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December 18, 2013

**VIA ELECTRONIC FILING**

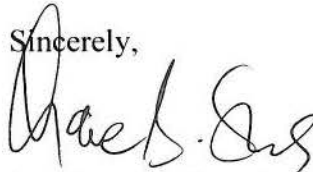
Gail L. Mount  
Chief Clerk  
North Carolina Utilities Commission  
4325 Mail Service Center  
Raleigh, North Carolina 27699-4325

Re: Home Energy Improvement Program EM&V Report  
Docket No. E-2, Sub 936

Dear Ms. Mount:

Pursuant to the Commission's April 30, 2009 *Order Approving Program*, I enclose for filing in this matter Duke Energy Progress, Inc.'s report summarizing the 2012 Program Year Evaluation, Measurement and Verification ("EM&V") results for the Home Energy Improvement Program. Duke Energy Progress 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,  
  
Lawrence B. Somers

Enclosure

Dec 18 2013 OFFICIAL COPY

CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Progress, Inc.'s Home Energy Improvement Program EM&V Report in Docket No. E-2, Sub 936 has been served by electronic mail, hand delivery, or by depositing a copy in the United States Mail, 1<sup>st</sup> Class Postage Prepaid, properly addressed to the following parties of record:

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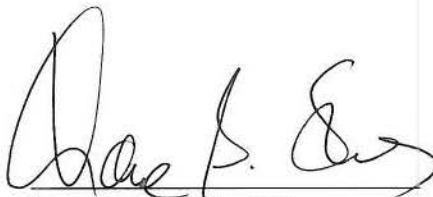
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This the 18<sup>th</sup> day of December, 2013.



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## 2012 EM&V Report for the Home Energy Improvement Program

Prepared for:  
Duke Energy Progress



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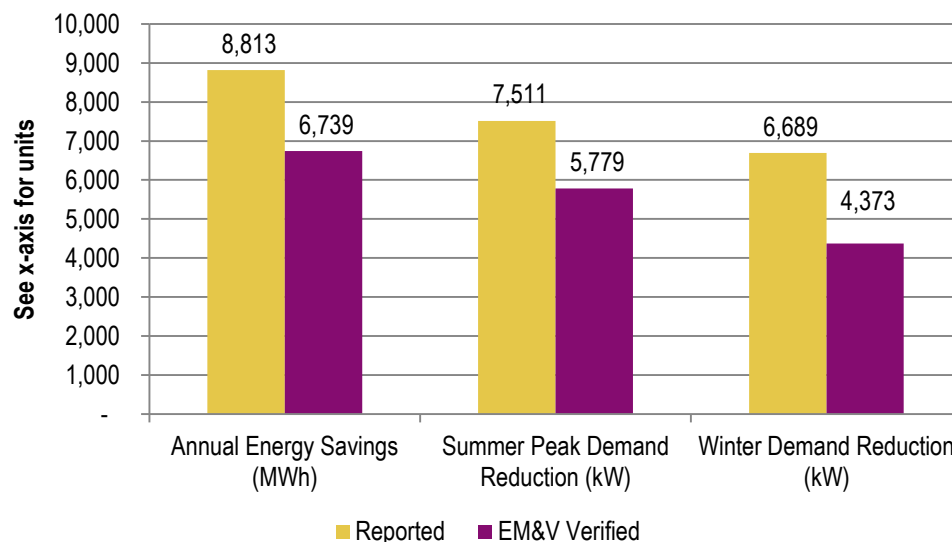
## Executive Summary

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 the Duke Energy Progress (DEP) HEIP for Program Year 2012 (PY 2012) projects, defined as those receiving rebates during the 2012 calendar year. The primary purpose of the EM&V assessment was to estimate net annual energy and peak demand impacts associated with 2012 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 offering 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 2012 was about 76 percent of the reported savings for both energy and demand. Figure 1 shows the reported and verified energy and demand impacts from HEIP for PY 2012.

**Figure 1. Comparison of Reported and Verified Gross Program Impacts for PY 2012**



Sources: Navigant analysis, HEIP tracking database

## ES.1 Program Summary

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

1. Heating, ventilation, and air conditioning (HVAC) equipment replacement (central air conditioner, air source, and geothermal heat pumps)
2. HVAC level 1 tune-up (condenser coil cleaning and general maintenance)<sup>1</sup>
3. HVAC audit (same as level 1, plus correcting refrigerant charge)<sup>2</sup>
4. Duct sealing
5. Window replacement<sup>1</sup>
6. Attic insulation
7. Heat pump water heater
8. Room air conditioner

The heat pump water heater and room air conditioner measures were new to the program in 2012. 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<sup>3</sup> based on estimated (“deemed”) savings values. The HVAC audit measure was the largest share of reported energy and summer demand savings, accounting for about 36 percent of the reported savings for energy and summer demand. This is a substantial increase over previous program years, during which the measure accounted for only a few percent of program 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 represents a major change in the program from previous years, during which multi-family savings accounted for about 2-6 percent of total savings.

## ES.2 Evaluation Methodology

The EM&V assessment of HEIP activity in 2012 included impact and process evaluations. The impact evaluation consisted primarily of 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.

<sup>1</sup> This measure was discontinued from the program; however, some rebates were paid early in 2012, so results are included in this report.

<sup>2</sup> 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.

<sup>3</sup> “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.

The evaluation team also developed updated deemed savings estimates by applying unit savings from the PY 2009 building energy simulation models to the PY 2012 tracking databases.<sup>4</sup> 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 250 HEIP participants to assess overall satisfaction with the program and 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 interviews with five trade allies and also conducted surveys with ten 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.

### ***ES.3 Program Impact Findings***

#### **ES.3.1 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 2012 by performing on-site field assessments
2. Determine combined field verification rates for PY 2009-2012
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.

---

<sup>4</sup> Energy simulation models were calibrated to the billing data of PY 2009 HEIP participants. Navigant assumed that the energy model characteristics used in the PY 2009 evaluation remained valid for 2012 participants. These models are not used to estimate savings from the HVAC audit measure, which accounted for roughly two-thirds of the reported savings from the multi-family housing segment.

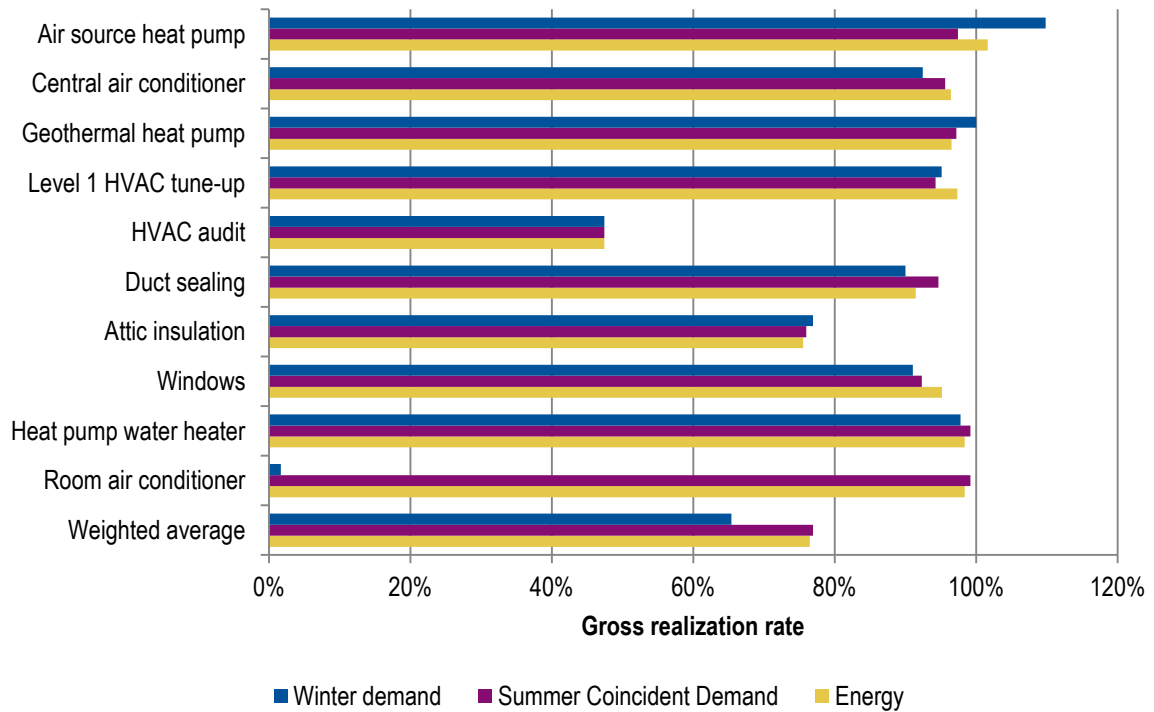
**Table 1. 2012 Program-Level Gross Realization Rates and Verified Gross Savings**

|                        | Annual Energy Savings (MWh) | Summer Coincident Demand Savings (MW) | Winter Coincident Demand Savings (MW) |
|------------------------|-----------------------------|---------------------------------------|---------------------------------------|
| Reported Gross Savings | 8,813                       | 7.51                                  | 6.69                                  |
| Verified Gross Savings | 6,739                       | 5.78                                  | 4.37                                  |
| Gross Realization Rate | 76%                         | 77%                                   | 65%                                   |

*Source: Navigant analysis*

Gross realization rates for most measures were near 100 percent, with the exceptions of attic insulation (76 percent) and the HVAC audit (47 percent). These two measures drove the program-level result (76 percent), since they accounted for about half of the reported savings. The program saw a drastic increase of participation from the multi-family housing segment during 2012, which contributed to the decrease in per-site savings from the HVAC audit and attic insulation measures. Participation in the HVAC audit measure increased more than tenfold, from 735 rebates in PY 2011 to more than 8,000 rebates in PY 2012. These issues are discussed in detail in Section 3 of this report. Gross realization rates by measure are shown in Figure 2. It is important to note that the underlying unit savings values used to calculate measure-level savings for PY 2012 are consistent with the same energy simulation models used for PY 2009. Realization rates are affected by field verification rates and by the annual trends in measure characteristics, baseline efficiencies, regional distributions, each of which contributes to the unique deemed savings value assigned to each rebated measure.

**Figure 2. 2012 Gross Realization Rates by Measure**



Source: Navigant analysis

### ES.3.2 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 23 percent of program savings and spillover to be 7 percent of program savings. The resulting NTG ratio is 0.84, which implies that, for every 100 kilowatt-hours (kWh) of realized savings, 84 kWh can be attributed to the program.<sup>5</sup>

Table 2 shows the verified net impacts.

<sup>5</sup> Totals subject to rounding.

**Table 2. 2012 Verified Net Impacts**

|                        | Annual Energy Savings (MWh) | Summer Coincident Demand Savings (MW) | Winter Coincident Demand Savings (MW) |
|------------------------|-----------------------------|---------------------------------------|---------------------------------------|
| Verified Gross Savings | 6,739                       | 5.78                                  | 4.37                                  |
| NTG Ratio              | 0.84                        |                                       |                                       |
| Verified Net Savings   | 5,646                       | 4.84                                  | 3.66                                  |

Source: Navigant analysis

#### **ES.4 Process Findings**

Process analysis findings are based on results of the 250 HEIP participant surveys, ten multi-family property manager surveys (representing about 1,500 HVAC audit customer rebates and 500 attic insulation customer rebates), five trade ally interviews, discussions with program staff, and high-level review of program documents and functionality.

Key findings are as follows:

- » The relations among DEP, Honeywell (the implementation contractor), and HEIP prequalified contractors (or trade allies) are strong. Training and guidance provided by DEP and Honeywell to contractors appears to result in high-quality work and effective implementation.
- » About two-thirds of program participants in single family housing learned about HEIP directly from contact or marketing from trade allies, which demonstrates the success of DEP and Honeywell's partnerships with these trade allies. Six out of ten multi-family property managers indicated they were approached directly by the trade ally, while four learned about the program through DEP mailings, internet research, or a banner on the freeway.
- » Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP.
- » 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":
  - Over 90 percent of participants indicated 8-10 for satisfaction with overall program experience.
  - Over 85 percent of participants indicated 8-10 for satisfaction with the contractor's quality of work.
  - Over 80 percent of participants indicated 8-10 for satisfaction with the final cost of the program measure.
- » About two-thirds of single family respondents reported a decrease in their energy bill.

## ES.5 Recommendations

HEIP continues to display strong participation and customer satisfaction. The program-level verified net energy savings for PY 2012 were similar to 2010 and 2011, but two measures were removed from the program, and two new measures were added. The increase in participation from the multi-family segment, particularly for the HVAC audit and attic insulation measures, was a driving force for the findings in PY 2012.

The evaluation team recommends several discrete actions for improving the HEIP offering, based on insights gained through discussions with program staff and trade allies, participant surveys, analysis of program records and assumptions, and 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, and 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
- » 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

## 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 the Duke Energy Progress (DEP) HEIP for Program Year 2012 (PY 2012) projects, defined as those receiving rebates during the 2012 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 on-site 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 2012 HEIP activity. Secondary objectives included the following:

- » Estimate net and gross impacts by measure
- » Provide updated deemed savings estimates for each measure<sup>6</sup>
- » Evaluate the strengths and weaknesses of current program processes and customer perceptions of the program offering 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 eight residential measures and equipment, focused on heating and air conditioning savings:

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<sup>6</sup> Deemed savings estimates are the savings assigned to each measure. Each measure is tracked in the database with a deemed value for energy, summer coincident demand, and winter demand savings.

1. Heating, ventilation, and air conditioning (HVAC) equipment replacement (central air conditioner, air source, and geothermal heat pumps)
2. HVAC level 1 tune-up (condenser coil cleaning and general maintenance)<sup>7</sup>
3. HVAC audit (same as level 1, plus correcting refrigerant charge)<sup>8</sup>
4. Duct sealing
5. Window replacement<sup>7</sup>
6. Attic insulation
7. Heat pump water heater
8. Room air conditioner

The heat pump water heater and room air conditioner measures were new to the program in 2012. 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<sup>9</sup> based on estimated (“deemed”) savings values.

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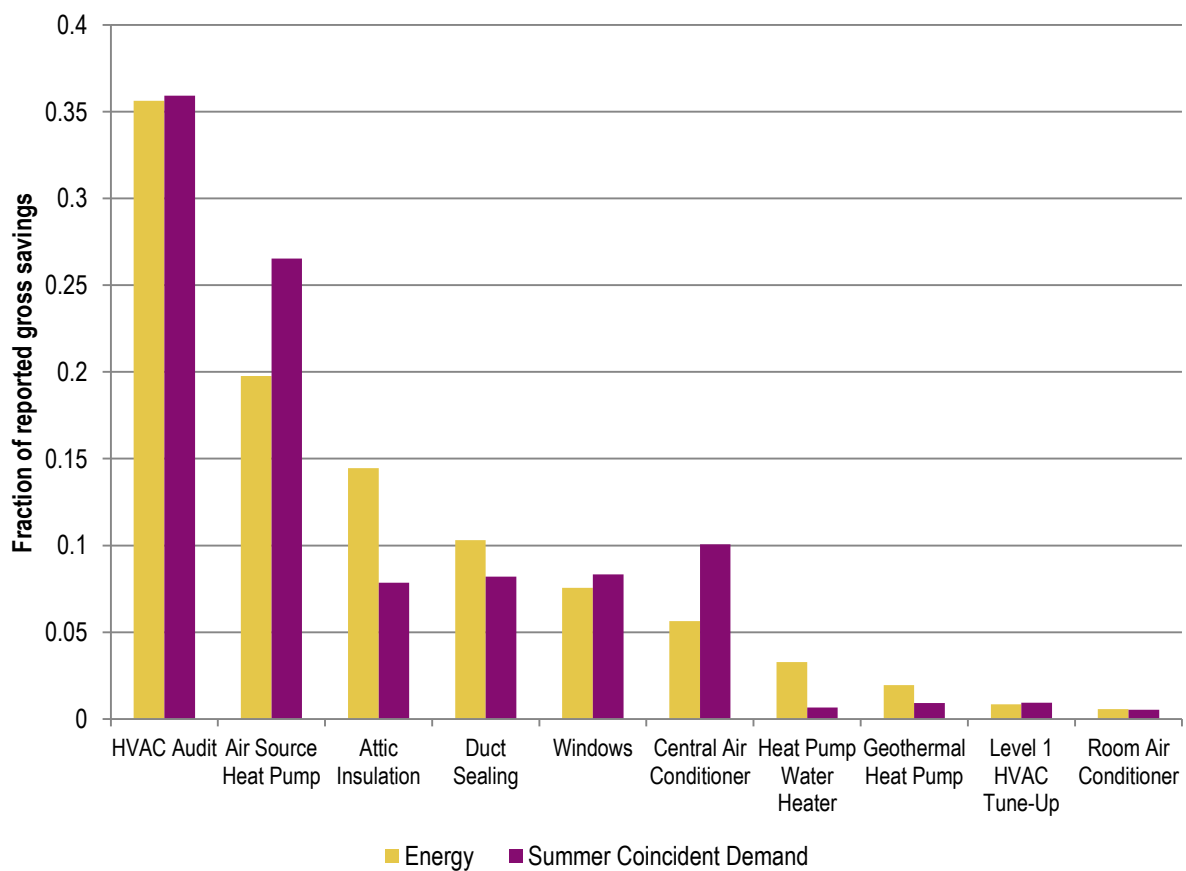
<sup>7</sup> This measure was discontinued from the program; however, some rebates were paid early in 2012, so the results are included in this report.

<sup>8</sup> For the purposes of this report, the term “HVAC audit” is synonymous with the term “level 2 HVAC 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.

<sup>9</sup> “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 territory.

Reported gross savings from PY 2012 measures were more than 8.8 gigawatt-hours (GWh) and 7.5 megawatts (MW). The HVAC audit measure was the largest contributor to reported energy and summer demand savings, accounting for over one-third of the reported savings in those categories. This finding indicates a significant change in program participation from previous years. Participation in the HVAC audit measure increased more than tenfold, from 735 rebates in PY 2011 to more than 8,000 rebates in PY 2012. The share of peak demand reductions by measure was roughly the same as it was for total energy savings. Figure 3 shows the reported energy and demand savings by measure type for PY 2012.

**Figure 3. HEIP 2012 Fraction of Reported Gross Savings by Measure**



Source: Navigant analysis of HEIP tracking database

Table 3 presents a summary of participation and gross savings reported by measure.

