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July 21, 2015

VIA ELECTRONIC FILING

Ms. Gail L. Mount
Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4325

RE: Duke Energy Progress, Inc. Home Energy Improvement Program 2014 EM&V Report
Docket No. E-2, Sub 936

Dear Ms. Mount:

Pursuant to the Commission's April 30, 2009 Order issued in Docket No. E-2, Sub 936, I enclose for filing in this matter, Duke Energy Progress, Inc.'s report summarizing the 2013 program year evaluation, measurement and verification ("EM&V") results for its Home Energy Improvement Program. Duke Energy Progress, Inc. is currently evaluating the recommendations provided in the EM&V report.

Thank you for your attention to this matter. If you have any questions, please let me know.

Sincerely,

Brian L. Franklin

Enclosure

cc: Parties of Record

NAVIGANT

2013 EM&V Report for the Home Energy Improvement Program

Prepared for:
Duke Energy Progress

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July 6, 2015

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Executive Summary

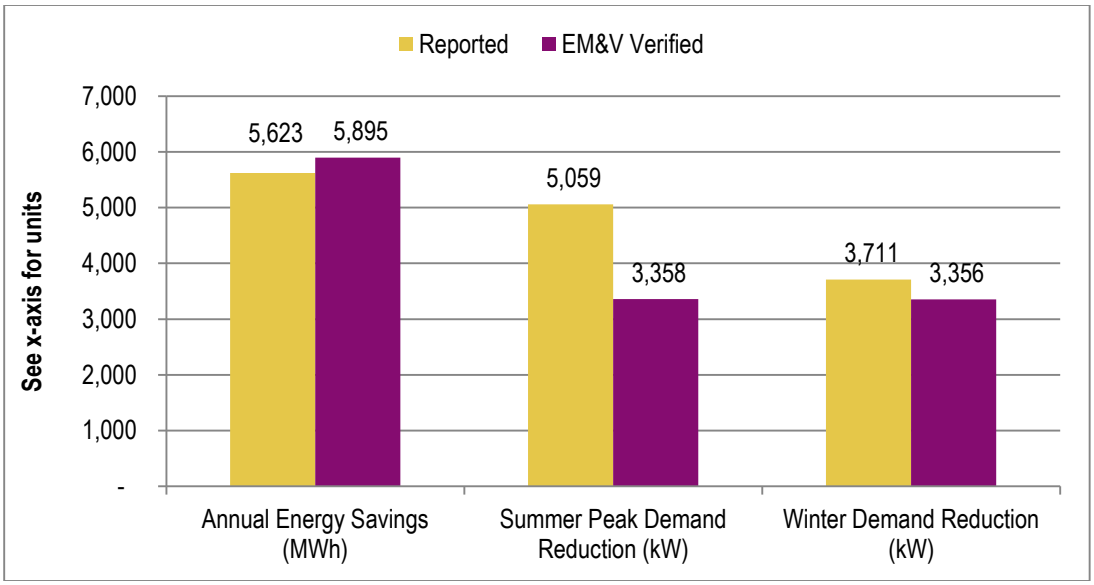
The Home Energy Improvement Program (HEIP) is part of the portfolio of energy efficiency programs initiated by Progress Energy Carolinas (PEC) beginning in late 2008. HEIP provides rebates for the retrofit and maintenance of equipment in existing homes, while other portfolio offerings address efficiency opportunities in new homes, for specific equipment and appliances, and in commercial buildings. This report covers evaluation, measurement, and verification (EM&V) activities by Navigant Consulting, Inc. (Navigant) for Duke Energy Progress's (DEP's) HEIP for Program Year 2013 (PY 2013) projects, defined as those receiving rebates during the 2013 calendar year. The primary purpose of the EM&V assessment was to estimate net annual energy and peak demand impacts associated with 2013 HEIP activity. Secondary objectives included the following:

- Estimate net and gross impacts by measure
- Provide updated deemed savings estimates for each measure
- Evaluate the strengths and weaknesses of current program processes and customer perceptions of the program offerings and delivery
- Recommend improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction

The gross savings verified through EM&V assessment for PY 2013 was about 105 percent of the reported savings for energy, 66 percent for summer demand, and 90 percent for winter demand. Figure 1 shows the reported and verified energy and demand impacts from HEIP for PY 2013. Navigant developed a new set of calibrated energy simulation models that incorporated data from a heating, ventilation, and air conditioning (HVAC) metering study for PY 2013. The new models largely drove the verified savings, in addition to analysis of the HVAC audit data provided by DEP.[1]

[1] On a measure basis, the largest impact to demand savings was from the HVAC audit measure and was based on review of the data provided by DEP.

Figure 1. Comparison of Reported and Verified Gross Program Impacts: PY 2013



Sources: Navigant analysis, HEIP tracking database

Program Summary

HEIP generates energy and peak demand reductions by offering rebates for the following residential measures, focused on heating and air conditioning savings:

- HVAC equipment replacement (central air conditioner, air source, and geothermal heat pumps)
- HVAC audit (performance audit and tune-up including condenser coil cleaning, filter change, refrigerant charge correction)[2]
- Duct sealing
- Window replacement[3]
- Attic insulation
- Heat pump water heater
- Room air conditioner

DEP maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[4] based on estimated ("deemed") savings values. The air source heat pump was the largest share of reported energy

[2] For the purposes of this report, the term HVAC audit is synonymous with the term HVAC level 2 tune-up. The program rebate application refers to the measure as the former, and the program tracking database refers to the measure as the latter.

[3] This measure was discontinued from the program, although a small number of units were rebated in PY 2013. Navigant suspects these units were likely installed during previous years but rebates were paid in 2013 due to processing delays.

[4] Peak demand reductions are defined as the reduction in peak power demand that is coincident with the utility system peak, which is synonymous with summer peak demand reductions in DEP's service territory. Coincident peak times were provided by Duke Energy.

and summer demand savings, accounting for 32 percent of reported energy savings and 40 percent of summer demand savings. In PY 2012, HEIP saw a significant shift in participation toward the multi-family housing sector, which accounted for more than half (53 percent) of the total reported program savings. This represented a major change in the program from previous years, during which multi-family savings accounted for about 2 percent to 6 percent of total savings. In PY 2013, the share of reported energy savings from the multi-family sector fell to about 33 percent of the program total.

Evaluation Methodology

The EM&V assessment of HEIP activity in 2013 included impact and process evaluations. The impact evaluation consisted primarily of a field verification of a sample of participants to assess measure quantity, size, and efficiency. The field sample was stratified by measure and region and aimed to obtain a significant sample for each verified measure, spread across all regions, with targets of 90/10 confidence and precision for sampling at the program level. Field verification rates were derived by finding the ratio of the savings using the site-verified measure quantity, size, and efficiency to the savings using the reported quantity, size, and efficiency.

For PY 2013, Navigant developed a new set of calibrated energy simulation models to estimate energy and demand savings for several high-impact measures. The models also incorporated data from an HVAC metering study. In addition, the evaluation team estimated updated deemed savings estimates by applying unit savings from the new energy simulation models to the PY 2013 tracking databases. For each measure, an updated deemed savings value was calculated that represents the actual mix of measure characteristics, installation trends, and field verification rates for that year. These values were based on efficiency level, region, and heating type. The gross realization rates for each measure were then calculated by comparing verified savings to reported savings.

The process evaluation was conducted by administering surveys to 200 HEIP participants to assess overall satisfaction with the program and to estimate free ridership and spillover to calculate a net-to-gross (NTG) ratio. To assess the NTG ratio for HVAC audits and attic insulation in the multi-family housing segment, Navigant conducted surveys with 13 property managers or site representatives at multi-family housing complexes. Discussions were conducted with DEP program staff to gauge operational performance. Additionally, Navigant reviewed the program website and various program documents.

Program Impact Findings

Verified Gross Energy and Peak Demand Savings

DEP's program tracking database provided savings values for energy and peak demand based on program participation data and assumed deemed savings values. The EM&V team verified the accuracy of the total reported savings values for each measure using a four-step process:

1. Determine field verification rates for PY 2013 by performing onsite field assessments
2. Determine combined field verification rates for PY 2011–2013

3. Update measure savings values by considering the actual mix of efficiencies and regional distribution for each year
4. Calculate program-level savings

The program-level energy and demand savings are shown in Table 1.

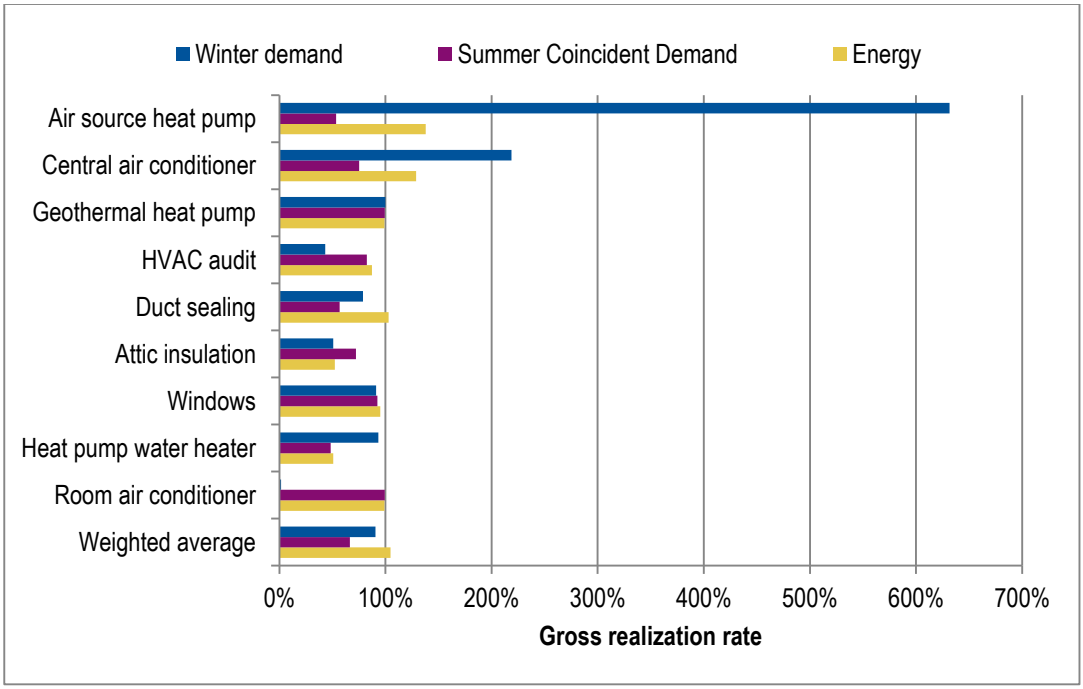
Table 1. Program-Level Gross Realization Rates and Verified Gross Savings: 2012

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Reported gross savings	5,623	5.06	3.71
Verified gross savings	5,895	3.36	3.36
Gross realization rate	105%	66%	90%

Note: Totals subject to rounding.
Source: Navigant analysis

Although the program-level gross realization rate for energy savings was 105 percent, it is important to note that there was significant variation in measure-level gross realization rates. Due to the many factors affecting the new energy simulation models, gross realization rates by measure for energy varied from as low as 51 percent for the heat pump water heater to as high as 138 percent for the air source heat pump. The gross realization rate for winter demand savings for the air source heat pump was over 600 percent. This is a result of the new energy simulation models, which Navigant believes to be an improvement over the previous models for this measure because the summer and winter demand savings are now similar in magnitude. The gross realization rates are shown in Figure 2. A detailed discussion of the new energy simulation models is provided in Appendix D of this report.

Figure 2. Gross Realization Rates by Measure: 2013



Source: Navigant analysis

Net Savings

Net savings incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records) and are commonly expressed as a NTG ratio, which is applied to the verified gross savings values.

The evaluation team estimates free ridership across all measures for HEIP to be 38 percent of program savings and spillover to be 6 percent of program savings. The resulting NTG ratio is 0.68, which implies that for every 100 kilowatt-hours (kWh) of realized savings, 68 kWh can be attributed to the program.[5] Table 2 shows the verified net impacts.

[5] Totals subject to rounding.

Table 2. Verified Net Impacts: PY 2013

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Verified gross savings	5,895	3.36	3.36
NTG ratio		0.68	
Verified net savings	4,006	2.28	2.28

Note: Totals subject to rounding.
Source: Navigant analysis

Process Findings

Process analysis findings are based on results of the 200 HEIP participant surveys, 13 multi-family property manager surveys (representing approximately 600 HVAC audit customer rebates and 200 attic insulation customer rebates), discussions with program staff, and a high-level review of program documents and functionality.

Key findings are as follows:

- About two-thirds of program participants in single family housing learned about HEIP directly from contact with or marketing from trade allies, which demonstrates the success of DEP and Honeywell's partnerships with these trade allies.
- Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP. Replacing old or broken equipment was also reported by 28 percent of respondents.
- A majority of HEIP participants were satisfied with the program. On a scale of 0 to 10, where 0 indicates "Not satisfied at all" and 10 indicates "Extremely satisfied:"
    - About 85 percent of participants indicated either an 8, 9, or 10 for satisfaction with overall program experience. This is a decrease from 90 percent in PY 2012.
    - Over 90 percent of participants indicated either an 8, 9, or 10 for satisfaction with the contractor's quality of work. This is an increase from 85 percent in PY 2012.
    - About 88 percent of participants indicated either an 8, 9, or 10 for satisfaction with the final cost of the program measure. This is an increase from 80 percent in PY 2012.
- About 58 percent of single family respondents reported a decrease in their energy bill. This is a decrease from 66 percent in PY 2012. About 21 percent of PY 2013 respondents reported "no change" in their energy bill after the measure installation.

Recommendations

HEIP continues to display strong participation and customer satisfaction. Participation levels for most key measures remained about the same as PY 2012, with the exception of HVAC audits, which saw a decrease in participation from over 8,000 units in PY 2012 to less than 4,000 in PY 2013. The program-level verified net savings decreased by about 28 percent between PY 2012 and PY 2013. The decrease was driven by changes in participation levels as well as updated savings estimates from the new energy simulation models.

The evaluation team recommends several discrete actions for improving the HEIP offering based on insights gained through discussions with program staff, participant surveys, analysis of program records and assumptions, and a review of field verification data. These recommendations provide DEP with a roadmap to fine-tune HEIP for continued success and are organized around three broad objectives:

1. Improving average savings and increasing program participation
2. Improving program delivery
3. Enhancing program tracking and evaluation efforts

The following list summarizes the program recommendations; further details can be found in Section 5:

- Update the tracking database to reflect measure-level deemed savings from this report
- Tighten eligibility requirements for measures not meeting savings expectations
- Continue to offer technical training and workshops for contractors, with particular emphasis on using the diagnostic tool for HVAC audits to achieve maximum savings[6]
- Continue to offer marketing training for contractors
- Increase direct marketing through DEP
- Increase participant awareness regarding receipt of rebate payment
- Ensure that all information from rebate application forms is included in program tracking database extracts
- Modify program processes to integrate data collection activities required for EM&V

[6] The diagnostic tool is a handheld device used by HVAC contractors to assess the operating performance of an HVAC unit. The tool can be connected to the HVAC unit and provide the user with real-time displays of several key operating parameters. Measurements from the tool are used in a savings algorithm that estimates the energy and demand impact associated with service performed by the contractor.

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1. Introduction and Program Summary

The Home Energy Improvement Program (HEIP) is part of the portfolio of energy efficiency programs initiated by Progress Energy Carolinas (PEC) beginning in late 2008. HEIP provides rebates for the retrofit and maintenance of equipment in existing homes, while other portfolio offerings address efficiency opportunities in new homes, for specific equipment and appliances, and in commercial buildings. This report covers evaluation, measurement, and verification (EM&V) activities by Navigant Consulting, Inc. (Navigant) for Duke Energy Progress's (DEP's) HEIP for Program Year 2013 (PY 2013) projects, defined as those receiving rebates during the 2013 calendar year.

EM&V is a term adopted by DEP that refers generally to the assessment and quantification of the energy and peak demand impacts of an energy efficiency program. EM&V uses a variety of analytic approaches, including onsite field verification of installed measures, analysis of customer billing records, and application of engineering and energy simulation models. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys. A glossary of evaluation terms is provided in Appendix A.

1.1 Objectives of Evaluation

The primary purpose of the EM&V assessment was to estimate net annual energy and peak demand impacts associated with 2013 HEIP activity. Secondary objectives included the following:

- Estimate net and gross impacts by measure
- Provide updated deemed savings estimates for each measure
- Evaluate the strengths and weaknesses of current program processes and customer perceptions of the program offerings and delivery
- Recommend improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction

Ultimately, DEP can use these results for reporting impacts to the North Carolina Utilities Commission (NCUC) and the Public Service Commission of South Carolina (PSCSC) and as an input to system planning. In addition, this report describes strengths and weaknesses of the current program delivery and recommendations for improving total program impacts. The results of this evaluation should allow DEP staff to improve the design of HEIP to increase benefits delivered while remaining cost-effective, thus providing greater value to ratepayers.

1.2 Reported Program Participation and Savings

HEIP generates energy and peak demand reductions by offering rebates for the following residential measures and equipment, focused on heating and air conditioning savings:

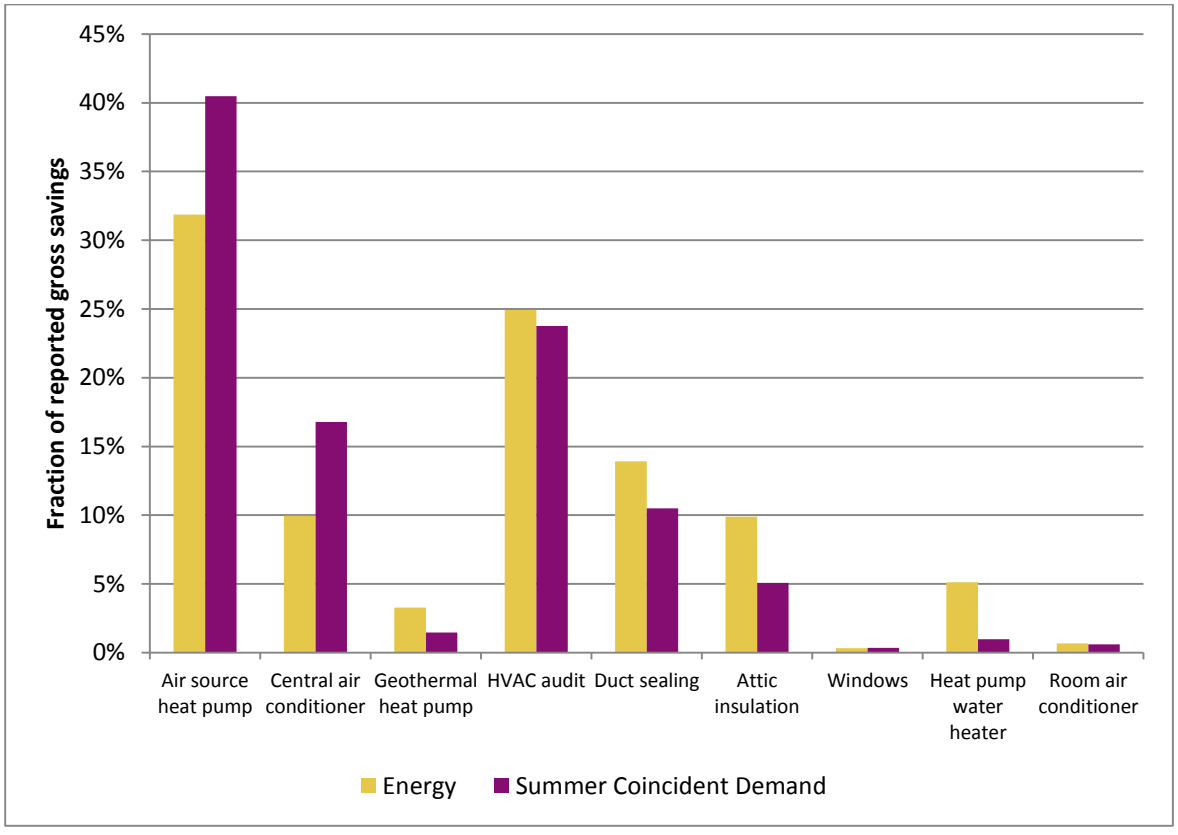
- Heating, ventilation, and air conditioning (HVAC) equipment replacement (central air conditioner, air source, and geothermal heat pumps)

- HVAC audit (performance audit and tune-up including condenser coil cleaning, filter change, refrigerant charge correction)
- Duct sealing
- Window replacement
- Attic insulation
- Heat pump water heater
- Room air conditioner

DEP maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[7] based on estimated ("deemed") savings values.

Reported gross savings from PY 2013 measures were more than 5.6 gigawatt-hours (GWh) and 5.1 megawatts (MW). The air source heat pump measure was the largest contributor to reported energy and summer demand savings, accounting for about one-third of the reported savings in those categories. The share of peak demand reductions by measure was roughly the same as it was for total energy savings. Figure 1-1 shows the reported energy and demand savings by measure type for PY 2013.

Figure 1-1. Fraction of Reported Gross Savings by Measure: PY 2013



[7] Summer peak demand reductions are defined as the single maximum hourly reduction in peak power demand that is coincident with the utility system peak, which occurs in month 7 hour 17 in the DEP territory.

Source: Navigant analysis of HEIP tracking database

Table 1-1 presents a summary of participation and gross savings reported by measure.

Table 1-1. Reported Gross Annual Energy and Peak Demand Savings by Measure: PY 2013

Measure	Rebate Count	Annual Energy Savings (MWh)	Fraction of Annual Energy Savings	Coincident Summer Demand Savings (kW)	Fraction of Coincident Summer Demand Savings	Coincident Winter Demand Savings (kW)	Fraction of Coincident Winter Demand Savings
Air source heat pump	4,884	1,792	32%	2,051	40%	195	5%
Central air conditioner	1,979	560	10%	851	17%	79	2%
Geothermal heat pump	107	185	3%	74	1%	-	0%
HVAC audit	3,650	1,402	25%	1,205	24%	1,387	37%
Duct sealing	2,956	783	14%	532	10%	1,271	34%
Attic insulation	834	556	10%	258	5%	557	15%
Windows	35	19	0%	18	0%	7	0%
Heat pump water heater	100	289	5%	50	1%	58	2%
Room air conditioner	305	38	1%	31	1%	177	5%
Total	**14,850**	**5,623**	**100%**	**5,059**	**100%**	**3,711**	**100%**

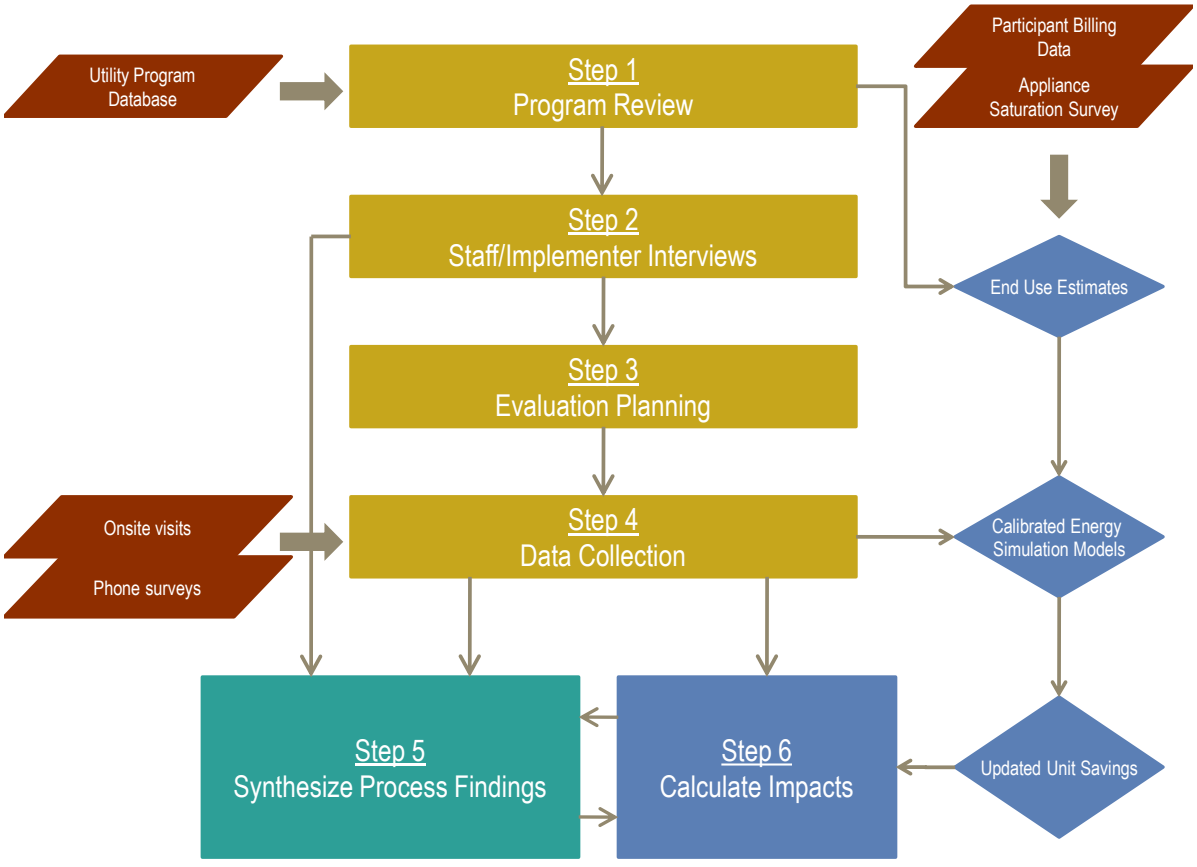
Note: Totals subject to rounding.

