savings tracked in the utility data, (2) the distribution of these participants by heating and water heating types, and (3) the application of evaluated adjusted gross savings from the gas billing analysis models.

Table 40. HES-IE Total Evaluated Oil and Propane Savings, by Heating and Water Heating Fuel Type

Fuel Type	Configuration	n*	Gas Model Savings (CCF per participant)	Conversion Factor (gallons/CCF)	Converted Oil/Propane Savings (gallons per participant)	Total Oil/Propane Savings (gallons)
Oil	Heating Only	1,531	55	0.7419	40	61,962
	Water Heating Only	117	18	0.7419	13	1,578
	Combo	2,859	73	0.7419	54	154,279
	Overall	**4,507**	**n/a**	**n/a**	**n/a**	**217,820**
Propane	Heating Only	63	55	1.1267	61	3,872
	Water Heating Only	66	18	1.1267	20	1,352
	Combo	66	73	1.1267	82	5,409
	Overall	**195**	**n/a**	**n/a**	**n/a**	**10,633**

* CL&P HES-IE SP4 participants have been removed from these totals.

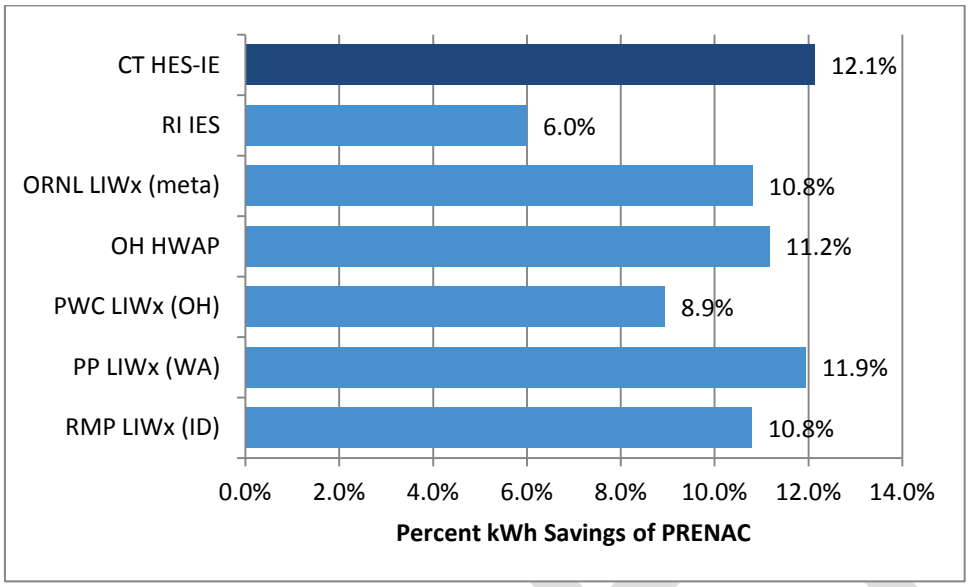
Benchmarking

Benchmarking: HES-IE Electric

To provide context for the program's savings estimates, Figure 7 compares results from other whole-house low-income energy-efficiency programs similar to HES-IE.[21] This comparison comprises studies for which gross savings are available (i.e., no adjustment for nonparticipants included).

[21] The comparables are Rhode Island Income-Eligible Services, Oak Ridge National Laboratory Metaevaluation of low-income weatherization programs, Ohio Home Weatherization Assistance Program, People Working Cooperative Low-Income Weatherization Program in Ohio, Pacific Power Low-Income Weatherization Program in Washington, and Rocky Mountain Power Low-Income Weatherization Program in Idaho.

Figure 7. Evaluated HES-IE Electric Impact Comparison: Gross Savings Percentage of Pre-Installation Period Consumption



As shown in Figure 7, the Connecticut HES-IE program's electric savings percentage was slightly higher than the range of estimates observed through the other programs. The 2005 Oak Ridge National Laboratory metaevaluation of six states' low-income weatherization programs reported savings percentages (relative to pre-installation weatherization usage) ranging from 6.6% to 11.5% for electric-heat participants (average 9%) and -2.9% to 17.8% for non-electric-heat participants (average 7.5%).[22] Estimated impacts for the Connecticut HES-IE program were above these ranges for both electric- and non-electric-heat homes.

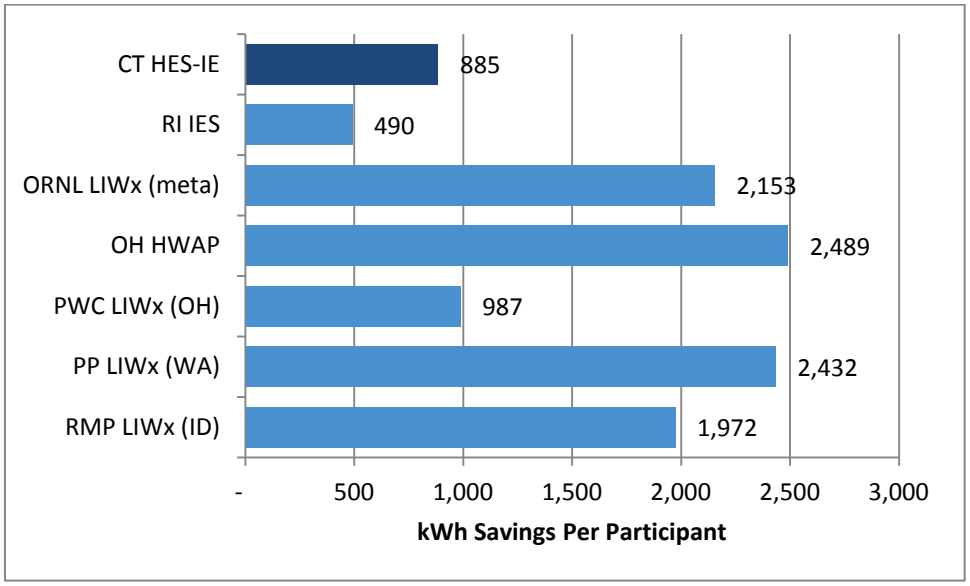
Higher savings for the Connecticut HES-IE program may be characterized by the mix of electric-saving measures installed;[23] however, these program participants are also unique because, on average, they used less electric heat than similar programs. Connecticut HES-IE participant pre-installation usage was 7,292 kWh for the average participant; the other studies ranged from 11,000 kWh to 22,000 kWh, indicating higher levels of electrically heated participant homes.