**Table 3. HEIP 2012 Reported Gross Annual Energy and Peak Demand Savings by Measure**

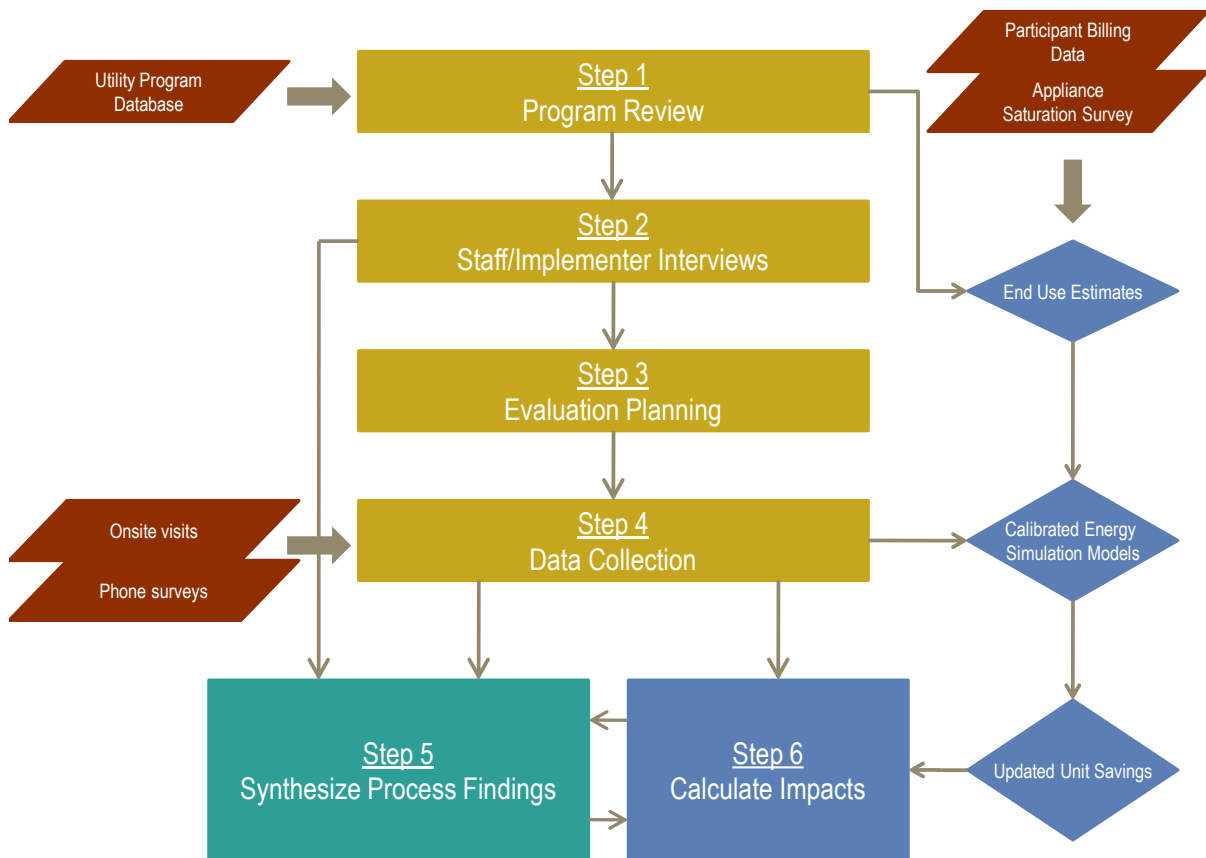
| Measure                 | Rebate Count  | Annual Energy Savings (MWh) | Fraction of Annual Energy Savings | Coincident Summer Demand Savings (kW) | Fraction of Coincident Summer Demand Savings | Coincident Winter Demand Savings (kW) | Fraction of Coincident Winter Demand Savings |
|-------------------------|---------------|-----------------------------|-----------------------------------|---------------------------------------|----------------------------------------------|---------------------------------------|----------------------------------------------|
| HVAC Audit              | 8,174         | 3,139                       | 36%                               | 2,697                                 | 36%                                          | 3,106                                 | 46%                                          |
| Air Source Heat Pump    | 4,746         | 1,742                       | 20%                               | 1,993                                 | 27%                                          | 190                                   | 3%                                           |
| Attic Insulation        | 1,908         | 1,274                       | 14%                               | 591                                   | 8%                                           | 1,276                                 | 19%                                          |
| Duct Sealing            | 3,426         | 908                         | 10%                               | 617                                   | 8%                                           | 1,473                                 | 22%                                          |
| Windows                 | 1,228         | 667                         | 8%                                | 626                                   | 8%                                           | 246                                   | 4%                                           |
| Central Air Conditioner | 1,759         | 498                         | 6%                                | 756                                   | 10%                                          | 70                                    | 1%                                           |
| Heat Pump Water Heater  | 100           | 289                         | 3%                                | 50                                    | 1%                                           | 58                                    | 1%                                           |
| Geothermal Heat Pump    | 100           | 173                         | 2%                                | 69                                    | 1%                                           | 0                                     | 0%                                           |
| Level 1 HVAC Tune-up    | 713           | 74                          | 1%                                | 71                                    | 1%                                           | 36                                    | 1%                                           |
| Room Air Conditioner    | 403           | 50                          | 1%                                | 40                                    | 1%                                           | 234                                   | 3%                                           |
| <b>Total</b>            | <b>22,557</b> | <b>8,813</b>                | <b>100%</b>                       | <b>7,511</b>                          | <b>100%</b>                                  | <b>6,689</b>                          | <b>100%</b>                                  |

Source: Navigant analysis of HEIP tracking database

## 2. Evaluation Methods

Navigant used a similar approach to evaluate PY 2012 to what was used in PY 2009-2011. The program database was the starting point for understanding the mix of measures. The team collected field data through on-site 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 4.<sup>10</sup>

**Figure 4. Evaluation Process Flow Diagram**



Source: Navigant

<sup>10</sup> The billing analysis and calibrated energy models were used to determine the deemed savings values during Navigant's 2009 EM&V analysis for HEIP.

## **2.1 Step 1: Program Review**

The evaluation followed a methodology similar to PY 2009. Program documentation was requested and reviewed, including the following:

- » E2DR Program tracking database, as provided by DEP
- » HVAC audit data from diagnostic tool
- » Site-specific attic insulation data
- » Program applications
- » Program guidance to contractors

The program review generated a picture of which measures and regions were providing the largest savings, which helped guide the subsequent evaluation research. For PY 2012, Navigant placed significant emphasis on the HVAC audit and attic insulation measures, due to the growth in participation from the multi-family housing segment and increased share of program savings.

## **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:

- » Specifics regarding trade allies' collection of HVAC audit data
- » Specifics regarding trade allies' collection of duct sealing data
- » Measures of particular interest to DEP staff

## **2.3 Step 3: Evaluation Planning**

Navigant focused on field verification of HVAC replacement, duct sealing, and attic insulation, due to their large contribution to program savings. Furthermore, Navigant conducted an in-depth analysis of the HVAC audit data recorded by trade allies, and a field study is planned for PY 2013 to assess the HVAC audit measure in more detail. Due to the expense related to field verification, a small amount of value would have been added by focusing on the smaller contributing measures, although Navigant did provide a review of savings estimates for the two new program measures (heat pump water heater and room air conditioner).

The PY 2009 evaluation team performed a comprehensive assessment of the per-unit energy and demand savings values for each measure (e.g., kilowatt-hour [kWh] savings per square foot of attic insulation in the northern region, etc.). The per-unit savings values from those efforts were applied to the mix of rebated measures in PY 2012 to estimate the updated deemed savings value for each measure. Navigant also performed review of literature and other client engagements to assess the need for other savings updates.

## **2.4 Step 4: Data Collection**

Data collection was conducted using a combination of telephone surveys and site visits. 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 4, 250 participating customers responded to the telephone survey.

**Table 4. Sample Sizes for Participant Telephone Surveys<sup>a</sup>**

| Measure Category <sup>b</sup> | Number of Respondents | Number of Rebates in 2012 <sup>c</sup> | Percent of Population Surveyed for Each Measure |
|-------------------------------|-----------------------|----------------------------------------|-------------------------------------------------|
| Heat pump/AC                  | 108                   | 6,505                                  | 1.7%                                            |
| HVAC audit                    | 27                    | 8,174                                  | 0.3%                                            |
| Duct sealing                  | 50                    | 3,426                                  | 1.5%                                            |
| Attic insulation              | 32                    | 1,908                                  | 1.7%                                            |
| Geothermal heat pump          | 5                     | 100                                    | 5.0%                                            |
| Room air conditioner          | 22                    | 403                                    | 5.5%                                            |
| Heat pump water heater        | 6                     | 100                                    | 6.0%                                            |
| <b>Total</b>                  | <b>250</b>            | <b>20,616</b>                          | <b>1.2%<sup>d</sup></b>                         |

- a. An additional ten surveys were conducted with property managers or site representatives at multi-family housing complexes to assess NTG in that market.
- b. Surveys were not conducted for window and level 1 HVAC tune-up participants because those two measures have been removed from the program.
- c. Includes rebates paid in calendar year 2012.
- d. Represents ratio of total surveyed respondents to total rebates

*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 AC installations, attic insulation, and duct sealing—measures accounting for more than 50 percent of energy savings in 2012.<sup>11</sup>

<sup>11</sup> Field verification was not conducted for room air conditioners, heat pump water heaters, or geothermal heat pumps, due to lower contribution to overall savings. Furthermore, the evaluation team did not perform field verification for the HVAC audit measure, although a field study is being conducted for PY 2013 HVAC audit participants.

The field verification sample is shown in Table 5.

**Table 5. Field Verification Sample**

| Measure Category <sup>a</sup> | # Measures | # of Rebates in 2012 |
|-------------------------------|------------|----------------------|
| Heat pump/AC                  | 23         | 6,505                |
| Attic insulation              | 20         | 1,908                |
| Duct sealing                  | 16         | 3,426                |
| <b>Total<sup>b</sup></b>      | <b>59</b>  | <b>11,839</b>        |

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 43, but many sites had multiple measures. Participants include all those receiving rebates in calendar years 2012.

*Source: Navigant analysis*

## 2.5 Step 5: Impact Analysis

The impact analysis consisted of three parts: 1) determining field verification rates from on-site visits, 2) updating measure-level deemed savings by applying per-unit savings from 2009 energy simulation models to the 2012 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.

1. **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.
2. **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

Navigant’s PY 2009 evaluation team created building energy simulation models for each combination of measure and region and then used them to generate estimates for unit energy savings and unit peak

demand reductions.<sup>12</sup> A detailed description of this process can be found in Navigant’s 2009 EM&V report for HEIP.<sup>13</sup> Navigant updated the deemed savings values for each measure in PY 2012 by applying the 2009 simulation outputs to the 2012 tracking databases on a project-by-project basis and subsequently applying the field verification rates.

### 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.

<sup>12</sup> “Unit energy savings” refers to the assumed savings at a single family home for the unit basis of each measure (e.g., per ton of central air conditioning system, per square foot of attic insulation).

<sup>13</sup> 2009 EM&V Report for the Home Energy Improvement Program, Final Report, prepared by Navigant Consulting, Inc., April 11, 2011.

### 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. As discussed in Section 2.5, the EM&V team verified the accuracy of these reported savings values for each measure category using on-site data collection to conduct field verification of measure installations and program participant characteristics.<sup>14</sup> 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.<sup>15</sup> Table 6 compares the verified gross savings to the reported savings for PY 2012. The relationship between these two values is the "gross realization rate," shown here to be 76 percent for energy savings and 77 percent for summer peak demand reductions.

**Table 6. PY 2012 Annual Energy and Demand Reductions**

|                        | Annual Energy Savings (MWh) | Summer Coincident Demand Savings (MW) | Winter Coincident Demand Savings (MW) |
|------------------------|-----------------------------|---------------------------------------|---------------------------------------|
| Reported Gross Savings | 8,813                       | 7.51                                  | 6.69                                  |
| Verified Gross Savings | 6,739                       | 5.78                                  | 4.37                                  |
| Gross Realization Rate | <b>76%</b>                  | <b>77%</b>                            | <b>65%</b>                            |

*Source: Navigant analysis*

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

1. **Field verification rate:** field verification rate is the ratio of savings from measures verified on-site to those reported in the program database
2. **Updated deemed savings values:** these are the estimated savings for each measure determined by annual measure mix in 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 gross realization rate is the ratio of verified gross savings to reported savings

<sup>14</sup> The PY 2009 evaluation team used billing data, appliance saturation data, and energy simulation modeling to assess the most appropriate unit savings values.

<sup>15</sup> 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 chapter.

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

1. **Quantity** reflects comparison in quantity and size between the program database and actual, on-site 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).
2. **Measure characteristic** reflects 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 43 field verification site visits for HEIP participants who received rebates through the program in 2012. The 43 site visits included verification of 59 measures, as some 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 and central air conditioners (combined into one category for sampling purposes), attic insulation, and duct sealing.<sup>16</sup> Table 7 shows the quantities of field verification measures assessed.

**Table 7. Evaluated Measures for 2012**

|                  | Evaluated Measures (PY 2012) |
|------------------|------------------------------|
| Heat pump/AC     | 23                           |
| Attic insulation | 20                           |
| Duct sealing     | 16                           |

Source: Navigant analysis

<sup>16</sup> Navigant did not conduct field verification for several other measures, due to low contribution to overall program savings. A field study to measure the effects of the HVAC audit measure will be conducted for PY 2013 participants during the PY 2013 evaluation cycle.

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 conditioner:** Reported equipment quantities and efficiencies were all correct, leading to a field verification rate of 100 percent for both energy and demand.
- » **Duct sealing:** Navigant conducted verification visits at 13 sites for a total of 16 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. All 16 evaluated measures achieved Navigant's criteria for properly sealed ducts, translating to field verification rate of 100 percent. Verification rates were determined on a pass/fail basis. This signifies an improvement over previous years, where the field verification rate has been in the 85 percent to 90 percent range for this measure.
- » **Attic insulation:** Navigant conducted field verification of 20 attic insulation sites. The evaluation team recorded measurements of insulation square footage and R-value. In total, the measured square footage amounted to 91 percent of the reported square footage. The measured R-value amounted to 107 percent of the reported R-value, when weighted by measured square footage. To calculate the 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 94 percent for energy savings and 95 percent for summer and winter demand savings. Further details are provided in Section 3.2.3.1.
- » **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.<sup>17</sup> 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.

Field verification rates for energy and demand are shown in Table 8 below.

**Table 8. PY 2012 Field Verification Rates by Measure**

| Measure                 | Annual Energy Savings | Peak Demand Reductions <sup>a</sup> | Winter Demand Reductions <sup>b</sup> |
|-------------------------|-----------------------|-------------------------------------|---------------------------------------|
| Air source heat pump    | 100%                  | 100%                                | 100%                                  |
| Central air conditioner | 100%                  | 100%                                | 100%                                  |
| Geothermal heat pump    | 98%                   | 99%                                 | 98%                                   |
| Level 1 HVAC tune-up    | 98%                   | 99%                                 | 98%                                   |
| HVAC audit <sup>b</sup> | 47%                   | 47%                                 | 47%                                   |
| Duct sealing            | 100%                  | 100%                                | 100%                                  |

<sup>17</sup> The HVAC audit measure is an exception and is discussed in detail later in this section.

|                                    |            |            |            |
|------------------------------------|------------|------------|------------|
| Attic insulation                   | 94%        | 95%        | 95%        |
| Windows <sup>c</sup>               | 93%        | 91%        | 91%        |
| Heat pump water heater             | 98%        | 99%        | 98%        |
| Room air conditioner               | 98%        | 99%        | 98%        |
| <b>Program average<sup>d</sup></b> | <b>98%</b> | <b>99%</b> | <b>98%</b> |

- The energy and demand field verification rates can be different due to a measure's contribution to overall energy or demand savings.
- Verification rates for the HVAC audit measure were based on an analysis of the trade ally audit data.
- For windows, Navigant assigned the average field verification rates from the PY 2009-2011 field EM&V.
- "Program average" represents the weighted average field verification rate from the measures assessed during site visits for PY 2012, 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 and PY 2011 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. Weighted field verification rates for energy are shown in Table 9. 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 9. Weighted Field Verification Rates for Energy across PY 2009-2012**

| Measure Category        | PY 2009 | PY 2010 | PY 2011 | PY 2012 | Weighted |
|-------------------------|---------|---------|---------|---------|----------|
| Air source heat pump    | 99%     | 100%    | 100%    | 100%    | 100%     |
| Central air conditioner | 99%     | 100%    | 100%    | 100%    | 100%     |
| Geothermal heat pump    | 100%    | 96%     | 95%     | 98%     | 97%      |
| Level 1 HVAC tune-up    | 100%    | 96%     | 95%     | 98%     | 97%      |
| HVAC audit <sup>a</sup> | N/A     | 96%     | 95%     | 47%     | 47%      |
| Duct sealing            | 92%     | 90%     | 86%     | 100%    | 92%      |
| Attic insulation        | 110%    | 100%    | 100%    | 94%     | 97%      |
| Windows                 | 102%    | 92%     | 91%     | 93%     | 93%      |
| Heat pump water heater  | N/A     | N/A     | N/A     | 98%     | 98%      |
| Room air conditioner    | N/A     | N/A     | N/A     | 98%     | 98%      |

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

During EM&V activities for PY 2009, Navigant's evaluation team determined the most appropriate unit savings values for each measure through energy simulation modeling and consideration of relevant data on program participants and appliance saturations. The savings estimates included energy simulation results spanning a broad range of pre- and post-retrofit conditions, which were then weighted for the true participant mix across geographies, appliance types, home types, energy consumption levels, and other relevant characteristics. A summary of simulation results can be found in Appendix D, and a full description of the process used to estimate the impacts can be found in Navigant's 2009 EM&V report.<sup>18</sup>

Navigant updated the deemed energy and demand savings values for each HEIP measure by applying the energy simulation model outputs used for the PY 2009 HEIP analysis to the 2012 program tracking databases and subsequently applying field verification rates. For example, a participant who 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 2012.<sup>19</sup> Changes from one year to the next were driven 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 367 kWh per unit in 2011 to 374 kWh per unit in 2012), while other values decreased (e.g., summer demand savings for attic insulation decreased from 0.31 kW per participant in 2011 to 0.24 kW in 2012).

### 3.2.1 New Measure Savings Review

The heat pump water heater and room air conditioner were new measures for HEIP in 2012. When combined, these two measures accounted for less than 4 percent of the reported energy savings for the program. Navigant performed a review of the savings estimates for these measures.

#### 3.2.1.1 Heat Pump Water Heater

The program design assumption was 2,885 kWh energy savings per year, making it the largest deemed savings for any HEIP-rebated measure. Heat pump water heaters are gaining traction in many residential energy efficiency programs in suitable climate zones.

Navigant performed a review of savings estimates from outside sources to assess the appropriateness of the deemed savings assumptions. When selected for North Carolina, the ENERGY STAR® calculator estimates that 2,446 kWh can be saved annually over a "standard electric water heater" (assuming an

<sup>18</sup> 2009 EM&V Report for the Home Energy Improvement Program, Final Report, prepared by Navigant Consulting, Inc., April 11, 2011.

<sup>19</sup> Navigant assumed that the energy model characteristics used in the PY 2009 evaluation remained valid for 2012 participants.

average electric rate of \$0.1022/kWh).<sup>20</sup> Furthermore, the American Council for an Energy-Efficient Economy (ACEEE) estimates the annual savings to be 2,873 kWh over a “minimum efficiency” electric water heater and 1,400 kWh over a “high efficiency” electric water heater.<sup>21</sup>

At this time, Navigant does not believe it is necessary to adjust the deemed savings for the heat pump water heater, given the low contribution to HEIP savings and the similarity of savings to other accepted sources. However, in future program years and if the measure continues to grow, it may be necessary to assess that the savings estimates are based on the proper baseline since this is most likely a replace on burnout measure.

### 3.2.1.2 Room Air Conditioner

The program design assumption is 125 kWh of annual energy savings, 0.1 kW of summer demand savings, and 0.58 kW of winter demand savings for the room air conditioner (or “window air conditioner,” as it is referred to on the HEIP website). It is difficult to know which of the following possible reasons prompted HEIP participants to purchase a room air conditioner:

- » To replace an existing, lower efficiency room air conditioner
- » To be their sole source of cooling
- » To reduce the usage of their existing central cooling unit (and achieve possible energy savings)
- » To add supplemental cooling to the existing central cooling unit (possibly resulting in negative savings)

The real savings are contingent on the proper baseline assumptions. During the phone survey, 63 percent of survey respondents indicated that they definitely would have installed the same efficiency room air conditioner in the absence of the program.

At this time, Navigant does not believe it is necessary to adjust the deemed energy savings assumptions for the room air conditioner, since the measure accounted for less than 1 percent of program savings. However, Navigant does believe that the winter demand savings should be adjusted to 0.01 kW, assuming that a portion of the rebated units will actually be heat pumps and therefore result in winter demand savings. Many of the ENERGY STAR® qualified room air conditioners are reverse cycle, which means that they act as heat pumps and can be used to heat a room in the winter. Without this capability, it is unlikely the unit would be used at all during the heating season. The current estimate of 0.58 kW is almost 15 times as high as the savings assumptions for the air source heat pump measure. In future years and if the measure continues to grow, the baseline assumptions should be reassessed.

