Progress Energy

June 29, 2012

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

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Clerk's Office
N.C. Utilities Commission

RE: Docket No. E-2, Sub 936

Dear Ms. Mount:

Pursuant to the Commission's April 30, 2009 order issued in Docket No. E-2, Sub 936, Progress Energy Carolinas, Inc. submits the attached report summarizing the results of the 2010 and 2011 Program Year evaluation, measurement & verification (EM&V) efforts for its Home Energy Improvement Program. Progress Energy Carolinas, Inc. is currently evaluating the recommendations provided in the EM&V report.

Very truly yours,

Len S. Anthony
General Counsel
Progress Energy Carolinas, Inc.

LSA:mhm

Attachment

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NAVIGANT

2010 AND 2011 EM&V REPORT

E-2, Sub 936

FOR THE HOME ENERGY IMPROVEMENT PROGRAM

Presented to:
Progress Energy Carolinas

Prepared by:
Navigant Consulting, Inc.

June 27, 2012

NAVIGANT

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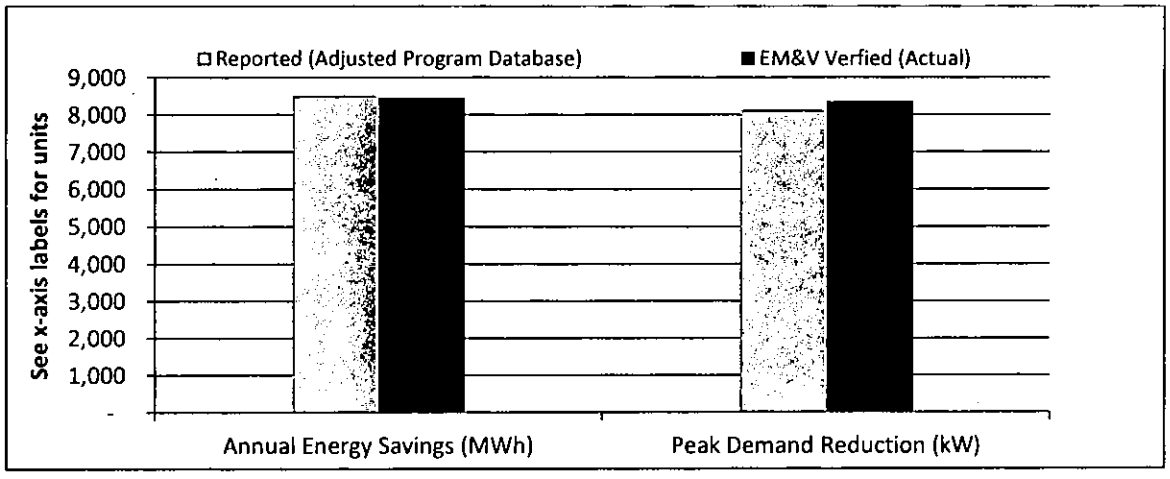
Executive Summary

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 PEC offerings address efficiency opportunities in new homes and commercial buildings. This report covers evaluation, measurement, and verification (EM&V) activities for HEIP for Program Year 2010 (PY 2010) and PY 2011 projects, defined as those receiving rebates during the 2010 and 2011 calendar years. Navigant Consulting, Inc. (Navigant) chose to perform simultaneous EM&V efforts and reporting for PY 2010 and PY 2011 in order to leverage program budgets for additional field verification and survey sample sizes, and to align evaluation efforts more closely with program delivery. The primary purpose of the EM&V assessment was to estimate **net annual energy and peak demand impacts** associated with 2010 and 2011 HEIP activity. Secondary objectives included:

- Estimate net and gross impacts by measure
- Provide updated deemed savings values 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

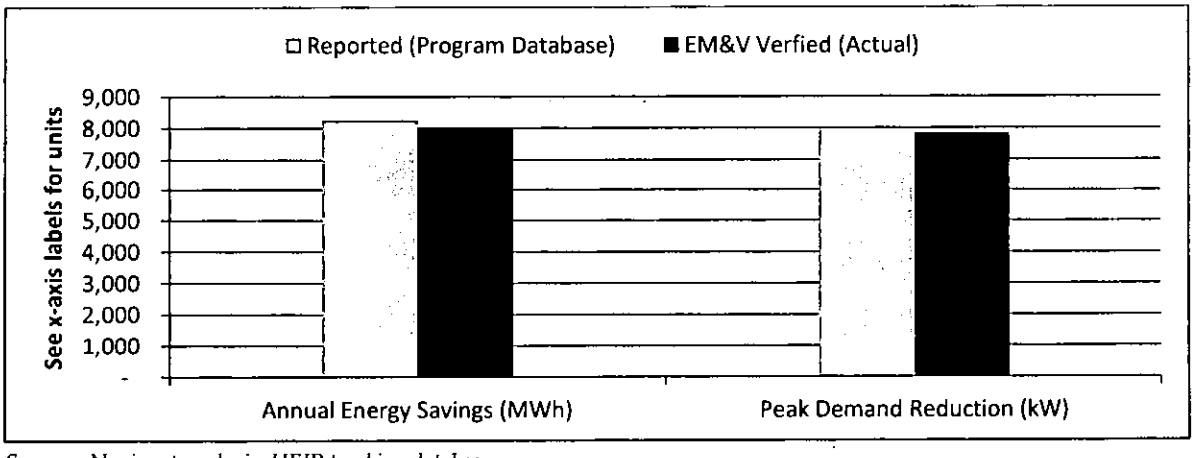
The savings verified through EM&V assessment for PY 2010 and PY 2011 were nearly 100% of the reported savings for both energy and demand.[1] Figure ES-1 and Figure ES-2 show the reported and verified energy and demand impacts from HEIP for PY 2010 and PY 2011, respectively. The slightly lower energy and demand savings in 2011 may have been due in part to the expiration of federal tax incentives that had been dispersed through the American Recovery and Reinvestment Act of 2009 (ARRA).