[22] Schweitzer, Martin. Estimating the National Effects of the U.S. Department of Energy's Weatherization Assistance Program with State-Level Data: A Metaevaluation Using Studies from 1993 to 2005. 2005. http://weatherization.ornl.gov/pdfs/ORNL_CON-493.pdf

[23] Nearly all of the comparison studies are programs that leverage the DOE Weatherization Assistance Program infrastructure and the associated delivery and installation protocols, which offer a mix of measures including low-cost direct installations (e.g., CFLs, aerators, low-flow showerheads), appliance replacement, HVAC equipment repair and replacement, and weatherization measures (e.g., insulation, air sealing, duct sealing). The measure mix associated with the Rhode Island IES program impacts is atypical by comparison, composed primarily of lighting (98%) and refrigerator replacement (38%).

Absolute estimates of savings should also be considered. The Evaluation Team normalized the above percentage comparison to the average level of pre-installation period consumption, which accounted for variation in participation across different geographies, climates, and levels of electric heating and cooling saturations. Figure 8 compares average per participant kWh savings from the Connecticut HES-IE and the comparable studies.

Figure 8. Evaluated HES-IE Electric Impact Comparison: Average Per-Participant Savings



As shown, average kWh for Connecticut's HES-IE program participants was less than most other programs, which is a function of higher saturations of non-electric heat and lower associated pre-installation period electric usage. In these higher kWh-saving programs, more electric heating (and cooling for SRP) and more installations of shell measures (e.g., insulation) appeared to drive these differences.

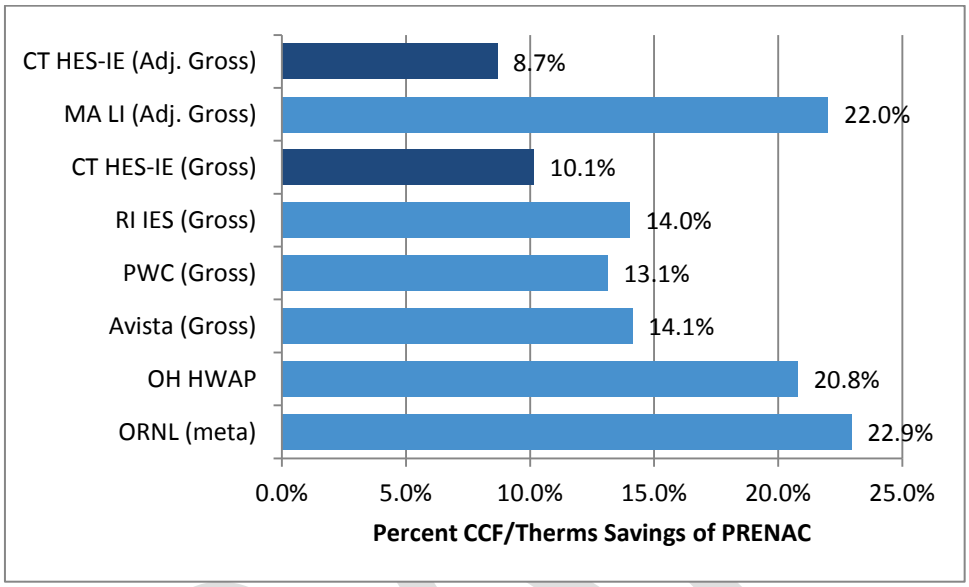
A comparison of total 2011 program expenditures to the total reported savings (from the Plan) reveals an expected $/kWh ranging from $0.66 per kWh to $0.71 per kWh across the Connecticut HES-IE electric utility programs. These metrics provide some context around the anticipated program cost-effectiveness associated with *ex ante* savings and costs associated with the measure mix, delivery, and program administration. To contract the Connecticut programs, similar electric-savings low-income retrofit programs for four Massachusetts utilities showed a range between $1.13 per kWh to $2.37 per kWh for 2011 program activity, reflecting a significantly higher expected program cost relative to reported savings.[24]

[24] Massachusetts Utility Mid-Term Modifications to Three-Year Plans for 2011(Exhibit G (08-50 Tables)). Massachusetts Energy Efficiency Advisory Council. http://www.ma-eeac.org/Mid-Term%20Modifications.html

Benchmarking: HES-IE Gas

To provide context for the program's savings estimates, Figure 9 compares results from other whole-house low-income energy-efficiency programs similar to HES-IE.[25] This comparison comprises studies for which gross savings are available (i.e., no adjustment for nonparticipants included).

Figure 9. Evaluated HES-IE Gas Impact Comparison: Savings Percentage of Pre-Period Consumption



As shown in the figure, the Connecticut HES-IE program's gas savings percentages were below the range of estimates observed in other programs. It seems likely that this disparity was attributed to the primary gas-savings measure mix driving each of these programs' impacts.