<sup>20</sup> <http://www.energystar.gov>

<sup>21</sup> <http://aceee.org/consumer/water-heating>

### 3.2.2 Measure-Specific Deemed Savings Values

The simulation results were applied to the 2012 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 2012 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 10. 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 10. Deemed Energy Savings for Each Measure in PY 2009-2012**

| Energy                            | PY 2009<br>(kWh) | PY 2010<br>(kWh) | PY 2011<br>(kWh) | PY 2012<br>(kWh) |
|-----------------------------------|------------------|------------------|------------------|------------------|
| Air source heat pump              | 371              | 366              | 367              | 373              |
| Central air conditioner           | 293              | 279              | 283              | 273              |
| Geothermal heat pump              | 1725             | 1725             | 1725             | 1725             |
| Level 1 HVAC tune-up <sup>a</sup> | 96               | 104              | 104              | 101              |
| HVAC audit                        | N/A              | 384              | 384              | 182              |
| Duct sealing                      | 244              | 265              | 265              | 242              |
| Windows <sup>a</sup>              | 516              | 572              | 543              | 517              |
| Attic insulation                  | 830              | 727              | 669              | 504              |
| Heat pump water heater            | N/A              | N/A              | N/A              | 2,885            |
| Room air conditioner              | N/A              | N/A              | N/A              | 125              |

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

### 3.2.3 Discussion of Deemed Savings Adjustments

In the previous section, several savings values were presented for PY 2012 that differ from those found during previous EM&V years. Annual variation in energy and demand savings among different measures is commonplace for most comparable energy efficiency programs. Typically, differences in the mix of installed measures are responsible for these changes. The five primary drivers affecting the change in annual deemed savings values are listed below:

1. Annual mix of rebated measure efficiencies
2. Annual mix of baseline measure efficiencies
3. Annual trends in geographic location, as defined by DEP's northern, southern, eastern, and western regions
4. Measure location (e.g., vented crawlspace vs. attic for duct sealing)
5. 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 findings for attic insulation and HVAC audit measures, which had the largest impact on program-level realization rates for PY 2012.

### 3.2.3.1 Attic Insulation

The energy savings per site for attic insulation in 2012 were 22 percent lower than they were 2011 and about 37 percent less than they were in 2009. Table 11 summarizes the annual differences in the installation trends for attic insulation.

**Table 11. Annual Trends in Attic Insulation Characteristics**

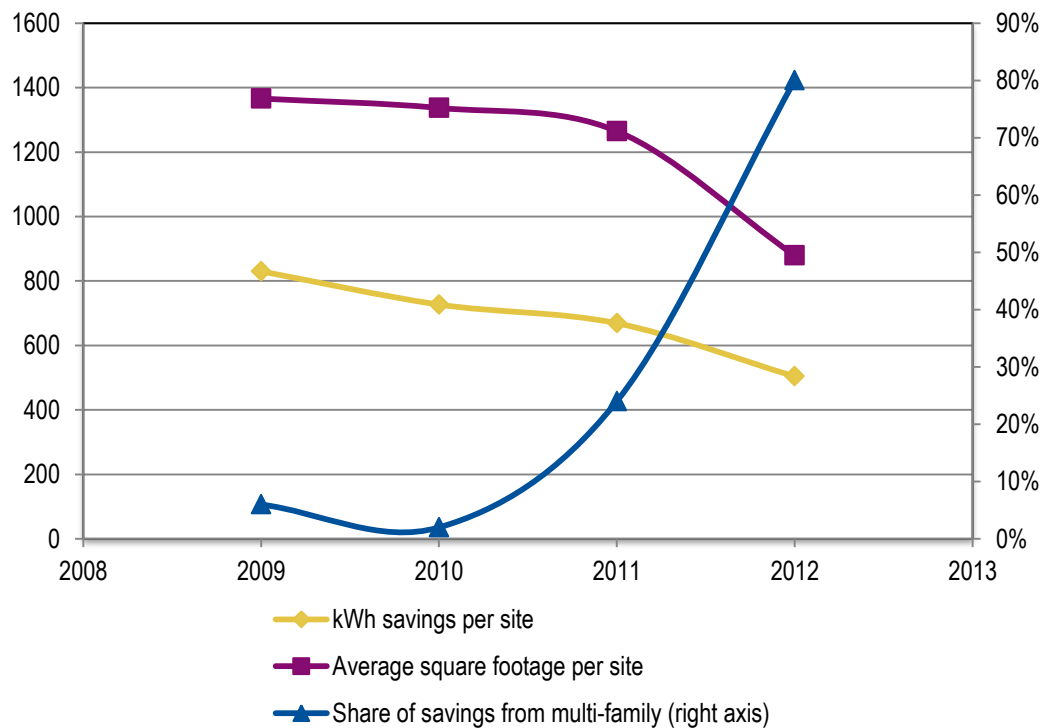
|                                           | PY 2009          | PY 2010 | PY 2011 | PY 2012 |
|-------------------------------------------|------------------|---------|---------|---------|
| kWh savings per site                      | 830 <sup>a</sup> | 727     | 669     | 504     |
| kWh savings per ft <sup>2</sup> installed | 0.61             | 0.54    | 0.53    | 0.57    |
| Average base R-value                      | 15.2             | 14.9    | 14.7    | 13.7    |
| Average rebated R-value                   | 35.2             | 36.2    | 35.0    | 33.5    |
| Average ft <sup>2</sup> installed         | 1,356            | 1,337   | 1,265   | 879     |

a. This value includes a field verification rate of 110%.

Source: Navigant analysis

The decrease in savings per participant was driven by a decrease in installed square footage due to the influx of participation in the multi-family housing segment. In 2012, nearly 80 percent of the reported savings from attic insulation occurred in the multi-family segment according to the program tracking database, up from 24 percent in 2011. Figure 5 shows a summary of attic insulation characteristics for PY 2009- 2012.

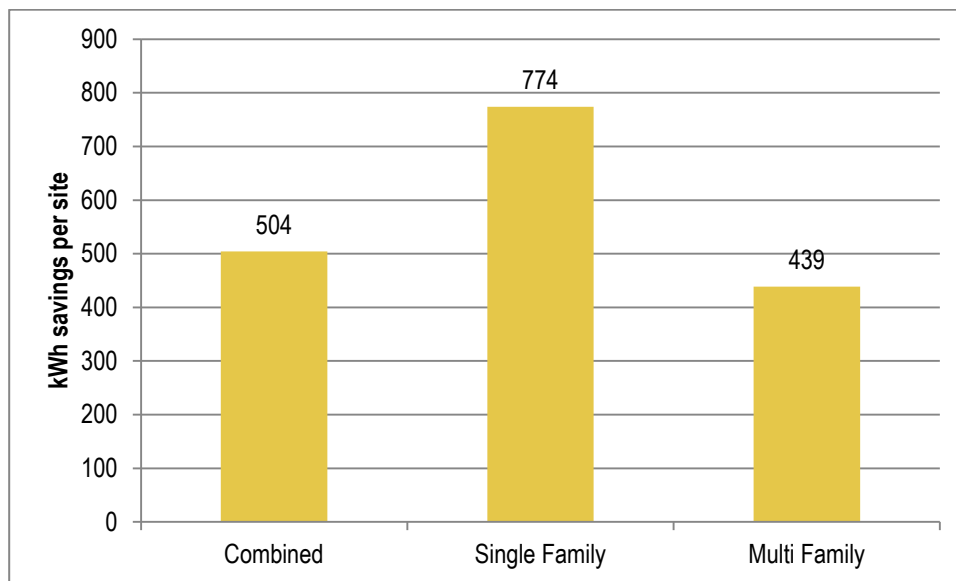
**Figure 5. Attic Insulation Characteristics for PY 2009-2012**



Source: Navigant analysis

DEP also requested that Navigant provide a summary of energy savings for multi-family vs. single family participants who installed attic insulation. Figure 6 shows the comparison of per-site energy savings across different housing segments, using PY 2012 data and field verification rates. These values are repeated along with the corresponding demand savings estimates in Table 12. If DEP decides to track deemed savings by housing segment, these values can be used going forward in the tracking database.

**Figure 6. Deemed Savings for Different Housing Segments**



Source: Navigant analysis

**Table 12. Deemed Savings for Attic Insulation by Housing Segment**

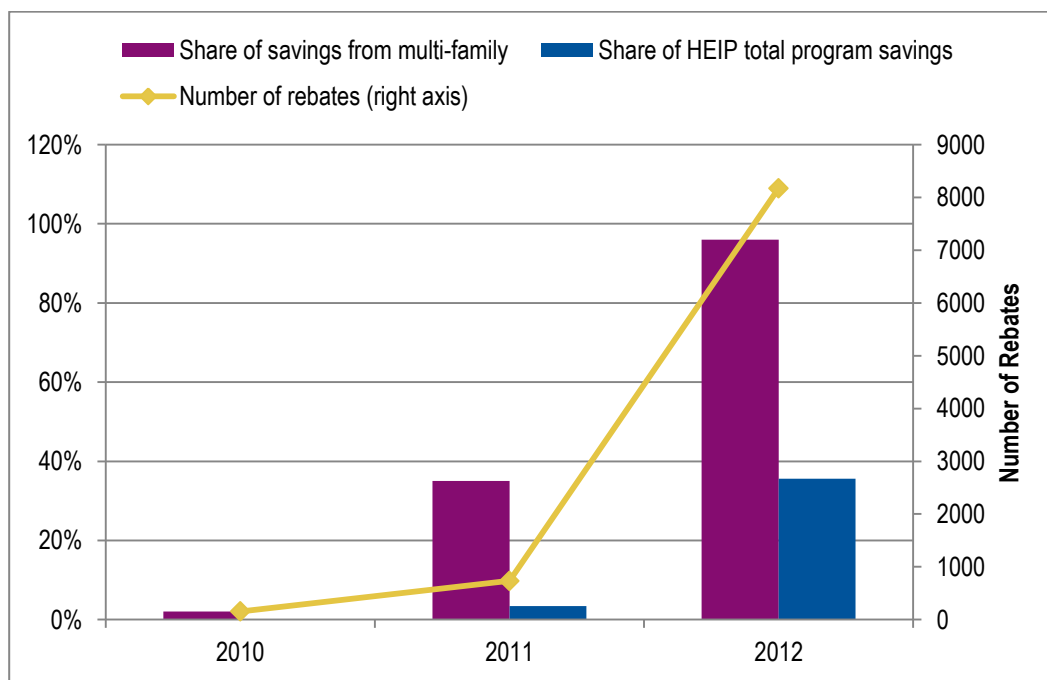
|                    | Combined | Single Family | Multi-Family |
|--------------------|----------|---------------|--------------|
| Energy (kWh)       | 504      | 774           | 439          |
| Summer demand (kW) | 0.24     | 0.36          | 0.20         |
| Winter demand (kW) | 0.52     | 0.78          | 0.45         |

Source: Navigant analysis

### 3.2.3.2 HVAC Audit

Participation in the HVAC audit (or level 2 HVAC tune-up) measure increased dramatically in PY 2012. Figure 7 and Table 13 show a summary of participation and program impacts for PY 2010-2012. 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.

**Figure 7. HVAC Audit Participation Trends**



Source: Navigant analysis

**Table 13. HVAC Audit Participation**

|                                          | PY 2010 | PY 2011 | PY 2012 |
|------------------------------------------|---------|---------|---------|
| Number of rebates                        | 155     | 735     | 8,174   |
| Multi-family share of HVAC audit savings | 2%      | 35%     | 96%     |
| Share of total HEIP savings              | 0.4%    | 3.4%    | 35.6%   |

Source: Navigant analysis

Due to the drastic increase in HVAC participation 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.<sup>22</sup> 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.

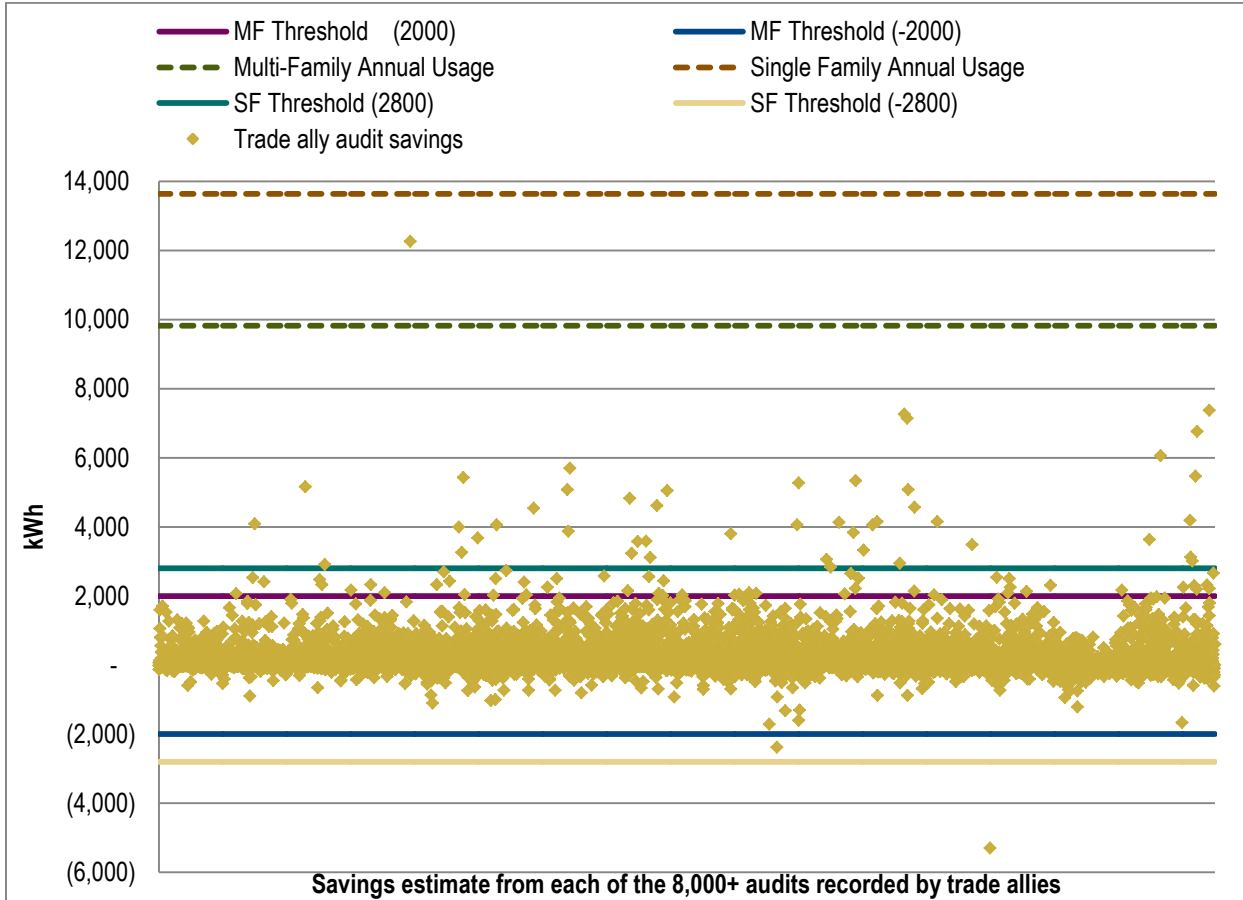
Upon reviewing the data, Navigant discovered that the average savings across all 2012 participants, as calculated by the diagnostic tool, was 216 kWh. The data also showed that about 45 percent of the HVAC units had an efficiency index greater than 90 percent before any tune-up was performed, indicating that the units were already in reasonable working order. Additionally, the review showed that there are many outliers in the data that do not represent realistic savings values. For example, a number of data points suggested annual energy savings in excess of 4,000 kWh for an HVAC tune-up, which far exceeds values that Navigant has seen in the literature and makes up about one-third of the total annual energy use for a typical residential customer. Furthermore, about 18 percent of all of the HVAC units had an efficiency index greater than 100 percent before any tune-up was performed, indicating that some default or pre-programmed parameters of the diagnostic tool were not appropriate for the units being audited. For these reasons, Navigant recommends using a conservative approach of removing outliers that do not represent a realistic savings value. In the evaluation team’s experience, HVAC usage makes up about 40 percent of total annual residential electricity usage. The evaluation team recommends removing outliers that exceed plus or minus 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 182 kWh per participant.

Figure 8 shows a summary of the HVAC audit analysis. The diamond markings indicate annual energy savings estimates for more than 8,000 HVAC audits. The solid lines indicate which data points fall within plus or minus 20 percent of the total annual electricity consumption for a typical customer. The dashed lines indicate average multi-family and single-family annual energy use obtained from billing data for Progress Energy Neighborhood Energy Saver (NES) participants.<sup>23</sup> The goal of this plot is to illustrate that many of the energy savings estimates calculated by the diagnostic tool are not realistic when compared to typical annual residential energy use.

<sup>22</sup> Navigant is also conducting a field study of 2013 HVAC audit participants and anticipates results in the PY 2013 EM&V report.

<sup>23</sup> Although NES participant characteristics may differ from those of HEIP participants, the billing data provides a reasonable picture of typical energy use. In Navigant’s experience, these values are consistent with typical residential energy use.

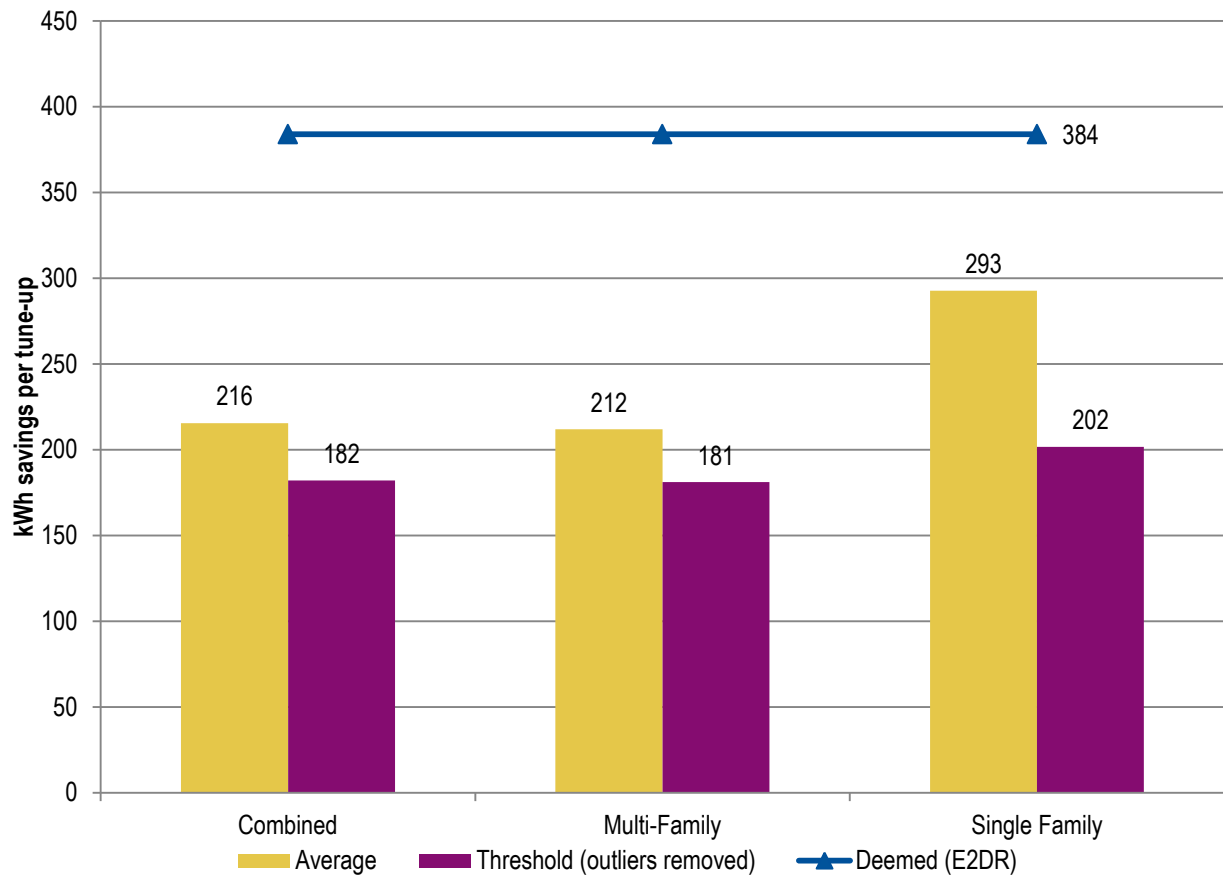
Figure 8. HVAC Audit Data from Trade Allies



Source: Navigant analysis

Figure 9 shows the segmented results of the audit data analysis. The colored bars show the average savings with and without the outliers removed for the single family, multi-family, and combined segments. The previous deemed savings of 384 kWh/audit is also shown for comparison. Going forward, Navigant recommends using savings values with outliers removed as the deemed savings for the HVAC audit measure.