Source: Navigant analysis of HEIP tracking database

2. Evaluation Methods

Navigant used a similar approach to evaluate PY 2013 to what was used in PYs 2009–2012, with the exception of an updated energy simulation modeling effort in 2013. The program database was the starting point for understanding the mix of measures. The team collected field data through an HVAC metering study as well as onsite visits to verify tracking data and to select appropriate outputs from the energy models, which drove the impact analysis. Finally, Navigant synthesized participant phone interview data into process recommendations and calculated total program impacts by using the results of the energy models and the field verification data. This general process is outlined in Figure 2-1.

Figure 2-1. Evaluation Process Flow Diagram



Source: Navigant

2.1 Step 1: Program Review

The evaluation followed a methodology similar to previous years. Program documentation was requested and reviewed, including the following:

- E2DR program tracking database, as provided by DEP
- HVAC audit data from diagnostic tool
- Program applications
- Program guidance to contractors

The program review generated a picture of which measures and regions were providing the largest savings, helping guide the subsequent evaluation research.

2.2 Step 2: Staff/Implementer Interviews

The evaluation team conducted discussions with the HEIP Program Manager in order to understand how the program was working and what program changes were in the works. The following topics were discussed during the interviews:

- Changes in delivery of HVAC audit measure
- Measures of particular interest to DEP staff

2.3 Step 3: Evaluation Planning

Navigant conducted an HVAC metering study and developed new energy simulation models to improve savings estimates for several measures. Navigant focused on field verification of HVAC replacement, duct sealing, and attic insulation due to their large contribution to program savings. Furthermore, Navigant repeated the in-depth analysis of the HVAC audit data recorded by trade allies that was used in PY 2012. Due to the expense related to field verification, a small amount of value would have been added by focusing on the smaller contributing measures.

2.4 Step 4: Data Collection

Data collection was conducted using a combination of telephone surveys, site visits, and metering. The telephone surveys were designed primarily to support the process evaluation and to inform the net-to-gross (NTG) analysis. A special request was submitted to DEP for the HVAC audit data because it is not included in the standard E2DR program tracking database.

The telephone sample was stratified primarily by measure and secondarily by region to accurately represent measure-level results. As shown in Table 2-1, 200 participating customers responded to the telephone survey.

Table 2-1. Sample Sizes for Participant Telephone Surveys[a]

Measure Category[b]	Number of Respondents	Number of Rebates in 2013[c]	Percent of Population Surveyed for Each Measure
Air source heat pump	69	4,884	1.4%
Central air conditioner	38	1,979	1.9%
Geothermal heat pump	7	107	6.5%
HVAC audit	4	3,650	0.1%
Duct sealing	44	2,956	1.5%
Attic insulation	18	834	2.2%
Heat pump water heater	12	100	12.0%
Room air conditioner	8	305	2.6%
Total	**200**	**14,580**	**1.3%[d]**

a. An additional 13 surveys were conducted with property managers or site representatives at multi-family housing complexes to assess NTG in that market, which represented several hundred participants.
b. Surveys were not conducted for windows and level 1 HVAC tune-up participants because those two measures have been removed from the program.
c. Includes rebates paid in calendar year 2013.
d. Represents ratio of total surveyed respondents to total rebates.
Totals subject to rounding.
Source: Navigant analysis

The field verification sample was stratified by measure and region, with the objective of obtaining a significant verification sample for each measure, spread across all regions, at 90/10 sampling confidence and precision. The fieldwork addressed heat pump and air conditioning installations, attic insulation, and duct sealing—measures accounting for about two-thirds of total reported energy savings in 2013.[8]

[8] Field verification was not conducted for room air conditioners, heat pump water heaters, or geothermal heat pumps due to a lower contribution to overall savings. Furthermore, the evaluation team did perform an HVAC audit field study during 2013 with results not conclusive enough to suggest an adjustment to the approach of analyzing the data provided by the HVAC audit tool.

The field verification sample is shown in Table 2-2.

Table 2-2. Field Verification Sample

Measure Category[a]	# Measures	# of Rebates in 2013
Air source heat pump	39	4,884
Central air conditioner	26	1,979
Attic insulation	24	834
Duct sealing	17	2,956
Total[b]	**106**	**10,653**

a. Several measures were not included in the field verification sample due to relatively low savings and/or the high cost and uncertainty of performing verification activities.
b. The total number of sites visited was 105, but one site had multiple measures. Participants include all those receiving rebates in the calendar years 2013.

Source: Navigant analysis

2.5 *Step 5: Impact Analysis*

The impact analysis consisted of three parts: 1) determining field verification rates from onsite visits, 2) developing new calibrated energy simulation models that incorporated metering data and updating measure-level deemed savings by applying model outputs to the 2013 tracking database and by reviewing HVAC audit data, and 3) estimating verified gross savings for the program.

The following detailed steps outline the impact analysis approach.

2.5.1 Derive Field Verification Rates

In order to determine field verification rates, Navigant compared results of the field data collection activity with the reported installations to check for both quantitative and qualitative differences.

- **Quantity:** This was determined by comparing the total quantity/size found at all sites in the sample to that reported in the tracking data for the same sites. For example, at a single family or multi-family home with rebated attic insulation, the number of insulated square feet was compared to the number of reported square feet.
- **Measure characteristics:** For each site in the sample, the efficiency, installation location, and installation quality of what was installed was compared to the value reported in the program database.

The evaluation team calculated the final field verification rate for each measure by assessing the results of verified quantity and characteristics.

2.5.2 Update Deemed Savings Values

For PY 2013, Navigant conducted a metering study and modeling effort to update the analysis upon which savings estimates for several HEIP measures are based. During this effort, Navigant deployed data loggers to monitor HVAC usage at 65 PY 2013 participant homes. The evaluation team then developed a new set of energy simulation models and calibrated them to the metered data and participant consumption data.

Navigant then updated the deemed savings values for each measure in PY 2013 by applying the new simulation outputs to the 2013 tracking databases on a project-by-project basis and subsequently applying the field verification rates. The modeling effort is described in further detail in Appendix D.

2.5.3 Calculate Program Impacts

Navigant computed program-level impacts by performing a line-item analysis of the tracking database. Each rebated measure was matched to a savings value based on the region, heating type, and best available match of base- and efficient-case measure characteristics. The evaluation team then multiplied the unit savings value by the measure quantity to derive an updated savings estimate for each rebated line item. Finally, the team summed the total savings values by measure over the whole program.

Navigant calculated the verified gross savings impacts by multiplying the updated total savings for each measure by the measure-level field verification rates. The team determined verified gross savings at the program level by summing measure-level verified savings. Finally, Navigant calculated realization rates as the ratio of verified savings to reported savings, both by measure and for the program as a whole.

Navigant used the results of the participant and property manager surveys to estimate a NTG ratio for each measure by combining free ridership and spillover estimates. Program participants indicated whether, in the absence of the program, they would have installed the same measure of similar efficiency and whether they had previously installed the same type of measure or had prior plans to do so. Survey participants also indicated whether the program had influenced them to install additional energy efficient measures. A description of the methodology for estimating NTG ratios is provided in Appendix B.

2.6 Step 6: Process Evaluation

The process evaluation focused on describing the program's processes and procedures, as well as assessing how well the program is running from several key perspectives, including those involved in the program's day-to-day management, trade allies who perform the work, and the customers who received program services. The evaluation team had discussions with internal DEP staff and conducted surveys with program participants. The evaluation team analyzed survey results to determine what portions of the program are working well and where DEP might be able to make improvements.

3. Program Impacts

DEP's program tracking database provided savings values for energy and peak demand ("reported gross savings") based on program participation data and assumed deemed savings estimates for each measure. Additionally, DEP provided Navigant with reported program total savings numbers to compare with the EM&V verified totals. As discussed in Section 2.5, the EM&V team verified the accuracy of these reported savings values for each measure category using onsite data collection to conduct field verification of measure installations and program participant characteristics.[9] The result was a set of verified gross savings by measure and for the program as a whole. The glossary in Appendix A provides brief descriptions of commonly used EM&V terms.

The term gross savings refers to reductions in energy consumption and peak demand based on engineering estimates for known quantities and types of measure installations. Gross savings do not account for whether the measures were installed as a result of the program.[10] Table 3-1 compares the verified gross savings to the reported savings for PY 2013. The relationship between these two values is the gross realization rate, shown here to be 105 percent for energy savings, 66 percent for summer peak demand reduction, and 90 percent for winter peak demand reduction.

Table 3-1. Annual Energy and Demand Reductions: PY 2013

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Reported gross savings	5,623	5.06	3.71
Verified gross savings	5,895	3.36	3.36
Gross realization rate	**105%**	**66%**	**90%**

Note: Totals subject to rounding.
Source: Navigant analysis

The remainder of this section presents the detailed impact findings, which are broken down into the following four components:

1. **Field verification rate:** The field verification rate is the ratio of savings from measures verified onsite to those reported in the program database.
2. **Updated deemed savings values:** These are the estimated savings for each measure determined by the annual measure mix in the tracking database and field verification rates.
3. **Verified gross savings and gross realization rate:** Verified gross savings represent gross reductions in energy consumption and peak demand that has been verified through EM&V activities, while the gross realization rate is the ratio of verified gross savings to reported savings.

[9] The PY 2009 evaluation team used billing data, appliance saturation data, and energy simulation modeling to assess the most appropriate unit savings values.
[10] Savings attributable to the program can be adjusted for free ridership and spillover/market effects. Free ridership and spillover are addressed at the end of this section.

4. **NTG ratio and net savings:** The NTG ratio and net savings both relate to reductions in energy consumption and peak demand that can be directly attributed to the program, accounting for free ridership and spillover.

3.1 Field Verification Rates

Field verification rates reflect differences between the equipment installed onsite and the equipment reported in the program tracking database. The EM&V team determined field verification rates for each assessed measure category using onsite verification of size, quantity, and efficiency characteristics and identifying both quantitative and qualitative differences:

- **Quantity** reflects comparison in quantity and size between the program database and actual, onsite conditions verified by the EM&V team (e.g., total square footage of attic insulation or the size of a new air conditioner measured in tons of cooling capacity).
- **Measure characteristic** reflects a comparison between reported and verified characteristics related to the efficiency of the equipment installed or the way it was installed (e.g., R-value of new insulation, seasonal energy efficiency ratio (SEER) rating of a new air conditioner, or the location of newly sealed ducts).

The final field verification rate for each measure category combines the effects of these two types of differences to determine a percentage adjustment on the reported savings based on what the evaluation team identified as installed in the field.

3.1.1 Final Field Verification Rates

Navigant conducted 105 field verification site visits for HEIP participants who received rebates through the program in 2013. The 105 site visits included verification of 106 measures, as one of the participants received rebates for more than one measure.

Navigant performed field verification on four measures contributing significantly to program-level energy savings: air source heat pumps, central air conditioners, attic insulation, and duct sealing. Table 3-2 shows the quantities of field verification measures assessed.

Table 3-2. Evaluated Measures for 2013

	Evaluated Measures (PY 2013)
Air source heat pump	39
Central air conditioner	26
Attic insulation	24
Duct sealing	17

Source: Navigant analysis

To calculate field verification rates, Navigant compared results from the field site visits to the program tracking database for each measure. The comparison included data relating to measure quantities and

measure efficiencies. Field verification rates are a quantifier of how closely the verified characteristics match the reported characteristics for each measure.
A summary of field verification findings for each measure is provided below:

- **Air source heat pump and central air conditioners:** Reported equipment quantities and efficiencies were all correct, leading to a field verification rate of 100 percent for both energy and demand. Navigant performed verification on these measures during the installation of the data loggers for the HVAC metering study.
- **Duct sealing:** Navigant conducted verification visits at 16 sites for a total of 17 duct sealing measures. The verification process consists of a thorough visual inspection of the duct work to ensure that criteria specified in the HEIP *Standards and Installation Procedures Manual* and rebate applications are met. In total, 16 of the 17 evaluated measures achieved Navigant's criteria for properly sealed ducts, translating to a field verification rate of 94 percent. Verification rates were determined on a pass/fail basis.
- **Attic insulation:** Navigant conducted field verification of 24 attic insulation sites. The evaluation team recorded measurements of insulation square footage and R-value. In total, the measured square footage amounted to nearly 100 percent of the reported square footage. The measured R-value amounted to 118 percent of the reported R-value when weighted by measured square footage. To calculate the final field verification rate, Navigant compared the energy and demand savings for each field site using the reported combination of square footage and R-value to the verified combination of square footage and R-value. The resulting field verification was 101 percent for energy savings and winter demand savings, and 100 percent for summer demand savings.
- **Other measures:** Navigant assigned the program average field verification rate to the measures not assessed during this round of site visits, which are also the measures contributing least to overall program savings.[11] Navigant believes that investing in EM&V for the lesser-contributing measures would result in only a marginal increase in the certainty of EM&V findings.

[11] The HVAC audit measure is an exception and is discussed in detail later in this section.

Field verification rates for energy and demand are shown in Table 3-3 below.

Table 3-3. Field Verification Rates by Measure: PY 2013

Measure	Annual Energy Savings	Peak Demand Reductions[a]	Winter Demand Reductions[b]
Air source heat pump	100%	100%	100%
Central air conditioner	100%	100%	100%
Geothermal heat pump	98%	99%	98%
HVAC audit[b]	99%	99%	97%
Duct sealing	94%	94%	94%
Attic insulation	101%	100%	101%
Windows[c]	93%	91%	91%
Heat pump water heater	99%	99%	97%
Room air conditioner	99%	99%	97%
Program average[d]	**99%**	**99%**	**97%**

a. The energy and demand field verification rates can be different due to a measure's contribution to overall energy or demand savings.
b. Verification rates for the HVAC audit measure were based on an analysis of the trade ally audit data.
c. For windows, Navigant assigned the average field verification rates from the PY 2009–2011 field EM&V.
d. Program average represents the weighted average field verification rate from the measures assessed during site visits for PY 2013, which includes air source heat pump, central air conditioner, duct sealing, and attic insulation. Program averages can be different for energy, summer demand, and winter demand because each assessed measure is weighted separately for its respective contribution to the total energy, summer demand, and winter demand savings.

Source: Navigant analysis

3.1.2 Combined Verification Rates

As in the PY 2010 –PY 2012 analyses, Navigant combined field verification results from multiple program years to achieve a single verification rate for each measure. The combined verification rates are weighted across years in terms of the respective annual energy savings for each measure. This methodology effectively represents the results of having an increased sample size for field verification, which is appropriate, given that there were no significant changes in the program operation or verification approach across different program years. Navigant uses a rolling average from the three previous program years. Weighted field verification rates for energy are shown in Table 3-4. The corresponding values for summer coincident demand and winter demand can be found in Appendix C. These results demonstrate that field verification rates are fairly consistent each year, and a combined value provides the best representation of program performance.

Table 3-4. Weighted Field Verification Rates for Energy across PY 2009–2012

Measure Category	PY 2011	PY 2012	PY 2013	Weighted
Air source heat pump	100%	100%	100%	100%
Central air conditioner	100%	100%	100%	100%
Geothermal heat pump	95%	98%	98%	99%
HVAC audit[a]	95%	47%	99%	99%
Duct sealing	86%	100%	94%	94%
Attic insulation	100%	94%	101%	97%
Windows	91%	93%	93%	93%
Heat pump water heater	N/A	98%	99%	99%
Room air conditioner	N/A	98%	99%	99%

Note: Verification rates were not weighted for the HVAC audit measure due to the significance of the 2012 findings.
Source: Navigant analysis

3.2 *Updated Deemed Savings Estimates*

For PY 2013, Navigant developed a new set of calibrated energy simulation models to estimate energy and demand savings for several measures. The simulation models incorporated data from the HVAC metering study and were calibrated to HEIP participant billing records. Navigant conducted a series of model runs to represent a wide range of pre- and post-retrofit measure characteristics. A detailed discussion of the metering study and modeling effort is included in Appendix D.

Navigant updated the deemed energy and demand savings values for several HEIP measures by applying the energy simulation model outputs to the 2013 program tracking databases and subsequently applying field verification rates. For example, a participant that installed an air source heat pump of a given efficiency in DEP's northern region was credited the savings from the respective energy model output. This approach ensures the deemed savings values appropriately represent the mix of measures for 2013. Changes from one year to the next were driven largely by the new energy simulation models, 2013 participant billing data, analysis of the HVAC audit data provided by DEP, and by year-to-year differences in the overall mix of measure characteristics installed by program participants (e.g., average heat pump tonnage, average insulation square footage, and DEP service region). Some values increased (e.g., kWh savings for air source heat pump increased from 373 kWh per unit in 2012 to 506 kWh per unit in 2013), while other values decreased (e.g., energy savings for attic insulation decreased from 519 kWh per participant in 2012 to 349 kWh in 2013).

3.2.1 Measure-Specific Deemed Savings Values

The simulation results were applied to the 2013 program data to determine updated deemed savings values that represent the actual mix of efficiencies and regional distribution of rebated measures during that year. Once each rebated measure was matched with the appropriate savings estimate, the field verification rates were applied to estimate final verified savings values. The deemed savings values for 2013 differ from 2009 due to differences in these installation trends and in field verification rates. Updated deemed savings estimates for energy are found in Table 3-5. Going forward, these values should be used in the tracking database. The corresponding values for summer coincident demand and winter demand can be found in Appendix C.

Table 3-5. Deemed Energy Savings for Each Measure in PY 2009–2012

Energy	PY 2009 (kWh)	PY 2010 (kWh)	PY 2011 (kWh)	PY 2012 (kWh)	PY 2013 (kWh)
Air source heat pump	371	366	367	373	506
Central air conditioner	293	279	283	273	364
Geothermal heat pump	1,725	1,725	1,725	1,725	1,725
Level 1 HVAC tune-up[a]	96	104	104	101	N/A
HVAC audit	N/A	384	384	182	334
Duct sealing	244	265	265	242	273
Windows[a]	516	572	543	517	517
Attic insulation	830	727	669	504	349
Heat pump water heater	N/A	N/A	N/A	2,885	1,462
Room air conditioner	N/A	N/A	N/A	125	124

a. Level 1 HVAC tune-ups and windows have been removed from the program, but some rebates were paid in 2012. Deemed savings are shown here for comparison purposes only.

Source: Navigant analysis

3.2.2 Discussion of Deemed Savings Adjustments

In Section 3.2.1, several savings values were presented for PY 2013 that differ from those found during previous EM&V years. The seven primary drivers affecting the change in annual deemed savings values are listed below:

1. New energy simulation models
2. Analysis of HVAC audit data provided by DEP
3. Annual mix of rebated measure efficiencies
4. Annual mix of baseline measure efficiencies
5. Annual trends in geographic location, as defined by DEP's northern, southern, eastern, and western regions
6. Measure location (e.g., vented crawlspace vs. attic for duct sealing)
7. Field verification rates

Understanding the changes in these trends can help to identify target areas from which greater energy savings can be achieved. This section presents some additional discussion regarding the impacts of new energy simulation models, as well as a discussion specifics to the HVAC audit measure.

3.2.2.1 Energy Simulation Model Impacts

For the PY 2009 –PY 2012 EM&V cycles, Navigant used the results of energy simulation models built in 2010 to estimate energy and demand savings for most HEIP measures. Those models had been developed using the best available data for housing characteristics and were calibrated to 2009 HEIP participant billing data. Additionally, those models were run using Typical Meteorological Year 2 (TMY2) weather data, which represents the typical weather from 1961 through 1990.

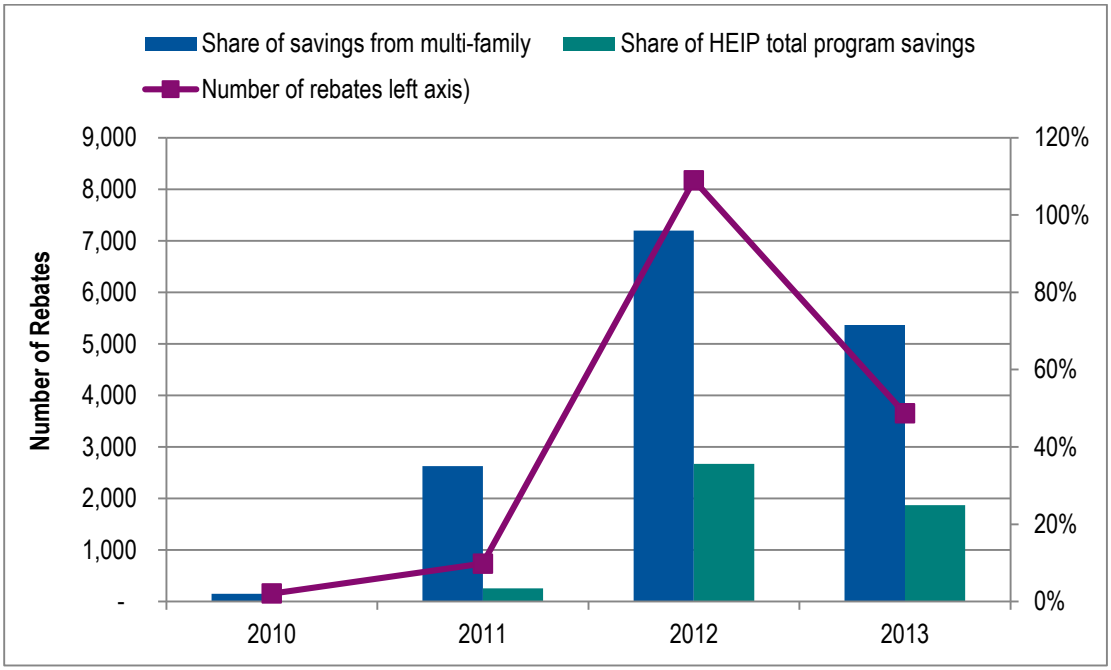
For PY 2013, Navigant developed a new set of energy simulation models. The new models were based on similar housing characteristics as the previous models, with some updates coming from additional sources: the 2013 Duke Energy Residential End-Use Studies, DEP demographic data, Navigant field verification data, and other secondary research. The new models were then calibrated to participant data from PY 2013, as well as the measured HVAC consumption data that Navigant collected during the field metering study. Additionally, the new model runs to estimate energy and demand savings were conducted using TMY3 data, which represents typical weather from 1991 through 2005.

All of the differences described above, in addition to any changes in the mix of measure sizes and efficiencies in 2013, account for the differences in deemed savings between PY 2013 and previous program years. Navigant believes the new values are an improvement over previous estimates and incorporate the most contemporary EM&V techniques. Further discussion of the modeling effort and metering study is provided in Appendix D.

3.2.2.2 *HVAC Audit*

As in the PY 2012 EM&V report, Navigant thought it was appropriate to provide some additional discussion regarding the HVAC audit measure. Participation in the HVAC audit (or level 2 HVAC tune-up) measure increased dramatically in PY 2012. Figure 3-1 shows a summary of participation and program impacts for PYs 2010–2013. Incentives were paid for over 8,000 HVAC audits in 2012, which is more than ten times the 753 that were paid in 2011. Also, about 96 percent of the 2012 audits were performed at multi-family housing complexes, up from 35 percent in 2011. This trend was largely driven by a single trade ally that performed about 95 percent of all audits in 2012, the vast majority of which were at multi-family sites. The participation decreased in 2013.

Figure 3-1. HVAC Audit Participation Trends



Source: Navigant analysis

Due to the drastic increase in HVAC participation in 2012 and the implications for program-level savings, Navigant performed a detailed analysis of the trade ally audit data from all audits performed in PY 2012. DEP provided Navigant with audit data from the diagnostic tool used by trade allies during the audit process. This data includes a number of parameters measured by the tool, as well as the calculated efficiency index value that the tool uses to estimate annual energy savings. Additionally, Navigant conducted a field study in 2013 on HVAC audit participants to attempt to further understand the savings estimates. The field study was not conclusive enough to suggest any adjustment to the analysis done on the contractor audit data, but several key process findings were discovered.

Navigant repeated this process for PY 2013. Upon reviewing the HVAC audit data, Navigant discovered that the average savings across all 2013 participants, as calculated by the diagnostic tool, was 398 kWh. The share of savings by equipment type and housing sector is shown in Table 3-6. Average savings from

air conditioner tune-ups was higher than average savings from heat pump tune-ups, which appears to be a result of differences in pre- and post-efficiency index values.