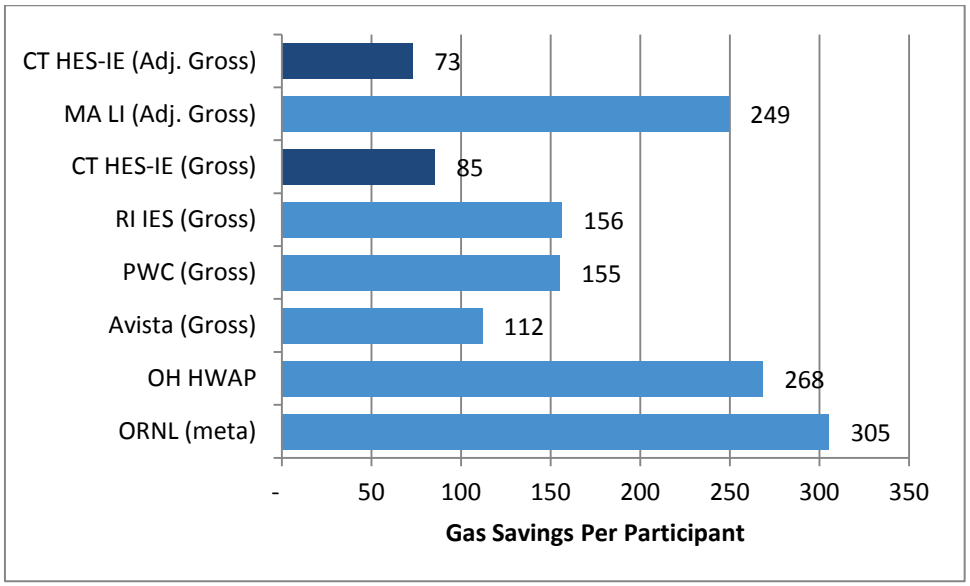
Specifically, the high percentage of savings for Massachusetts' low-income program reflected the high frequencies of insulation measures (75% of participants) and heating equipment replacement (48%), along with some water-heating measures (20%). Additionally, Rhode Island's Income-Eligible Services program showed high levels of air sealing (55%), attic insulation (47%), and floor insulation (23%).

In Connecticut's HES-IE program, while there were high levels of air sealing (79%) and hot-water saving measures (76%), there were lower levels of attic insulation (12%), wall insulation (13%), and heating system replacements (5%), all of which represented high gas-savings measures like the comparison programs.

[25] The comparables are Massachusetts Low-Income Program, Rhode Island Income-Eligible Services, Oak Ridge National Laboratory Metaevaluation of low-income weatherization programs, Ohio Home Weatherization Assistance Program, People Working Cooperative Low-Income Weatherization Program in Ohio, Avista Utilities Low-Income Weatherization Program in Idaho and Washington.

A comparison of absolute estimates of savings presents a similar story. Figure 10 shows the average CCF or therms savings, regardless of the normalized per-installation period consumption levels, but Connecticut's HES-IE program showed lower savings estimates by comparison.

Figure 10. Evaluated HES-IE Gas Impact Comparison: Average Per-Participant Savings



A comparison of total 2011 program expenditures to the total reported savings (from the Plan) reveals an expected $/CCF ranging from $4.91 per therm to $5.69 per therm across the Connecticut HES-IE gas utility programs. These metrics provide some context around the anticipated program cost-effectiveness associated with *ex ante* savings and costs associated with the measure mix, delivery, and program administration. Low-income retrofit programs for six Massachusetts utilities showed a range between $11.24 per therm to $30.07 per therm for program activity in 2011, reflecting significantly higher cost per therm saved.[26] While the Massachusetts low-income retrofit programs demonstrate higher savings based on evaluation results, higher costs per unit of gas savings suggest differences in program cost-effectiveness by comparison to Connecticut HES-IE.

[26] Massachusetts Utility Mid-Term Modifications to Three-Year Plans for 2011(Exhibit G (08-50 Tables)). Massachusetts Energy Efficiency Advisory Council. http://www.ma-eeac.org/Mid-Term%20Modifications.html

Recommendations

The Evaluation Team has developed several preliminary recommendations for improvement, which are specific to the research and evaluation findings presented in Volume 1. Additional recommendations will be provided in association with the detailed measure-level analysis in Volume 2. The key recommendations presented in this Volume are specific to data challenges deriving from the whole-building analysis and relate to the issues discussed in the Data Challenges section of the report. The Evaluation Team believes that these suggestions will not only benefit the evaluation but will provide valuable data to inform delivery for these programs into the future.

- Identify changes to utility tracking system to ensure consistent and comprehensive tracking of electric and gas account numbers, or some other unique identifier, for program participants;
- Develop a data dictionary clearly documenting tracking data;
- Standardize program tracking data extracts, including consistent use of naming conventions (e.g., measure names or descriptions), and provide comprehensive data fields for key program information, including unique identifiers, *ex ante* fuel savings, subprogram or other categorical participation designation (e.g., HES tier 1 versus tier 2), participant contact information, building and fuel characteristics, and measure details; and
- Standardize queries or take steps (1) to eliminate errors in development of data extracts and (2) to reduce the time and burden associated with common data requests.

The drivers of the program realization rates will be further explored through the measure-level analysis in Volume 2. Additionally, Volume 2 will further explore issues regarding data quality and availability, barriers to measure installations, and potential behavioral changes (e.g., energy education, participant take-back).

Appendix A. Billing Analysis Fixed-Effects Model Specifications

Model Specification: Gas Whole House

To estimate gas energy savings from the HES and HES-IE programs, a pre- and post-installation savings analysis fixed-effects modeling method was used, which used pooled monthly time-series (panel) billing data. The fixed-effects modeling approach corrected for:

- Differences between pre- and post-installation weather conditions; and
- Differences in usage consumption between participants, through inclusion of a separate intercept for each participant.

This modeling approach ensured that model savings estimates would not be skewed by unusually high-usage or low-usage participants. The following model specification determined overall savings:[27]

$$ADC_{it} = \alpha_i + \Phi_i AVGHDD_{it} + \beta_1 POST_i + \beta_2 POST_i * AVGHDD_{it} + \varepsilon_{it}$$

Where for each participant or nonparticipant customer "i" and monthly billing period "t":

ADC_{it}	=	the average daily CCF consumption during the pre- or post-installation program period.
α_i	=	the average daily CCF base-load intercept for each customer. (This is part of the fixed-effects specification.)
Φ_i	=	the baseline usage per HDD for each customer.
$AVGHDD_{it}$	=	the average daily base 65 HDDs, based on home location.
β_1	=	the average daily whole-house base-load CCF savings.
$POST_i$	=	an indicator variable that is 1 in the post-period (after the latest measure installation) and 0 in the pre-period (prior to participation).
β_2	=	the whole-house heating CCF savings per heating degree-day.
$POST_i * AVGHDD_{it}$	=	an interaction between the *POST* indicator variable and the heating degree-days (*AVGHDD*).
ε_{it}	=	the modeling estimation error.