**Figure 9. Segmented Savings for HVAC Audit**



Source: Navigant analysis

There are two reasons for the savings adjustments. First, multi-family participation was high. Furthermore, almost half of the audited units had an efficiency index<sup>24</sup> greater than 90 percent before any tune-up activities were performed, indicating that they were already in reasonable working order and the potential for savings from a tune-up was minimal. Table 14 shows a summary of operating conditions by housing segment before the tune-ups were conducted. Navigant understands that DEP has implemented a program change to require the efficiency index to be below the 90 percent threshold before the tune-up to be eligible for a rebate.

**Table 14. Efficiency Index Summary**

|               | Efficiency index $\geq$ 90%<br>(before tune-up) | Efficiency index $<$ 90%<br>(before tune-up) |
|---------------|-------------------------------------------------|----------------------------------------------|
| Multi-family  | 3,723                                           | 4,601                                        |
| Single family | 248                                             | 169                                          |

*Source: Navigant analysis*

<sup>24</sup> The efficiency index is a term specific to the diagnostic tool used by trade allies during the HVAC audits. The term is a measure of an HVAC unit's operating efficiency relative to the typical or achievable operating efficiency of the same make and model of unit.

### 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 47 percent for the HVAC audit measure to as high as 102 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 field verification rate for attic insulation and the data analysis for the HVAC audit measure. Verified gross savings per measure are shown in Table 15.

**Table 15. Verified Gross Energy Savings Summary by Measure**

| Measure Category        | Number of Rebates | Deemed Savings per Rebate (kWh) | Field Verification Rate | Verified Gross Savings (MWh) <sup>a</sup> | Reported Gross Savings (MWh) <sup>a</sup> | Gross Realization Rate <sup>a</sup> |
|-------------------------|-------------------|---------------------------------|-------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------|
| Air source heat pump    | 4,746             | 374                             | 100%                    | 1,771                                     | 1,742                                     | 102%                                |
| Central air conditioner | 1,759             | 273                             | 100%                    | 480                                       | 498                                       | 96%                                 |
| Geothermal heat pump    | 100               | 1,725                           | 97%                     | 167                                       | 173                                       | 97%                                 |
| Level 1 HVAC tune-up    | 713               | 104                             | 97%                     | 72                                        | 74                                        | 97%                                 |
| HVAC audit              | 8,174             | 182                             | 100% <sup>b</sup>       | 1,489                                     | 3,139                                     | 47%                                 |
| Duct sealing            | 3,426             | 262                             | 92%                     | 830                                       | 908                                       | 91%                                 |
| Attic insulation        | 1,908             | 557                             | 97%                     | 963                                       | 1,274                                     | 76%                                 |
| Windows                 | 1,228             | 519                             | 93%                     | 635                                       | 667                                       | 95%                                 |
| Heat pump water heater  | 100               | 2,885                           | 98%                     | 284                                       | 289                                       | 98%                                 |
| Room air conditioner    | 403               | 125                             | 98%                     | 50                                        | 50                                        | 98%                                 |
| <b>Total</b>            | <b>22,557</b>     |                                 |                         | <b>6,739</b>                              | <b>8,813</b>                              | <b>76%</b>                          |

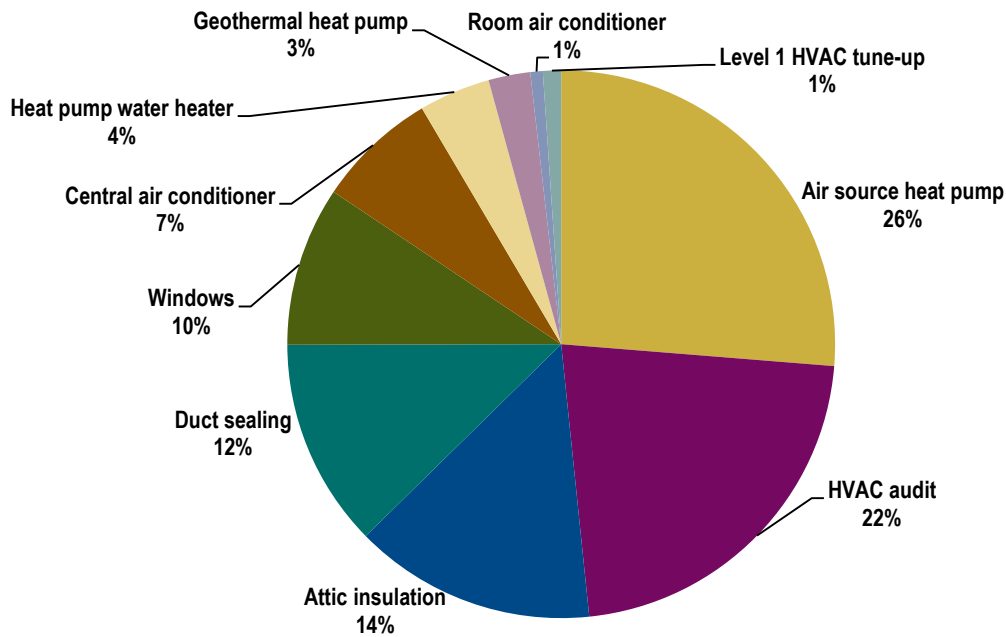
a. Totals subject to rounding.

b. A field verification rate of 100% is shown for the HVAC audit measure to account for the fact that adjustments have already been made to arrive at the updated deemed savings estimate of 152 kWh.

Source: Navigant analysis

Figure 10 shows each measure's contribution to overall verified gross energy savings for PY 2012. As in previous years, the air source heat pump measure contributed the greatest portion verified energy savings. The HVAC audit measure contributed about 22 percent of verified gross energy savings, which is a significant increase over the 3 percent contribution from PY 2011.

**Figure 10. Measure-level Contribution to Verified Gross Energy Savings for PY 2012**



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 2012 as was used for PY 2010 and PY 2011, so the results should be directly comparable. However, for the HVAC audit and attic insulation measures, Navigant used a modified approach to incorporate input from property managers at multi-family housing sites, which is where the majority of those two measures were installed. Results of the multi-family surveys were weighted by

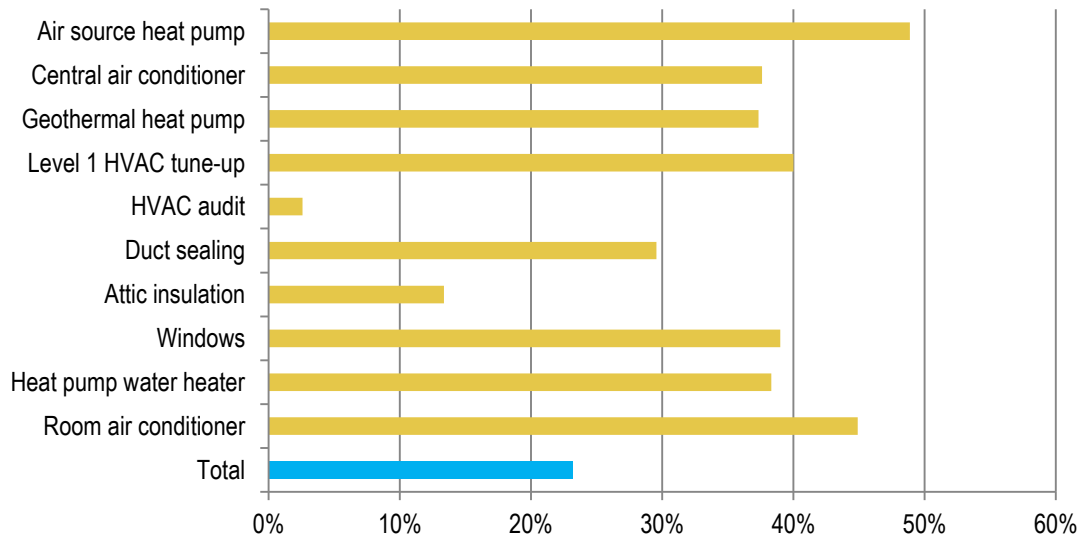
reported savings with results of the single family participant surveys to estimate free ridership and spillover for the attic insulation and HVAC audit measures.

#### 3.4.1 Free Ridership

The participant survey asked a series of questions regarding the likelihood, scope, and timing of the investments in energy efficiency if the respondent had not participated in the program. The purpose of the surveys was to elicit explicit estimates of free ridership and perspectives on the influence of the program. Findings from this effort are presented in Figure 11 as a free ridership estimate for each measure category. Free ridership for HEIP (i.e., across all measures) is estimated at 23 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 30 percent for duct sealing to a high of 49 percent for air source heat pump replacement. The free ridership values for HVAC audit and attic insulation were 3 percent and 13 percent, respectively. For these two 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.

When considering only participants in the single family housing segment, the program-level free ridership was 41 percent for PY 2012. During Navigant's EM&V efforts for PY 2010 and PY 2011, survey participants also indicated a 41 percent free ridership level. Therefore, the free ridership among single family housing participants has remained about the same. The lower program-level free ridership of 23 percent in PY 2012 was largely driven by the increase in multi-family participation whereby trade allies sought out multi-family customers and were able to offer the services for low or no cost.

**Figure 11. Free Ridership by Measure Category**



- Windows and level 1 HVAC tune-ups were not assessed during the PY 2012 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.
- The heat pump water heater measure was assigned the average free ridership from all other measures, due to low survey response rates.

*Source: Navigant analysis*

### 3.4.2 Spillover

About 26 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 increase over the 23 percent from PY 2010 and PY 2011.<sup>25</sup> More than half 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).

For the multi-family housing sector, only two of the ten property managers indicated taking spillover actions. Both of these had received rebates for attic insulation. One indicated having installed energy efficient doors to improve tenant comfort and reduce air leakage, and the other installed energy efficient windows. The resulting spillover was 2.3 percent for the multi-family attic insulation and zero for multi-family HVAC audits.

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

<sup>25</sup> The survey assessed additional installed equipment only and did not assess behavioral changes

### 3.4.3 Net-to-Gross Ratio

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

$$NTG = 1 - \text{free ridership} + \text{total spillover}$$

Using the overall free ridership value of 23 percent and the overall spillover value of 7 percent, the NTG ratio is  $1 - 0.23 + 0.07 = 0.84$ .<sup>26</sup> The estimated NTG ratio of 0.84 implies that, for every 100 kWh of realized savings recorded in HEIP records, 84 kWh can be attributed to the program. This is an increase over the 0.68 NTG from PY 2010 and PY 2011, although it is largely due to the low free ridership at multi-family complexes that received attic insulation or HVAC audits.

Table 16 displays the free ridership scores by measure category and the free ridership, spillover, and NTG scores for the program as a whole.

**Table 16. NTG for HEIP**

| Measure Category        | Free Ridership | Spillover | NTG Ratio  |
|-------------------------|----------------|-----------|------------|
| Air source heat pump    | 49%            | 7%        | 58%        |
| Central air conditioner | 38%            |           | 69%        |
| Geothermal heat pump    | 37%            |           | 70%        |
| Level 1 HVAC tune-up    | 40%            |           | 67%        |
| HVAC audit              | 3%             |           | 104%       |
| Duct sealing            | 30%            |           | 77%        |
| Attic insulation        | 13%            |           | 94%        |
| Windows                 | 39%            |           | 68%        |
| Heat pump water heater  | 38%            |           | 69%        |
| Room air conditioner    | 45%            |           | 62%        |
| <b>Total</b>            | <b>23%</b>     |           | <b>84%</b> |

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 and level 1 HVAC tune-ups because they were removed from the program in 2012.

c. The heat pump water heater measure was assigned the average savings from other measures due to low response rates.

d. Values subject to rounding.

Source: Navigant analysis

<sup>26</sup> Total subject to rounding

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 17. It should be noted that the program-level or total NTG shown in Table 16 and Table 17 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 ( $6,739 \times 0.838 = 5,646$ ), rather than by summing the measure-level net savings. For this reason, the total verified net savings shown in Table 17 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 17. Verified Net Energy Impacts for PY 2012**

| Measure Category                                                                                    | Verified Gross Energy Savings (MWh) | NTG Ratio   | Verified Net Energy Savings (MWh) |
|-----------------------------------------------------------------------------------------------------|-------------------------------------|-------------|-----------------------------------|
| Air source heat pump                                                                                | 1,771                               | 0.58        | 1,029                             |
| Central air conditioner                                                                             | 480                                 | 0.69        | 333                               |
| Geothermal heat pump                                                                                | 167                                 | 0.70        | 116                               |
| Level 1 HVAC tune-up                                                                                | 72                                  | 0.67        | 48                                |
| HVAC audit                                                                                          | 1,489                               | 1.04        | 1,554                             |
| Duct sealing                                                                                        | 830                                 | 0.77        | 643                               |
| Attic insulation                                                                                    | 963                                 | 0.94        | 901                               |
| Windows                                                                                             | 635                                 | 0.68        | 432                               |
| Heat pump water heater                                                                              | 284                                 | 0.69        | 195                               |
| Room air conditioner                                                                                | 50                                  | 0.62        | 31                                |
| <b>Total<sup>a</sup></b>                                                                            | <b>6,739</b>                        | <b>0.84</b> | <b>5,646</b>                      |
| a. Totals indicated the weighted average by each measure's contribution to reported program savings |                                     |             |                                   |

Source: Navigant analysis

Table 18 shows a comparison of reported and verified net impacts for both program years.

**Table 18. Reported and Verified Net Energy Savings<sup>27</sup>**

| Measure Category                                   | PY 2012 |
|----------------------------------------------------|---------|
| Reported NTG Ratio                                 | 0.70    |
| Reported Net Energy Savings (MWh)                  | 6,184   |
| Reported Net Summer Coincident Demand Savings (MW) | 5.20    |
| Verified NTG Ratio                                 | 0.84    |
| Verified Net Energy Savings (MWh)                  | 5,646   |
| Verified Net Summer Coincident Demand Savings (MW) | 4.84    |

*Source: Navigant analysis*

<sup>27</sup> Reported net savings come from the E2DR tracking data website

## 4. Process Findings

Process analysis findings are based on results of the 250 customer surveys, ten property manager surveys (representing about 2,000 rebates), five trade ally interviews, discussions with program staff, and high-level review of program documents and functionality. HEIP continues to be a well-run and successful program. Customer satisfaction and contractor satisfaction are high. Additional survey findings can be found in 5.2.3 Appendix E.

Key findings are as follows:

- » The relations among DEP, Honeywell (the implementation contractor), and HEIP prequalified contractors (or trade allies) are strong. Training and guidance provided by DEP and Honeywell to contractors appears to result in high-quality work and effective implementation.
- » About two-thirds of program participants in the single family housing learned about HEIP directly from contact or marketing from trade allies, which demonstrates the success of DEP and Honeywell's partnerships with these trade allies. Six out of ten multi-family property managers indicated they were approached directly by the trade ally, while four learned about the program through DEP mailings, internet research, or a banner on the freeway.
- » Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP.
- » 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":
  - Over 90 percent of participants indicated 8-10 for satisfaction with overall program experience.
  - Over 85 percent of participants indicated 8-10 for satisfaction with the contractor's quality of work.
  - Over 80 percent of participants indicated 8-10 for satisfaction with the final cost of the program measure.
- » About two-thirds of respondents reported a decrease in their energy bill.

### 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 *Multi-Family Segment and Trade Ally Interviews*

As previously mentioned, there was a significant increase in HEIP participation from the multi-family housing segment in PY 2012. The evaluation team conducted surveys with property managers or site representatives at ten multi-family complexes, along with interviews of five trade allies to assess this trend. The ten property managers represented the decision-making process for about 1,500 HVAC audit rebates and about 500 attic insulation rebates. The five trade allies that were interviewed were responsible for about 99 percent of the HVAC audits and about 97 percent of the attic insulation rebates in PY 2012.

The multi-family housing segment is often underserved by utility energy efficiency rebate programs because they are primarily occupied by (relatively short-term) renters who won't reap the long term savings, and the property owners typically don't pay for electricity consumption. Therefore, neither the tenant nor owner is likely to invest in equipment or maintenance for the purpose of saving energy.

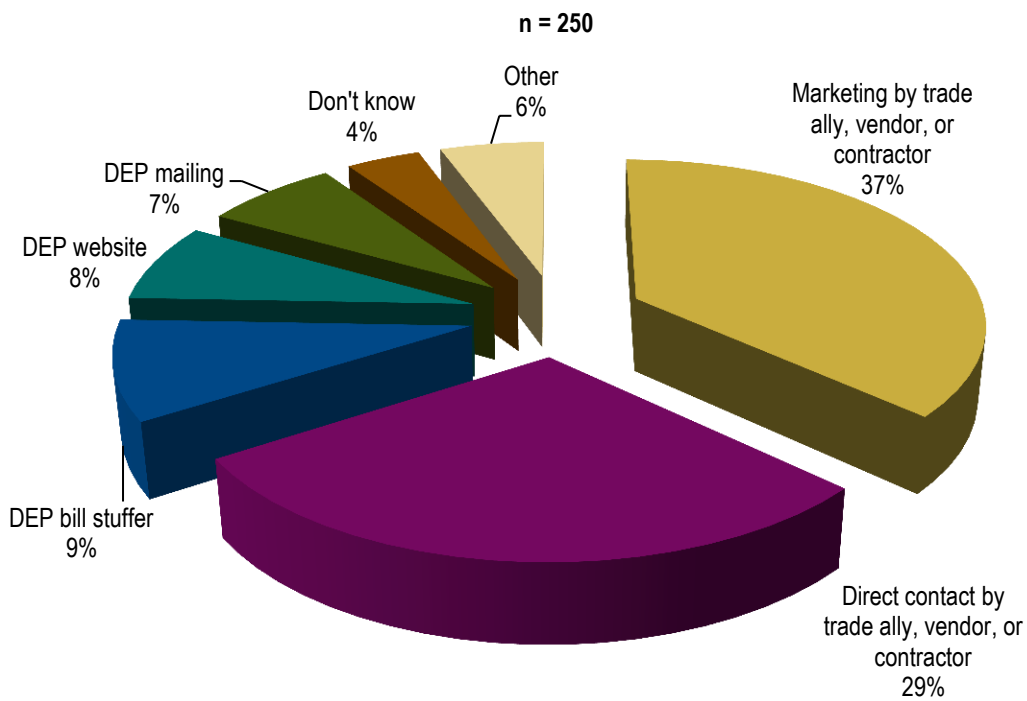
In this case, it appears that the HEIP Program was the driving factor in the multi-family participation. The trade allies pursued large projects at multi-family complexes and were able to offer the HVAC audits and attic insulation at little or no cost to the property managers by using the rebate as the sole form of reimbursement. This allowed them to focus on project volume.