Table 3-6. Breakout of Savings and Efficiency Parameters by HVAC Type

Category	Number of Units	Average Savings per Unit (kWh)	Average Efficiency Index before Tune-Up	Average Efficiency Index after Tune-Up
AC package average	**12**	**491**	**88**	**97**
Duplex/Single Family Attached	1	-16	90	90
Single Family Detached	11	541	87	98
AC split average	**582**	**453**	**75**	**85**
Duplex/Single Family Attached	5	82	81	90
Multi-family Dwelling	557	460	75	84
Single Family Detached	20	350	92	99
HP package average	**10**	**152**	**90**	**94**
Single Family Detached	10	152	90	94
HP split average	**3,040**	**388**	**76**	**87**
Duplex/Single Family Attached	6	368	82	93
Multi-family Dwelling	2,944	392	76	87
Single Family Detached	90	254	90	97
Total	**3,644**	**398**	**76**	**87**

Source: Navigant analysis

The data also showed that about 3 percent of the HVAC units had an efficiency index greater than 90 percent before any tune-up was performed, indicating that the units were already in reasonable working order. This is a significant improvement over PY 2012 where about 45 percent of units had an efficiency index of greater than 90 before the tune-up. Navigant used the conservative approach of removing outliers that do not represent realistic savings values used in PY 2012. Navigant's billing analysis provided the average annual consumption for typical HEIP customers in the single family and multi-family sector. Additionally, the metering study provided the HVAC load during summer months, which averaged about 42 percent of total home energy consumption.

The evaluation team recommends removing HVAC audit savings estimates that exceed ±20 percent of total annual electric usage of a typical residential customer (effectively representing 50 percent of annual HVAC consumption). This recommendation results in a savings of 338 kWh per participant.

Additional parameters from Navigant's analysis of the HVAC audit tracking data are shown below in Table 3-7. The average savings per unit from the multi-family housing segment was larger than that

from the single family segment because the units tended to operate at lower efficiencies prior to the tune-ups.

Table 3-7. Parameters from Navigant's Analysis of HVAC Audit Data

	Single Family	Multi-Family
Average savings per unit (kWh)	283	341
Average Efficiency Index before tune-up	90	97
Average Efficiency Index after tune-up	76	86

Source: Navigant analysis

3.2.2.3 Attic Insulation

The energy savings per site for attic insulation in 2013 were lower than previous years due to different results from the new energy simulation models. Table 3-8 summarizes the annual differences in the installation trends for attic insulation. Although the average square footage of installed insulation in 2013 was greater than 2012, the newly calibrated models resulted in a lower savings per square foot.

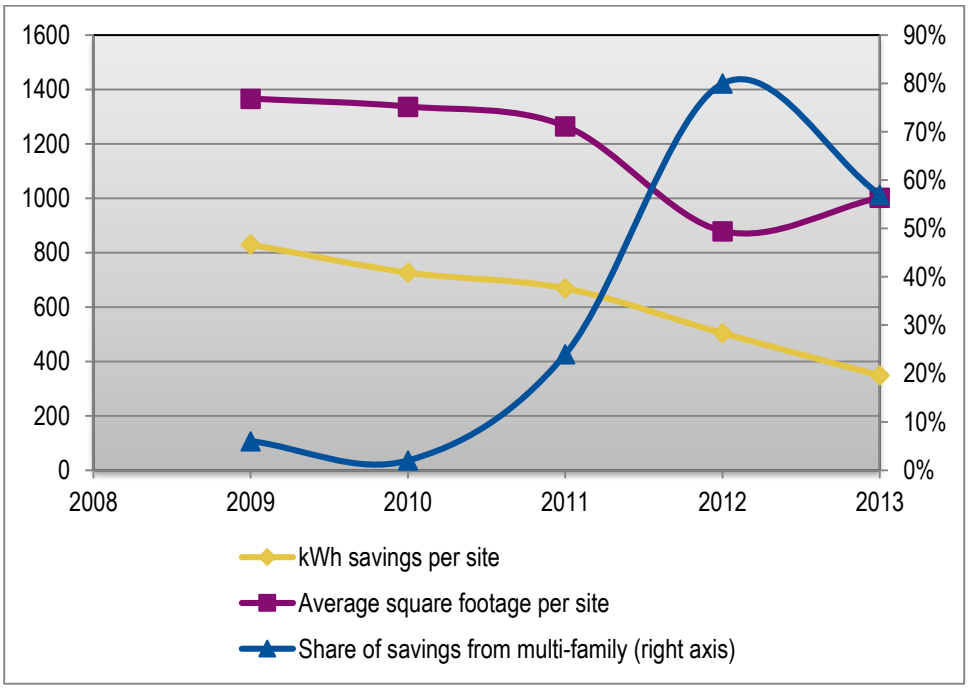
Table 3-8. Annual Trends in Attic Insulation Characteristics

	PY 2009	PY 2010	PY 2011	PY 2012	PY 2013
kWh savings per site	830[a]	727	669	504	349
kWh savings per ft^2 installed	0.61	0.54	0.53	0.57	0.36
Average base R-value	15.2	14.9	14.7	13.7	14.3
Average rebated R-value	35.2	36.2	35.0	33.5	33.1
Average ft^2 installed	1,356	1,337	1,265	879	1,002

a. This value includes a field verification rate of 110%.
Source: Navigant analysis

Figure 3-2 shows a summary of attic insulation characteristics for PY 2009–2013.

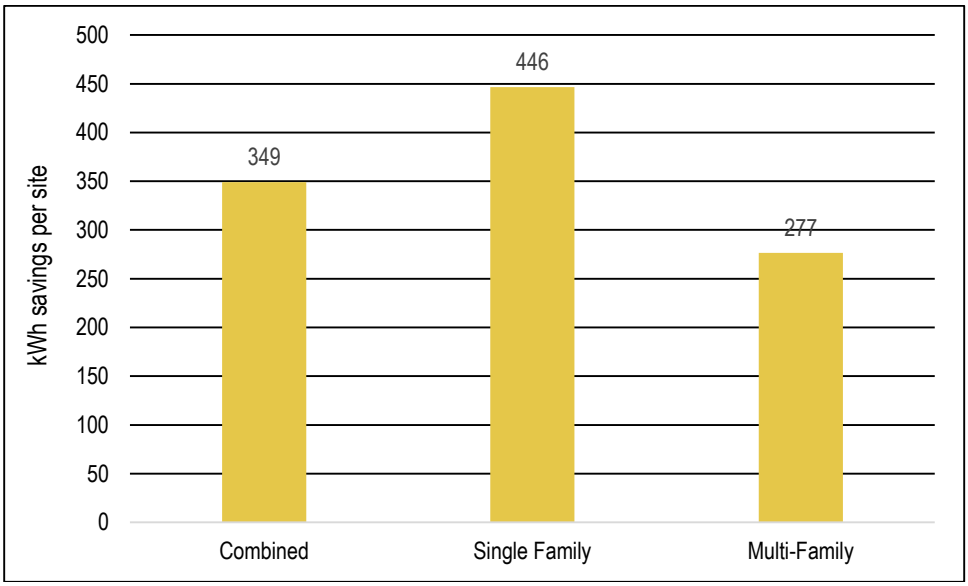
Figure 3-2. Attic Insulation Energy Savings and Square Footage for PY 2009-2013



Source: Navigant analysis

DEP also requested that Navigant provide a summary of energy savings for multi-family versus single family participants that installed attic insulation. Figure 3-3 shows the comparison of per-site energy savings across different housing segments, using PY 2013 data and field verification rates. These values are repeated along with the corresponding demand savings estimates in Table 3-9. If DEP decides to track deemed savings by housing segment, these values can be used going forward in the tracking database.

Figure 3-3. Deemed Savings for Different Housing Segments



Source: Navigant analysis

Table 3-9. Deemed Savings for Attic Insulation by Housing Segment

	Combined	Single Family	Multi-Family
Energy (kWh)	349	446	277
Summer demand (kW)	0.223	0.285	0.176
Winter demand (kW)	0.339	0.507	0.213

Source: Navigant analysis

3.3 *Verified Gross Savings and Gross Realization Rate*

The evaluation team estimated verified gross savings for each measure by multiplying the field verification rates by the savings values. Navigant then calculated the gross realization rates for each measure by dividing the verified gross savings by the reported gross savings. Gross realization rates for energy savings range from 51 percent for the heat pump water heater measure to as high as 138 percent for air source heat pump. The deemed savings adjustments discussed in Section 3.2 drove the gross energy realization rates in most cases, aside from the data analysis for the HVAC audit measure. Verified gross savings per measure are shown in Table 3-10.

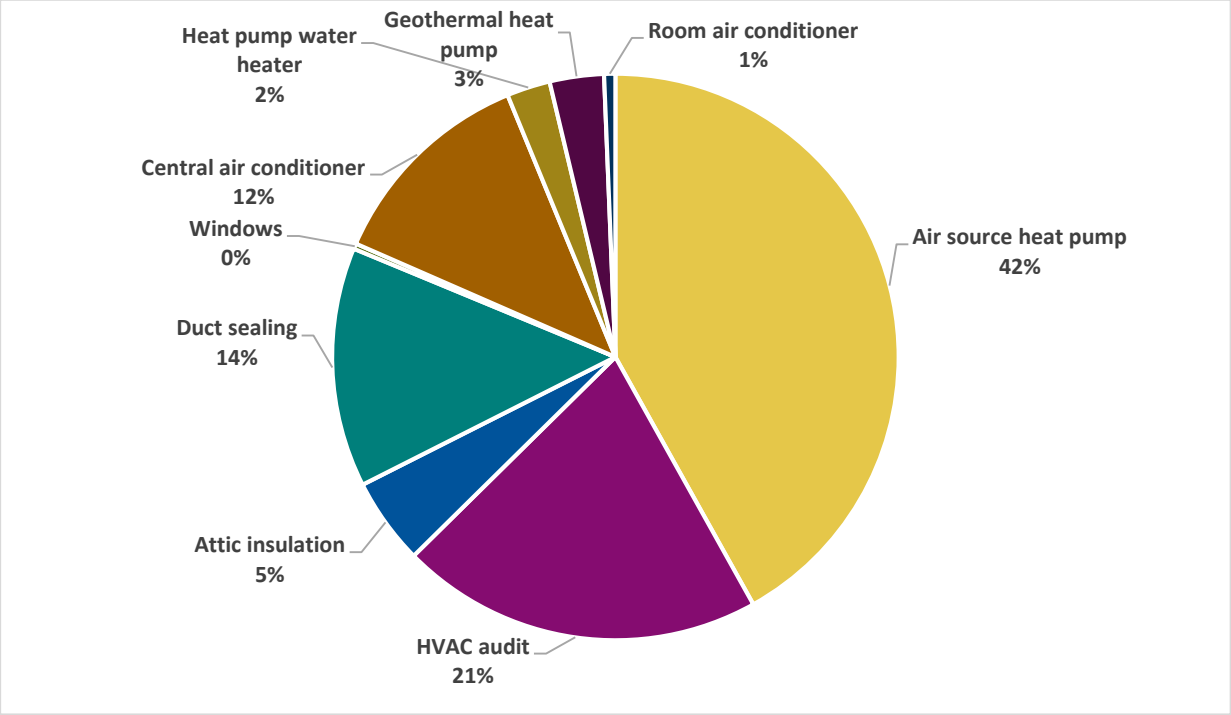
Table 3-10. Verified Gross Energy Savings Summary by Measure

Measure Category	Number of Rebates	Deemed Savings per Rebate (kWh)	Field Verification Rate	Verified Gross Savings (MWh)[a]	Reported Gross Savings (MWh)[a]	Gross Realization Rate[a]
Air source heat pump	4,884	506	100%	2,470	1,792	138%
Central air conditioner	1,979	364	100%	721	560	129%
Geothermal heat pump	107	1,725	99%	182	185	99%
HVAC audit	3,650	334	99%	1,221	1,402	87%
Duct sealing	2,956	273	94%	807	783	103%
Attic insulation	834	349	97%	291	556	52%
Windows	35	517	93%	18	19	95%
Heat pump water heater	100	1,462	99%	146	289	51%
Room air conditioner	305	124	99%	38	38	99%
Total	**14,850**			**5,895**	**5,623**	**105%**

a. Totals subject to rounding.
Source: Navigant analysis

Figure 3-4 shows each measure's contribution to overall verified gross energy savings for PY 2013. As in previous years, the air source heat pump measure contributed the greatest portion of verified energy savings. The air source heat pump was the largest contributor to verified gross energy savings at 42 percent.

Figure 3-4. Measure-Level Contribution to Verified Gross Energy Savings for PY 2013



Source: Navigant analysis

The corresponding values for summer and winter demand impacts are presented in Appendix C.

3.4 Net Savings

The impact analysis described above addressed gross program savings, which are based on program records and modified by an engineering review and field verification of measure installations. Net savings incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records). Net savings are commonly expressed as an NTG ratio applied to the verified gross savings values.

This section displays the high-level results of the NTG analysis, while Appendix B provides definitions, methods, and further detail on the analysis and findings. For most measures, Navigant used the same NTG analysis in PY 2013 as was used for PY 2012, so the results should be directly comparable. This method includes customer surveys for most measures and a supplemental sample of multi-family property managers for the HVAC audit and attic insulation measures. Results of the multi-family

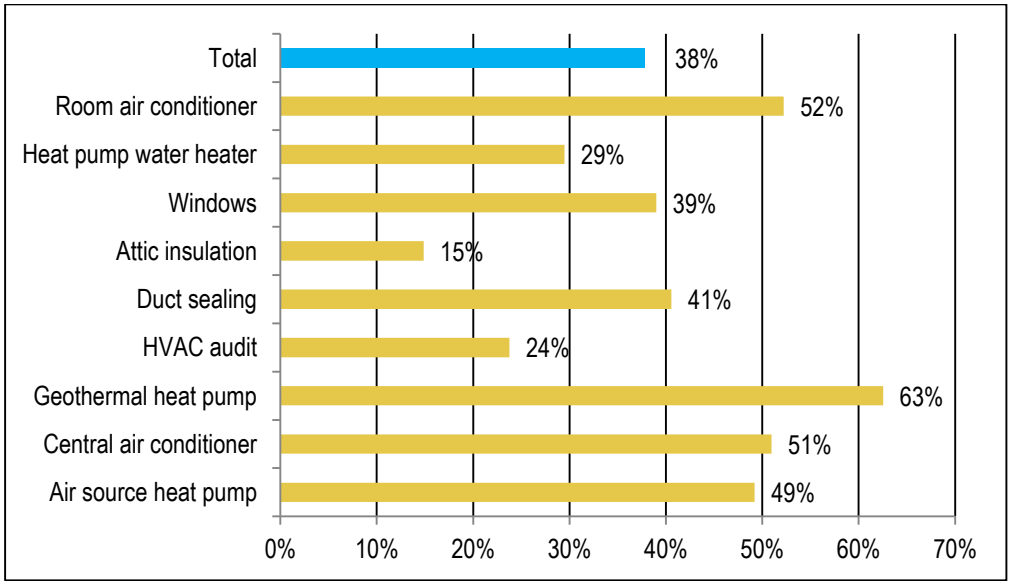
surveys were weighted by reported savings with results of the single family participant surveys to estimate free ridership and spillover for the attic insulation and HVAC audit measures.

3.4.1 Free Ridership

The participant survey asked a series of questions regarding the likelihood, scope, and timing of investments in energy efficiency if the respondent had not participated in the program. The purpose of the survey was to elicit explicit estimates of free ridership and perspectives on the influence of the program. Findings from this effort are presented in Figure 3-5 as a free ridership estimate for each measure category. Free ridership for HEIP (i.e., across all measures) is estimated at 38 percent of program-reported savings when the measure-specific free ridership values are weighted according to the measure category's share of total reported savings. For measures installed mostly in single family housing, the free ridership scores range from 15 percent for attic insulation to a high of 63 percent for geothermal heat pump replacement. The free ridership values for the HVAC audit and attic insulation measures were calculated using a weighted average of the results from the property manager surveys at multi-family sites and the single family respondents from the customer surveys.

The program-level free ridership is relatively consistent with previous years. Although 38 percent is higher than the 23 percent in PY 2012, there was also a decrease in the multi-family HVAC audit participation, which drove down the free ridership in 2012 as compared to previous years. The 2013 value of 38 percent is more consistent with 2010 and 2011, which had a 41 percent free ridership.

Figure 3-5. Free Ridership by Measure Category: PY 2013



a. Windows were not assessed during the PY 2013 survey efforts because they have been dropped from the program. They were assigned free ridership values from the PY 2010 and PY 2011 survey efforts.

Source: Navigant analysis

For attic insulation and HVAC audit measures, Navigant assessed free ridership separately for the single family and multi-family housing segments. Results are shown in Table 3-11. The weighted averages are reflected in Figure 3-5.

Table 3-11. Free Ridership Share from Single Family and Multi-Family Housing Segments

	Attic Insulation	HVAC Audit
Single family free ridership	35%	33%
Multi-family free ridership	0%	20%
Weighted average	**15%**	**24%**

Source: Navigant analysis

3.4.2 Spillover

About 18 percent of survey participants from the single family housing sector indicated that HEIP influenced them to install additional energy efficiency measures that were not rebated or included in program records, a slight decrease over the 26 percent from PY 2012.[12] Almost two-thirds of these respondents taking spillover actions indicated that the program was important in influencing their decision to install the high-efficiency equipment (8 or higher on a 10-point importance scale).

For the multi-family housing sector, only one of the 13 property managers indicated taking spillover actions. This respondent indicated having completed weatherization measures at the facility. The resulting spillover was 1 percent for the multi-family HVAC audit and 0 percent for multi-family attic insulation.

Based on the survey findings, the EM&V team estimates the overall program spillover to be 6 percent of program-reported savings, which is similar to the 7 percent from PY 2012. See Appendix B for additional explanation, including methods.

3.4.3 Net-to-Gross Ratio

The NTG ratio represents the ratio of net savings to gross savings and is defined as follows:

$$NTG = 1 - free\ ridership + total\ spillover$$

Using the overall free ridership value of 38 percent and the overall spillover value of 6 percent, the NTG ratio is 1 – 0.38 + 0.06 = 0.68.[13] The estimated NTG ratio of 0.68 implies that for every 100 kWh of realized savings recorded in HEIP records, 68 kWh can be attributed to the program.[14] This is a decrease from the 0.84 value found in PY 2013 (largely driven by multi-family HVAC audit participation) but is consistent with the 0.68 NTG from PY 2010 and PY 2011.

[12] The survey only assessed additional installed equipment and did not assess behavioral changes.
[13] Total subject to rounding.
[14] DEP assumes a net-to-gross ratio of 0.7 for reporting purposes.

Table 3-12 displays the free ridership scores by measure category and the free ridership, spillover, and NTG scores for the program as a whole.

Table 3-12. NTG for HEIP

Measure Category	Free Ridership	Spillover	NTG Ratio
Air source heat pump	49%		57%
Central air conditioner	51%		55%
Geothermal heat pump	63%		43%
HVAC audit	24%		82%
Duct sealing	41%	6%	65%
Attic insulation	15%		91%
Windows	39%		67%
Heat pump water heater	29%		76%
Room air conditioner	52%		54%
Total	**38%**		**68%**

a. HEIP total values for free ridership, spillover, and NTG are weighted values, calculated based on each measure category's share of total reported energy savings. The results by measure show unweighted values.
b. PY 2011 free ridership estimates were used for windows because they were removed from the program in 2012.
c. Values subject to rounding.
Source: Navigant analysis

Navigant calculated the verified net energy and demand savings for each measure category by multiplying the measure's NTG ratio by its verified gross savings. Verified net energy savings are shown in Table 3-13. It should be noted that the program-level or total NTG shown in Table 3-12 and Table 3-13 is calculated by weighting the measure-level NTG estimates by each measure's share of reported program savings. Navigant uses reported savings to weight the results because the NTG survey sample targets were stratified by reported savings (refer to Table B-2 in Appendix B for weightings), and weighting by verified gross savings could shift the contribution for measures if there were already adjustments made to gross savings. The program-level verified net savings is calculated by multiplying the program-level verified gross savings by the program-level NTG (5,895 x 0.68 = 4,006) rather than by summing the measure-level net savings. For this reason, the total verified net savings shown in Table 3-13 differs from the sum of the measure-level net savings. Due to the NTG survey sample sizes for each measure and the relatively low incidence of spillover in each measure category, Navigant believes it is more appropriate to apply a single program-level NTG than to sum the net savings for each individual measure. The corresponding tables for net demand impacts can be found in Appendix C.

Table 3-13. Verified Net Energy Impacts: PY 2013

Measure Category	Verified Gross Energy Savings (MWh)	NTG Ratio	Verified Net Energy Savings (MWh)
Air source heat pump	2,470	57%	1,398
Central air conditioner	721	55%	395
Geothermal heat pump	182	43%	79
HVAC audit	1,221	82%	1,002
Duct sealing	807	65%	527
Attic insulation	291	91%	265
Windows	18	67%	12
Heat pump water heater	146	76%	112
Room air conditioner	38	54%	20
Total[a]	**5,895**	**68%**	**4,006**

a. Totals indicate the weighted average by each measure's contribution to reported program savings. All values subject to rounding.

Source: Navigant analysis

Table 3-14 shows a comparison of reported and verified net impacts between PY 2012 and PY 2013. The higher NTG ratio in PY 2012 was driven by low free ridership that year due to the prevalence of HVAC audits and attic insulation in the multi-family sector.

Table 3-14. Reported and Verified Net Energy Savings[15]

Measure Category	PY 2012	PY 2013
Reported NTG ratio	0.70	0.70
Reported net energy savings (MWh)	6,184	3,925
Reported net summer coincident demand savings (MW)	5.20	3.54
Verified NTG ratio	0.84	0.68
Verified net energy savings (MWh)	5,646	4,006
Verified net summer coincident demand savings (MW)	4.84	2.28

Source: Navigant analysis

[15] Reported net savings provided by DEP.

4. Process Findings

Process analysis findings are based on results from the 200 HEIP participant surveys, 13 multi-family property manager surveys (representing about 600 HVAC audit customer rebates and 200 attic insulation customer rebates), discussions with program staff, and a high-level review of program documents and functionality. Additional survey findings can be found in Appendix E.

Key findings are as follows:

- About two-thirds of program participants in single family housing learned about HEIP directly from contact with or marketing from trade allies, which demonstrates the success of DEP and Honeywell's partnerships with these trade allies.
- Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP. Replacing old or broken equipment was also reported by 28 percent of respondents.
- A majority of HEIP participants were satisfied with the program. On a scale of 0 to 10, where 0 indicates "Not satisfied at all" and 10 indicates "Extremely satisfied:"
    - About 85 percent of participants indicated either an 8, 9, or 10 for satisfaction with overall program experience. This is a decrease from 90 percent in PY 2012.
    - Over 90 percent of participants indicated either an 8, 9, or 10 for satisfaction with the contractor's quality of work. This is an increase from 85 percent in PY 2012.
    - About 88 percent of participants indicated either an 8,9, or 10 for satisfaction with the final cost of the program measure. This is an increase from 80 percent in PY 2012.
- About 58 percent of single family respondents reported a decrease in their energy bill. This is a decrease from 66 percent in PY 2012. About 21 percent of PY 2013 respondents reported "no change" in their energy bill after the measure installation.

4.1 Program Staffing and Trade Ally Network

DEP's project manager oversees the program and Honeywell manages the implementation, which includes maintaining the trade ally network and inspecting completed trade ally work. The two work jointly to administer trade ally training.