Model Specification: Electric Whole House

To estimate electric energy savings for the HES and HES-IE programs, a pre- and post-installation savings analysis fixed-effects modeling method was used, which used pooled monthly time-series (panel) billing data. The fixed-effects modeling approach corrected for:

- Differences between pre- and post-installation weather conditions; and

[27] Indicator variables for non-HES/HES-IE program participation were not included in the gas modeling, given a participation rate of 0.2% for these other energy-efficiency programs. There was only other-program participation during the pre-period. The models that incorporated these indicators of non-HES/HES-IE program participation yielded identical savings estimates to the models without these variables.

- Differences in usage consumption between participants, through inclusion of a separate intercept for each participant.

This modeling approach ensured that model savings estimates would not be skewed by unusually high-usage or low-usage participants. The model estimates savings after accounting for other non-HES/HES-IE program participation and HER participation. The following model specification determined overall savings:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 OTHERPROG_i * AVGHDD_{it} + \beta_4 OTHERPROG_i * AVGCDD_{it} + \beta_5 HER_i * AVGHDD_{it} + \beta_6 HER_i * AVGCDD_{it} + \beta_7 POST_i + \beta_8 POST_i * AVGHDD_{it} + \beta_9 POST_i * AVGCDD_{it} + \beta_{10} OTHERPROG_i * POST_i + \beta_{11} HER_i * POST_i + \varepsilon_{it}$$

Where for each participant or nonparticipant customer "i" and monthly billing period "t":

ADC_{it}	=	the average daily kWh consumption during the pre- or post-installation program period.
α_i	=	the average daily kWh base-load intercept for each customer. (This is part of the fixed effects specification.)
β_1	=	the average daily per heating degree-day usage in the pre-period.
$AVGHDD_{it}$	=	the average daily base 65 HDDs, based on home location.
β_2	=	the average daily per cooling degree-day usage in the pre-period
$AVGCDD_{it}$	=	the average daily base 65 CDDs, based on home location.
$OTHERPROG_i$	=	an indicator variable for other program participation (other than HER).
HER_i	=	an indicator variable for HER program participation.
β_3	=	the incremental per heating degree-day usage in the pre-period from other program participation.
$OTHERPROG_i * AVGHDD_{it}$	=	interaction of other program participation and AVGHDD.
β_4	=	the incremental per cooling degree-day usage in the pre-period from other program participation.
$OTHERPROG_i * AVGCDD_{it}$	=	interaction of other program participation and AVGHDD.
B_5	=	the incremental per heating degree-day usage in the pre-period from HER program participation.
$HER_i * AVGHDD_{it}$	=	interaction of HER program participation and AVGHDD.
$\beta_{\backslash 6}$	=	the incremental per cooling degree-day usage in the pre-period from HER program participation.
$HER_i * AVGCDD_{it}$	=	interaction of HER program participation and AVGHDD.
β_7	=	the average daily whole-house program base-load kWh savings.
$POST_i$	=	an indicator variable that is 1 in the post-period (after the latest measure installation) and 0 in the pre-weatherization period.
β_8	=	the whole-house heating kWh savings per heating degree-day.

$POST_i * AVGHDD_{it}$	=	an interaction between the *POST* indicator variable and the heating degree-days (*AVGHDD*).
β_9	=	the whole-house cooling kWh savings per cooling degree-day
$POST_i * AVGCDD_{it}$	=	an interaction between the *POST* indicator variable and the cooling degree-days (*AVGCDD*).
β_{10}	=	the average daily other program kWh savings.
$OTHERPROG_i * POST_i$	=	an interaction of OTHERPROG and an indicator variable that is 1 in the post-period (after the other program participation date) and 0 in the pre-other participation program period.
β_{11}	=	the average daily HER program kWh savings.
$HER_i * POST_i$	=	an interaction of HER and an indicator variable that is 1 in the post-period (after the HER program participation date) and 0 in the pre-HER participation program period.
ε_{it}	=	the modeling estimation error.

Appendix B. PRISM Model Specifications

The heating and cooling PRISM model was estimated in both the pre- and post-period for each customer using the following specification:[28]

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer "i" and calendar month "t":

ADC_{it} = average daily CCF or kWh consumption in the pre- or post-program period.

α_i = the participant intercept, representing the average daily CCF or kWh base load.

β_1 = the model space heating slope (used only in the heating only, heating + cooling model).

$AVGHDD_{it}$ = the base 65 average daily HDDs for the specific location (used only in the heating only, heating + cooling model).

β_2 = the model space cooling slope (used only in the cooling only, heating + cooling model).

$AVGCDD_{it}$ = the base 65 average daily CDDs for the specific location (used only in the cooling only, heating + cooling model).

ε_{it} = the error term.

Using the above model, weather-NAC could be computed as:[29]

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \beta_2 LRCDD_{it} + \varepsilon_{it}$$

Where, for each customer "i":

NAC_i = normalized annual CCF or kWh consumption.

α_i = the intercept equaling the average daily or base load for each participant, representing the average daily base load from the model.

$\alpha_i * 365$ = annual base-load CCF or kWh usage (non-weather sensitive).

β_1 = the heating slope (in effect, usage per heating degree from the model above).

[28] For gas savings models, cooling data and parameters are omitted (i.e., $\beta_2, AVGCDD_{it}$).

[29] For gas savings models, cooling data and parameters are omitted (i.e., $\beta_2, LRCDD_i$).