## 4.3 *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 two-thirds indicated they had learned about HEIP through a contractor (nearly 37 percent through contractor marketing and about 29 percent through direct contact from a vender or contractor). Figure 12 shows the range of ways in which customers found out about the program.

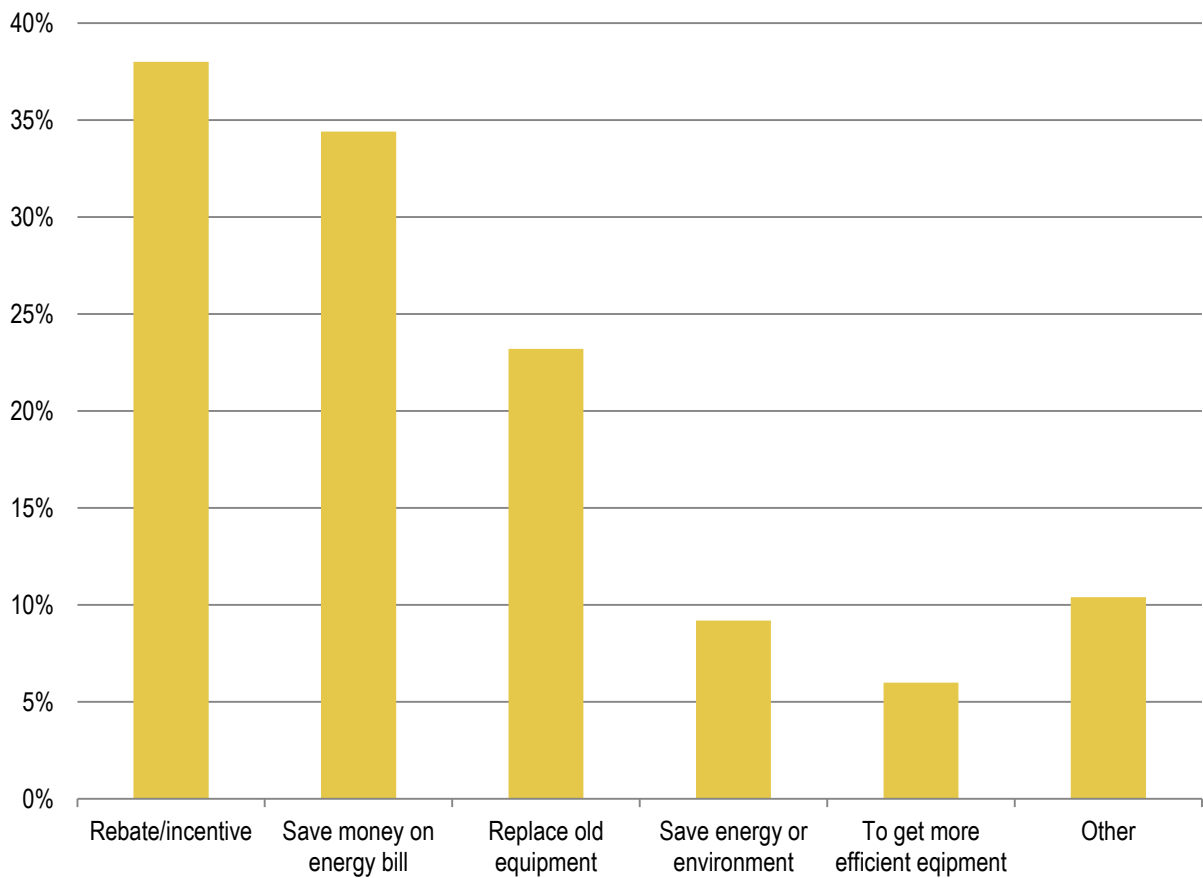
**Figure 12. Where Program Participants First Learned About HEIP**



Source: Navigant analysis

When asked why they chose to participate in the program, more than 35 percent of survey respondents cited the rebate as a reason (see Figure 13).

**Figure 13. Primary Reasons for Deciding to Participate in the Program<sup>a</sup>**



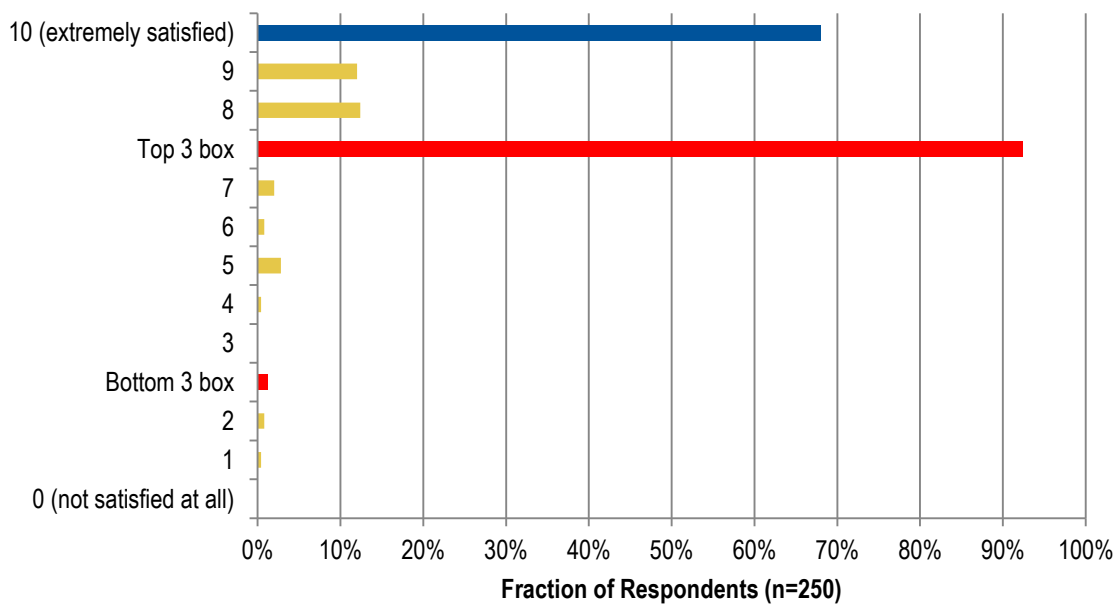
a. Totals exceed 100% because respondents were allowed to offer more than one answer.

Source: Navigant analysis

#### 4.4 Customer Experience

Customers reported very high satisfaction with their overall program experience during 2012. On a scale of 0 to 10 where 0 is “not satisfied at all” and 10 is “extremely satisfied”, 92 percent of participants ranked their overall experience with the program as an 8, 9, or 10, with 68 percent responding that their experience was a 10 (see Figure 14). These findings were similar to PY 2010 and PY 2011. Participants who ranked their overall experience low did so because they had difficulty understanding the program or received incorrect information from the contractor.

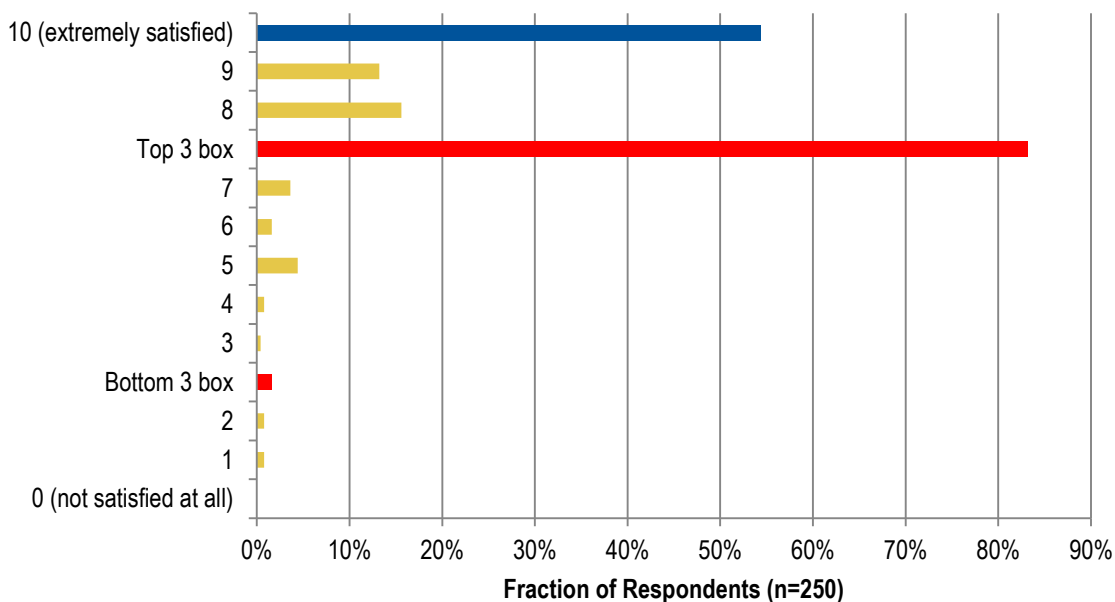
**Figure 14. Customer Satisfaction with Overall Program Experience**



Source: Navigant analysis

Customers were also satisfied with program costs. When aggregated by measure, at least 80 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 15).

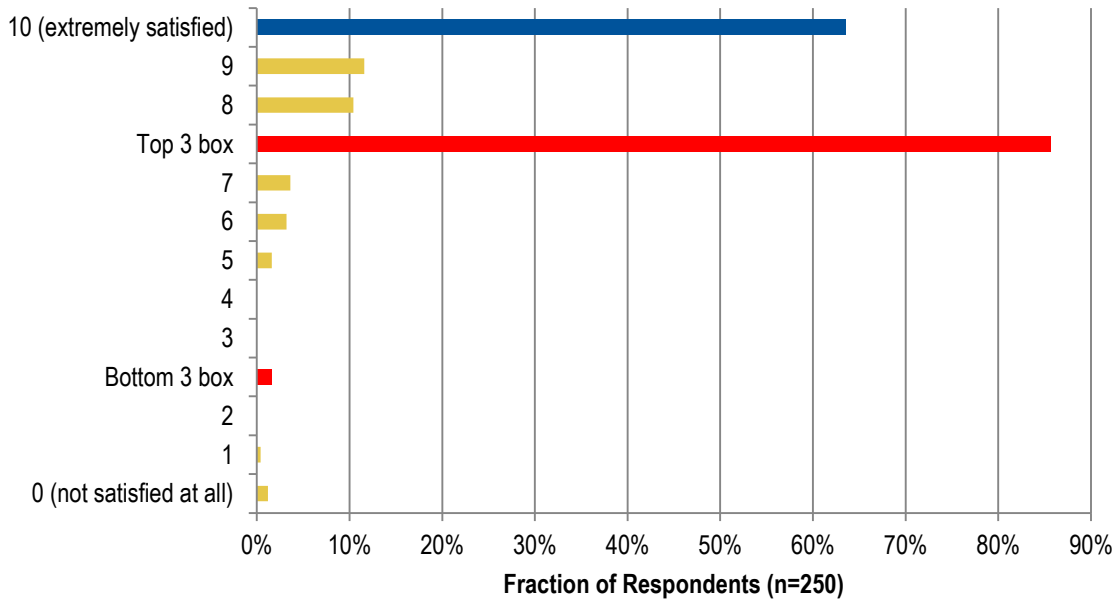
**Figure 15. Customer Satisfaction with Final Cost of Measure**



Source: Navigant analysis

Customer satisfaction with contractor quality of work is 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 16 shows that over 85 percent of survey respondents ranked their satisfaction with contractor work as an 8, 9, or 10.

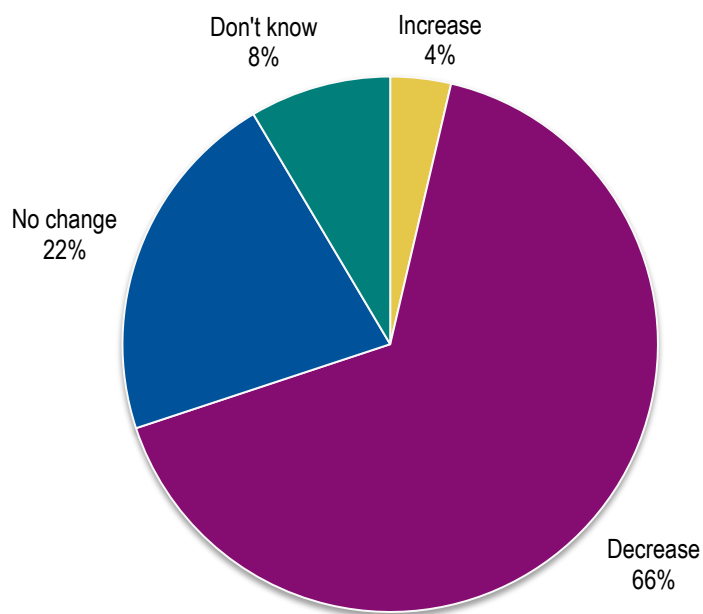
**Figure 16. Customer Satisfaction with Contractor Quality of Work**



Source: Navigant analysis

Another important survey finding was that two-thirds of participants reported noticing a decrease in their energy bill after installing the new measure (see Figure 17).

**Figure 17. 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 2012, 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 6.7 GWh in 2012. Verified gross summer coincident demand savings were approximately 5.8 MW. Navigant found free ridership to be 23 percent for HEIP. Spillover was found to be 7 percent, which resulted in a final NTG ratio of 0.84.<sup>28</sup>

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. Measure-level realization rates were primarily driven by changes in the mix of measure efficiencies, sizes, and regional distributions from the 2009 mix that were used to estimate deemed savings values. Small annual adjustments to deemed savings estimates are meant to accurately reflect program activity for each evaluated program year.

HEIP exhibited a major shift in participation toward the multi-family housing segment in 2012, particularly with the HVAC audit and attic insulation measures, which together account for about half of the reported program savings. The EM&V verified savings were largely impacted by decreased "per-site" savings associated with multi-family housing. Additionally, analysis of HVAC audit data showed savings estimates that were lower than previous assumptions. Trade allies indicated that they pursued large projects at multi-family complexes and were generally able to offer the services at no or very low cost to the property managers.

### 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 review of on-site 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

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<sup>28</sup> Total subject to rounding

Table 19 summarizes these program recommendations, and a more detailed discussion follows.

**Table 19. Summary of Recommendations**

| Program Impacts                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1. Update the tracking database to reflect measure-level deemed savings from this report.</b>                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Improving Program Cost-Effectiveness                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>2. Tighten eligibility requirements for measures not meeting savings expectations.</b>                                                                                          | <ul style="list-style-type: none"> <li>a. Require the efficiency index to be less than 90% before tune-up activities for units to qualify for the HVAC audit incentive.</li> <li>b. Consider a tiered incentive for HVAC replacement that pays a greater rebate for higher SEER units</li> </ul>                                                                                                                                                                                                                                                                                                                                                                       |
| Improving Program Delivery                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>3. Continue to offer technical training and workshops for contractors, with particular emphasis on using the diagnostic tool for HVAC audits and achieving maximum savings.</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>4. Continue to offer marketing training for contractors.</b>                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>5. Increase direct marketing through DEP.</b>                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>6. Increase participant awareness regarding receipt of rebate payment.</b>                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Enhancing Program Tracking and Evaluation Efforts                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>7. Ensure that all information from rebate application forms is included in program tracking database extracts.</b>                                                             | <ul style="list-style-type: none"> <li>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.</li> <li>b. HVAC audit: include fields in tracking database for before and after efficiency index % readings and calculated energy savings from Service Assistant, as well as unit SEER rating.</li> <li>c. Duct sealing: include fields in tracking database for location of ducts that were sealed and results of pressure testing, if applicable.</li> <li>d. Multi-family housing: include complex name and trade ally that performed the work.</li> </ul> |
| <b>8. Modify program processes to integrate data collection activities required for EM&amp;V.</b>                                                                                  | <ul style="list-style-type: none"> <li>a. Require the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) number of the new equipment combination installed for HVAC system replacements.</li> <li>b. Invite participants to complete a customer satisfaction and free ridership survey at or shortly after the time of measure installation.</li> </ul>                                                                                                                                                                                                                                                                                                     |

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). Recommendations are as follows:

1. **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 2012, 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. In future years, Navigant suggests ways improve measure-level realization rates via the following approaches:

- a. Adjust deemed savings values to reflect a weighted average of the deemed savings across all program years. This would incorporate the mix of installed measures over a greater number of program years. If the same energy simulation estimates are used, this method would not change program-level verified savings, but it would most likely lead to EM&V realization rates closer to 100 percent.<sup>29</sup>
- b. 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. Again, 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.<sup>29</sup>

## 2. Tighten eligibility requirements for measures that are not meeting average savings expectations.

If a measure is not cost-effective based on the 2012 verification results, there may be a subset of installations that are cost-effective. The energy simulation 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.<sup>30</sup> Options include the following:

- a. Require electric heating (and thus increased savings) for participation where a measure does not satisfy cost-effectiveness requirements.
- b. Consider limiting eligibility for duct sealing to systems where at least half of the ducts are located in the attic.
- c. Consider adjusting post-retrofit insulation R-values to be based on pre-retrofit R-value. For example, baseline R-values of 15-19 could require an upgrade to at least R-38 instead of R-30.
- d. Require the efficiency index to be less than 90 percent before tune-up activities are performed for units to be eligible for the HVAC audit incentive.
- e. Consider creating a tiered incentive structure for HVAC replacement that provides a larger rebate for higher SEER units.

<sup>29</sup> DEP has indicated that reported program-level savings can be retroactively adjusted after EM&V activities are complete. For this reason, it may not be necessary to adjust deemed savings each year because there will most likely be small adjustments to verified savings estimates each year.

<sup>30</sup> The evaluation team did not review cost-effectiveness calculations or perform new calculations using revised measure savings assumption. Thus, the team cannot identify specific measures for which modifying eligibility requirements might be appropriate to increase cost-effectiveness.

### 5.2.2 Recommendations for Improving Program Delivery

3. **Offer technical training and workshops for contractors**, particularly for proper use of the diagnostic tool for HVAC audits. Proper use is critical for achieving actual savings.
4. **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 clearly a success. However, additional participation may be gained by training contractors to promote simultaneous implementation of multiple measures.
5. **Increase direct marketing through DEP**. As a means to increase program participation and customer awareness, DEP could elect to increase marketing efforts. Almost 40 percent of surveyed customers cited DEP's rebate as one factor in their decision to install the program measure, and about 26 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 and PY 2011.
6. **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 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:

7. **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 from the E2DR website 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 from the E2DR website:
  - a. **All measures**: include fields in the E2DR database extract to Navigant for square footage of home, year home was built, heating type, cooling type, and trade ally.
  - b. **HVAC audit**: include fields in the E2DR 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.

- c. **Duct sealing:** include fields in the E2DR 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.
  - d. **Multi-family housing:** include the complex name and trade ally for each line item.
8. **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. Specific recommendations include the following:
- a. Require the "AHRI" number of the new equipment combination installed for HVAC system replacements.
  - b. Invite participants to complete a customer satisfaction and free ridership survey at or shortly after the time of measure installation. Perhaps even include 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 on site 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. HEIP 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:

$$NTG = 1 - \text{free ridership} + \text{spillover}$$

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*

### B.2.1 **Estimating Free Ridership**

Data to assess free ridership were gathered through the self-report method using a series of survey questions asked of 250 HEIP participants. A slightly modified version was delivered to ten 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 of 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 these three categories<sup>31</sup> and then averaged and divided by 10 to convert the scores into a free ridership percentage. Next, a timing multiplier was applied to the

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<sup>31</sup> 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.

## B.2.2 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 zero 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 4 program importance questions (see 5.2.3 Appendix 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.