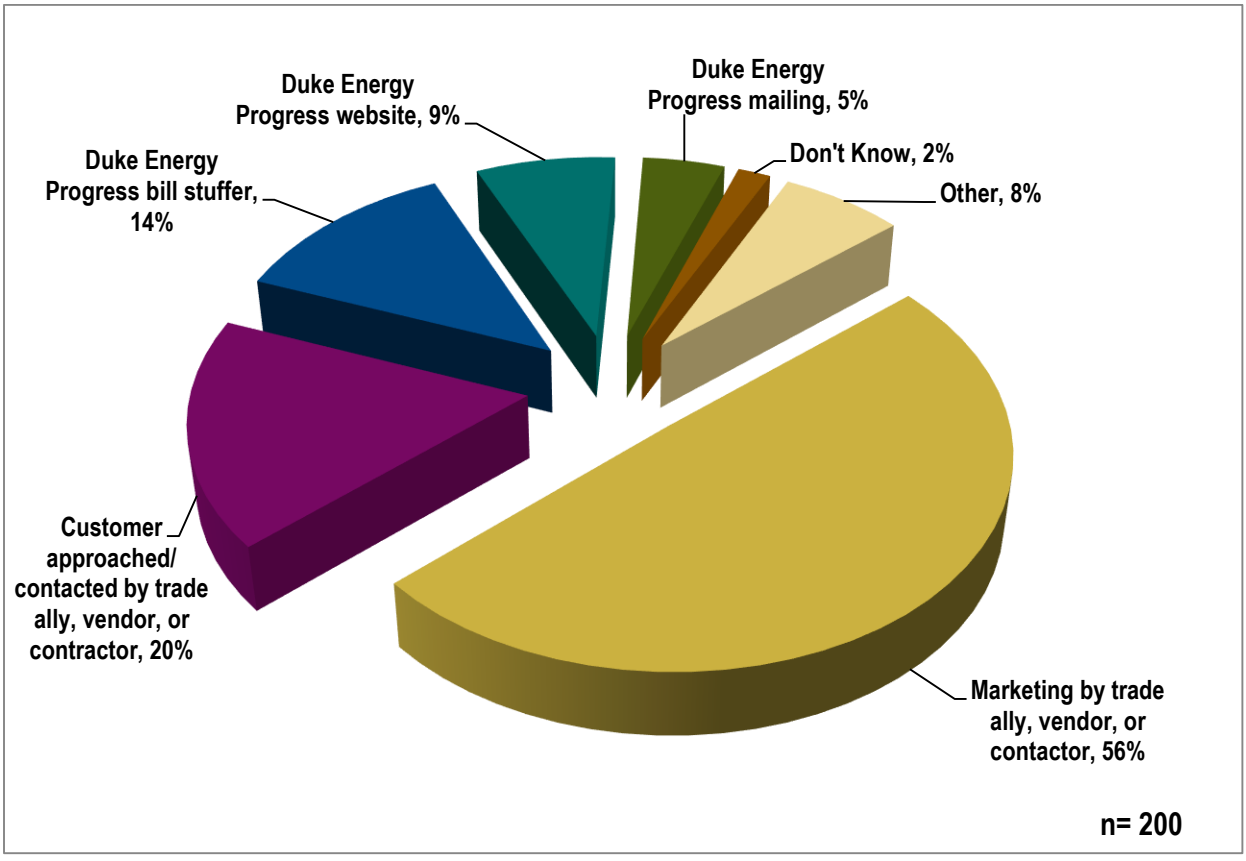
The trade ally network is the core of HEIP. Trade allies do not receive any incentive for participating in the program, but many seem to see it as a competitive edge in a tight market. Trade allies receive several benefits for program participation, including initial training, marketing support, and a web tile (a message block and image button on their website). Their work must pass quality assurance inspections. To obtain and maintain their status as prequalified, trade allies must sign a release and indemnity agreement and abide by program rules and conditions.

4.2 *Overall Marketing and Outreach*

DEP markets the program primarily through bill stuffers, bill envelopes, e-mail blasts, and the trade ally network. Honeywell helps recruit trade allies into the program, and the trade allies then market to customers.

Customer survey results indicate that the program is working as designed and that trade allies play an important role in the program process. Participants were asked to indicate all the sources through which they learned about the program, and about three-quarters indicated they had learned about HEIP through a contractor (56 percent through contractor marketing and about 20 percent through direct contact from a vender or contractor). About 14 percent of participants also mentioned DEP bill stuffers as a source of discovering the program. Figure 4-1 shows the range of ways in which customers found out about the HEIP program.

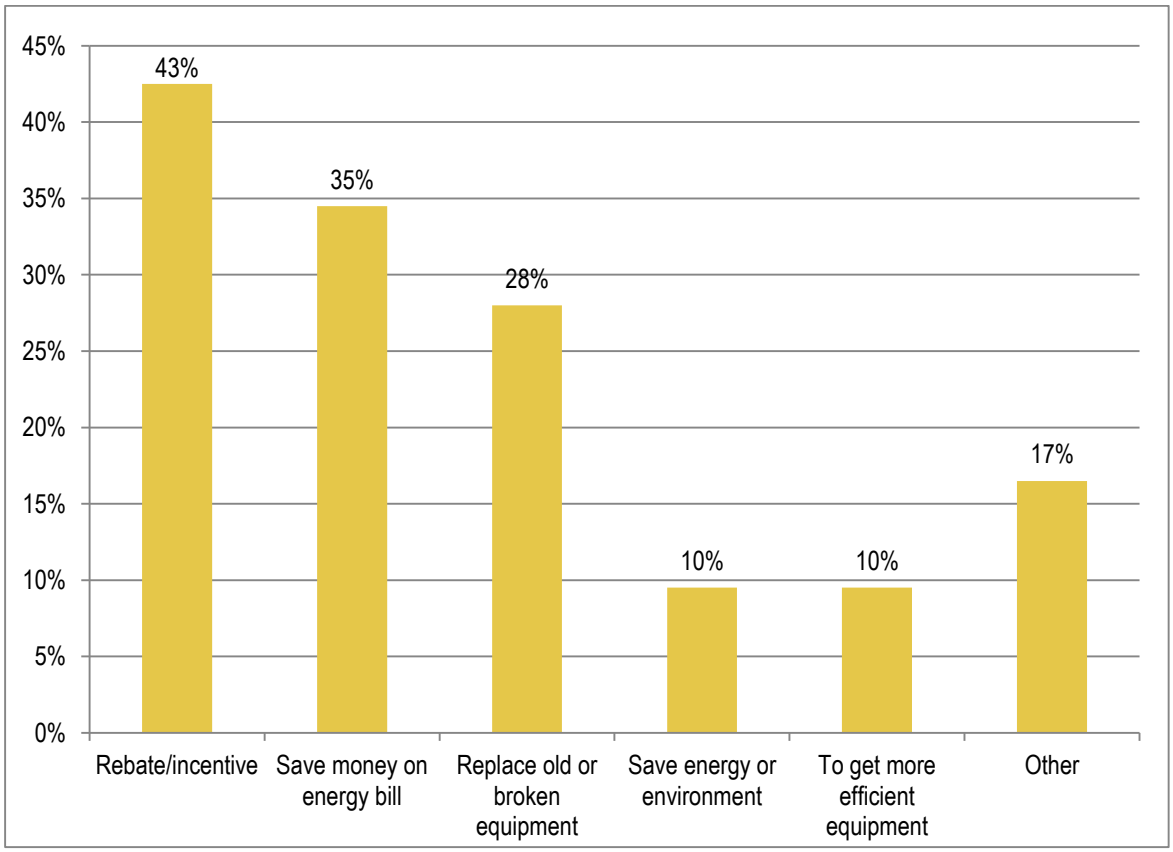
Figure 4-1.Where Program Participants First Learned about HEIP[a]



a. Totals exceed 100 percent because respondents were allowed to offer more than one answer.
Source: Navigant analysis

When asked why they chose to participate in the program, 43 percent of survey respondents cited the rebate as a reason (see Figure 4-2).

Figure 4-2.Primary Reasons for Deciding to Participate in the Program[a]



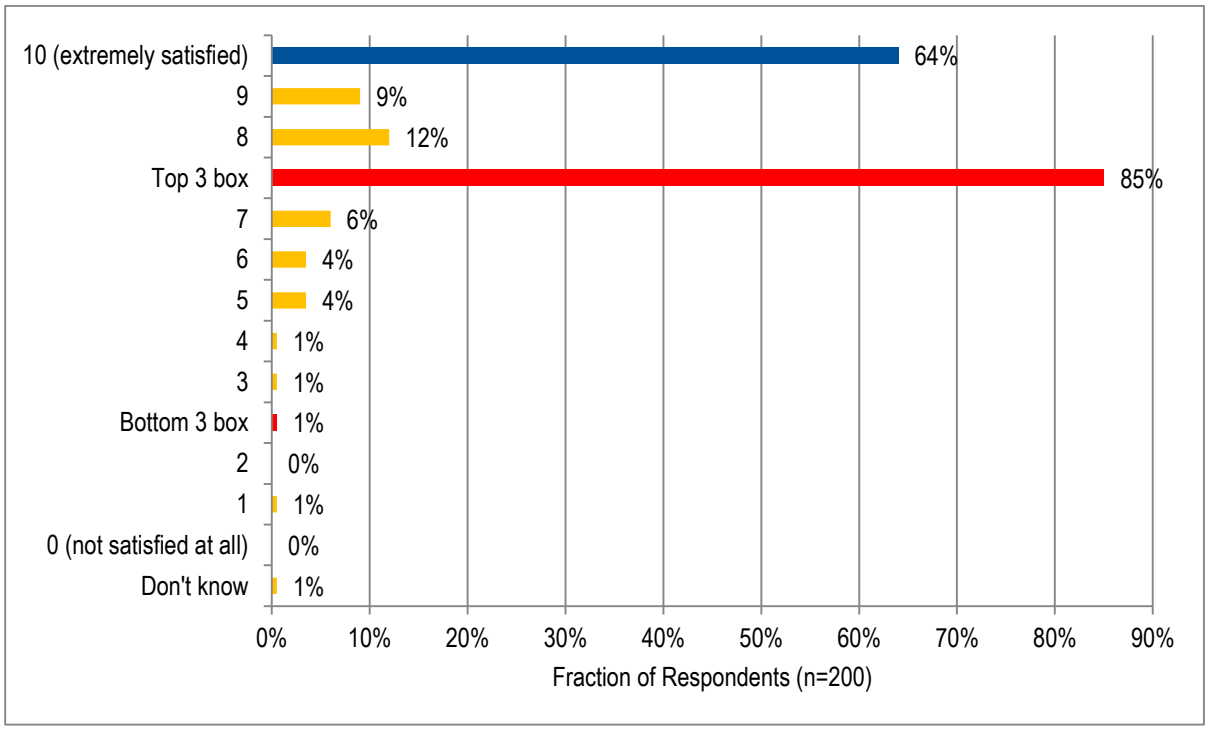
a. Totals exceed 100 percent because respondents were allowed to offer more than one answer.

Source: Navigant analysis

4.3 *Customer Experience*

Customers reported high satisfaction with their overall program experience during 2013. On a scale of 0 to 10 where 0 is "Not satisfied at all" and 10 is "Extremely satisfied," 85 percent of participants ranked their overall experience with the program as an 8, 9, or 10, with 64 percent responding that their experience was a 10 (see Figure 4-3). Customer satisfaction levels were slightly lower than 2012, where 90 percent of respondents rated their experience as an 8, 9, or 10.

Figure 4-3. Customer Satisfaction with Overall Program Experience



Source: Navigant analysis

Participants who ranked their overall experience low did so because it took longer than expected to receive the rebate check and they did not notice a change in their energy bill. One participant indicated that the previous HVAC equipment worked better and used less energy. Direct quotes are shown below:

- **Participant 1:** "Old equipment was better than the new. My electric bill was cheaper. I have energy efficient equipment and it is still not as cheap."
- **Participant 2:** "One end of the program in Virginia didn't know about the other end of the program in North Carolina, and it took too long to receive the rebate."
- **Participant 3:** "The person who came to inspect it. It was a very inconvenient experience. It required two times and took a long time to receive the check. I had to call about it."

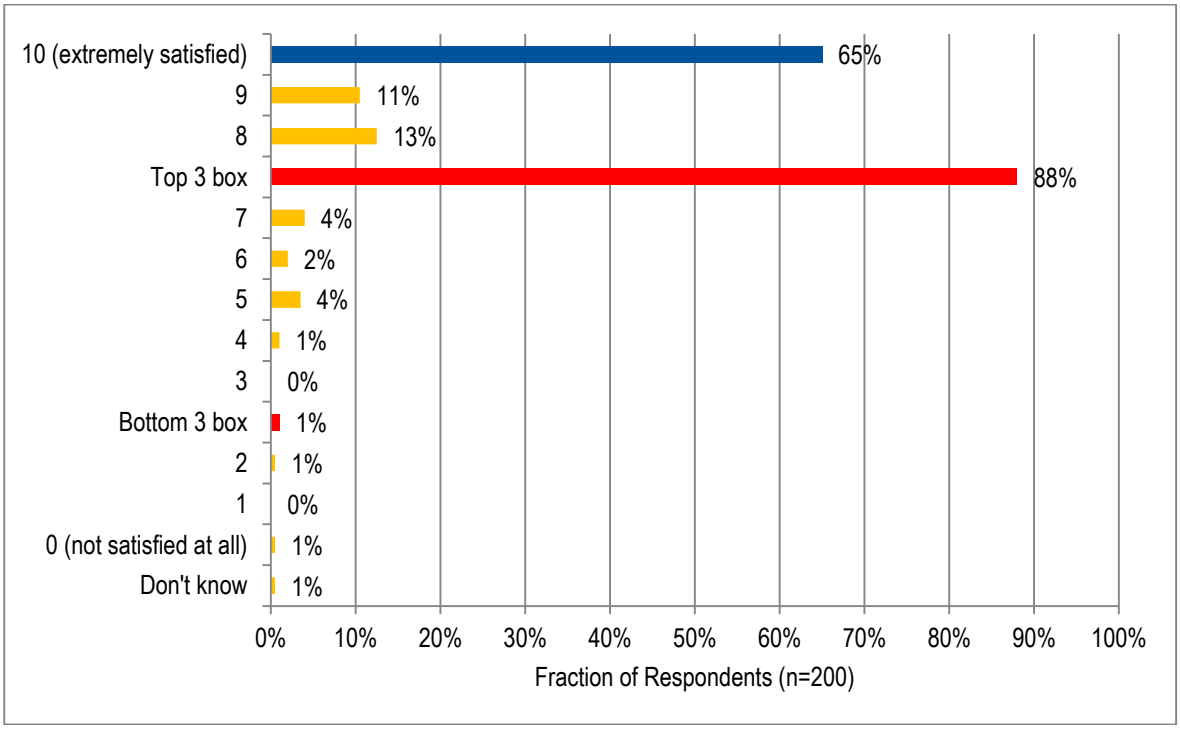
- **Participant 4:** "Because I don't like it. It runs constantly and it cost me money. I would like my old one fixed."

- **Participant 5:** "My electric bill is higher."

- **Participant 6**: "Our power consumption has not gone down."

Overall, customers were also satisfied with program costs. When aggregated by measure, nearly 90 percent of the customers who installed each measure were satisfied or very satisfied with the measure's final cost, ranking their satisfaction as an 8, 9, or 10 on the 0-10 scale (see Figure 4-4).

Figure 4-4. Customer Satisfaction with Final Cost of Measure



Source: Navigant analysis

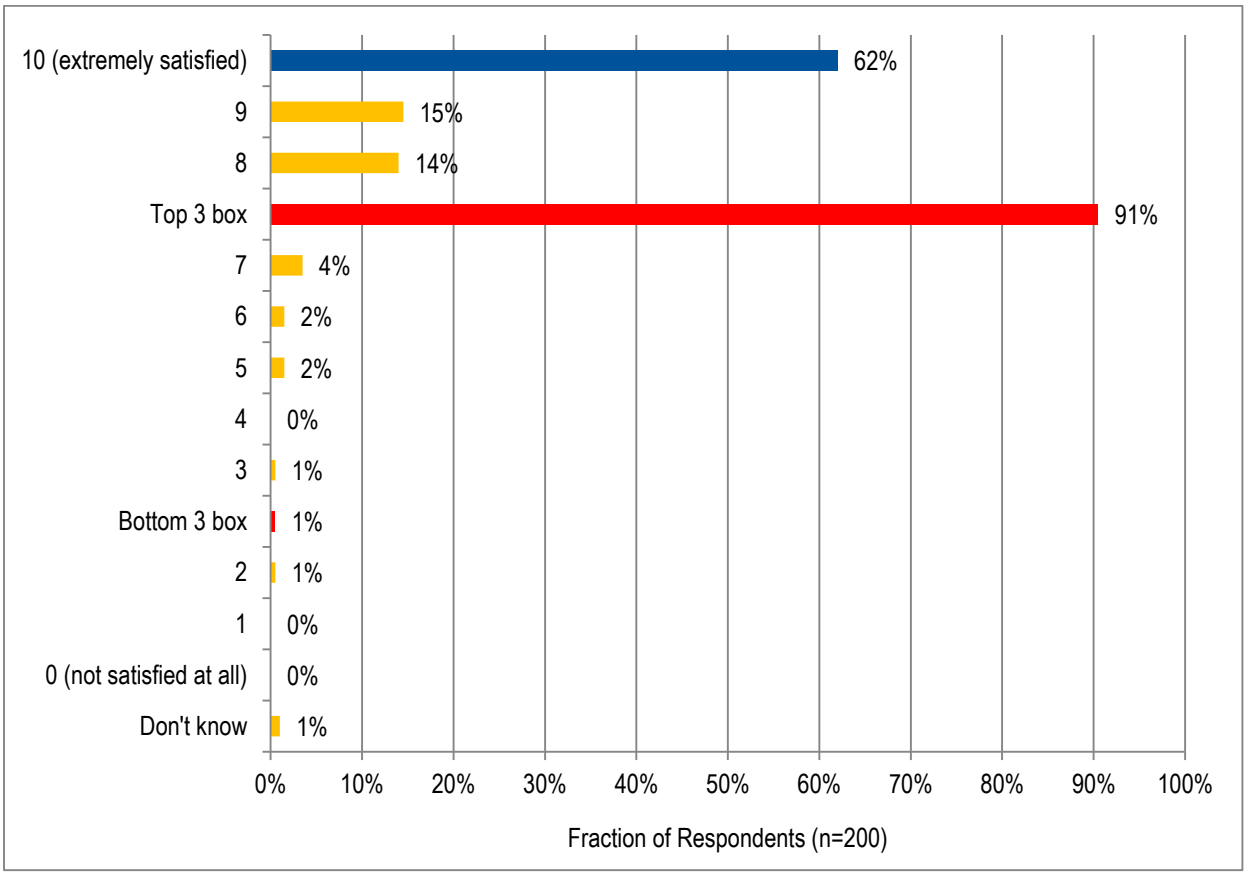
Two quotes are shown below from customers who indicated low satisfaction with the final cost.

- **Participant 1:** "It was more than what I expected. They itemized things that I thought would not be included, so I ended up with a higher bill. They sent two different contractors on the same day. Both showed up to do it. They had not communicated with each other."

- **Participant 2:** "It cost more. I wasn't expecting to pay $2,000 for an upgrade."

Customer satisfaction with contractor quality of work is also high. This is one of the most significant findings of the process evaluation, given that program success and energy savings rely heavily on the quality of contractor work. Figure 4-5 shows that over 90 percent of survey respondents ranked their satisfaction with contractor work as an 8, 9, or 10.

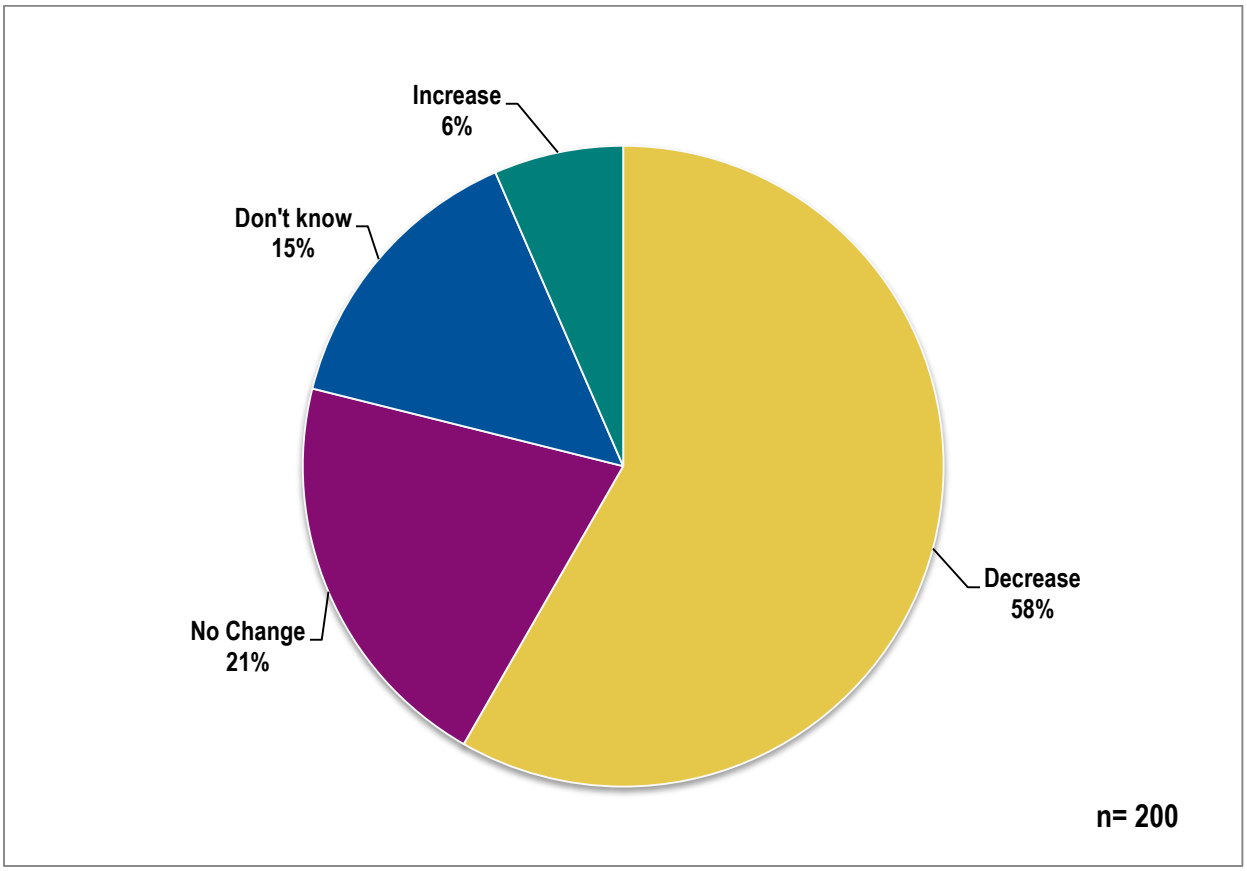
Figure 4-5. Customer Satisfaction with Contractor Quality of Work



Source: Navigant analysis

Another important survey finding was that 58 percent of participants reported noticing a decrease in their energy bill after installing the new measure (see Figure 4-6), which is a decrease from 66 percent in PY 2012.

Figure 4-6. Participants Who Noticed a Change in their Energy Bill after Installing the New Measure (n=246)



Source: Navigant analysis

Additional findings from the customer survey can be found in Appendix E.

5. Conclusions and Recommendations

HEIP continued to be a well-run program in PY 2013, and the strong relationships among DEP, Honeywell, and prequalified contractors were the backbone of the program's success. Customer satisfaction was high, and program tracking has been effective to estimate energy savings and identify areas for improvement.

5.1 Conclusions

Verified gross energy savings from HEIP were approximately 5.9 GWh in 2013. Verified gross summer coincident demand savings were approximately 3.4 MW. Navigant found free ridership to be 38 percent for HEIP. Spillover was found to be 6 percent, which resulted in a final NTG ratio of 0.68.[16]

Navigant's field verification efforts demonstrated good overall alignment with measure quantities and characteristics reported in the program tracking database, along with a high quality of contractor work. The measure-level realization rates were primarily driven by the new energy simulation models and HVAC metering data, as well as the mix of measure sizes and efficiencies. Navigant believes these values are an improvement over the previous estimates and that they incorporate cutting-edge evaluation techniques.

5.2 Recommendations

The evaluation team recommends several discrete actions for improving the HEIP offering based on insights gained through discussions with program staff, participant surveys, analysis of program records and assumptions, and a review of onsite verification data. These recommendations provide DEP with a roadmap to fine-tune HEIP for continued success and are organized around four broad objectives:

1. Enhancing program impacts
2. Improving cost-effectiveness
3. Improving program delivery
4. Enhancing program tracking and evaluation efforts

[16] Total subject to rounding

Table 5-1 summarizes these program recommendations, and a more detailed discussion follows.

Table 5-1. Summary of Recommendations

Program Impacts	
1. Update the tracking database to reflect measure-level deemed savings from this report.	
Improving Program Cost-Effectiveness	
2. Tighten eligibility requirements for measures not meeting savings expectations.	Consider a tiered incentive for HVAC replacement that pays a greater rebate for higher SEER units as well as a tiered incentive that pays a higher rebate for attic insulation upgrades to higher R-values.
Improving Program Delivery	
3. Continue to offer technical training and workshops for contractors, with a particular emphasis on using the diagnostic tool for HVAC audits and achieving maximum savings.	
4. Continue to offer marketing training for contractors.	
5. Continue direct marketing through DEP.	
6. Increase participant awareness regarding the receipt of a rebate payment.	
Enhancing Program Tracking and Evaluation Efforts	
7. Ensure that all information from rebate application forms is included in program tracking database extracts.	a. All measures: Include square footage of home, year home was built, heating and cooling types from rebate application, and trade ally that performed the work. b. Duct sealing: Include fields in tracking database for location of ducts that were sealed and results of pressure testing, if applicable. c. Multi-family housing: Include complex name and trade ally that performed the work. d. Require the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) number of the new equipment combination installed for HVAC system replacements.
8. Modify program processes to integrate data collection activities required for EM&V.	a. Invite participants to complete a customer satisfaction and free ridership survey at or shortly after the time of measure installation.