$LRHDD_i$ = the annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location

$\beta_1 * LRHDD_i$ = weather-normalized, annual weather-sensitive (heating) usage (i.e., HEATNAC)

β_2 = the cooling slope; in effect, usage per cooling degree from the model above

$LRCDD_I$ = the annual, long-term CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location

$\beta_2 * LRCDD_i$ = weather-normalized, annual weather-sensitive (cooling) usage (i.e., COOLNAC)

ε_I = the error term

Appendix C. Model Attrition

Table 41. Participant Attrition: Electric Analysis (HES)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	19,320	100%	0	0%
Matched to billing data provided	17,348	90%	1,972	10%
Insufficient pre- and post-period months	15,308	79%	2,040	11%
Changed usage from the pre to post (> 70%)	15,240	79%	68	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	14,946	77%	294	2%
Pre- or post-period usage less than 1000 kWh	14,937	77%	9	0%
PRISM screen: wrong signs on PRISM parameters	14,872	77%	65	0%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	11,110	58%	3,762	19%
Final analysis group	**11,110**	**58%**	**8,210**	**42%**

Table 42. Comparison Group Attrition: Electric Analysis (HES)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	12,391	100%	0	0%
Matched to billing data provided	12,077	97%	314	3%
Insufficient pre- and post-period months	8,677	70%	3,400	27%
Changed usage from the pre to post (> 70%)	8,602	69%	75	1%
Pre- or post-period usage less than 1000 kWh or more than maximum participant usage	8,593	69%	9	0%
PRISM screen: wrong signs on PRISM parameters	8,547	69%	46	0%
Final analysis group	**8,547**	**69%**	**3,844**	**31%**

Table 43. Participant Attrition: Gas Analysis (HES)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	4,922	100%	0	0%
Matched to billing data provided	2,718	55%	2,204	45%
Insufficient pre- and post-period months	2,369	48%	349	7%
Changed usage from the pre to post (> 70%)	2,346	48%	23	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	2,145	44%	201	4%
Pre- or post-period usage less than 200 therms	2,071	42%	74	2%
PRISM screen: wrong signs on PRISM parameters	2,028	41%	43	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	1,862	38%	166	3%
Final analysis group	**1,862**	**38%**	**3,060**	**62%**

Table 44. Comparison Group Attrition: Gas Analysis (HES)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	3,290	100%	0	0%
Matched to billing data provided	2,039	62%	1,251	38%
Insufficient pre- and post-period months	1,312	40%	727	22%
Changed usage from the pre to post (> 70%)	1,288	39%	24	1%
Pre- or post-period usage less than 200 therms or more than max part usage	1,221	37%	67	2%
PRISM screen: wrong signs on PRISM parameters	1,192	36%	29	1%
Final analysis group	**1,192**	**36%**	**2,098**	**64%**

Table 45. Participant Attrition: Electric Analysis (HES-IE)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	11,577	100%	0	0%
Matched to billing data provided	11,395	98%	182	2%
Insufficient pre- and post-period months	8,378	72%	3,017	26%
Changed usage from the pre to post (> 70%)	8,325	72%	53	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	7,815	68%	510	4%
Pre- or post-period usage less than 1000 kWh	7,782	67%	33	0%
PRISM screen: wrong signs on PRISM parameters	7,705	67%	77	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	5,481	47%	2,224	19%
Final analysis group	**5,481**	**47%**	**6,096**	**53%**

Table 46. Comparison Group Attrition: Electric Analysis (HES-IE)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original electric accounts	9,103	100%	0	0%
Matched to billing data provided	8,721	96%	382	4%
Insufficient pre- and post-period months	5,690	63%	3,031	33%
Changed usage from the pre to post (> 70%)	5,599	62%	91	1%
Pre- or post-period usage less than 1000 kWh or more than maximum participant usage	5,497	60%	102	1%
PRISM screen: wrong signs on PRISM parameters	5,430	60%	67	1%
Final analysis group	**5,430**	**60%**	**3,673**	**40%**

Table 47. Participant Attrition: Gas Analysis (HES-IE)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	5,120	100%	0	0%
Matched to billing data provided	2,374	46%	2,746	54%
Insufficient pre- and post-period months	1,872	37%	502	10%
Changed usage from the pre to post (> 70%)	1,864	36%	8	0%
Ex ante savings higher than pre-usage, or *ex ante* savings <1% of pre-usage	1,529	30%	335	7%
Pre; or post-period usage less than 200 therms	1,480	29%	49	1%
PRISM screen: wrong signs on PRISM parameters	1,446	28%	34	1%
Account-level inspection of pre/post 12-month usage (e.g., vacancies, anomalies)	1,250	24%	196	4%
Final analysis group	**1,250**	**24%**	**3,870**	**76%**

Table 48. Comparison Group Attrition: Gas Analysis (HES-IE)

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original gas accounts	3,738	100%	0	0%
Matched to billing data provided	1,759	47%	1,979	53%
Insufficient pre- and post-period months	846	23%	913	24%
Changed usage from the pre to post (> 70%)	831	22%	15	0%
Pre- or post-period usage less than 200 therms or more than max part usage	668	18%	163	4%
PRISM screen: wrong signs on PRISM parameters	644	17%	24	1%
Final analysis group	**644**	**17%**	**3,094**	**83%**

Appendix D. Frequency Distribution of Measure Installations from Participant Analysis Samples

Table 49. Frequency Distribution of Electric Measures for HES and HES-IE Participant Samples, by Utility Program and Overall