### B.2.3 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.

#### B.3.1 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 somewhat representative of program participation; however, Navigant also attempted to obtain at least 20 completed surveys for each measure.<sup>32</sup> 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    | 83            |
| Central air conditioner | 25            |
| Geothermal heat pump    | 5             |
| HVAC audit              | 27            |
| Duct sealing            | 50            |
| Attic insulation        | 32            |
| Heat pump water heater  | 6             |
| Room air conditioner    | 22            |
| <b>Total</b>            | <b>250</b>    |

*Source: Navigant analysis*

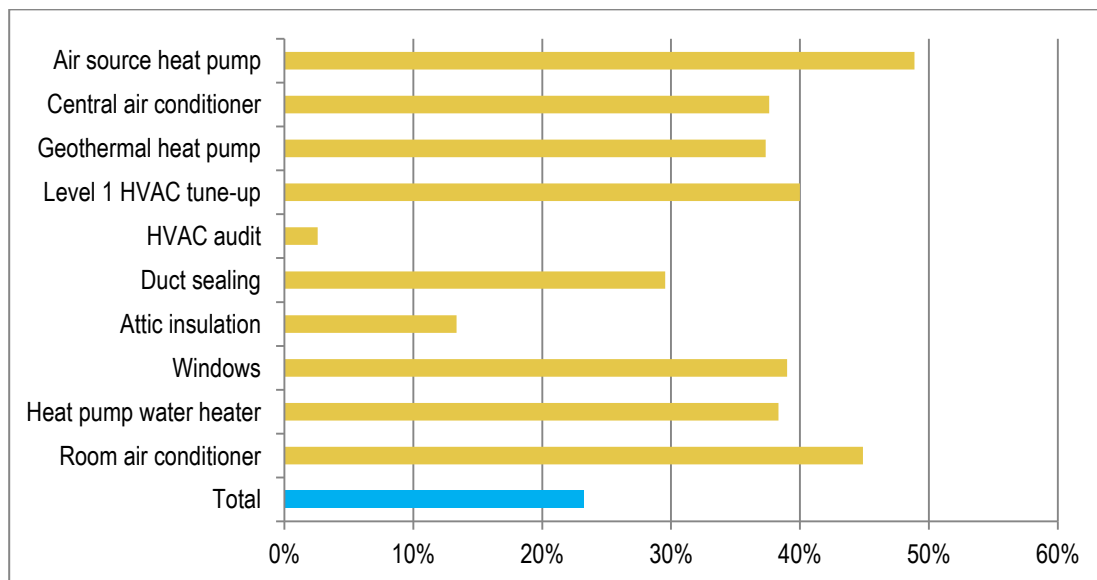
<sup>32</sup> The minimum target of 20 completed surveys was not met for the geothermal heat pump or heat pump water heater measures due to the very small overall participation numbers (100 rebates for each) and the difficulties involved in achieving a high customer response rate. Furthermore, a target sample that was exactly representative of program participation and also required a minimum of 20 completes for each of the smallest measure would have been cost-prohibitive.

### B.3.2 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 30 percent for duct sealing to a high of 49 percent for air source heat pump. Free ridership for attic insulation and HVAC audit were 13 percent and 3 percent, respectively. For these two 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.

When considering only participants in the single family housing segment, the program-level free ridership was 41 percent for PY 2012. During Navigant's EM&V efforts for PY 2010 and PY 2011, survey participants also indicated a 41 percent free ridership level. Therefore, the free ridership among single family housing participants has remained about the same. The lower program-level free ridership of 23 percent in PY 2012 was largely driven by the increase in multi-family participation whereby trade allies sought out multi-family customers and were able to offer the services for low or no cost.

**Figure B-1. Free Ridership by Measure Category (n = 250)**



- Windows and level 1 HVAC tune-ups 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 2012
- The heat pump water heater was assigned the average free ridership from the other measures, due to unreliable results

Source: Navigant analysis

Free ridership for HEIP (i.e., across all measures) was estimated at 23 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 <sup>a</sup> |
|-------------------------------------|-------------------------------|------------------------------|-----------------------------------|
| Air source heat pump                | 1,742                         | 20%                          | 49%                               |
| Central air conditioner             | 498                           | 6%                           | 38%                               |
| Geothermal heat pump                | 172                           | 2%                           | 37%                               |
| Level 1 HVAC tune-up                | 74                            | 1%                           | 40%                               |
| HVAC audit                          | 3,139                         | 36%                          | 3%                                |
| Duct sealing                        | 908                           | 10%                          | 30%                               |
| Attic insulation                    | 1,274                         | 14%                          | 13%                               |
| Windows                             | 667                           | 8%                           | 39%                               |
| Heat pump water heater <sup>b</sup> | 289                           | 3%                           | 38%                               |
| Room air conditioner                | 50                            | 1%                           | 45%                               |
| <b>Total</b>                        | <b>8,813</b>                  | <b>100%</b>                  | <b>23%</b>                        |

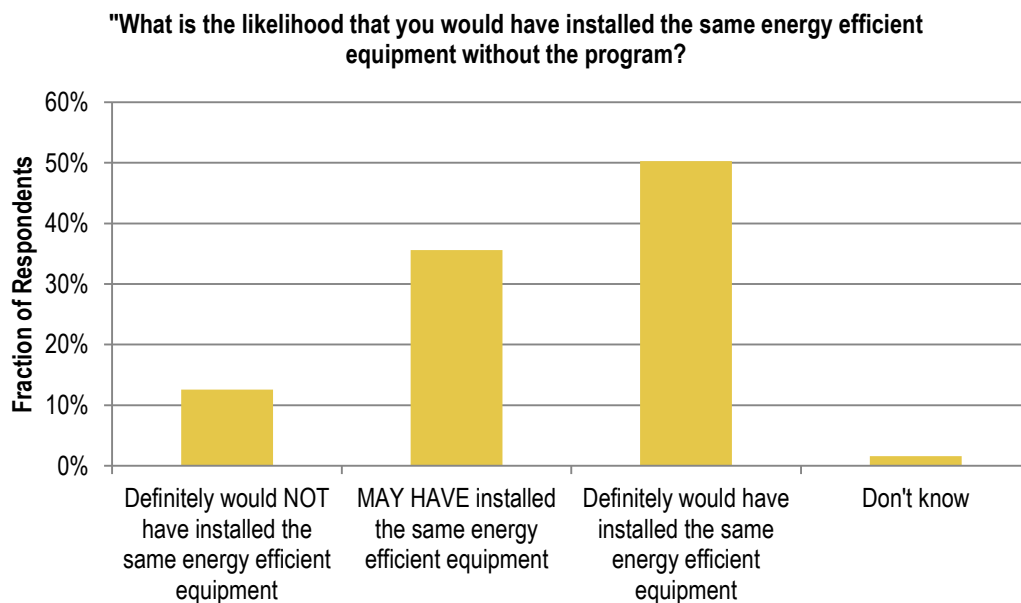
a. Total free ridership score is calculated by summing the product of each category's free rider score and their share of savings.

b. Free ridership for the heat pump water heater was take as the average of other single family measures due to low response rate during customer surveys.

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 the 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. 13 percent said they would not have installed the same equipment, while 50 percent said they would have. 36 percent said they "may have" installed the same equipment.

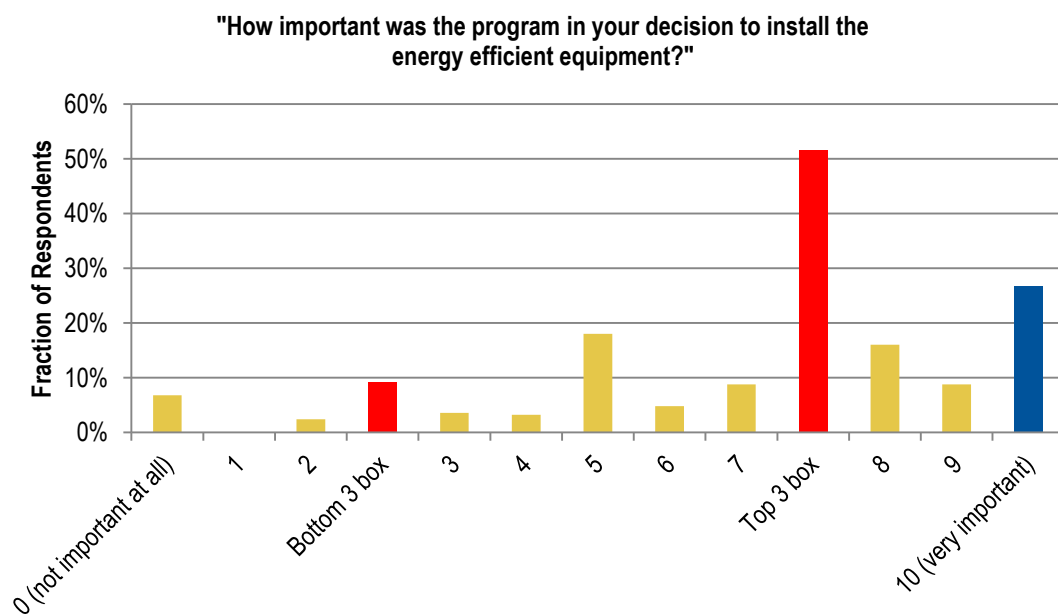
**Figure B-2. Likelihood of Installing without the Program (n = 250)**



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. 52 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). 34 percent reported a score of 5 or lower.

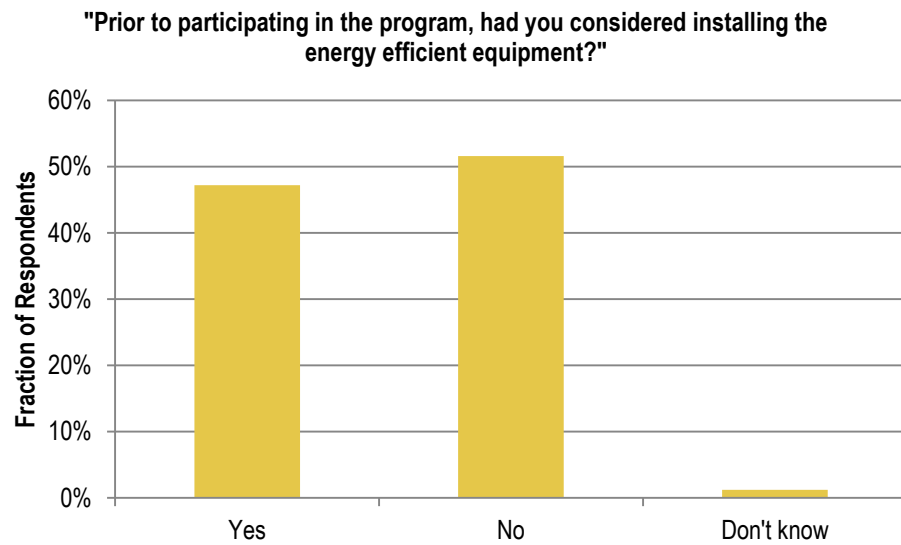
**Figure B-3. Program Importance (n = 250)**



Source: Navigant analysis

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

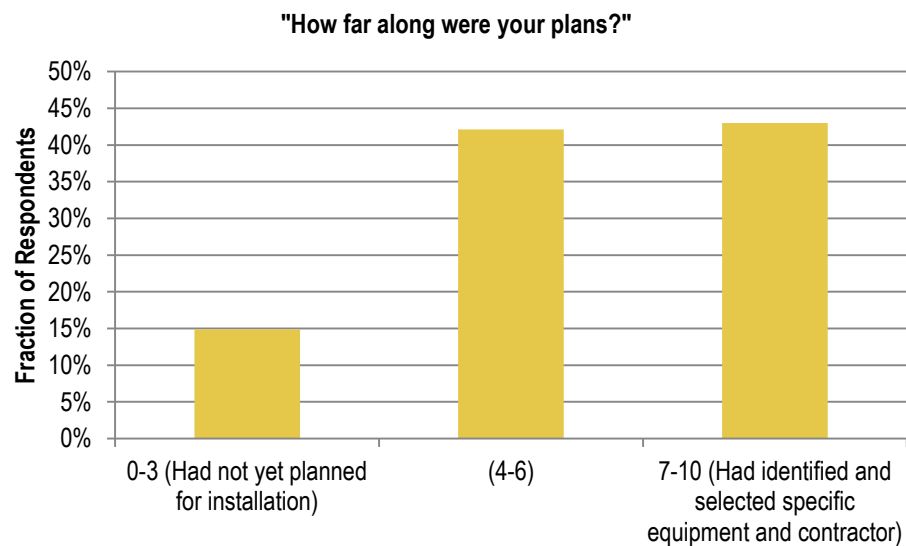
**Figure B-4. Prior Planning (n = 250)**



Source: Navigant analysis

Figure B-5 shows that 18 of the 121 customers who had planned to install energy efficient measures had little to no installation planning. 45 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. 52 customers had more detailed plans to install the equipment (43 percent of those with plans, 21 percent of all respondents).

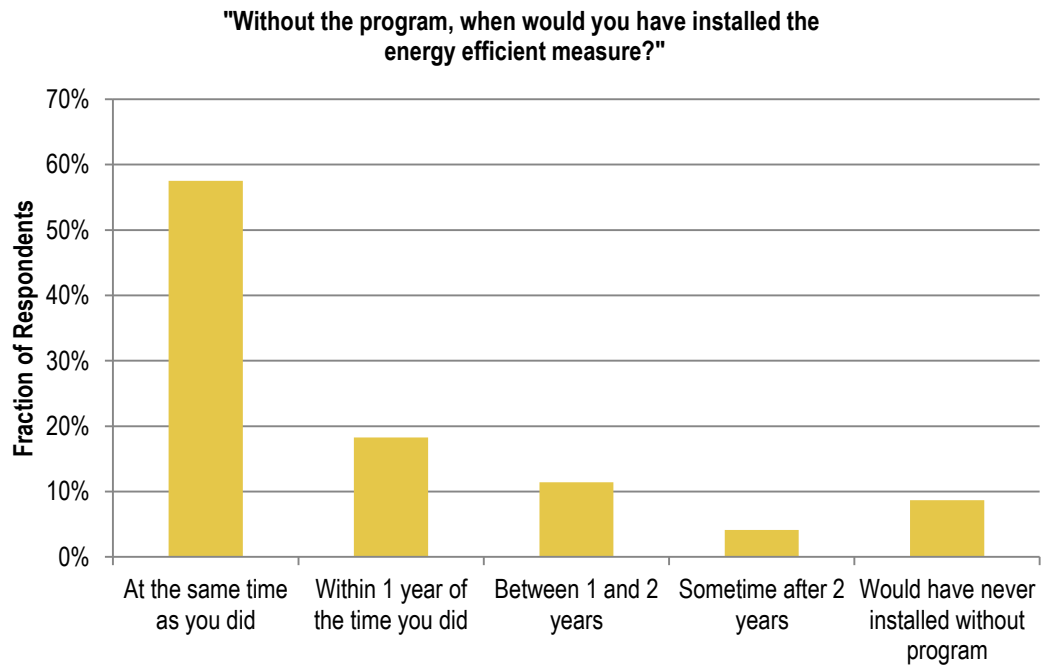
**Figure B-5. Extent of Prior Plans (n = 121)**



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. 58 percent said they would have installed the equipment at the same time as they did, and another 18 percent said they would install within one year. 13 percent said they would not have installed for two or more years, never, or did not answer.

**Figure B-6. Timing (n = 219)**



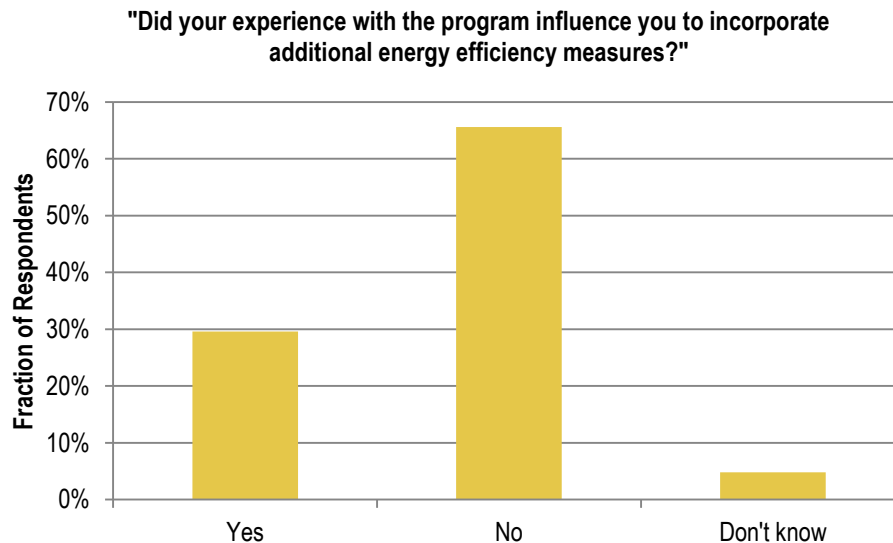
Source: Navigant analysis

### B.3.3 Spillover Results

HEIP influenced approximately 30 percent of single family participants to install additional energy efficiency measures (see Figure B-7). This is an increase over the 23 percent found in PY 2010 and PY 2011. About 47 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 a decrease from the 63 percent found in PY 2010 and PY 2011. Two of the ten 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

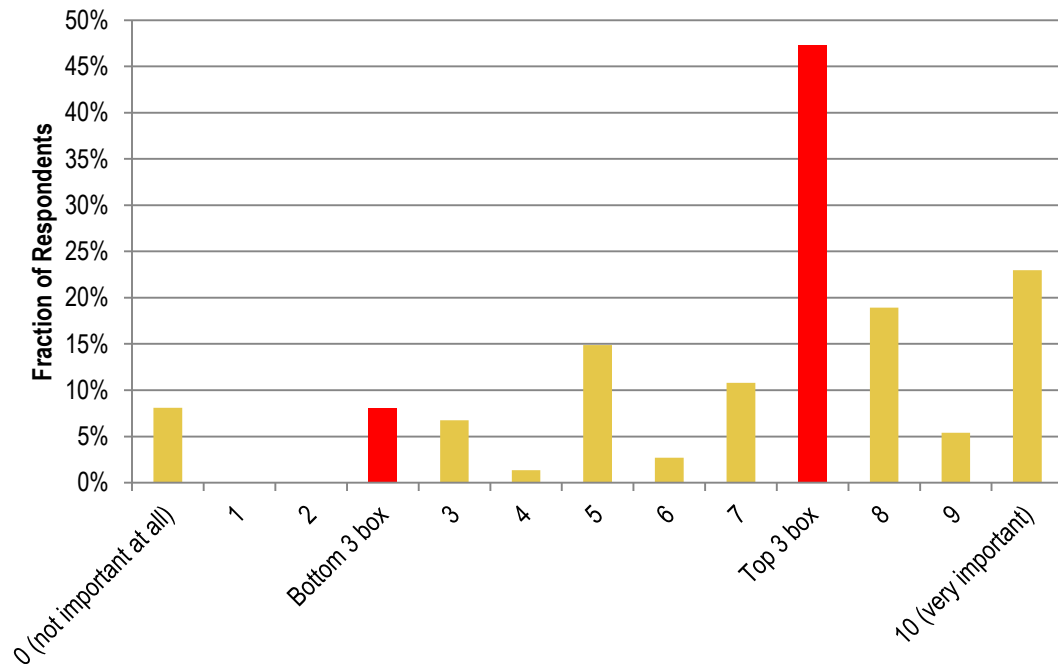
Table B-3, which represents the non-incented measures that were installed as a result of participation in HEIP. Based on the survey findings, the EM&V team estimates the overall program spillover to be 7 percent of program-reported savings. Spillover savings were calculated for each measure, and the program-wide value of 7 percent was calculated by weighting the spillover from each measure according to that measure's share of total reported energy savings.