Source: Navigant analysis

5.2.1 Recommendations for Program Impacts and Improving Program Cost-Effectiveness

In general, the dual objectives of maintaining high average savings and increasing program participation are difficult to reconcile. If average savings targets are not being met, options include limiting or expanding participation to high savings applications (e.g., efficiency measures in homes with electric heat or where the replacement baseline is low). Navigant's recommendations are as follows:

- **Update the tracking database to reflect measure-level deemed savings from this report.** The updated deemed savings represent the average savings for each measure from PY 2013 based on the mix of efficiencies, quantities, regional distribution, and field verification. Inherently, these factors will change from year to year, and measure-level realization rates will fluctuate. Additionally, the new energy simulation models had a significant impact in PY 2013. In future years, Navigant suggests that DEP adjust the deemed savings values to track at a finer resolution. For example, the tracking database could be adjusted to assign deemed savings

values based on line-by-line characteristics, such as measure efficiencies, sizes, and regional location, instead of assigning deemed savings by measure name only. Doing so would not have any impact on the program-level verified savings, but it would lead to EM&V realization rates closer to 100 percent by creating closer alignment between savings used for tracking and those used for EM&V.

- **Tighten eligibility requirements for measures that are not meeting average savings expectations.** If a measure is not cost-effective based on the 2013 verification results, there may be a subset of installations that are cost-effective. The energy and demand estimates included in Appendix D serve as a resource for determining the specific requirements for each measure that will produce the desired savings. Measure eligibility rules can be optimized to allow as many customers as possible to participate while still meeting cost-effectiveness requirements for the measure on the whole. If cost-effectiveness requirements for a given measure can be met without restricting participation, then there is no need to make changes.[17] Options include the following:
    - Require electric heating (and thus increased savings) for participation where a measure does not satisfy cost-effectiveness requirements. For example, attic insulation and duct sealing measures could be more cost effective on a per-customer basis if electric heating was a program requirement, although total participation levels would decrease.
    - Consider adjusting post-retrofit insulation R-values to be based on pre-retrofit R-value. For example, baseline R-values of 15 to 19 could require an upgrade to at least R-38 instead of R-30.
    - Consider creating a tiered incentive structure for HVAC replacement that provides a larger rebate for higher SEER units.

5.2.2 Recommendations for Improving Program Delivery

- **Offer technical training and workshops for contractors.** This is particularly for the proper use of the diagnostic tool for HVAC audits. Proper use is critical for achieving actual savings.
- **Continue to offer marketing training for contractors.** Program marketing and promotion by contractors is a key component of DEP's marketing strategy, and as such, a continued and greater focus on marketing tactics and program sell points is likely to increase participation. About two-thirds of surveyed customers learned about HEIP through a contractor or trade ally, which is a success. However, additional participation may be gained by training contractors to promote simultaneous implementation of multiple measures.
- **Continue direct marketing through DEP.** As a means to increase program participation and customer awareness, DEP should continue marketing efforts. Over 40 percent of surveyed customers cited DEP's rebate as one factor in their decision to install the program measure, and about 28 percent of surveyed customers reported finding out about HEIP through DEP (via bill stuffers, DEP's website, and mailings). This is an increase over the share of participants who indicated they discovered HEIP through the utility in PY 2010–PY 2012.
- **Increase participant awareness of receipt of rebate.** During both the field verification visits and participant telephone surveys, Navigant noticed that many HEIP participants were unaware that they had received a rebate from DEP. In general, this is probably because the average customer

[17] The evaluation team did not review cost-effectiveness calculations or perform new calculations using revised measure savings assumptions. Thus, the team cannot identify specific measures for which modifying eligibility requirements might be appropriate to increase cost-effectiveness.

is concerned with the bottom-line price for each measure, and the rebate may simply be worked into the contractor's pricing estimate. It could also be that many multi-family customers may not have known that they participated in the program because rebates may have been vetted through the property management. DEP may find added value by increasing participant awareness because it may lead to pursuit of HEIP rebates for additional measures as well as a customer sense of partnership with DEP.

5.2.3 Recommendations for Enhancing Program Tracking and Evaluation Efforts

The following recommendations will aid the evaluation process and ensure that reported results track closely with verified savings and that the evaluation provides beneficial and actionable recommendations for program staff:

- **Ensure that all information from rebate applications is included in program tracking database extracts to Navigant.** The rebate applications for HEIP are clear and comprehensive. However, the data extracts provided by DEP do not include all fields. To streamline the data request process for evaluation purposes, Navigant recommends the following fields be included in the data extracts provided to Navigant by DEP:
  - **All measures:** Include fields in the database extract to Navigant for square footage of home, year home was built, heating type, cooling type, and trade ally.
  - **Air source heat pump and central air conditioner:** Include AHRI number.
  - **HVAC audit**: Include fields in the database extract to Navigant for the energy index efficiency readings and calculated energy savings from the Service Assistant diagnostic tool before and after the HVAC tune-up, as well as SEER rating of the HVAC unit. DEP currently provides Navigant with a separate database containing HVAC audit information, but it is difficult to match the entry with the corresponding customers in the program tracking database.
  - **Duct sealing**: Include fields in the database extract to Navigant for the location of sealed ducts from checked boxes on rebate forms instead of providing this information only in contractor notes as well as the results of any pre- and post-installation pressure testing.
  - **Multi-family housing:** Include the complex name and trade ally for each line item.
- **Modify program processes to integrate data collection activities required for EM&V.** Integrated data collection (IDC) is a process by which data used in evaluation is collected during program delivery. This may include equipment specifications, engineering measurements, and customer feedback. DEP already has incorporated significant IDC for the impact analysis through collection of baseline data. Expansion of IDC would improve the evaluation, particularly with regard to process evaluation and assessment of free ridership.

DEP could consider inviting participants to complete a customer satisfaction and free ridership survey at or shortly after the time of measure installation—perhaps even including these questions on the rebate application or a separate form to be filled out by the customer with no help from the contractor. Issuance of the incentive payment provides an additional opportunity for measures where customers receive rebates directly from DEP or its implementation contractor.

Appendix A. Glossary of Terms

This glossary presents some of the common terms used throughout this report. The evaluation team has endeavored to define terms the first time they appear in the body of the report and to describe them in context where the authors deem that repeated explanation may be warranted.

Deemed savings: Average savings per rebated measure, based on the participant mix of efficiencies, sizes, geographic regions, and field verification rates.

EM&V: Evaluation, measurement, and verification; the assessment and quantification of the energy and peak demand impacts of an energy efficiency program.

Energy savings: kWh savings over a period of time, generally expressed in savings per year.

Field verification rate: The ratio of savings from equipment and measures verified onsite versus that reported in the program database; incorporates findings relating to equipment quantities and measure efficiency characteristics.

Free ridership: Share of gross savings that participants would have taken anyway, even in the absence of the program.

Gross realization rate: The ratio of verified gross savings to reported gross savings.

Gross savings: Reductions in energy consumption and peak demand based on engineering estimates for known quantities and types of measure installations; gross savings do not account for whether the measures were installed as a result of the program.

Net savings: Savings attributable to the program, after adjustments for free ridership and spillover.

Peak demand reduction: The reduction in peak power demand that is coincident with the utility system peak. When the season is not specified, the implicit assumption is that peak demand reductions are summer peak demand reductions.

Reported gross savings: The program savings as reported in the HEIP tracking database.

Spillover: Additional energy savings that are not reported or captured by program records but were influenced by the program.

Unit savings: The energy or peak demand reductions of a given measure per unit installed. Units differ by measure; for example, unit savings may be given as kWh per ton cooling capacity.

Verified gross savings: The gross savings verified by the EM&V team; these are the final third-party-verified gross savings for the program.

Appendix B. Home Energy Improvement Program Attribution

This appendix provides definitions, methods, and further detail on the analysis and findings of the net savings assessment. The discussion is divided into the following three sections:

1. Definitions of free ridership, spillover, and net-to-gross (NTG) ratio
2. Methods for estimating free ridership and spillover
3. Results for free ridership, spillover, and NTG ratio

B.1 Definitions of Free Ridership, Spillover, and Net-to-Gross Ratio

The methodology for assessing the energy savings attributable to a program is based on a NTG ratio. The NTG ratio has two main components: free ridership and spillover.

Free ridership is the share of the gross savings that is due to actions participants would have taken anyway (i.e., actions that were not induced by the program). This is meant to account for naturally occurring adoption of energy efficiency measures. The Home Energy Improvement Program (HEIP) and most other Duke Energy Progress (DEP) programs cover a wide range of energy efficiency measures and are designed to advance the overall energy efficiency market. However, it is likely that, for various reasons, some participants would have wanted to install some high-efficiency measures (possibly a subset of those installed under HEIP), even if they had not participated in the program or been influenced by the program in any way.

Spillover captures program savings that go beyond the measures installed through the program. Also called market effects, the term spillover is often used because it reflects savings that extend beyond the bounds of the program records. Spillover adds to a program's measured savings by incorporating indirect (i.e., non-incentivized) savings and effects that the program has had on the market above and beyond the directly incentivized or directly induced program measures.

The overall NTG ratio accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the NTG ratio is multiplied by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program). The NTG formula is shown below:

$$NTG = 1 - free\ ridership + spillover$$

The underlying concept inherent in the application of the NTG formula is that only savings caused by the program should be included in the final net program savings estimate but that this estimate should include all savings caused by the program.

B.2 Methods for Estimating Free ridership and Spillover

Estimating Free Ridership

Data to assess free ridership was gathered through the self-report method using a series of survey questions asked of 200 HEIP participants. A slightly modified version was delivered to 13 property managers or site representatives at multi-family housing complexes where heating, ventilation, and air conditioning (HVAC) audits or attic insulation measures were rebated in order to assess free ridership for that market. The survey was stratified by measure-level energy savings. It is designed to represent the distribution within DEP's geographic regions. The survey assessed free ridership using both direct questions, which aimed to obtain respondent estimates of the appropriate free ridership rate that should be applied to them, and supporting or influencing questions, which could be used to verify whether the direct responses were consistent with participants' views of the program's influence.

Each respondent to the survey provided perspectives on one measure that was reported to the program (e.g., HVAC replacement or duct sealing). The core set of questions addressed the following three categories:

- **Likelihood:** To estimate the likelihood that they would have incorporated measures "of the same high level of efficiency," if not for the assistance of HEIP. In cases where respondents indicated that they might have incorporated some but not all of the measures, they were asked to estimate the share of measures that would have been incorporated anyway at high efficiency. This flexibility in how respondents could conceptualize and convey their views on free ridership allowed respondents to give their most informed response, thus improving the accuracy of the free ridership estimates.
- **Prior planning:** To further estimate the probability that a participant would have implemented the measures without the program. Participants were asked the extent to which they had considered installing the energy efficient measure prior to participating in the program. The general approach holds that if customers were not definitively planning to install all of the efficiency measures prior to participation then the program can reasonably be credited with at least a portion of the energy savings resulting from the high-efficiency measures. Strong free ridership is reflected by those participants who indicated they had already allocated funds for the purchase and selected the equipment and an installer.
- **Program importance:** To clarify the role that program components (e.g., information, incentives) played in decision-making and to provide supporting information on free ridership. Responses to these questions were analyzed for each respondent, not just in aggregate, and were used to identify whether the direct responses on free ridership were consistent with how each respondent rated the influence of the program.

The EM&V team adjusted prior planning and program importance scores based on the open-ended responses as well. Bounds were placed on scores with open-ended responses that did not support the given score. For example, if a participant designated a prior planning score of 10 (indicating they were planning to install the measure) but gave an open-ended response saying that they had "thought about installing the measure," then the prior planning score was adjusted downward to a 6. A more detailed description of score adjustments appears below:

- **Prior planning:** The EM&V team assigned an open-ended score, using a 3-point scale for each response, as follows:
    - **1:** Response indicated low free ridership, and a minimum score of 0 and a maximum score of 6 was permitted. Examples responses include "I thought about replacing the equipment," "I didn't have enough money to buy a more efficient model until the incentive program came along," and "I didn't have any plans prior to the incentive being available."
    - **2:** Response indicated medium free ridership, and a minimum score of 2 and a maximum score of 8 was permitted. Example responses include "I needed to replace the old equipment" without also stating the importance of the efficiency level and "I don't know."
    - **3:** Response indicated high free ridership, and a minimum score of 4 and a maximum score of 10 was permitted. Example responses include "I got an estimate," "I hired a contractor," "I needed to replace old equipment and I desired the efficient option," and "I was planning to do it anyway, regardless of the incentive."
- **Program importance:** The EM&V team assigned an open-ended score, using a 3-point scale for each response, as follows:
    - **1:** Response indicated low free ridership, and a minimum score of 4 and a maximum score of 10 was permitted. Example responses include "I wouldn't have done it without the rebate/program," "I was convinced by the program representative," and "The lower cost to me made the efficient option more attractive."
    - **2:** Response indicated medium free ridership, and a minimum score of 2 and a maximum score of 8 was permitted. Example responses include "I don't know" and "I needed to replace old equipment" without also stating the importance of the efficiency level.
    - **3:** Response indicated high free ridership, and a minimum score of 0 and a maximum score of 6 was permitted. Example responses include "I would have done it anyway" and "The rebate was just an added bonus."

Free ridership scores were calculated for each of the three categories[18] and then averaged and divided by 10 to convert the scores into a free ridership percentage. Next, a timing multiplier was applied to the

[18] Scores were calculated by the following formulas:

- Likelihood: The likelihood score is 0 for those that "definitely would NOT have installed the same energy efficient measure" and 1 for those that "definitely WOULD have installed the same energy efficient measure." For those that "MAY HAVE installed the same energy efficient measure," the likelihood score is their answer to the following question: "On a scale of 0 to 10, where 0 is DEFINITELY WOULD NOT have installed and 10 is DEFINITELY WOULD have installed the same energy efficient measure, can you tell me the likelihood that you would have installed the same energy efficient measure?" If more than one measure was installed in the project, then this score was also multiplied by the respondent's answer to what share they would have done.
- Prior Planning: If participants stated they had considered installing the measure prior to program participation, then the prior planning score is the average of their answers to the following two questions: "On a scale of 0 to 10, where 0 means you 'Had not yet planned for equipment and installation' and 10 means you 'Had identified and selected specific equipment and the contractor to install it,' please tell me

average of the three scores to reflect the fact that respondents indicating that their energy efficiency actions would not have occurred until far into the future may be overestimating their level of free ridership. Participants were asked when they would have installed the equipment without the program. Respondents who indicated that they would not have installed the equipment for at least two years were not considered free riders and received a timing multiplier of 0. If they would have installed at the same time as they did, they received a timing multiplier of 1; within one year, a multiplier of 0.67; and between one and two years, a multiplier of 0.33. Participants were also asked when they learned about the financial incentive; if they learned about it after the equipment was installed then they received a timing multiplier of 1.

Estimating Spillover

The basic method for assessing participant spillover was an approach that asked a set of questions to determine the following:

- **Whether spillover exists at all.** These were yes-or-no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records and did not receive any rebates from DEP.
- **The savings that could be attributed to the influence of the program.** Participants were asked to list the extra measures they installed, and the evaluation team assigned a savings value. See below for the method of assigning savings.
- **Program attribution**. Estimates were derived from a question asking the program importance on a 0 to 10 scale. Participants were also asked how the program influenced their decisions to incorporate additional energy efficiency measures.

If respondents said no, they did not install additional measures, they were assigned a 0 score for spillover. If they said yes, then the individual's spillover was estimated as the spillover savings, as estimated below, multiplied by the program influence score.

Navigant used a line-by-line approach to estimate the spillover savings from additional, non-rebated measures installed by telephone survey participants. These measures fell into two categories:

1) **Program measures:** Non-rebated measures that matched HEIP measure categories (e.g., heat pump replacement and attic insulation). If a participant indicated a spillover measure that matched an existing HEIP measure, Navigant assigned 50 percent of the program savings for the corresponding HEIP measure. This credit was based on the assumption that the non-rebated measure did not meet the minimum qualifying efficiency for HEIP; otherwise, the customer

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how far along your plans were" and "On a scale of 0 to 10, where 0 means 'Had not yet budgeted or considered payment' and 10 means 'Already had sufficient funds budgeted and approved for purchase,' please tell me how far along your budget had been planned and approved."

- Program Importance: This score was calculated by taking the maximum importance on a 0 to 10 scale of the four program importance questions (see 5.2.3Appendix E for survey questions) and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free ridership).

would have received the rebate. The 50 percent discount also reflects a conservative assumption that self-reported measures are likely less efficient than those qualifying for the program.

2) **Non-program measures:** Non-rebated measures that do not match HEIP measure categories (e.g. high-efficiency refrigerator or clothes washer, weatherization). Navigant performed a literature review to estimate the savings for non-program spillover measures. The evaluation team used the ENERGY STAR calculator to estimate energy savings for appliance measures, as well as a variety of technical reference manuals (TRMs) from other utility programs for other measures.

Combining Results across Respondents

The evaluation team determined free ridership and spillover estimates for each of the following:

- Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above
- Measure categories
    - **For free ridership:** By taking the average of each respondent's score within each category
    - **For spillover:** By taking the sum of the individual spillover results for each measure category and weighting each category by the population
- The program as a whole, by combining measure-level results
    - **For free ridership:** Measure category results were subsequently weighted by each category's share of total savings
    - **For spillover:** Measure category results were summed and then weighted by the sum of the reported savings for the sample and by the population

B.3 Results for Free Ridership, Spillover, and Net-to-Gross

The results of the attribution analysis are presented in this section, both by measure type and in aggregate for HEIP. Specifically, results are presented for free ridership and spillover, which are used collectively to calculate a NTG ratio.

Review of Data Collection Efforts for Attribution Analysis

Surveys were conducted with HEIP participants to provide the information to estimate free ridership, spillover, and NTG ratios. The sample target for each measure was stratified to be representative of program participation. Table B-1 shows the number of completions, by measure group, specific to the attribution data gathered.

Table B-1. Attribution Survey Completes by Measure Type

	# Respondents
Air source heat pump	69
Central air conditioner	38
Geothermal heat pump	7
HVAC audit	4
Duct sealing	44
Attic insulation	18
Heat pump water heater	12
Room air conditioner	8
Total	**200**

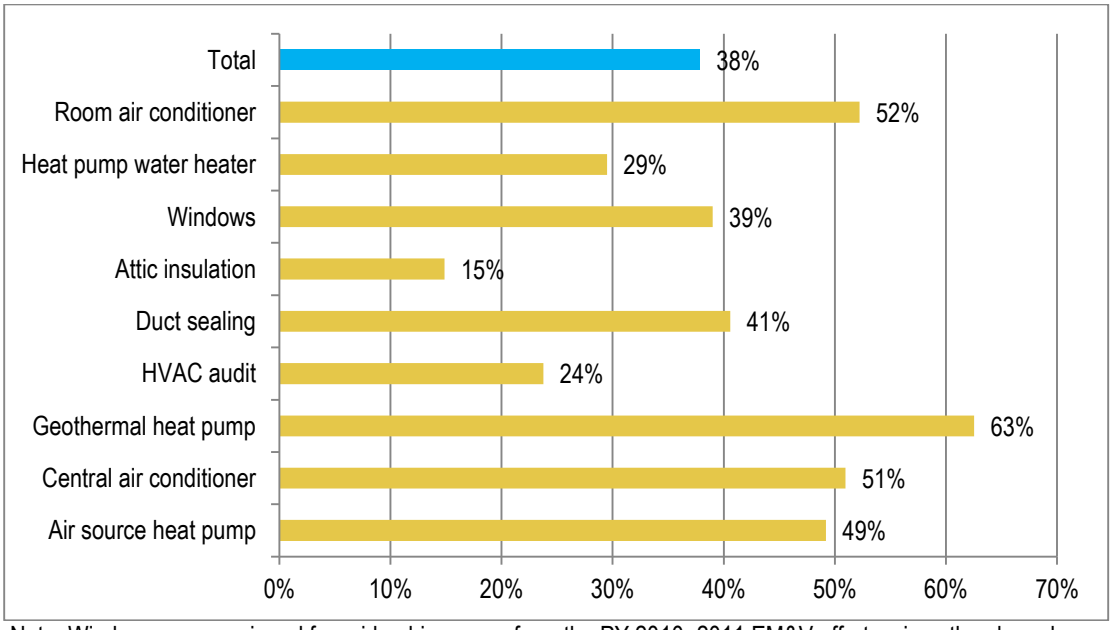
Source: Navigant analysis

Free Ridership Results

As described above, surveyed participants responded to a series of questions intended to elicit explicit estimates of free ridership, as well as ratings of program influence. Findings from this effort are presented in Figure B-1 for each measure category. These estimates are based on questions regarding the likelihood, scope, and timing of the investments in energy efficiency if the respondent had not participated in the program. The free ridership scores for measures installed mostly in single family housing range from about 15 percent for attic insulation to a high of 63 percent for geothermal heat pump. For the HVAC audit and attic insulation measures, the free ridership was calculated using a weighted average of the results from the property manager surveys at multi-family sites and the single family respondents from the customer surveys. For attic insulation, the multi-family free ridership was 0 percent. For the HVAC audit, multi-family free ridership was 20 percent.

Program-level free ridership was higher than PY 2012 but similar to PY 2011 and PY 2010. Low free ridership levels in PY 2012 were driven by the higher percentage of multi-family HVAC audit and attic insulation participants.

Figure B-1. Free Ridership by Measure Category (n = 200)



Note: Windows were assigned free ridership scores from the PY 2010–2011 EM&V efforts, since they have been discontinued from the program and were not assessed for PY 2013.

Source: Navigant analysis

Free ridership for HEIP (i.e., across all measures) was estimated at 38 percent, weighting the measure-specific free ridership values according to their share of total reported savings for each stratum (see Table B-2).

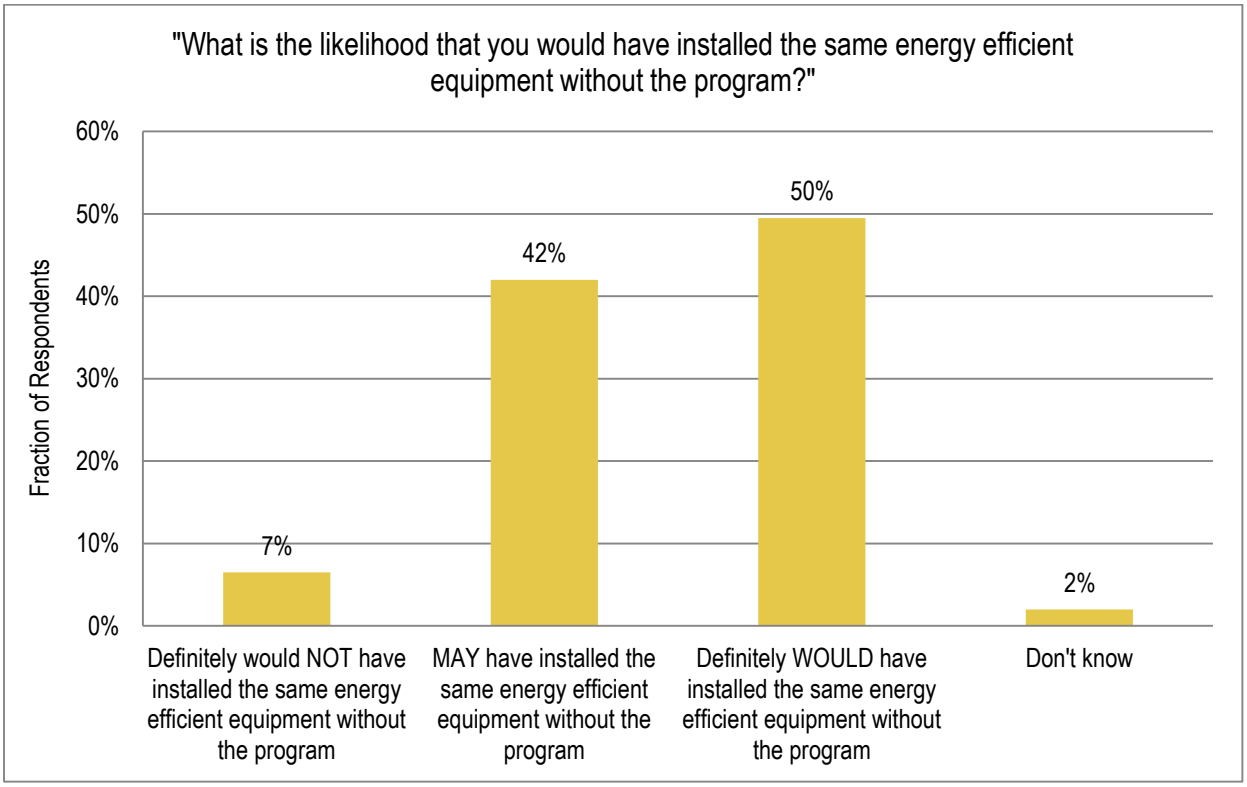
Table B-2. Free Ridership for HEIP

Measure Category	Reported Energy Savings (MWh)	Share of HEIP Energy Savings	Free Ridership Score[a]
Air source heat pump	1,792	32%	49%
Central air conditioner	560	10%	51%
Geothermal heat pump	185	3%	63%
HVAC audit	1,402	25%	24%
Duct sealing	783	14%	41%
Attic insulation	556	10%	15%
Windows	19	0%	39%
Heat pump water heater	289	5%	29%
Room air conditioner	38	1%	52%
Total	**5,623**	**100%**	**38%**

a. Total free ridership score is calculated by summing the product of each category's free rider score and their share of savings.
Totals subject to rounding.
Source: Navigant analysis

Navigant developed the free ridership estimates presented above based on responses to a variety of questions that related to survey respondents' intentions prior to participating in the program and to the influence of the program itself. Figure B-2 displays the self-reported likelihood that customers would have installed the same energy efficient equipment: 7 percent said they would not have installed the same equipment, which is down from 13 percent in PY 2012; 50 percent said they would have installed the equipment without the program; and 42 percent said they "may have" installed the same equipment.