Category	Measure	HES			HESIE		
		CLP	UI	Overall	CLP	UI	Overall
Lighting	Lighting	97%	97%	97%	84%	96%	89%
Shell	Air sealing	76%	67%	74%	32%	53%	41%
	Attic insulation	n/a	<1%	<1%	9%	2%	6%
	Wall insulation	n/a	<1%	<1%	2%	<1%	1%
	Insulation other*	4%	n/a	3%	2%	n/a	1%
	Windows	<1%	n/a	<1%	2%	n/a	1%
Water heat	DWH bundle**	12%	9%	12%	39%	21%	32%
	Pipe insulation	9%	<1%	7%	6%	n/a	3%
	Water heater Replacement	n/a	n/a	n/a	3%	n/a	2%
	Heat pump water heater	<1%	<1%	<1%	n/a	n/a	n/a
HVAC	Duct sealing	15%	30%	19%	<1%	4%	2%
	Heating system replacement	<1%	<1%	<1%	n/a	n/a	n/a
	Heat pump	<1%	<1%	<1%	2%	n/a	1%
	Ductless heat pump	<1%	<1%	<1%	19%	7%	14%
	Ground-source heat pump	<1%	n/a	<1%	n/a	n/a	n/a
	Window AC	n/a	n/a	n/a	4%	n/a	2%
	Central AC	1%	4%	2%	n/a	<1%	<1%
Appliance	Clothes washer	<1%	<1%	<1%	n/a	n/a	n/a
	Dehumidifier	<1%	<1%	<1%	n/a	n/a	n/a
	Freezer	<1%	n/a	<1%	3%	n/a	2%
	Refrigerator	<1%	1%	<1%	26%	n/a	15%
	Appliance other***	n/a	n/a	n/a	n/a	13%	5%
Other	Other	n/a	<1%	<1%	<1%	n/a	<1%
Sample (n)		**8,695**	**2,415**	**11,110**	**3,196**	**2,285**	**5,481**

* Projects that consist of insulation installations without available detail on location

** Contains a mix of low-flow showerheads and faucet aerators

*** Projects composed of appliance installations with specific category details

Table 50. Frequency Distribution of Gas Measures for HES and HES-IE Participant Samples, by Utility Program and Overall

Category	Measure	HES				HESIE			
		CNG	SCG	YGS	Overall	CNG	SCG	YGS	Overall
Shell	Air sealing	90%	97%	91%	92%	77%	96%	68%	79%
	Attic insulation	n/a	3%	n/a	<1%	5%	4%	26%	12%
	Wall insulation	n/a	1%	n/a	<1%	12%	3%	22%	13%
	Insulation other*	<1%	n/a	<1%	<1%	n/a	n/a	n/a	n/a
	Windows	n/a	n/a	<1%	<1%	2%	n/a	5%	3%
Water heat	DWH bundle**	67%	75%	63%	67%	80%	90%	61%	76%
	Pipe insulation	50%	6%	48%	39%	34%	<1%	11%	16%
	Water heater replacement	n/a	n/a	n/a	n/a	32%	<1%	5%	14%
HVAC	Duct sealing	12%	26%	15%	17%	n/a	10%	<1%	3%
	Heating system replacement	<1%	<1%	<1%	<1%	<1%	n/a	12%	5%
Appliance	Clothes washer	n/a	<1%	n/a	<1%	n/a	n/a	n/a	n/a
	Appliance other***	n/a	n/a	n/a	n/a	n/a	1%	n/a	<1%
Other	Other	n/a	n/a	n/a	n/a	<1%	n/a	1%	<1%
Sample (n)		**649**	**461**	**752**	**1,862**	**460**	**340**	**450**	**1,250**

* Projects that consist of insulation installations without available detail on location

** Contains a mix of low-flow showerheads and faucet aerators

*** Projects composed of appliance installations with specific category details

Table 51. Frequency Distribution of Measure Installed for HES and HES-IE Participants with Oil / Propane Heating or Water Heating*

Category	Measure	HES		HES-IE	
		Oil	Propane	Oil	Propane
Shell	Air sealing	94%	95%	77%	91%
	Attic insulation	<1%	n/a	9%	9%
	Wall insulation	<1%	n/a	6%	5%
	Insulation other**	n/a	n/a	<1%	<1%
	Windows	n/a	n/a	7%	8%
Water heat	DWH bundle***	12%	4%	16%	6%
	Low-flow showerhead	34%	36%	48%	57%
	Pipe insulation	39%	37%	15%	19%
	Faucet aerator	37%	39%	55%	76%
	Water heater set back	n/a	n/a	6%	14%
	Water heater replacement	<1%	n/a	<1%	<1%
	Heat pump water heater	<1%	n/a	<1%	<1%
HVAC	Duct sealing	17%	20%	1%	<1%
	Heating system repair	n/a	n/a	<1%	<1%
	Heating system replacement	n/a	n/a	3%	3%
Appliance	Clothes washer	<1%	n/a	<1%	<1%
Other	Other	14%	15%	n/a	n/a
Sample (n)		**12,076**	**769**	**4,507**	**195**

* CL&P HES-IE SP4 participants are not included in these frequencies.

** Projects that consist of insulation installations without available detail on location

*** Contains a mix of low-flow showerheads and faucet aerators

Appendix E. Billing Analysis Model Outputs

HES Electric Models

Table 52. Overall HES Electric Savings Model Output After Screening

(n=11,110 participants, n=8,547 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.4126	0.0078	52.93	<.0001
	AvgCDD	1.9841	0.0201	98.68	<.0001
	Other program * HDD	0.0462	0.0316	1.46	0.1432
	HER *HDD	0.5380	0.0507	10.61	<.0001
	Other program *CDD	0.0727	0.0733	0.99	0.3214
	HER * CDD	1.5933	0.1236	12.89	<.0001
	Post	-1.2443	0.0728	-17.1	<.0001
	Post*HDD	-0.0960	0.0040	-24.1	<.0001
	Post*CDD	-0.1516	0.0107	-14.12	<.0001
	HER * post	-2.2197	0.4392	-5.05	<.0001
	Other program * Post	-1.9197	0.5492	-3.5	0.0005
Comparison	AvgHDD	0.3457	0.0072	48.14	<.0001
	AvgCDD	1.8572	0.0205	90.67	<.0001
	Other program * HDD	0.0527	0.0357	1.48	0.1398
	HER *HDD	0.3924	0.0619	6.34	<.0001
	Other program *CDD	0.0786	0.0863	0.91	0.3626
	HER * CDD	1.5995	0.1413	11.32	<.0001
	Post	-0.2562	0.0718	-3.57	0.0004
	Post*HDD	-0.0074	0.0034	-2.15	0.0312
	Post*CDD	0.1742	0.0116	14.96	<.0001
	HER * Post	-1.2313	0.4405	-2.8	0.0052
	Other program * Post	0.0139	0.5945	0.02	0.9813