**Figure B-7. Spillover (n = 250)**



Source: Navigant analysis

**Figure B-8. Program Importance for Respondents with Spillover (n = 74)**



Source: Navigant analysis

**Table B-3. Spillover Measures Installed by Survey Participants**

| Program Measures <sup>a</sup> | 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             |            |
|                               | Dishwasher     |                   |            |
|                               | Water heater   |                   |            |
|                               | Microwave      |                   |            |
|                               | Electric stove |                   |            |

- 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% 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.

Source: Navigant analysis

### B.3.4 Net-to-Gross Ratio

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

$$NTG = 1 - \text{free ridership} + \text{total spillover}$$

Using the overall free ridership value of 23 percent and the overall spillover value of 7 percent, the NTG ratio for PY 2012 is  $1 - 0.23 + 0.07 = 0.84$ .<sup>33</sup> The estimated NTG ratio of 0.84 implies that, for every 100 kWh of realized savings recorded in HEIP records, 84 kWh can be attributed to the program.

Table B-4 displays 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 <sup>a</sup> | Spillover <sup>a</sup> | NTG Ratio <sup>a</sup> |
|-------------------------------------|-----------------------------|------------------------|------------------------|
| Air source heat pump                | 49%                         | 7%                     | 58%                    |
| Central air conditioner             | 38%                         |                        | 69%                    |
| Geothermal heat pump                | 37%                         |                        | 70%                    |
| Level 1 HVAC tune-up <sup>b</sup>   | 40%                         |                        | 67%                    |
| HVAC audit                          | 3%                          |                        | 104%                   |
| Duct sealing                        | 30%                         |                        | 77%                    |
| Attic insulation                    | 13%                         |                        | 94%                    |
| Windows <sup>b</sup>                | 39%                         |                        | 68%                    |
| Heat pump water heater <sup>c</sup> | 38%                         |                        | 69%                    |
| Room air conditioner                | 45%                         |                        | 62%                    |
| <b>Total<sup>d</sup></b>            | <b>23%</b>                  |                        | <b>84%</b>             |

- HEIP total values for free ridership, spillover, and NTG are weighted values, calculated based on each measure category's share of total energy savings. The results by measure show unweighted values.
- PY 2011 free ridership estimates were used for windows and level 1 HVAC tune-ups because they were removed from the program in 2012.
- The heat pump water heater measure was assigned the average savings from other measures, due to low response rates.
- Values subject to rounding.

Source: Navigant analysis

<sup>33</sup> Total subject to rounding

## 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 2009-2012**

| Measure                 | PY 2009 | PY 2010 | PY 2011 | PY 2012 | Weighted         |
|-------------------------|---------|---------|---------|---------|------------------|
| Air source heat pump    | 100%    | 100%    | 100%    | 100%    | 100%             |
| Central air conditioner | 100%    | 100%    | 100%    | 100%    | 100%             |
| Geothermal heat pump    | 98%     | 97%     | 96%     | 99%     | 97% <sup>a</sup> |
| Level 1 HVAC tune-up    | 98%     | 97%     | 96%     | 99%     | 97% <sup>b</sup> |
| HVAC audit              | N/A     | 97%     | 96%     | 47%     | 47%              |
| Duct sealing            | 95%     | 90%     | 86%     | 100%    | 94%              |
| Attic insulation        | 110%    | 97%     | 96%     | 95%     | 98%              |
| Windows                 | 93%     | 92%     | 91%     | 91%     | 91% <sup>b</sup> |
| Room air conditioner    | N/A     | N/A     | N/A     | 99%     | 99%              |
| Heat pump water heater  | N/A     | N/A     | N/A     | 99%     | 99%              |

a. Geothermal heat pumps were not assessed for PY 2012, and Navigant assigned the program average verification rates to be conservative.

b. Level 1 HVAC tune-ups and 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 2009-2012**

| Measure                 | PY 2009 <sup>a</sup> | PY 2010 | PY 2011 | PY 2012 | Weighted         |
|-------------------------|----------------------|---------|---------|---------|------------------|
| Air source heat pump    | N/A                  | 100%    | 100%    | 100%    | 100%             |
| Central air conditioner | N/A                  | 100%    | 100%    | 100%    | 100%             |
| Geothermal heat pump    | N/A                  | 97%     | 90%     | 98%     | 95% <sup>b</sup> |
| Level 1 HVAC tune-up    | N/A                  | 97%     | 90%     | 98%     | 96%              |
| HVAC audit              | N/A                  | 97%     | 90%     | 47%     | 47%              |
| Duct sealing            | N/A                  | 90%     | 86%     | 100%    | 94%              |
| Attic insulation        | N/A                  | 97%     | 90%     | 95%     | 97%              |
| Windows                 | N/A                  | 92%     | 91%     | 91%     | 91%              |
| Room air conditioner    | N/A                  | N/A     | N/A     | 98%     | 98%              |
| Heat pump water heater  | N/A                  | N/A     | N/A     | 98%     | 98%              |

a. Values were not included in PY 2009 analysis.

b. Geothermal heat pumps were not assessed for PY 2012, and Navigant assigned the program average verification rates to be conservative.

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 2009-2012**

| Summer Demand                     | PY 2009<br>(kW) | PY 2010<br>(kW) | PY 2011<br>(kW) | PY 2012<br>(kW) |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|
| Air source heat pump              | 0.424           | 0.419           | 0.416           | 0.409           |
| Central air conditioner           | 0.429           | 0.430           | 0.432           | 0.411           |
| Geothermal heat pump              | 0.690           | 0.690           | 0.690           | 0.690           |
| Level 1 HVAC tune-up <sup>a</sup> | 0.092           | 0.099           | 0.098           | 0.094           |
| HVAC audit                        | N/A             | 0.33            | 0.33            | 0.157           |
| Duct sealing                      | 0.167           | 0.182           | 0.182           | 0.170           |
| Attic insulation                  | 0.344           | 0.332           | 0.311           | 0.235           |
| Windows <sup>a</sup>              | 0.480           | 0.532           | 0.505           | 0.471           |
| Room air conditioner              | N/A             | N/A             | N/A             | 0.100           |
| Heat pump water heater            | N/A             | N/A             | N/A             | 0.496           |

a. Windows and attic insulation have been removed from the program. Values are shown here for comparison purposes only.

Source: Navigant analysis

**Table C-4. Deemed Winter Demand Savings for Each Measure in PY 2009-2012**

| Winter Demand                     | PY 2009<br>(kW) | PY 2010<br>(kW) | PY 2011<br>(kW) | PY 2012<br>(kW) |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|
| Air source heat pump              | 0.037           | 0.034           | 0.038           | 0.044           |
| Central air conditioner           | 0.038           | 0.034           | 0.035           | 0.037           |
| Geothermal heat pump              | 0               | 0               | 0               | 0               |
| Level 1 HVAC tune-up <sup>a</sup> | 0.039           | 0.048           | 0.046           | 0.048           |
| HVAC audit                        | N/A             | 0.38            | 0.38            | 0.180           |
| Duct sealing                      | 0.397           | 0.432           | 0.431           | 0.387           |
| Attic insulation                  | 0.869           | 0.749           | 0.668           | 0.515           |
| Windows <sup>a</sup>              | 0.190           | 0.206           | 0.196           | 0.182           |
| Room air conditioner              | N/A             | N/A             | N/A             | 0.01            |
| Heat pump water heater            | N/A             | N/A             | N/A             | .0567           |

a. Windows and attic insulation have been removed from the program. Values are shown here for comparison purposes only.

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.

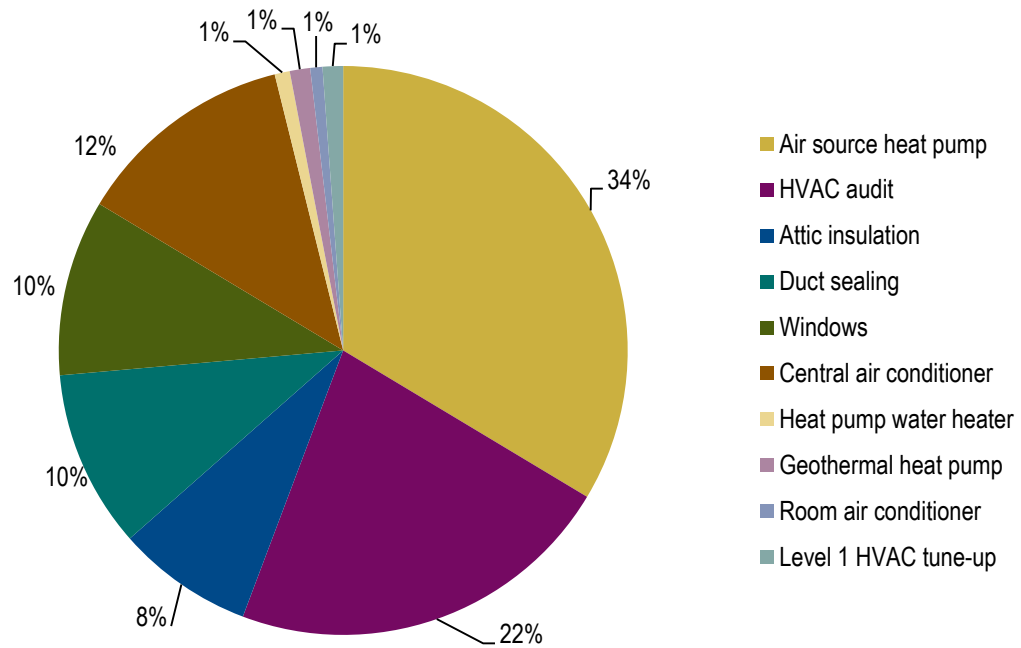
**Table C-5. Verified Gross Peak Summer Demand Reductions by Measure for PY 2012**

| Measure Category        | Reported Gross<br>Demand Reduction<br>(kW) | Verified Gross<br>Demand Reduction<br>(kW) | Gross Realization<br>Rate |
|-------------------------|--------------------------------------------|--------------------------------------------|---------------------------|
| Air source heat pump    | 1,993                                      | 1,942                                      | 97%                       |
| Central air conditioner | 756                                        | 723                                        | 96%                       |
| Geothermal heat pump    | 69                                         | 67                                         | 97%                       |
| Level 1 HVAC tune-up    | 71                                         | 67                                         | 94%                       |
| HVAC audit              | 2,697                                      | 1,279                                      | 47%                       |
| Duct sealing            | 617                                        | 584                                        | 95%                       |
| Attic insulation        | 591                                        | 449                                        | 76%                       |
| Windows                 | 626                                        | 578                                        | 92%                       |
| Room air conditioner    | 40                                         | 40                                         | 99%                       |
| Heat pump water heater  | 50                                         | 50                                         | 99%                       |
| <b>Total</b>            | <b>7,511</b>                               | <b>5,779</b>                               | <b>77%</b>                |

Source: Navigant analysis

Figure C-1 shows each measure's contribution to overall gross summer coincident demand reductions for PY 2012. Again, air source heat pump was the largest contributor.

**Figure C-1. Measure-Level Contribution to Verified Gross Summer Coincident Demand Savings for PY 2012**



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 2012 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.

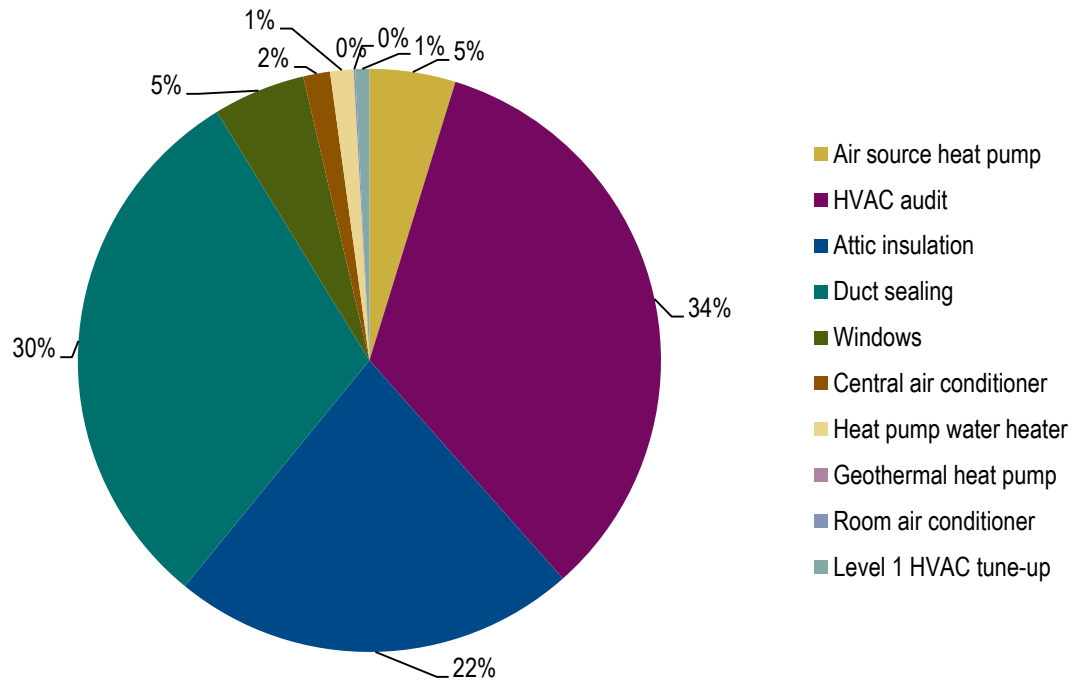
**Table C-6. Verified Gross Winter Peak Demand Reductions by Measure for PY 2012**

| Measure Category        | Reported Gross Demand Reduction (kW) | Verified Gross Demand Reduction (kW) | Gross Realization Rate |
|-------------------------|--------------------------------------|--------------------------------------|------------------------|
| Air source heat pump    | 190                                  | 209                                  | 110%                   |
| Central air conditioner | 70                                   | 65                                   | 92%                    |
| Geothermal heat pump    | 0                                    | 0                                    | 100%                   |
| Level 1 HVAC tune-up    | 36                                   | 34                                   | 95%                    |
| HVAC audit              | 3,106                                | 1,473                                | 47%                    |
| Duct sealing            | 1,473                                | 1,326                                | 90%                    |
| Attic insulation        | 1,276                                | 982                                  | 77%                    |
| Windows                 | 246                                  | 224                                  | 91%                    |
| Room air conditioner    | 234                                  | 4                                    | 2%                     |
| Heat pump water heater  | 58                                   | 57                                   | 98%                    |
| <b>Total</b>            | <b>6,689</b>                         | <b>4,373</b>                         | <b>65%</b>             |

*Source: Navigant analysis*

Each measure's contribution to overall verified gross winter demand reduction for 2012 is shown in Figure C-2. Duct sealing, HVAC audit, and attic insulation provided the most winter demand savings.

**Figure C-2. Measure-Level Contribution to Verified Gross Winter Demand Savings for PY 2012**



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 2012.

**Table C-7. Verified Net Summer Demand Impacts for PY 2012**

| Measure Category         | Verified Gross Demand Reduction (kW) | NTG Ratio   | Verified Net Demand Reductions (kW) |
|--------------------------|--------------------------------------|-------------|-------------------------------------|
| Air source heat pump     | 1,942                                | 0.58        | 1,129                               |
| Central air conditioner  | 723                                  | 0.69        | 502                                 |
| Geothermal heat pump     | 67                                   | 0.70        | 47                                  |
| Level 1 HVAC tune-up     | 67                                   | 0.67        | 45                                  |
| HVAC audit               | 1,279                                | 1.04        | 1,336                               |
| Duct sealing             | 584                                  | 0.77        | 452                                 |
| Attic insulation         | 449                                  | 0.94        | 420                                 |
| Windows                  | 578                                  | 0.68        | 393                                 |
| Room air conditioner     | 40                                   | 0.62        | 25                                  |
| Heat pump water heater   | 50                                   | 0.69        | 34                                  |
| <b>Total<sup>a</sup></b> | <b>5,779</b>                         | <b>0.84</b> | <b>4,842</b>                        |

a. Totals indicated the weighted average by each measure's contribution to program savings.

Source: Navigant analysis

**Table C-8. Verified Net Winter Demand Impacts for PY 2012**

| Measure Category         | Verified Gross Demand Reduction(kW) | NTG Ratio   | Verified Net Demand Reductions (kW) |
|--------------------------|-------------------------------------|-------------|-------------------------------------|
| Air source heat pump     | 209                                 | 0.58        | 121                                 |
| Central air conditioner  | 65                                  | 0.69        | 45                                  |
| Geothermal heat pump     | 0                                   | 0.70        | 0                                   |
| Level 1 HVAC tune-up     | 34                                  | 0.67        | 23                                  |
| HVAC audit               | 1,473                               | 1.04        | 1,538                               |
| Duct sealing             | 1,326                               | 0.77        | 1,027                               |
| Attic insulation         | 982                                 | 0.94        | 919                                 |
| Windows                  | 224                                 | 0.68        | 152                                 |
| Room air conditioner     | 4                                   | 0.62        | 2                                   |
| Heat pump water heater   | 57                                  | 0.69        | 39                                  |
| <b>Total<sup>a</sup></b> | <b>4,373</b>                        | <b>0.84</b> | <b>3,664</b>                        |

a. Totals indicated the weighted average by each measure's contribution to program savings.

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), and air conditioners and heat pumps were combined into one stratum, as presented in the body of this EM&V report. 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.<sup>34</sup> 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, 90/5 and 90/3, indicating a relative precision of  $\pm 5$  percent for energy savings and  $\pm 3$  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, central air conditioner, and duct sealing 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  $\pm 10$  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                                   | 6,739                       | 5.78                                       | 4.37                                       |
| Verified Net Savings                                     | 5,646                       | 4.84                                       | 3.66                                       |
| Relative Precision ( $\pm$ %) at 90% Level of Confidence | $\pm 5\%$                   | $\pm 3\%$                                  | $\pm 10\%$                                 |

Source: Navigant analysis

<sup>34</sup> 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. Unit Savings Values

Section 3 of this report presents updated deemed savings values for each measure, which were based on the 2012 participants' mix of measure efficiency, heating type, region, and Navigant's field verification rates. This appendix presents the per-unit savings for each measure, which are based on the detailed analysis performed during the 2009 EM&V cycle.<sup>35</sup> These unit savings do not include adjustments due to field verification rates from the EM&V sample; rather, they reflect anticipated savings for a variety of categories.<sup>36</sup>

Table D-1 shows the deemed measure unit savings by efficiency level.