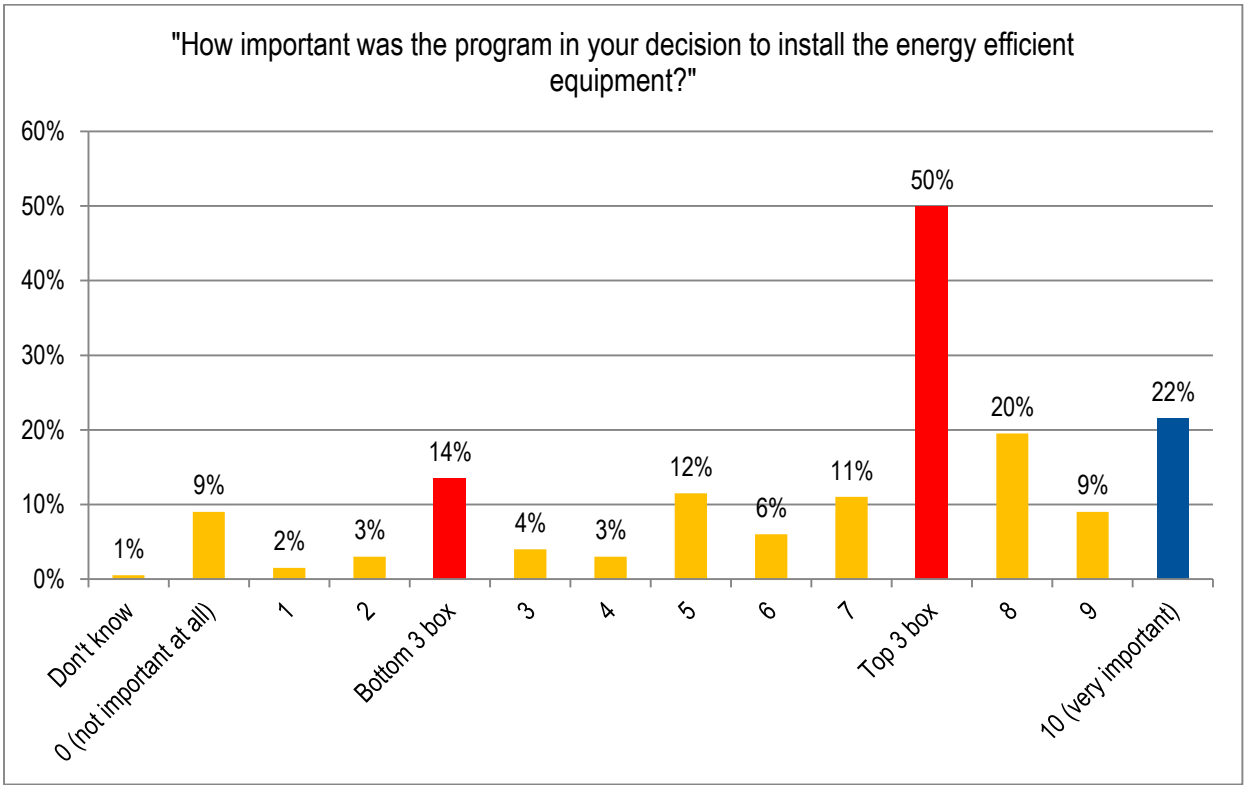
Figure B-2. Likelihood of Installing without the Program (n = 200)



Source: Navigant analysis

Respondents indicated that HEIP significantly influenced them in selecting high-efficiency equipment. A score of 0 indicates no program influence (i.e., the respondent replied "no" to the question about whether the program "in any way" influenced their decisions regarding energy efficiency), and a score of 10 indicates that HEIP was the primary reason for the selection of high-efficiency equipment. 50 percent of the customers said the program was very important in influencing their decision to install the high-efficiency equipment and reported scores of 8 or higher (see Figure B-3) while 33 percent reported a score of 5 or lower.

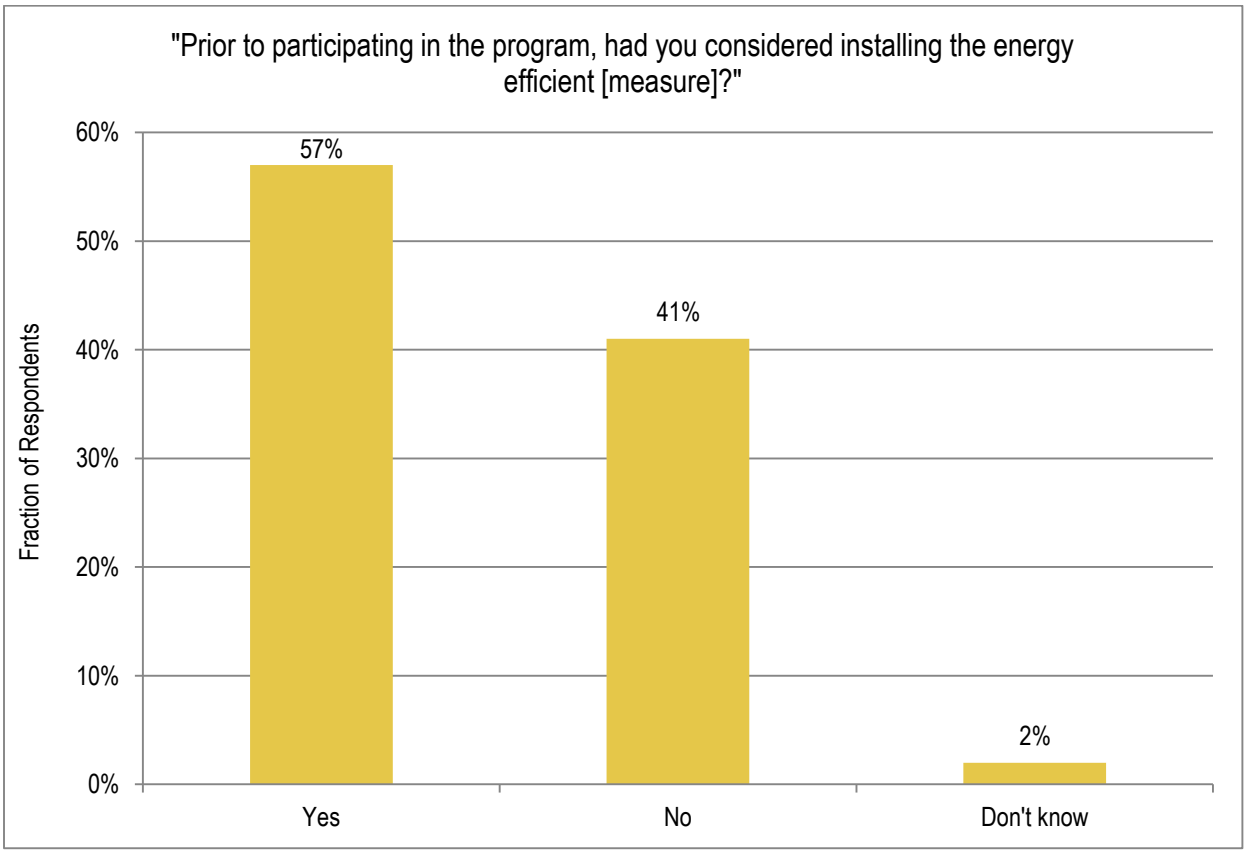
Figure B-3. Program Importance (n = 200)



Source: Navigant analysis

Respondents indicated that some energy efficiency measures were being planned, at least in part, for 57 percent of all projects prior to participation in HEIP (Figure B-4). This is up from 47 percent in PY 2012, and 38 percent in PY 2010 and PY 2011.

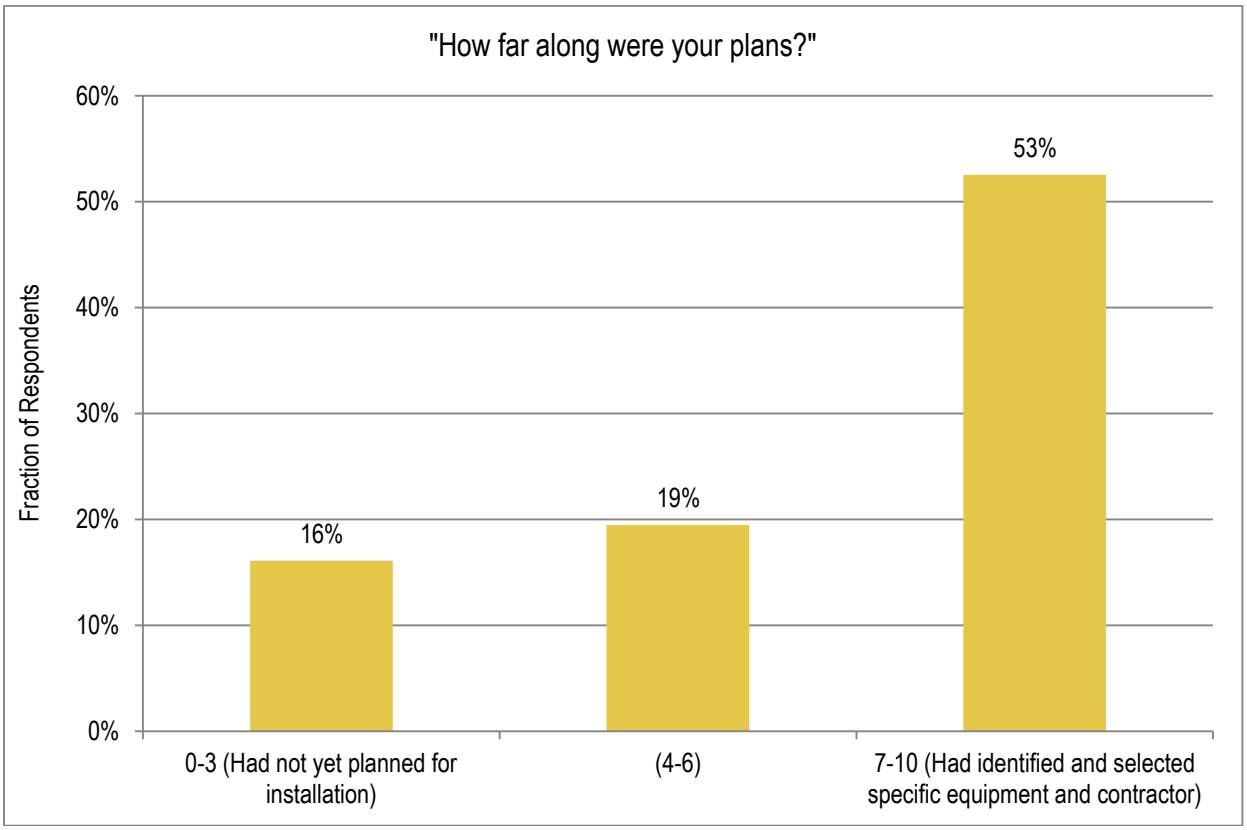
Figure B-4. Prior Planning (n = 200)



Source: Navigant analysis

Figure B-5 shows that 16 percent of customers who had planned to install energy efficient measures had little to no installation planning, while 19 percent of customers had been planning to a moderate degree (4-6 on the 10-point scale), which generally indicates that the customers took some initial steps toward acquiring high-efficiency equipment—such as discussing energy efficiency alternatives with a contractor—but had not reviewed specific options in detail. 53 percent of customers who had planned to install equipment had more detailed plans to install the equipment.

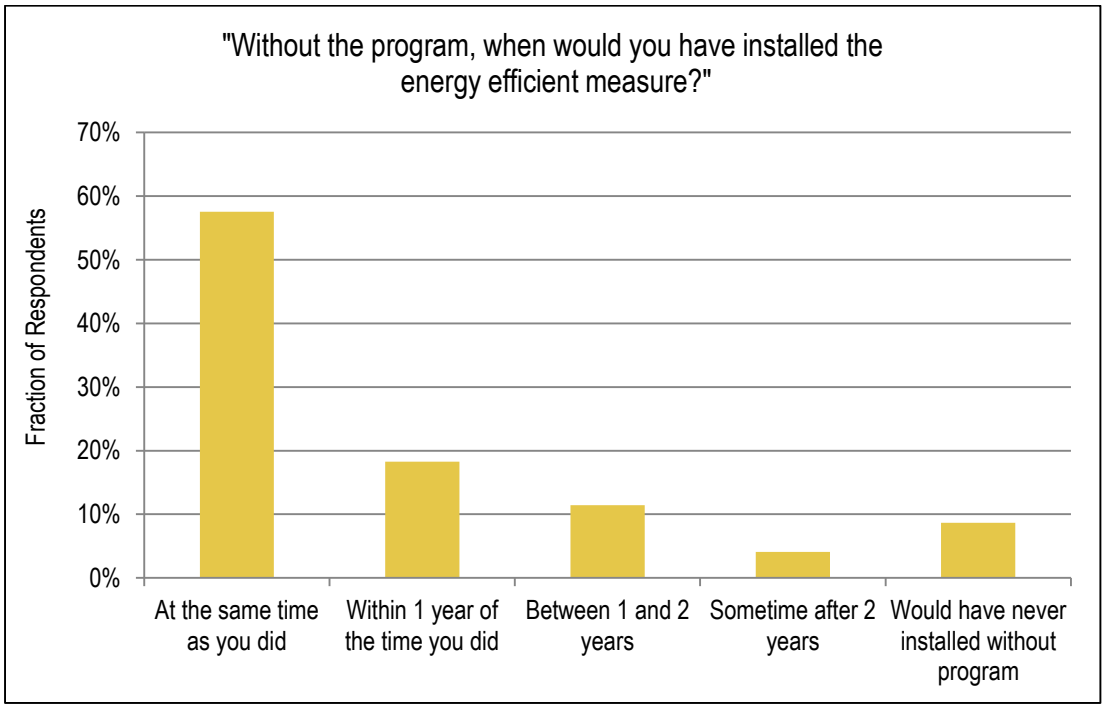
Figure B-5. Extent of Prior Plans (n =118)



Source: Navigant analysis

Figure B-6 provides further information on customers' prior plans by displaying the timeframe in which equipment was planned to be installed. 66 percent said they would have installed the equipment at the same time as they did, which is up from 58 percent in PY 2012. Another 12 percent said they would install within one year, while 22 percent said they would not have installed for two or more years, never, or did not answer.

Figure B-6. Timing (n = 177)

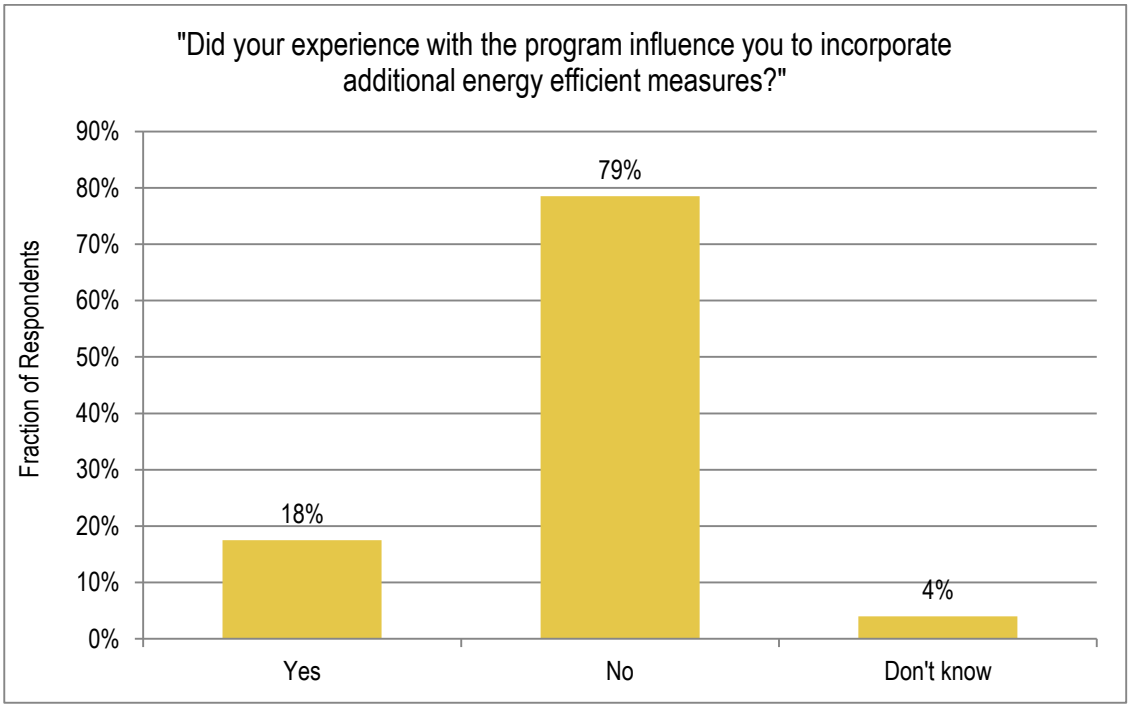


Source: Navigant analysis

Spillover Results

HEIP influenced approximately 18 percent of single family participants to install additional energy efficiency measures (see Figure B-7). This is a decrease from the 30 percent from PY 2012 but closer to the 23 percent found in PY 2010 and PY 2011.

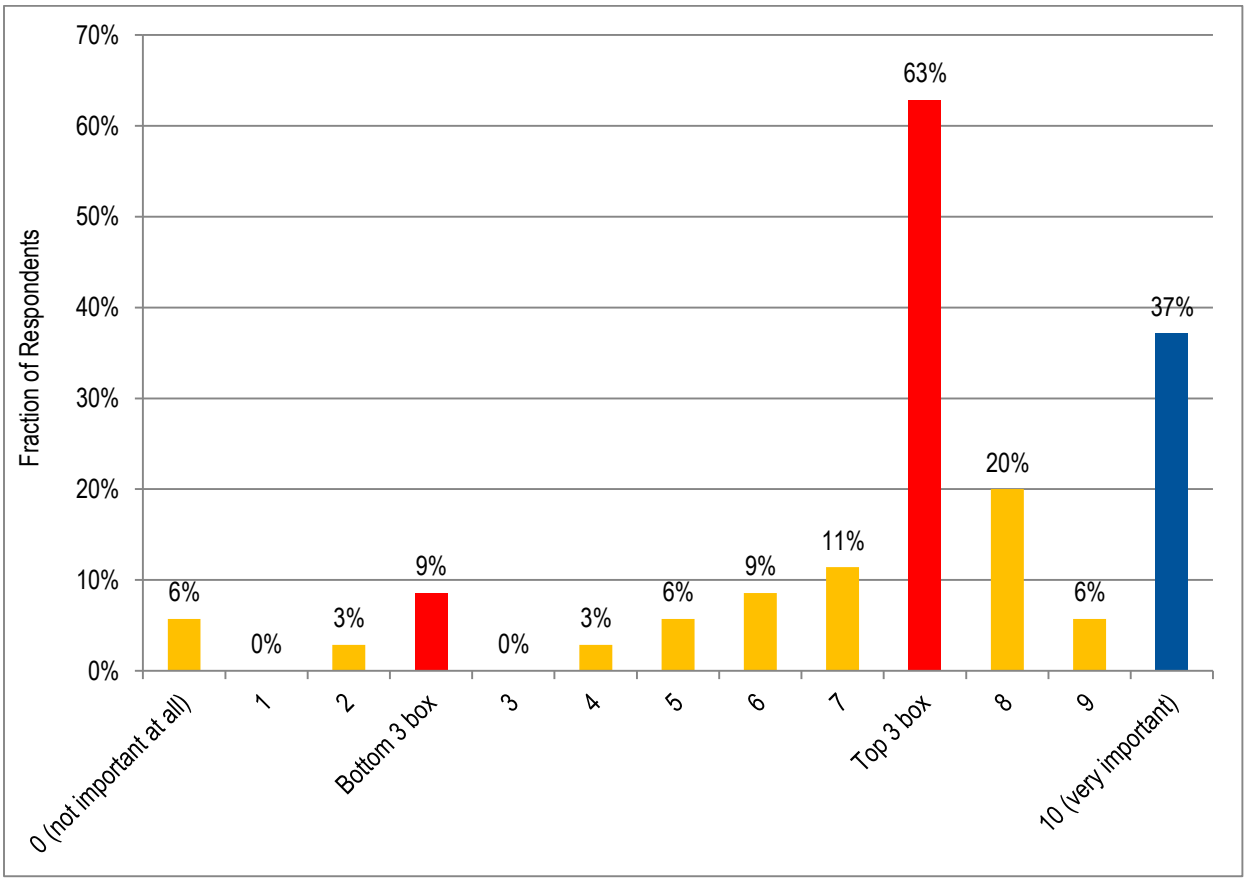
Figure B-7. Spillover (n = 200)



Source: Navigant analysis

About 63 percent of these respondents taking spillover actions indicated that the program was very important in influencing their decision to install the high-efficiency equipment (8 or higher on a 10-point importance scale; see Figure B-8. This figure is an increase from the 47 percent in PY 2012 and the same as the 63 percent found in PY 2010 and PY 2011.

Figure B-8. Program Importance for Respondents with Spillover (n = 35)



Source: Navigant analysis

Only one of the 13 multi-family property managers surveyed indicated that they pursued spillover measures as a result of the program. A list of the spillover measures indicated by survey participants is shown in Table B-3, which represents the non-incented measures that were installed as a result of participation in HEIP. Based on the survey findings, the EM&V team estimates the overall program spillover to be 6 percent of program-reported savings. Spillover savings were calculated for each measure, and the program-wide value of 6 percent was calculated by weighting the spillover from each measure according to that measure's share of total reported energy savings.

Table B-3. Spillover Measures Installed by Survey Participants

Program Measures[a]	Appliances	Envelope	Other
Heat pump	Refrigerator	Air sealing	Lighting
Insulation	Freezer	Weatherization	Thermostat
Windows	Clothes washer	Weather stripping	Metal Roof
Duct sealing	Clothes dryer	Doors	Air filter
	Dishwasher		Attic fan
	Water heater		
	Microwave		
	Electric stove		
	Furnace		
	Water heater		

a. Program measures refer to measures that are similar to those that qualify for HEIP, although the customer reported having not received an incentive through HEIP. When estimating spillover for these measures, Navigant assigned 50 percent of program savings as a conservative assumption that the customer would have pursued a rebate through HEIP if the measure was eligible. Non-HEIP measures received full savings credit. Per request of the Public Staff in PY 2012, Navigant used PY 2013 verified savings to estimate spillover for program measures.
Source: Navigant analysis

Net-to-Gross Ratio

As stated in Section B.1, the NTG ratio is defined as follows:

$$NTG = 1 - free\ ridership + total\ spillover$$

Using the overall free ridership value of 38 percent and the overall spillover value of 6 percent, the NTG ratio for PY 2013 is 1 – 0.38 + 0.06 = 0.68.[19] The estimated NTG ratio of 0.68 implies that for every 100 kWh of realized savings recorded in HEIP records, 68 kWh can be attributed to the program.

[19] Total subject to rounding.

Table B-4displays the free ridership, spillover, and NTG scores by measure category and for the program as a whole.

Table B-4. NTG Scores for HEIP

Measure Category	Free Ridership	Spillover	NTG Ratio
Air source heat pump	49%	6%	57%
Central air conditioner	51%		55%
Geothermal heat pump	63%		43%
HVAC audit	24%		82%
Duct sealing	41%		65%
Attic insulation	15%		91%
Windows	39%		67%
Heat pump water heater	29%		76%
Room air conditioner	52%		54%
Total	**38%**		**68%**

a. HEIP total values for free ridership, spillover, and NTG are weighted values, calculated based on each measure category's share of total reported energy savings. The results by measure show unweighted values.
b. PY 2011 free ridership estimates were used for windows because they were removed from the program in 2012.
c. Values subject to rounding.
Source: Navigant analysis

Appendix C. Supplemental Information on Demand Impacts

This appendix provides additional information relating to summer and winter demand impacts and is meant to supplement Section 3 of the main report.