Table 53. CL&P HES Electric Savings Model Output After Screening

(n=8,695 participants, n=7,043 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.4541	0.0095	47.64	<.0001
	AvgCDD	2.0614	0.0246	83.73	<.0001
	Other program * HDD	0.0061	0.0320	0.19	0.8493
	HER *HDD	0.4995	0.0509	9.81	<.0001
	Other program *CDD	-0.0226	0.0745	-0.3	0.7621
	HER * CDD	1.5004	0.1242	12.08	<.0001
	Post	-1.4336	0.0876	-16.36	<.0001
	Post*HDD	-0.0965	0.0047	-20.43	<.0001
	Post*CDD	-0.1080	0.0128	-8.42	<.0001
	HER * post	-2.1322	0.4416	-4.83	<.0001
	Other program * post	-1.8589	0.5508	-3.37	0.0007
Comparison	AvgHDD	0.3610	0.0084	43.21	<.0001
	AvgCDD	1.8792	0.0234	80.28	<.0001
	Other program * HDD	0.0357	0.0360	0.99	0.3213
	HER *HDD	0.3764	0.0621	6.06	<.0001
	Other program *CDD	0.0342	0.0871	0.39	0.6949
	HER * CDD	1.5581	0.1418	10.99	<.0001
	Post	-0.4852	0.0825	-5.88	<.0001
	Post*HDD	-0.0028	0.0039	-0.71	0.4759
	Post*CDD	0.2255	0.0132	17.04	<.0001
	HER * post	-1.2050	0.4411	-2.73	0.0063
	Other program * post	-0.0050	0.5953	-0.01	0.9933

Table 54. UI HES Gas Savings Model Output After Screening

(n=2,415 participants, n=1,504 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.2715	0.0101	26.89	<.0001
	AvgCDD	1.7407	0.0314	55.41	<.0001
	Other program * HDD	0.0000	0.0000	.	.
	HER *HDD	0.0000	0.0000	.	.
	Other program *CDD	0.0000	0.0000	.	.
	HER * CDD	0.0000	0.0000	.	.
	Post	-0.7386	0.1112	-6.64	<.0001
	Post*HDD	-0.0948	0.0064	-14.85	<.0001
	Post*CDD	-0.2644	0.0180	-14.67	<.0001
	HER * post	0.0000	0.0000	.	.
	Other program * post	0.0000	0.0000	.	.
Comparison	AvgHDD	0.2757	0.0111	24.88	<.0001
	AvgCDD	1.7627	0.0413	42.72	<.0001
	Other program * HDD	0.0000	0.0000	.	.
	HER *HDD	0.0000	0.0000	.	.
	Other program *CDD	0.0000	0.0000	.	.
	HER * CDD	0.0000	0.0000	.	.
	Post	0.4417	0.1294	3.41	0.0006
	Post*HDD	-0.0156	0.0068	-2.3	0.0217
	Post*CDD	0.0039	0.0228	0.17	0.8631
	HER * post	0.0000	0.0000	.	.
	Other program * post	0.0000	0.0000	.	.

HES Gas Models

Table 55. Overall HES Gas Savings Model Output After Screening

(n=1,862 participants, n=1,192 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0121	0.0074	-1.64	0.1013
	Post * AvgHDD	-0.0120	0.0004	-30.63	<.0001
Comparison	Post	-0.0453	0.0060	-7.49	<.0001
	Post* Participation	0.0332	0.0094	3.55	0.0004
	Post * AvgHDD	-0.0120	0.0004	-31.55	<.0001

Table 56. CNG HES Gas Savings Model Output After Screening

(n=649 participants, n=508 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0499	0.0140	-3.56	0.0004
	Post * AvgHDD	-0.0104	0.0008	-13.81	<.0001
Comparison	Post	-0.0412	0.0098	-4.2	<.0001
	Post* Participation	-0.0087	0.0160	-0.54	0.5869
	Post * AvgHDD	-0.0104	0.0007	-15.3	<.0001

Table 57. SCG HES Gas Savings Model Output After Screening

(n=461 participants, n=243 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	0.0296	0.0145	2.03	0.0419
	Post * AvgHDD	-0.0131	0.0008	-16.22	<.0001
Comparison	Post	-0.0392	0.0141	-2.78	0.0055
	Post* Participation	0.0688	0.0208	3.31	0.0009
	Post * AvgHDD	-0.0131	0.0008	-15.45	<.0001

Table 58. YGS HES Gas Savings Model Output After Screening

(n=752 participants, n=441 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0045	0.0103	-0.44	0.6626
	Post * AvgHDD	-0.0128	0.0005	-23.99	<.0001
Comparison	Post	-0.0532	0.0090	-5.92	<.0001
	Post* Participation	0.0487	0.0136	3.57	0.0004
	Post * AvgHDD	-0.0128	0.0005	-24.03	<.0001