**Table D-1. Measure Unit Savings by Efficiency Level**

| Measure Category     | Base Case      | Efficient Case                        | Units      | kWh  | Summer kW | Winter kW |
|----------------------|----------------|---------------------------------------|------------|------|-----------|-----------|
| Air Source Heat Pump | SEER 13        | SEER 15                               | Tons       | 108  | 0.144     | 0.003     |
| Air Source Heat Pump | SEER 13        | SEER 16                               | Tons       | 162  | 0.172     | 0.026     |
| Air Source Heat Pump | SEER 13        | SEER 17                               | Tons       | 186  | 0.158     | 0.038     |
| Air Source Heat Pump | SEER 13        | SEER 18                               | Tons       | 228  | 0.201     | 0.035     |
| Attic Insulation     | R-03           | R-30                                  | SF Ceiling | 1.34 | 0.00059   | 0.00129   |
| Attic Insulation     | R-03           | R-38                                  | SF Ceiling | 1.39 | 0.00061   | 0.00134   |
| Attic Insulation     | R-03           | R-49                                  | SF Ceiling | 1.42 | 0.00062   | 0.00138   |
| Attic Insulation     | R-08           | R-30                                  | SF Ceiling | 0.83 | 0.00035   | 0.00082   |
| Attic Insulation     | R-08           | R-38                                  | SF Ceiling | 0.87 | 0.00037   | 0.00086   |
| Attic Insulation     | R-08           | R-49                                  | SF Ceiling | 0.91 | 0.00038   | 0.00090   |
| Attic Insulation     | R-12           | R-30                                  | SF Ceiling | 0.64 | 0.00026   | 0.00064   |
| Attic Insulation     | R-12           | R-38                                  | SF Ceiling | 0.68 | 0.00028   | 0.00069   |
| Attic Insulation     | R-12           | R-49                                  | SF Ceiling | 0.72 | 0.00029   | 0.00073   |
| Attic Insulation     | R-19           | R-30                                  | SF Ceiling | 0.47 | 0.00018   | 0.00048   |
| Attic Insulation     | R-19           | R-38                                  | SF Ceiling | 0.52 | 0.00020   | 0.00053   |
| Attic Insulation     | R-19           | R-49                                  | SF Ceiling | 0.55 | 0.00022   | 0.00057   |
| Central AC           | SEER 13        | SEER 15                               | Tons       | 86   | 0.097     | 0.019     |
| Central AC           | SEER 13        | SEER 16                               | Tons       | 98   | 0.171     | 0.010     |
| Central AC           | SEER 13        | SEER 17                               | Tons       | 181  | 0.209     | 0.020     |
| Central AC           | SEER 13        | SEER 18                               | Tons       | 186  | 0.230     | 0.020     |
| Duct Sealing         | Ducts in Attic | Ducts in Attic,<br>Visually Inspected | Site       | 638  | 0.491     | 1.126     |

<sup>35</sup> For a detailed discussion of the methods used to estimate the unit deemed savings values, refer to Navigant's 2009 EM&V report for PEC's HEIP: *2009 EM&V Report for the Home Energy Improvement Program, Final Report*, prepared by Navigant Consulting, Inc., April 11, 2011.

<sup>36</sup> The unit savings values shown throughout this appendix represent a variety of pre- and post-installation conditions. The verified deemed savings will vary each year due to the actual mix of installed equipment and field verification rates.

| Measure Category     | Base Case                                                       | Efficient Case                                                                      | Units      | kWh  | Summer kW | Winter kW |
|----------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|------|-----------|-----------|
| Duct Sealing         | Ducts in Attic and Crawlspace/Basement                          | Ducts in Attic and Crawlspace/Basement, Visually Inspected                          | Site       | 430  | 0.305     | 0.725     |
| Duct Sealing         | Average Duct Location                                           | Average Duct Location, Visually Inspected                                           | Site       | 363  | 0.246     | 0.596     |
| Duct Sealing         | Ducts Half in Attic and Half in Conditioned Space               | Ducts Half in Attic and Half in Conditioned Space, Visually Inspected               | Site       | 319  | 0.246     | 0.563     |
| Duct Sealing         | Ducts in Crawlspace/Basement                                    | Ducts in Crawlspace/Basement, Visually Inspected                                    | Site       | 222  | 0.120     | 0.323     |
| Duct Sealing         | Ducts Half in Crawlspace/Basement and Half in Conditioned Space | Ducts Half in Crawlspace/Basement and Half in Conditioned Space, Visually Inspected | Site       | 111  | 0.060     | 0.162     |
| Duct Sealing         | Ducts in Conditioned Space                                      | Ducts in Conditioned Space, Visually Inspected                                      | Site       | 0    | 0.000     | 0.000     |
| HVAC Level 1 Tune-Up | No Tune-Up                                                      | Level 1 Tune-Up                                                                     | Site       | 146  | 0.137     | 0.064     |
| Windows              | Double Pane                                                     | U-0.24, SHGC 0.23                                                                   | SF Windows | 1.84 | 0.00218   | 0.00023   |
| Windows              | Double Pane                                                     | U-0.25, SHGC 0.29                                                                   | SF Windows | 1.86 | 0.00199   | 0.00033   |
| Windows              | Double Pane                                                     | U-0.25, SHGC 0.40                                                                   | SF Windows | 2.03 | 0.00170   | 0.00070   |
| Windows              | Double Pane                                                     | U-0.30, SHGC 0.23                                                                   | SF Windows | 1.33 | 0.00202   | 0.00015   |
| Windows              | Double Pane                                                     | U-0.30, SHGC 0.30                                                                   | SF Windows | 1.46 | 0.00177   | 0.00018   |
| Windows              | Double Pane                                                     | U-0.30, SHGC 0.41                                                                   | SF Windows | 1.67 | 0.00156   | 0.00036   |
| Windows              | Double Pane                                                     | U-0.33, SHGC 0.24                                                                   | SF Windows | 1.11 | 0.00192   | 0.00011   |
| Windows              | Double Pane                                                     | U-0.35, SHGC 0.29                                                                   | SF Windows | 1.07 | 0.00175   | 0.00011   |
| Windows              | Double Pane                                                     | U-0.35, SHGC 0.38                                                                   | SF Windows | 1.20 | 0.00150   | 0.00015   |
| Windows              | Single Pane                                                     | U-0.24, SHGC 0.23                                                                   | SF Windows | 4.03 | 0.00321   | 0.00166   |
| Windows              | Single Pane                                                     | U-0.25, SHGC 0.29                                                                   | SF Windows | 4.04 | 0.00302   | 0.00196   |
| Windows              | Single Pane                                                     | U-0.25, SHGC 0.40                                                                   | SF Windows | 4.21 | 0.00273   | 0.00234   |
| Windows              | Single Pane                                                     | U-0.30, SHGC 0.23                                                                   | SF Windows | 3.51 | 0.00305   | 0.00131   |
| Windows              | Single Pane                                                     | U-0.30, SHGC 0.30                                                                   | SF Windows | 3.65 | 0.00279   | 0.00157   |
| Windows              | Single Pane                                                     | U-0.30, SHGC 0.41                                                                   | SF Windows | 3.85 | 0.00258   | 0.00199   |
| Windows              | Single Pane                                                     | U-0.33, SHGC 0.24                                                                   | SF Windows | 3.29 | 0.00295   | 0.00117   |
| Windows              | Single Pane                                                     | U-0.35, SHGC 0.29                                                                   | SF Windows | 3.26 | 0.00278   | 0.00127   |

| Measure Category | Base Case   | Efficient Case    | Units      | kWh  | Summer kW | Winter kW |
|------------------|-------------|-------------------|------------|------|-----------|-----------|
| Windows          | Single Pane | U-0.35, SHGC 0.38 | SF Windows | 3.38 | 0.00253   | 0.00164   |

Source: Navigant analysis

Table D-2 shows unit savings by heating type.

**Table D-2. Measure Unit Savings by Heating Type**

| Measure Category     | Heat Type           | Units      | kWh  | Summer kW | Winter kW |
|----------------------|---------------------|------------|------|-----------|-----------|
| Air Source Heat Pump | Average             | Tons       | 136  | 0.156     | 0.012     |
| Air Source Heat Pump | Dual Fuel Heat Pump | Tons       | 156  | 0.156     | 0.065     |
| Air Source Heat Pump | Heat Pump           | Tons       | 134  | 0.156     | 0.008     |
| Attic Insulation     | Average             | SF Ceiling | 0.56 | 0.00025   | 0.00058   |
| Attic Insulation     | Dual Fuel Heat Pump | SF Ceiling | 0.56 | 0.00026   | 0.00015   |
| Attic Insulation     | Electric Resistance | SF Ceiling | 1.25 | 0.00024   | 0.00120   |
| Attic Insulation     | Gas Furnace         | SF Ceiling | 0.18 | 0.00024   | 0.00002   |
| Attic Insulation     | Heat Pump           | SF Ceiling | 0.73 | 0.00026   | 0.00096   |
| Central AC           | Average             | Tons       | 109  | 0.159     | 0.014     |
| Central AC           | Electric Resistance | Tons       | 100  | 0.160     | 0.000     |
| Central AC           | Gas Furnace         | Tons       | 110  | 0.160     | 0.015     |
| Duct Sealing         | Average             | Site       | 359  | 0.247     | 0.582     |
| Duct Sealing         | Dual Fuel Heat Pump | Site       | 339  | 0.253     | 0.103     |
| Duct Sealing         | Electric Resistance | Site       | 628  | 0.236     | 0.864     |
| Duct Sealing         | Gas Furnace         | Site       | 161  | 0.236     | 0.017     |
| Duct Sealing         | Heat Pump           | Site       | 468  | 0.253     | 0.974     |
| HVAC Level 1 Tune-Up | Average             | Site       | 143  | 0.137     | 0.058     |
| HVAC Level 1 Tune-Up | Dual Fuel Heat Pump | Site       | 181  | 0.137     | 0.132     |
| HVAC Level 1 Tune-Up | Electric Resistance | Site       | 99   | 0.136     | 0.000     |
| HVAC Level 1 Tune-Up | Gas Furnace         | Site       | 99   | 0.136     | 0.000     |
| HVAC Level 1 Tune-Up | Heat Pump           | Site       | 181  | 0.137     | 0.113     |
| Windows              | Average             | SF Windows | 2.75 | 0.00256   | 0.00104   |
| Windows              | Dual Fuel Heat Pump | SF Windows | 2.60 | 0.00258   | 0.00086   |
| Windows              | Electric Resistance | SF Windows | 2.59 | 0.00255   | 0.00208   |
| Windows              | Gas Furnace         | SF Windows | 2.68 | 0.00255   | 0.00004   |
| Windows              | Heat Pump           | SF Windows | 2.94 | 0.00258   | 0.00141   |

Source: Navigant analysis

Table D-3 shows measure unit savings by region.

**Table D-3. Measure Unit Savings by Region**

| Measure Category     | Region   | Units      | kWh   | Summer kW | Winter kW |
|----------------------|----------|------------|-------|-----------|-----------|
| Air Source Heat Pump | Eastern  | Tons       | 178   | 0.162     | 0.035     |
| Air Source Heat Pump | Northern | Tons       | 120   | 0.155     | 0.004     |
| Air Source Heat Pump | Southern | Tons       | 132   | 0.161     | 0.007     |
| Air Source Heat Pump | Western  | Tons       | 63    | 0.116     | 0.004     |
| Attic Insulation     | Eastern  | SF Ceiling | 0.500 | 0.00026   | 0.00050   |
| Attic Insulation     | Northern | SF Ceiling | 0.681 | 0.00025   | 0.00069   |
| Attic Insulation     | Southern | SF Ceiling | 0.664 | 0.00029   | 0.00077   |
| Attic Insulation     | Western  | SF Ceiling | 0.658 | 0.00022   | 0.00064   |
| Central AC           | Eastern  | Tons       | 94    | 0.144     | 0.014     |
| Central AC           | Northern | Tons       | 112   | 0.162     | 0.014     |
| Central AC           | Southern | Tons       | 81    | 0.152     | 0.016     |
| Central AC           | Western  | Tons       | 27    | 0.062     | 0.020     |
| Duct Sealing         | Eastern  | Site       | 348   | 0.250     | 0.492     |
| Duct Sealing         | Northern | Site       | 367   | 0.238     | 0.611     |
| Duct Sealing         | Southern | Site       | 369   | 0.285     | 0.612     |
| Duct Sealing         | Western  | Site       | 345   | 0.208     | 0.683     |
| HVAC Level 1 Tune-Up | Eastern  | Site       | 153   | 0.136     | 0.091     |
| HVAC Level 1 Tune-Up | Northern | Site       | 143   | 0.135     | 0.061     |
| HVAC Level 1 Tune-Up | Southern | Site       | 152   | 0.146     | 0.043     |
| HVAC Level 1 Tune-Up | Western  | Site       | 99    | 0.107     | 0.067     |
| Windows              | Eastern  | SF Windows | 3.40  | 0.00283   | 0.00148   |
| Windows              | Northern | SF Windows | 2.60  | 0.00248   | 0.00076   |
| Windows              | Southern | SF Windows | 2.46  | 0.00254   | 0.00098   |
| Windows              | Western  | SF Windows | 2.06  | 0.00276   | 0.00359   |

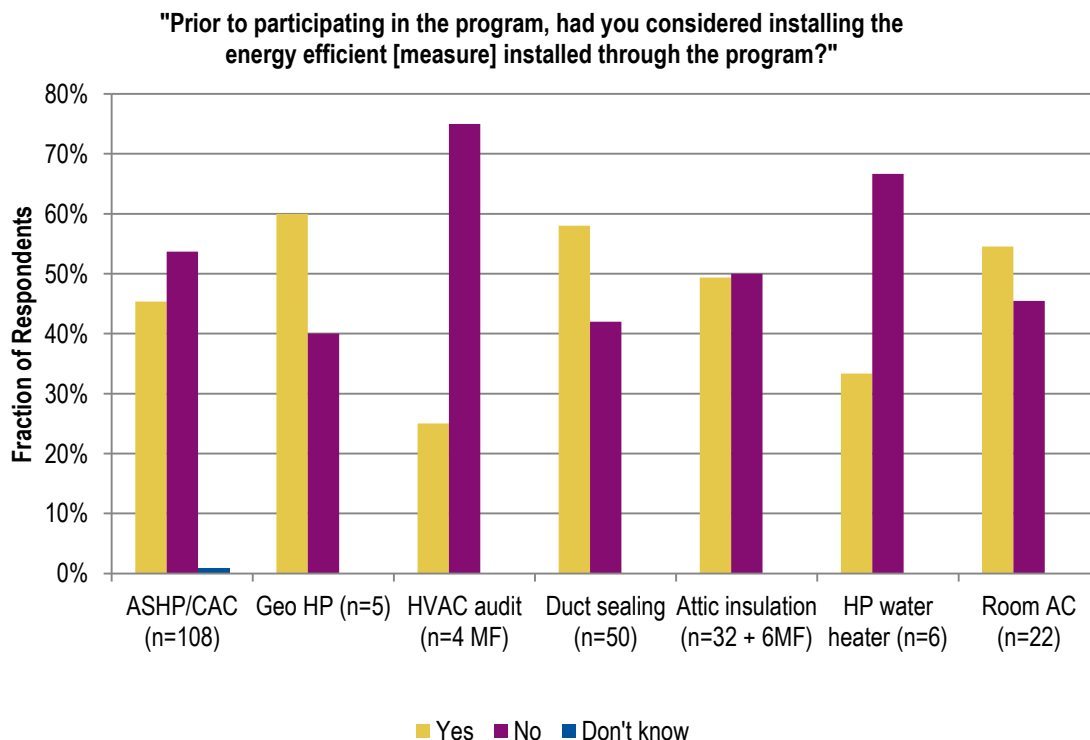
Source: Navigant analysis

## Appendix E. Additional Participant Survey Results

The evaluation team conducted telephone surveys with 250 HEIP participants and ten multi-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, 67 percent of the heat pump water heater respondents had not considered installing the measure prior to participating in the program.

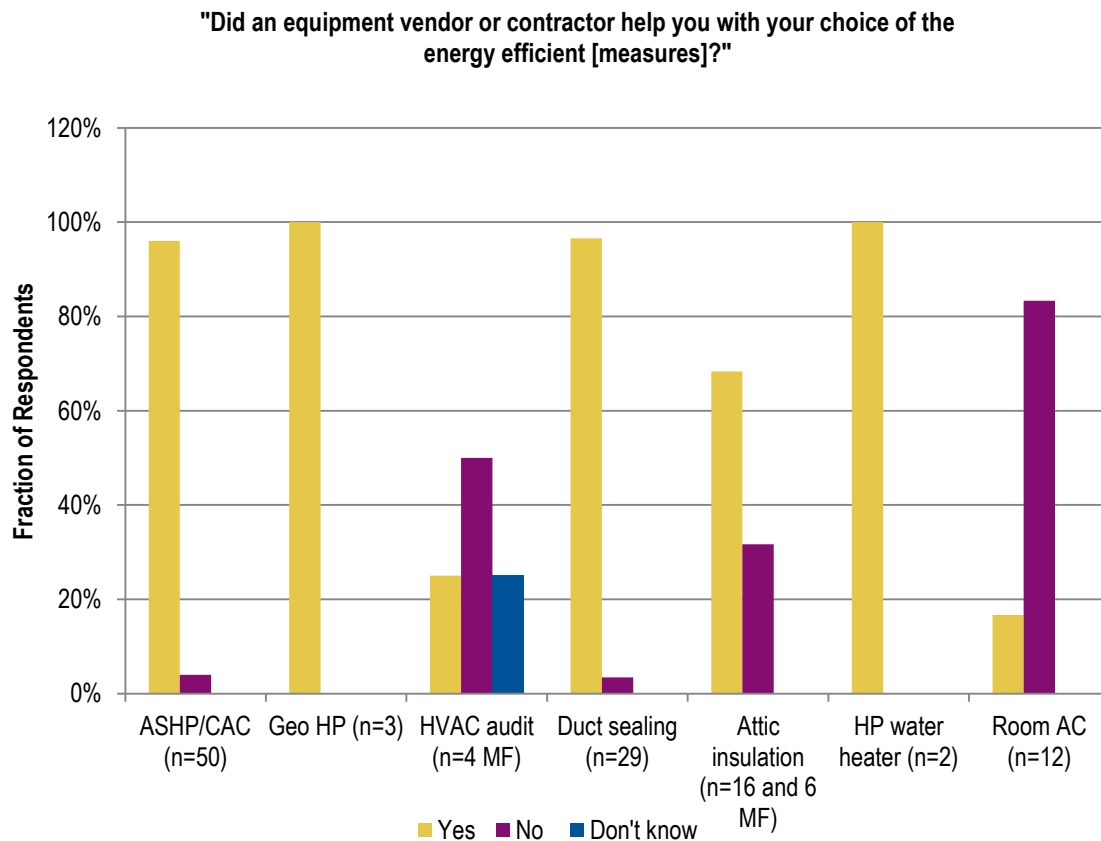
**Figure E-1. Number of Participants That Had Considered Installing Measure Prior to HEIP**



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).

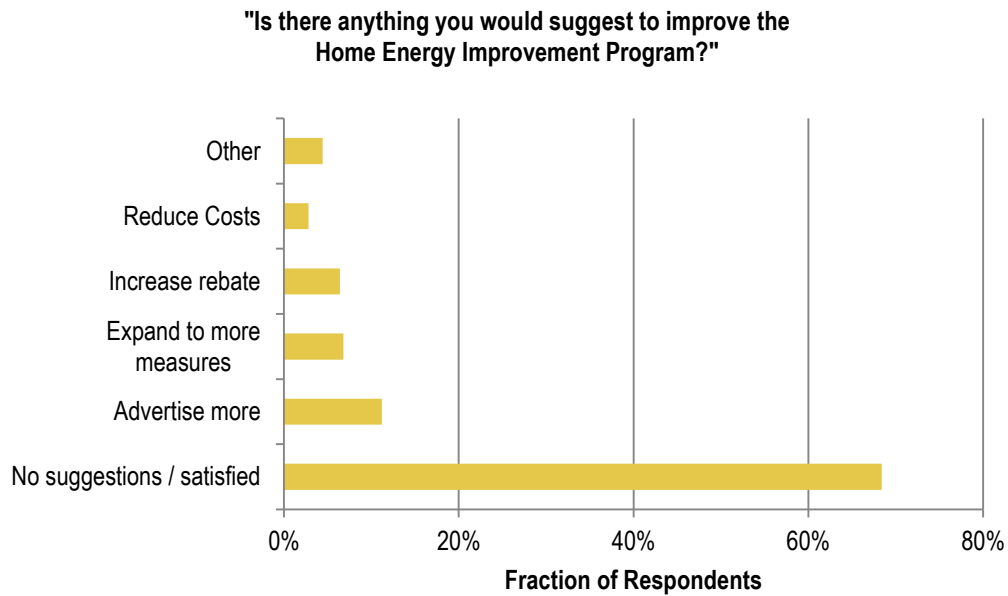
**Figure E-2. Participants Who Indicated the Contractor Aided in Their Final Equipment Choice, Despite Having Considered the Measure Prior to Participating in HEIP**



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 and PY 2011 (see Figure E-3).

**Figure E-3. Participant Suggestions for Improving the Program (n = 250)**



*Source: Navigant analysis*