C.1 Field Verification Rates (Demand)

Weighted field verification rates for summer and winter demand are shown, respectively, in Table C-1 and Table C-2.

Table C-1. Weighted Field Verification Rates for Summer Coincident Demand across PY 2011–2013

Measure	PY 2011	PY 2012	PY 2013	Weighted
Air source heat pump	100%	100%	100%	100%
Central air conditioner	100%	100%	100%	100%
Geothermal heat pump	96%	99%	99%	99%[a]
HVAC audit	96%	47%	99%	99%
Duct sealing	86%	100%	94%	94%
Attic insulation	96%	95%	100%	97%
Windows	91%	91%	91%	91%[b]
Heat pump water heater	N/A	99%	99%	99%
Room air conditioner	N/A	99%	99%	99%

a. HVAC audit verification rates were not weighted due to significance of findings in PY 2012.
b. Windows have been removed from the program going forward and were assigned program average field verification rates.

Source: Navigant analysis

Table C-2. Weighted Field Verification Rates for Winter Demand across PY 2011–2013

Measure	PY 2011	PY 2012	PY 2013	Weighted
Air source heat pump	100%	100%	100%	100%
Central air conditioner	100%	100%	100%	100%
Geothermal heat pump	90%	98%	97%	97%
HVAC audit	90%	47%	97%	97%[a]
Duct sealing	86%	100%	94%	94%
Attic insulation	90%	95%	101%	98%
Windows	91%	91%	91%	91%[b]
Heat pump water heater	N/A	98%	97%	97%
Room air conditioner	N/A	98%	99%	99%

a. HVAC audit verification rates were not weighted due to significance of findings in PY 2012.
b. Windows have been removed from the program going forward and were assigned program average field verification rates.

Source: Navigant analysis

C.2 *Updated Deemed Savings Estimates (Demand)*

The deemed savings for summer and winter demand are shown, respectively, in Table C-3 and Table C-4.

Table C-3. Deemed Summer Coincident Demand Savings for Each Measure in PY 2009–2013

Summer Demand	PY 2009 (kW)	PY 2010 (kW)	PY 2011 (kW)	PY 2012 (kW)	PY 2013 (kW)
Air source heat pump	0.424	0.419	0.416	0.409	0.224
Central air conditioner	0.429	0.430	0.432	0.411	0.324
Geothermal heat pump	0.690	0.690	0.690	0.690	0.684
HVAC audit	N/A	0.33	0.33	0.157	0.272
Duct sealing	0.167	0.182	0.182	0.170	0.102
Attic insulation	0.344	0.332	0.311	0.235	0.223
Heat pump water heater	N/A	N/A	N/A	0.496	0.241
Room air conditioner	N/A	N/A	N/A	0.100	0.099

Source: Navigant analysis

Table C-4. Deemed Winter Demand Savings for Each Measure in PY 2009–2013

Winter Demand	PY 2009 (kW)	PY 2010 (kW)	PY 2011 (kW)	PY 2012 (kW)	PY 2013 (kW)
Air source heat pump	0.037	0.034	0.038	0.044	0.253
Central air conditioner	0.038	0.034	0.035	0.037	0.087
Geothermal heat pump	0	0	0	0	0.000
HVAC audit	N/A	0.38	0.38	0.180	0.164
Duct sealing	0.397	0.432	0.431	0.387	0.339
Attic insulation	0.869	0.749	0.668	0.515	0.339
Heat pump water heater	N/A	N/A	N/A	0.567	0.541
Room air conditioner	N/A	N/A	N/A	0.01	0.010

Source: Navigant analysis

C.3 Verified Gross Savings and Gross Realization Rates (Demand)

The total verified gross demand reductions follow similar trends to energy. Table C-5 presents gross realization rates and peak summer demand reductions by measure. Realization rates were primarily driven by the new calibrated energy simulation models.

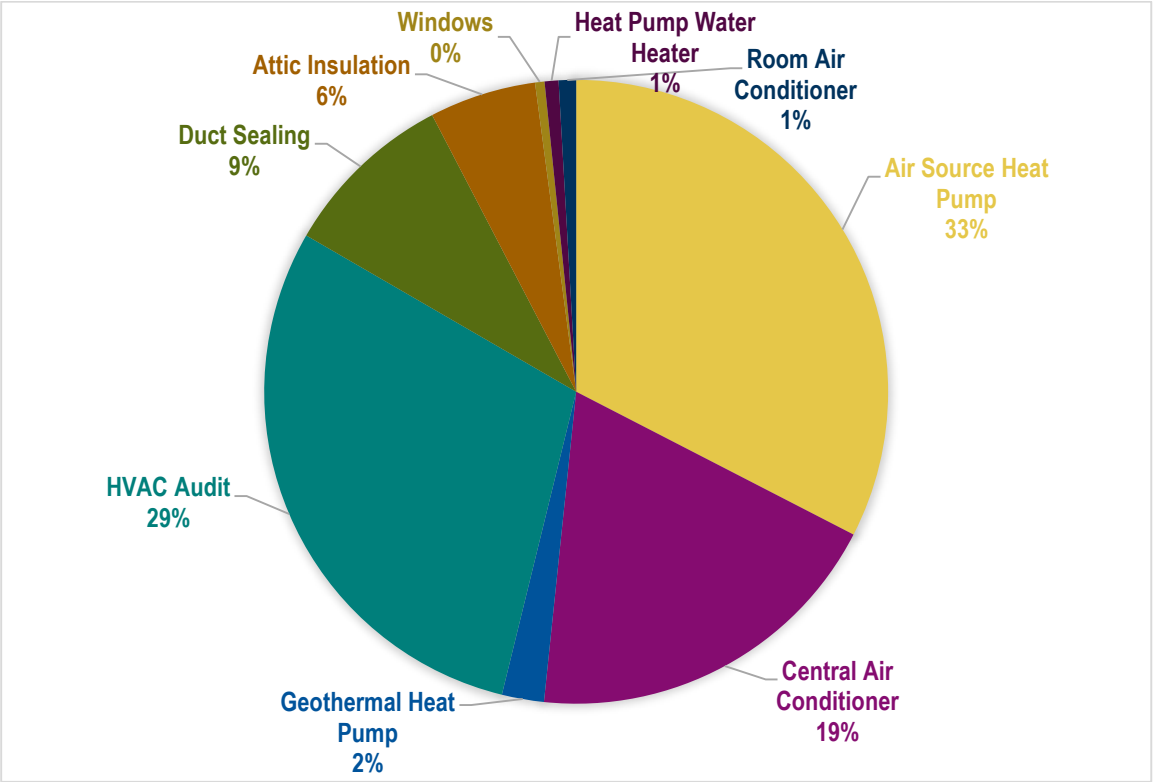
Table C-5. Verified Gross Peak Summer Demand Reductions by Measure: PY 2013

Measure Category	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction (kW)	Gross Realization Rate
Air source heat pump	2,051	1,094	53%
Central air conditioner	851	641	75%
Geothermal heat pump	74	73	99%
HVAC audit	1,205	991	82%
Duct sealing	532	302	57%
Attic insulation	258	186	72%
Windows	18	16	92%
Heat pump water heater	50	24	48%
Room air conditioner	31	30	99%
Total	**5,059**	**3,358**	**66%**

Note: Totals subject to rounding.
Source: Navigant analysis

Figure C-1 shows each measure's contribution to overall gross summer coincident demand reductions for PY 2013.

Figure C-1. Measure-Level Contribution to Verified Gross Summer Coincident Demand Savings: PY 2013



Source: Navigant analysis

Winter peak demand reductions are primarily important in the western region, where there is a more localized transmission constraint in the winter, while the overall summer peak demand affects the system peak for the entire service area. Verified winter peak demand reductions for 2013 are summarized in Table C-6. Navigant adjusted the winter demand savings for the room air conditioner measure. The program design assumed a deemed savings value of 0.58 kW for a room air conditioner, which is almost 15 times the current assumption for an air source heat pump. Navigant adjusted the savings to 0.01 kW under the assumption that some rebated units will be heat pumps and will result in winter demand savings.

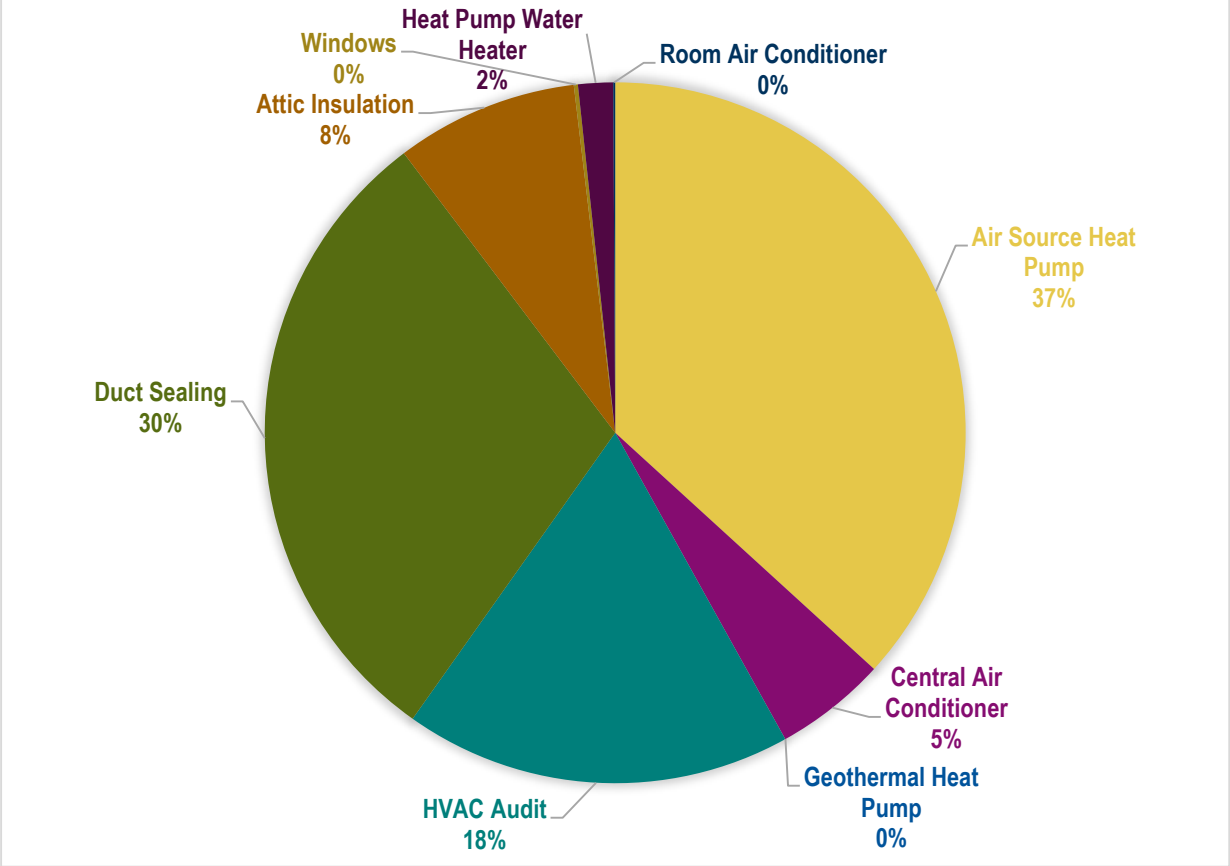
Table C-6. Verified Gross Winter Peak Demand Reductions by Measure: PY 2013

Measure Category	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction (kW)	Gross Realization Rate
Air source heat pump	195	1,234	632%
Central air conditioner	79	173	219%
Geothermal heat pump	0	0	100%
HVAC audit	1,387	600	43%
Duct sealing	1,271	1,003	79%
Attic insulation	557	282	51%
Windows	7	6	91%
Heat pump water heater	58	54	93%
Room air conditioner	177	3	2%
Total	**3,711**	**3,356**	**90%**

Note: Totals subject to rounding.
Source: Navigant analysis

Each measure's contribution to overall verified gross winter demand reduction for 2013 is shown in Figure C-2.

Figure C-2. Measure-Level Contribution to Verified Gross Winter Demand Savings: PY 2013



Source: Navigant analysis

C.4 *Verified Net Savings (Demand)*

Table C-7 and Table C-8 present the verified net summer and winter demand savings for PY 2013.

Table C-7. Verified Net Summer Demand Impacts: PY 2013

Measure Category	Verified Gross Demand Reduction (kW)	NTG Ratio	Verified Net Demand Reductions (kW)
Air source heat pump	1,094	0.57	619
Central air conditioner	641	0.55	351
Geothermal heat pump	73	0.43	32
HVAC audit	991	0.82	814
Duct sealing	302	0.65	197
Attic insulation	186	0.91	169
Windows	16	0.67	11
Heat pump water heater	24	0.54	18
Room air conditioner	30	0.76	16
Total[a]	**3,358**	**0.68**	**2,282**

a. Totals indicate the weighted average by each measure's contribution to program savings and are subject to rounding.
Source: Navigant analysis

Table C-8. Verified Net Winter Demand Impacts: PY 2013

Measure Category	Verified Gross Demand Reduction(kW)	NTG Ratio	Verified Net Demand Reductions (kW)
Air source heat pump	1,234	0.57	698
Central air conditioner	173	0.55	95
Geothermal heat pump	0	0.43	0
HVAC audit	600	0.82	492
Duct sealing	1,003	0.65	654
Attic insulation	282	0.91	257
Windows	6	0.67	4
Heat pump water heater	54	0.54	41
Room air conditioner	3	0.76	2
Total[a]	**3,356**	**0.68**	**2,281**

Totals indicate the weighted average by each measure's contribution to program savings and are subject to rounding.
Source: Navigant analysis

C.5 Statistical Significance of Impact Findings

Sampling precision was determined for each sample stratum's verification rate using a 90 percent confidence interval. The analysis was conducted for the four measures for which onsite verification was performed (air source heat pump, central air conditioner, duct sealing, and attic insulation). Precision values were calculated using stratified ratio estimation, in which the stratum verification rate (i.e., the weighted average ratio between verified and reported savings for sample measures of a given type) was multiplied by the reported savings for each sampled site measure in the stratum to yield a set of predicted savings values for each sampled measure.[20] The difference between each verified savings value and the same site's predicted value was then the basis for determining a variance for the stratum that was used for purposes of statistical precision calculations.

The confidence and precision of the energy and summer peak demand verification rates are, respectively, 90/4 and 90/3, indicating a relative precision of ± 4 percent for energy savings and ± 3 percent for summer peak demand savings at a 90 percent level of confidence. Precision levels for energy and summer demand were heavily affected by the 100 percent field verification rates for the air source heat pump and central air conditioner measures. The variance for attic insulation was high due to the range of verification rates for individual field sites. The precision for winter demand savings was ± 9 percent and was driven by the impacts of verification rates for attic insulation, which make a significant contribution to winter demand savings. The verified gross and net savings, as well as relative precision for the energy and peak demand savings estimates, are shown in Table C-9.

Table C-9. Statistical Significance of Verified Savings

	Annual Energy Savings (MWh)	Summer Coincident Peak Demand Savings (MW)	Winter Coincident Peak Demand Savings (MW)
Verified Gross Savings	5,895	3.36	3.36
Verified Net Savings	4,006	2.28	2.28
Relative Precision (± %) at 90% Level of Confidence	± 4%	± 3%	± 9%

Source: Navigant analysis

[20] The evaluation team stratified the sample by measure type. Ratio estimation refers to the method of assessing the statistical significance of reported savings. Rather than merely analyzing the verified savings values for each project in the sample, the evaluation analyzed the ratio of verified savings to reported savings (adjusted for changes in measure unit savings values), which generally reduces the variability of data across sampled sites and thus decreases the coefficient of variation.

Appendix D. PY 2013 Energy Simulation Models and HVAC Metering Study

For PY 2013, Navigant developed a new set of energy simulation models to estimate energy and demand savings for most HEIP measures. Navigant also conducted a field metering study to measure HVAC usage by HEIP participants. Navigant incorporated results of the metering study into the model calibration process. This exercise represents a significant update to the energy and demand savings estimates that Navigant has used to evaluate HEIP during PY 2009–PY 2012. This appendix includes a detailed discussion of this process.

D.1 Metering Study

During the summer of 2014, Navigant deployed data loggers to monitor HVAC usage at approximately 65 PY 2013 HEIP participant homes. Navigant stratified the metering sample by geographic region and HVAC type (central air conditioner vs. air source heat pump) to be representative of HEIP program participation. Data loggers were in place from mid-May through mid-September. The sampling structure is shown in Table D-1.

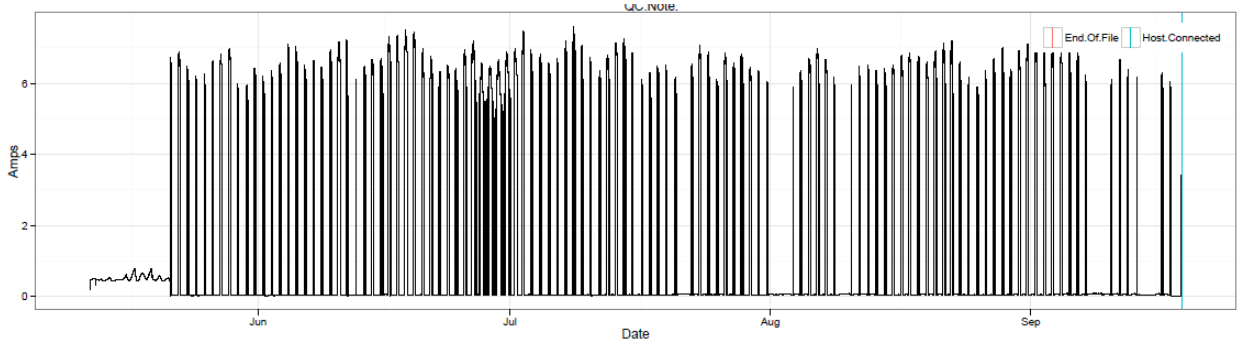
Table D-1. Sample Structure for HVAC Metering Study

Region	Air Source Heat Pump	Central Air Conditioner
Northern	7	8
Eastern	9	7
Southern	12	5
Western	11	6

Source: Navigant analysis

Navigant conducted a rigorous quality control (QC) process to clean and organize the logger data, as well as remove erroneous readings. The logged amperage readings were converted to kilowatts by applying voltage and power factor readings from spot measurements taken during the logger install and retrieval visits. A portion of sites had multiple HVAC units. The evaluation team logged every unit at the site, and data was combined to achieve the total HVAC consumption load shape at each site. An example plot of one logger file is shown in Figure D-1.

Figure D-1. Example Plot of Logger File



Source: Navigant analysis

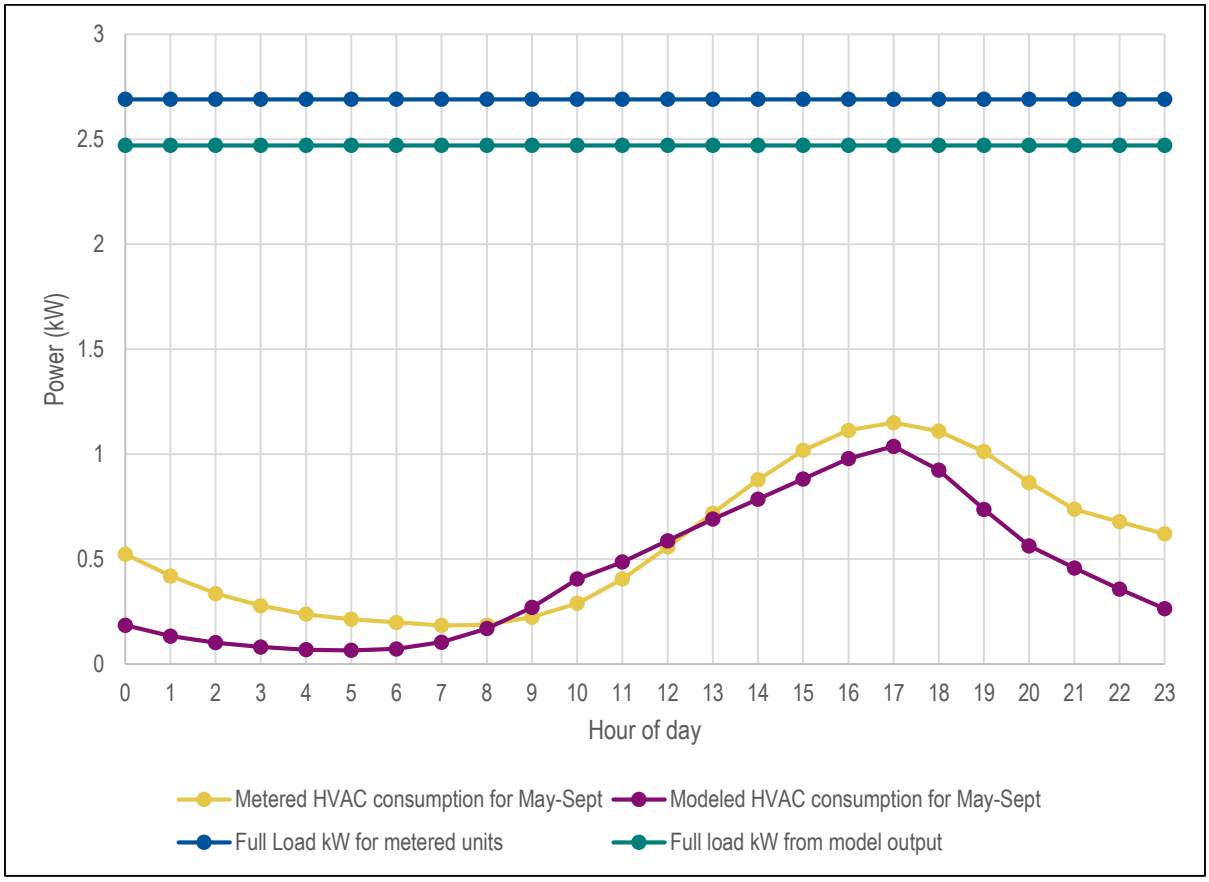
Subsequent to cleaning and organizing the logger data, Navigant aggregated the logger data by DEP geographic region and heating type to create representative HVAC load shapes for the metering period. Logger data was recorded at five-minute intervals. Navigant created hourly averages before aggregating to the regional and HVAC level.

D.2 Energy Simulation Modeling

Billing Data Analysis

DEP provided Navigant with consumption billing data for all PY 2013 HEIP participants. The consumption data covered the period from October 2012 through September 2013. Navigant cleaned and sorted the billing data and allocated consumption into calendar months by taking the total consumption for a billing cycle and dividing by the number of days in the billing cycle. After allocating to calendar months, Navigant aggregated the billing data to create a number of load shapes by geographic region and measure type. Navigant also aggregated data from the HVAC metering study into a diurnal load shape for the metering period. Figure D-2 shows a comparison between the aggregated diurnal participant billing data load shape as well as the metered HVAC usage used for model calibration (discussed below).

Figure D-2. Aggregated HEIP Billing Data Load Shape and Metered HVAC Consumption



Source: Navigant analysis

Model Construction

Navigant constructed the new energy simulation models for HEIP using the Building Energy Optimization (BEopt™) software package. BEopt is a residential software modeling platform developed by the National Renewable Energy Laboratory (NREL). It utilizes the industry-trusted EnergyPlus or DOE-2.2 simulation engines and contains built-in assumptions that are based on the DOE's Building America House Simulation Protocols.

Navigant built a series of energy simulation models to cover the four geographic regions of the DEP service territory. Table D-2 shows the weather files associated with each model.

Table D-2. Weather Files for Energy Models

DEP Geographic Region	Simulation Weather File
Northern	Raleigh
Eastern	Wilmington
Southern	Southern Pines
Western	Asheville

Source: Navigant analysis

To the extent possible, Navigant used data from the following sources to inform the simulation model inputs:

- Previous HEIP energy simulation models
- 2013 Duke Energy Residential End-Use Studies
- DEP demographic data
- Navigant field verification data for DEP from 2009-2014 EM&V efforts
- Secondary research

When data was not available for certain inputs, Navigant relied on the regional assumptions from the DOE Building America House Simulation Protocols.

Load Disaggregation and Model Calibration

Proper calibration of energy simulation models requires that the billing data load shape be disaggregated to estimate the contribution from the primary end uses of home energy. Navigant has developed a rigorous approach for load disaggregation, which has been accepted for several evaluations among various clients. This methodology is described in detail in the PY 2009 HEIP EM&V report.[21] For the new energy simulation models developed here, Navigant also incorporated data from the HEIP HVAC metering study to use as calibration targets for HVAC use during the summer months. Aggregated values of the metered consumption are shown above in Figure D-2.