HES-IE Electric Models

Table 59. Overall HES-IE Electric Savings Model Output After Screening

(n=5,481 participants, n=5,430 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.4642	0.0111	41.72	<.0001
	AvgCDD	1.0193	0.0193	52.87	<.0001
	Other Program * HDD	-0.2873	0.0579	-4.96	<.0001
	HER *HDD	0.4919	0.1349	3.65	0.0003
	Other Program *CDD	0.5328	0.3422	1.56	0.1194
	HER * CDD	0.8754	0.2286	3.83	0.0001
	Post	-0.6586	0.0760	-8.67	<.0001
	Post*HDD	-0.0996	0.0054	-18.34	<.0001
	Post*CDD	-0.1269	0.0116	-10.91	<.0001
	HER * Post	-1.2591	1.1810	-1.07	0.2864
	Other Program * Post	-5.7085	0.3880	-14.71	<.0001
Comparison	AvgHDD	0.3230	0.0086	37.41	<.0001
	AvgCDD	0.8151	0.0197	41.29	<.0001
	Other Program * HDD	0.1531	0.1120	1.37	0.1715
	HER *HDD	0.5924	0.1328	4.46	<.0001
	Other Program *CDD	0.2211	0.2261	0.98	0.3283
	HER * CDD	0.8338	0.2871	2.9	0.0037
	Post	0.0240	0.0610	0.39	0.6938
	Post*HDD	0.0080	0.0036	2.24	0.025
	Post*CDD	0.0759	0.0093	8.18	<.0001
	HER * Post	-1.7963	0.8507	-2.11	0.0347
	Other Program * Post	1.4996	0.9916	1.51	0.1304

Table 60. CL&P HES-IE Electric Savings Model Output After Screening

(n=3,196 participants, n=4,016 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.4982	0.0160	31.16	<.0001
	AvgCDD	0.9867	0.0273	36.12	<.0001
	Other Program * HDD	-0.3190	0.0590	-5.4	<.0001
	HER *HDD	0.4618	0.1353	3.41	0.0006
	Other Program *CDD	0.5488	0.3434	1.6	0.11
	HER * CDD	0.8959	0.2292	3.91	<.0001
	Post	-0.6047	0.1019	-5.93	<.0001
	Post*HDD	-0.1096	0.0076	-14.4	<.0001
	Post*CDD	-0.1050	0.0163	-6.43	<.0001
	HER * Post	-1.2001	1.1842	-1.01	0.3109
	Other Program * Post	-5.7615	0.3879	-14.85	<.0001
Comparison	AvgHDD	0.3497	0.0107	32.53	<.0001
	AvgCDD	0.8048	0.0248	32.5	<.0001
	Other Program * HDD	0.1287	0.1132	1.14	0.2557
	HER *HDD	0.5662	0.1331	4.25	<.0001
	Other Program *CDD	0.2167	0.2267	0.96	0.3392
	HER * CDD	0.8290	0.2876	2.88	0.0039
	Post	-0.0840	0.0745	-1.13	0.2595
	Post*HDD	0.0087	0.0042	2.06	0.0396
	Post*CDD	0.1060	0.0121	8.79	<.0001
	HER * Post	-1.7783	0.8511	-2.09	0.0367
	Other Program * Post	1.5086	0.9956	1.52	0.1297

Table 61. UI HES-IE Gas Savings Model Output After Screening

(n=2,285 participants, n=1,414 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	Z-Score	p-Value
Participant	AvgHDD	0.3973	0.0120	33.17	<.0001
	AvgCDD	1.0256	0.0214	47.94	<.0001
	Other Program * HDD	0.0000	0.0000	.	.
	HER *HDD	0.0000	0.0000	.	.
	Other Program *CDD	0.0000	0.0000	.	.
	HER * CDD	0.0000	0.0000	.	.
	Post	-0.7738	0.1052	-7.36	<.0001
	Post*HDD	-0.0863	0.0066	-13.04	<.0001
	Post*CDD	-0.1563	0.0141	-11.06	<.0001
	HER * Post	0.0000	0.0000	.	.
	Other Program * Post	0.0000	0.0000	.	.
Comparison	AvgHDD	0.2120	0.0111	19.02	<.0001
	AvgCDD	0.7859	0.0202	38.9	<.0001
	Other Program * HDD	0.0000	0.0000	.	.
	HER *HDD	0.0000	0.0000	.	.
	Other Program *CDD	0.0000	0.0000	.	.
	HER * CDD	0.0000	0.0000	.	.
	Post	0.2700	0.0945	2.86	0.0043
	Post*HDD	0.0030	0.0061	0.49	0.6225
	Post*CDD	-0.0105	0.0137	-0.77	0.4439
	HER * Post	0.0000	0.0000	.	.
	Other Program * Post	0.0000	0.0000	.	.

HES-IE Gas Models

Table 62. Overall HES-IE Gas Savings Model Output After Screening

(n=1,250 participants, n=644 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0383	0.0068	-5.63	<.0001
	Post * AvgHDD	-0.0126	0.0004	-34.43	<.0001
Comparison	Post	-0.0354	0.0067	-5.32	<.0001
	Post* Participation	-0.0028	0.0098	-0.29	0.7727
	Post * AvgHDD	-0.0126	0.0004	-32.79	<.0001

Table 63. CNG HES-IE Gas Savings Model Output After Screening

(n=460 participants, n=223 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0483	0.0124	-3.9	<.0001
	Post * AvgHDD	-0.0131	0.0007	-19.62	<.0001
Comparison	Post	-0.0628	0.0121	-5.17	<.0001
	Post* Participation	0.0145	0.0173	0.84	0.4021
	Post * AvgHDD	-0.0131	0.0007	-19.61	<.0001

Table 64. SCG HES-IE Gas Savings Model Output After Screening

(n=340 participants, n=233 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	0.0249	0.0149	1.67	0.0946
	Post * AvgHDD	-0.0139	0.0008	-16.52	<.0001
Comparison	Post	0.0086	0.0126	0.68	0.4969
	Post* Participation	0.0164	0.0198	0.83	0.4078
	Post * AvgHDD	-0.0139	0.0009	-16.15	<.0001

Table 65. YGS HES-IE Gas Savings Model Output After Screening

(n=450 participants, n=188 nonparticipants)

Group	Variable	Parameter Estimate	Standard Error	t-value	P-value
Participant	Post	-0.0657	0.0093	-7.03	<.0001
	Post * AvgHDD	-0.0115	0.0005	-23.52	<.0001
Comparison	Post	-0.0485	0.0103	-4.73	<.0001
	Post* Participation	-0.0171	0.0147	-1.16	0.2452
	Post * AvgHDD	-0.0115	0.0006	-20.82	<.0001