Once the billing load shape was disaggregated and combined with HVAC metering data, the evaluation team conducted a rigorous calibration procedure to calibrate simulation models to the relevant billing data load shapes for the respective geographic regions. Model calibration is carried out by adjusting simulation parameters so that modeled output is consistent with calibration targets established by the consumption load shapes. The calibration parameters were kept within reasonable ranges to ensure that simulation inputs were representative of realistic home and customer behaviors.

[21] *2009 EM&V Report for the Home Energy Improvement Program, Final Report*, prepared by Navigant Consulting, Inc., April 11, 2011.

Measure Savings Estimates

After creating a complete set of calibrated models, Navigant performed a number of model runs to estimate energy savings for the following HEIP program measures: air source heat pump, central air conditioner, attic insulation, duct sealing, and heat pump water heater. The evaluation team adjusted the efficiency parameters in order to simulate the baseline condition versus the efficient condition. The evaluation team chose criteria for the efficient categories that were consistent with actual HEIP program activity in order to simulate the most appropriate measure combinations.

During the calibration process, the evaluation team used weather data from the same time period as the billing data provided by DEP in order to ensure that models were properly adjusted to represent the consumption that occurred as a result of the weather during the same time period. Once the models were calibrated, measure savings estimates were generated using typical meteorological year (TMY3) weather data so that the savings reflect what would be observed during a typical weather year rather than a specific weather year.[22]

The following series of tables provide the energy simulation model outputs for various model runs conducted by Navigant. Ultimately, the values from these tables were applied to the HEIP tracking database to estimate verified savings for the program.

[22] Navigant chose to use TMY3 weather data for model savings because it provides the best estimate of the typical savings that a customer would experience. Furthermore, DEP generally uses the evaluated savings from one program year as the deemed savings for the next program year, which makes TMY3 data the most appropriate choice.

Table D-3. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Air Source Heat Pump Retrofit

Measure	Region	Base SEER	EE SEER	Annual Energy Savings (kWh/ton)	Annual Summer Demand Savings (kW/ton)	Annual Winter Demand Savings (kW/ton)
ASHP	Northern	13	14	97	0.038	0.069
ASHP	Northern	13	15	144	0.060	0.099
ASHP	Northern	13	16	215	0.087	0.077
ASHP	Northern	13	17	248	0.115	0.083
ASHP	Northern	13	18	282	0.091	0.119
ASHP	Northern	13	19	307	0.098	0.131
ASHP	Northern	13	22	495	0.255	0.299
ASHP	Eastern	13	14	87	0.040	0.049
ASHP	Eastern	13	15	129	0.062	0.071
ASHP	Eastern	13	16	220	0.096	0.079
ASHP	Eastern	13	17	252	0.123	0.085
ASHP	Eastern	13	18	271	0.099	0.121
ASHP	Eastern	13	19	292	0.105	0.134
ASHP	Eastern	13	22	476	0.262	0.180
ASHP	Southern	13	14	126	0.044	0.073
ASHP	Southern	13	15	186	0.069	0.105
ASHP	Southern	13	16	247	0.158	0.096
ASHP	Southern	13	17	296	0.186	0.102
ASHP	Southern	13	18	382	0.207	0.136
ASHP	Southern	13	19	434	0.238	0.147
ASHP	Southern	13	22	696	0.308	0.393
ASHP	Western	13	14	102	0.037	0.069
ASHP	Western	13	15	149	0.058	0.099
ASHP	Western	13	16	238	0.081	0.140
ASHP	Western	13	17	267	0.110	0.146
ASHP	Western	13	18	340	0.130	0.186
ASHP	Western	13	19	365	0.141	0.197
ASHP	Western	13	22	542	0.300	0.360

Source: Navigant analysis

Table D-4. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Central Air Conditioner Retrofit

Measure	Region	Base SEER	EE SEER	Annual Energy Savings (kWh/ton)	Annual Summer Demand Savings (kW/ton)	Annual Winter Demand Savings (kW/ton)
CAC	Northern	13	14	34	0.046	0.000
CAC	Northern	13	15	66	0.090	0.000
CAC	Northern	13	16	142	0.123	0.036
CAC	Northern	13	17	213	0.169	0.070
CAC	Northern	13	18	217	0.174	0.070
CAC	Northern	13	21	226	0.186	0.070
CAC	Northern	13	24.5	360	0.270	0.075
CAC	Eastern	13	14	38	0.046	0.000
CAC	Eastern	13	15	74	0.089	0.000
CAC	Eastern	13	16	134	0.120	0.021
CAC	Eastern	13	17	193	0.165	0.045
CAC	Eastern	13	18	182	0.152	0.045
CAC	Eastern	13	21	177	0.146	0.045
CAC	Eastern	13	24.5	366	0.279	0.047
CAC	Southern	13	14	34	0.038	0.000
CAC	Southern	13	15	66	0.074	0.000
CAC	Southern	13	16	145	0.107	0.038
CAC	Southern	13	17	216	0.147	0.073
CAC	Southern	13	18	234	0.166	0.073
CAC	Southern	13	21	255	0.190	0.073
CAC	Southern	13	24.5	354	0.251	0.078

Note: Central air conditioners were not simulated for the western region due to very low participation levels (<4%).
Source: Navigant analysis

Table D-5. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Attic Insulation Retrofit (with Electric Heating and Cooling)

Measure	Region	Base R-Value	EE R-Value	Annual Energy Savings (kWh/ft²)	Annual Summer Demand Savings (kW/ft²)	Annual Winter Demand Savings (kW/ft²)
Attic Insulation	Northern	7	30	0.686	0.00053	0.0012
Attic Insulation	Northern	7	38	0.744	0.00058	0.0013
Attic Insulation	Northern	7	49	0.796	0.00062	0.0013
Attic Insulation	Northern	7	60	0.828	0.00065	0.0014
Attic Insulation	Northern	13	30	0.185	0.00015	0.0003
Attic Insulation	Northern	13	38	0.243	0.00020	0.0004
Attic Insulation	Northern	13	49	0.295	0.00025	0.0005
Attic Insulation	Northern	13	60	0.327	0.00028	0.0005
Attic Insulation	Northern	19	30	0.148	0.00012	0.0003
Attic Insulation	Northern	19	38	0.206	0.00017	0.0003
Attic Insulation	Northern	19	49	0.258	0.00021	0.0004
Attic Insulation	Northern	19	60	0.290	0.00024	0.0005
Attic Insulation	Eastern	7	30	0.919	0.00053	0.0004
Attic Insulation	Eastern	7	38	0.998	0.00058	0.0004
Attic Insulation	Eastern	7	49	1.067	0.00063	0.0005
Attic Insulation	Eastern	7	60	1.110	0.00066	0.0005
Attic Insulation	Eastern	13	30	0.318	0.00020	0.0001
Attic Insulation	Eastern	13	38	0.397	0.00025	0.0002
Attic Insulation	Eastern	13	49	0.466	0.00030	0.0002
Attic Insulation	Eastern	13	60	0.509	0.00032	0.0002
Attic Insulation	Eastern	19	30	0.198	0.00012	0.0001
Attic Insulation	Eastern	19	38	0.277	0.00017	0.0001
Attic Insulation	Eastern	19	49	0.346	0.00022	0.0002
Attic Insulation	Eastern	19	60	0.389	0.00025	0.0002
Attic Insulation	Southern	7	30	1.012	0.00040	0.0011
Attic Insulation	Southern	7	38	1.099	0.00044	0.0012
Attic Insulation	Southern	7	49	1.175	0.00048	0.0013
Attic Insulation	Southern	7	60	1.222	0.00050	0.0014
Attic Insulation	Southern	13	30	0.348	0.00015	0.0004
Attic Insulation	Southern	13	38	0.435	0.00019	0.0005
Attic Insulation	Southern	13	49	0.511	0.00023	0.0006
Attic Insulation	Southern	13	60	0.558	0.00025	0.0007
Attic Insulation	Southern	19	30	0.219	0.00009	0.0002

Measure	Region	Base R-Value	EE R-Value	Annual Energy Savings (kWh/ft²)	Annual Summer Demand Savings (kW/ft²)	Annual Winter Demand Savings (kW/ft²)
Attic Insulation	Southern	19	38	0.306	0.00013	0.0004
Attic Insulation	Southern	19	49	0.381	0.00017	0.0005
Attic Insulation	Southern	19	60	0.429	0.00019	0.0005
Attic Insulation	Western	7	30	0.866	0.00041	0.0010
Attic Insulation	Western	7	38	0.939	0.00045	0.0011
Attic Insulation	Western	7	49	1.003	0.00049	0.0011
Attic Insulation	Western	7	60	1.044	0.00051	0.0012
Attic Insulation	Western	13	30	0.302	0.00016	0.0004
Attic Insulation	Western	13	38	0.375	0.00020	0.0004
Attic Insulation	Western	13	49	0.439	0.00023	0.0005
Attic Insulation	Western	13	60	0.479	0.00026	0.0006
Attic Insulation	Western	19	30	0.185	0.00009	0.0002
Attic Insulation	Western	19	38	0.257	0.00013	0.0003
Attic Insulation	Western	19	49	0.322	0.00017	0.0004
Attic Insulation	Western	19	60	0.362	0.00019	0.0004

Source: Navigant analysis

Table D-6. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Attic Insulation Retrofit (with Electric Cooling and Gas Heating)

Measure	Region	Base R-Value	EE R-Value	Annual Energy Savings (kWh/ft²)	Annual Summer Demand Savings (kW/ft²)	Annual Winter Demand Savings (kW/ft²)
Attic Insulation	Northern	7	30	0.686	0.00037	0.00017
Attic Insulation	Northern	7	38	0.744	0.00040	0.00019
Attic Insulation	Northern	7	49	0.796	0.00044	0.00020
Attic Insulation	Northern	7	60	0.828	0.00046	0.00021
Attic Insulation	Northern	13	30	0.185	0.00011	0.00005
Attic Insulation	Northern	13	38	0.243	0.00014	0.00006
Attic Insulation	Northern	13	49	0.295	0.00018	0.00008
Attic Insulation	Northern	13	60	0.327	0.00020	0.00009
Attic Insulation	Northern	19	30	0.148	0.00008	0.00004
Attic Insulation	Northern	19	38	0.206	0.00012	0.00005
Attic Insulation	Northern	19	49	0.258	0.00015	0.00007
Attic Insulation	Northern	19	60	0.290	0.00017	0.00008

Note: Insulation models with gas heating and electric cooling were only completed for the northern region due to the low participation numbers in other regions.

Source: Navigant analysis

Table D-7. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Duct Sealing Retrofit

Measure	Region	Annual Energy Savings (kWh/site)	Annual Summer Demand Savings (kW/site)	Annual Winter Demand Savings (kW/site)
Duct Sealing	Northern	292	0.112	0.367
Duct Sealing	Eastern	274	0.107	0.148
Duct Sealing	Southern	310	0.099	0.560
Duct Sealing	Western	279	0.105	0.524

Note: Duct sealing models were run using leakage rates ranging from 7.5 percent to 30 percent. Results shown here are aggregated to the regional level because leakage rates are not tracked by DEP.

Source: Navigant analysis

Table D-8. Calibrated Energy Simulation Model Results for Energy and Demand Savings from Heat Pump Water Heater Retrofit

Measure	Region	Annual Energy Savings (kWh/unit)	Annual Summer Demand Savings (kW/unit)	Annual Winter Demand Savings (kW/unit)
Heat Pump Water Heater	Northern	1,581	0.257	0.604
Heat Pump Water Heater	Eastern	1,386	0.224	0.530
Heat Pump Water Heater	Southern	1,114	0.178	0.412
Heat Pump Water Heater	Western	1,618	0.316	0.593

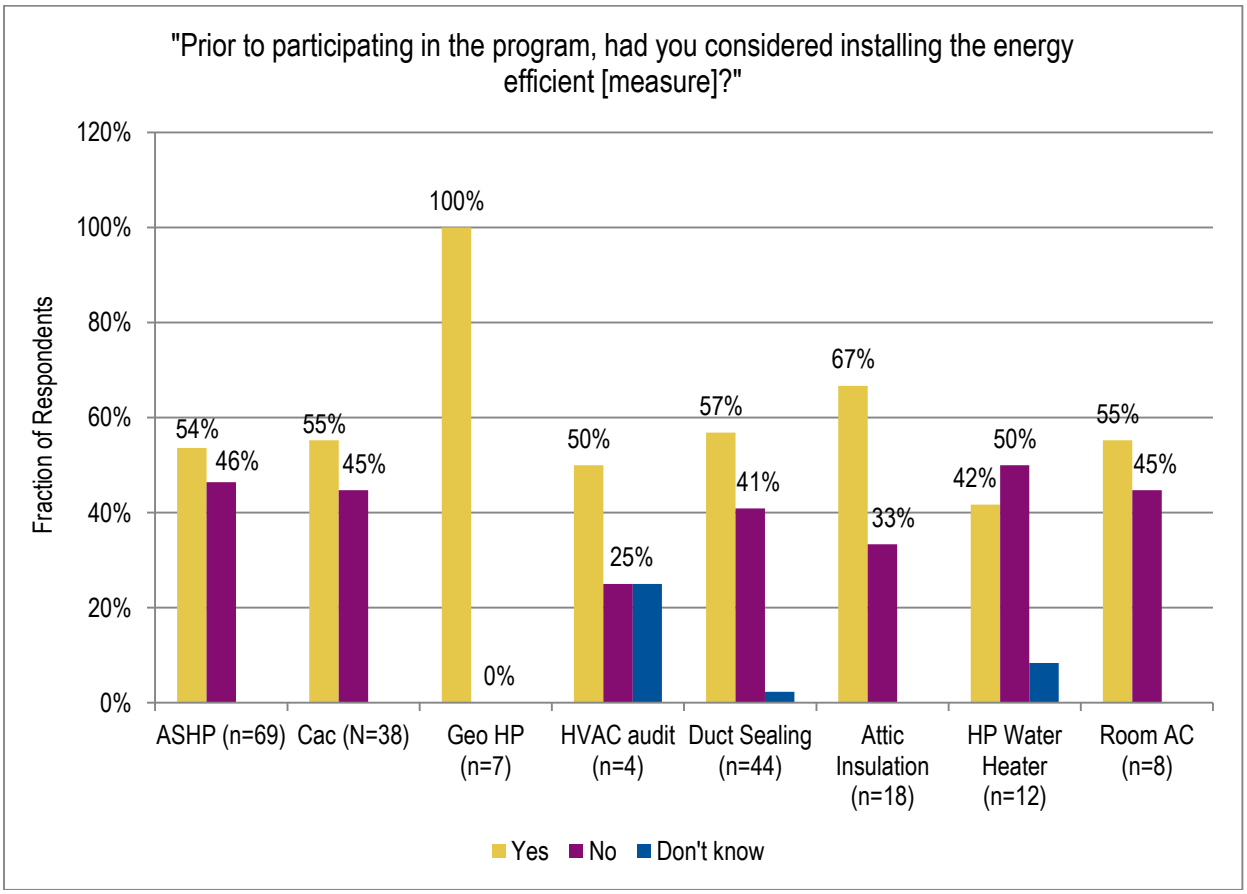
Source: Navigant analysis

Appendix E. Additional Participant Survey Results

The evaluation team conducted telephone surveys with 200 HEIP participants and 13multi-family property managers to assess overall satisfaction with the program and conduct a detailed NTG analysis. The NTG approach is discussed in Appendix B. The customer satisfaction component of the surveys was designed to ensure representation for all program measures—e.g., HVAC, duct sealing, and attic insulation. Section 4 of this report presents many of the key findings from the customer survey. This appendix provides detailed results covering the survey questions relating to customer satisfaction and program experience that were not addressed in Section 4.

Prior to learning about HEIP, participants indicated they were less likely to have considered having an HVAC audit or purchasing a heat pump water heater (see Figure E-1). For example, 50 percent of the heat pump water heater respondents had not considered installing the measure prior to participating in the program.

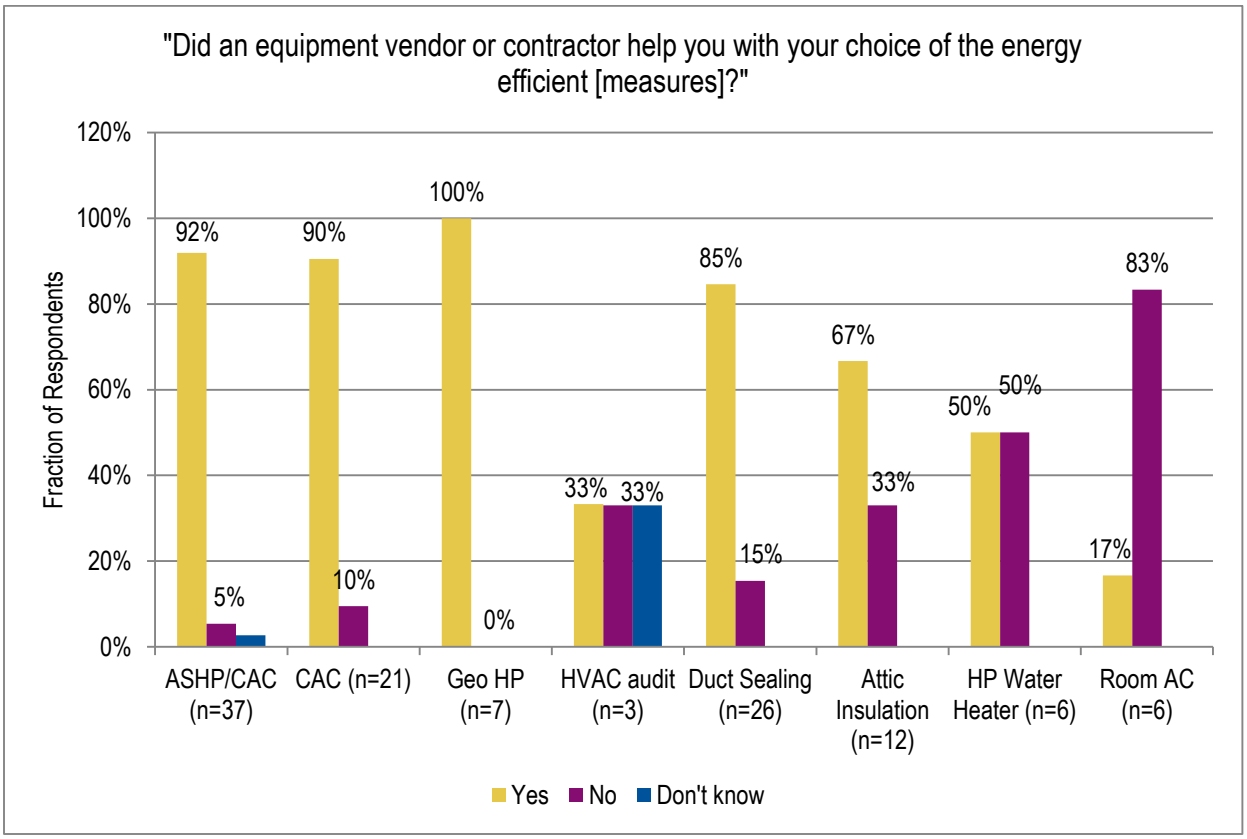
Figure E-1. Number of Participants that Had Considered Installing Measure Prior to HEIP



Source: Navigant analysis

Even if participants indicated they had already considered installing the measure prior to participating, most were still assisted by the contractor in their final equipment choice, with the exception of the room air conditioner, which does not require trade ally contact for participation (see Figure E-2).

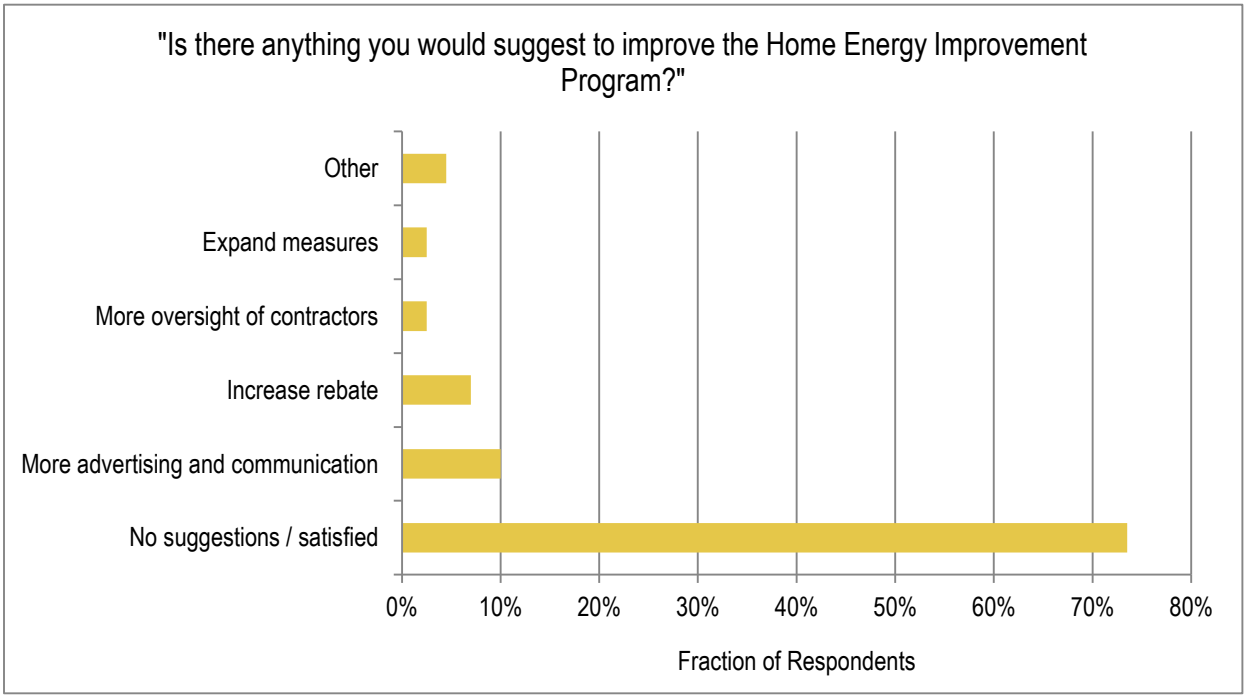
Figure E-2. Participants Who Indicated the Contractor Aided in their Final Equipment Choice, Despite Having Considered the Measure Prior to Participating in HEIP



Source: Navigant analysis

Most participants were satisfied with HEIP and had no suggestions for improvement. However, the most commonly cited improvement was to increase advertising and customer communication, which is the same finding as in PY 2010–PY 2012 (see Figure E-3).

Figure E-3. Participant Suggestions for Improving the Program (n = 200)



Source: Navigant analysis

Appendix F. Measure Level Findings for Future Impact Estimation

This appendix presents the measure level impacts from Navigant's PY 2013 HEIP evaluation efforts. These results can be used by DEP going forward to estimate program impacts. Table F-1 contains the gross energy and demand savings per measure. Navigant recommends that DEP use the values in Table F-1 for each measure going forward to estimate HEIP program impacts.

Table F-1. Gross Energy and Demand Impacts by Measure

Energy	Gross Energy Impacts per Measure (kWh)	Gross Summer Peak Demand Impacts per Measure (kW)	Gross Winter Peak Demand Impacts per Measure (kW)
Air source heat pump	506	0.224	0.253
Central air conditioner	364	0.324	0.087
Geothermal heat pump	1,725	0.684	0.000
HVAC audit	334	0.272	0.164
Duct sealing	273	0.102	0.339
Attic insulation	349	0.223	0.339
Heat pump water heater	1,462	0.241	0.541
Room air conditioner	124	0.099	0.010

Source: Navigant analysis

Table F-2 contains the NTG ratio along with the net energy and demand savings for each program measure. These values are provided for reference only. The values in Table F-2 are already adjusted for free ridership and spillover.

Table F-2. Net Energy and Demand Impacts by Measure

Energy	Net to Gross Ratio	Net Energy Impacts per Measure (kWh)	Net Summer Peak Demand Impacts per Measure (kW)	Net Winter Peak Demand Impacts per Measure (kW)
Air source heat pump	57%	286	0.127	0.143
Central air conditioner	55%	200	0.178	0.048
Geothermal heat pump	43%	1706	0.296	0.000
HVAC audit	82%	274	0.223	0.135
Duct sealing	65%	178	0.067	0.221
Attic insulation	91%	318	0.203	0.308
Heat pump water heater	76%	1116	0.184	0.413
Room air conditioner	54%	66	0.053	0.005

Source: Navigant analysis, totals subject to rounding

CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Progress, Inc.'s EM&V Report in Docket No. E-2, Sub 936 has been served by electronic mail (e-mail), hand delivery or by depositing a copy in the United States Mail, first class postage prepaid, properly addressed to parties of record.

This, the 21st day of July, 2015.

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