Figure ES-1. Comparison of Reported and Verified Program Impacts for PY 2010



Sources: Navigant analysis, HEIP tracking database

Figure ES-2. Comparison of Reported and Verified Program Impacts for PY 2011



Sources: Navigant analysis, HEIP tracking database

[1] PEC retroactively adjusted the PY 2010 reported savings to reflect recommendations on deemed savings values from Navigant's PY 2009 EM&V report. All reported values for PY 2010 shown in this report reflect those adjustments.

Program Summary

The HEIP generates energy and peak demand reductions by offering rebates for the following 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)
3. HVAC level 2 tune-up (same as level 1, plus correcting refrigerant charge and adjusting air flow)
4. Duct sealing
5. Window replacement
6. Attic insulation

PEC maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[2] based on assumed ("deemed") savings values. Reported gross savings from PY 2010 measures were over 8.5 gigawatt-hours (GWh) and 8.1 megawatts (MW). Reported savings from PY 2011 were approximately 8.3 GWh and 7.9 MW. In both 2010 and 2011, the air source heat pump replacement measure was the largest contributor to energy and summer demand savings, accounting for about 32% of the reported savings for energy and about 38% for coincident demand.

Evaluation Methodology

The EM&V assessment of HEIP program activity in 2010 and 2011 included impact and process evaluations. The *impact evaluation* consisted primarily of field verification on a sample of participants to assess measure quantity, size, and efficiency. The field sample was stratified by measure and region, with the objective of getting a significant sample for each verified measure, spread across all regions, and 90/10 confidence and precision at the program level. **Field verification rates** were derived by taking the ratio of savings using the site-verified measure quantity, size, and efficiency to the savings using the reported quantity, size, and efficiency.

The evaluation team also developed updated **deemed savings** values by applying **unit savings** from the PY 2009 building energy simulation models to the PY 2010 and PY 2011 tracking databases.[3] New savings values were assigned to each measure installation in the tracking data based on efficiency level, region, and heating type. For each measure, an updated **deemed savings** value was calculated that is representative of the actual mix of measure characteristics, installation trends, and **field verification rates** for that year. The **gross realization rates** for each measure were then calculated by comparing verified savings to reported savings.

[2] "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 PEC's service territory.

[3] 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 2010 and 2011 participants. There were no major program changes within the time span that would suggest a significant difference in the "typical" participant.

The *process evaluation* was conducted by administering surveys to 246 HEIP participants to assess overall satisfaction with the program and estimate an NTG ratio. Interviews were conducted with PEC program staff and several prequalified contractors to gauge operational performance. Additionally, the program website and various program documents were reviewed.

Program Impact Findings

Verified Gross Energy and Peak Demand Savings

PEC'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 2010 and PY 2011 by performing on-site field assessments
2. Determine combined field verification rates for PYs 2009-2011
3. Update measure deemed 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 for PY 2010 and 2011 are shown in Table ES-1 and Table ES-2, respectively.

Table ES-1. 2010 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	8,518	8.13	7.82
Verified Gross Savings	8,458	8.36	3.56
Gross Realization Rate	99%	103%	46%[a]

Source: Navigant analysis

a. PEC retroactively updated the reported savings for PY 2010 using adjustment factors from Navigant's PY 2009 EM&V report. The adjustment factors for summer demand savings were also applied to winter demand savings, resulting in a low realization rate for winter demand savings. PEC could further adjust 2010 winter demand savings by applying "measure unit savings adjustments" that are specific to winter demand.

Table ES-2. 2011 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	8,256	7.94	3.70
Verified Gross Savings	7,989	7.81	3.39
Gross Realization Rate	97%	98%	92%

Source: Navigant analysis

Gross realization rates by measure are shown in Table ES-3 and Table ES-4. It is important to note that the underlying unit savings values used to calculate measure-level net and gross savings for PY 2010 and PY 2011 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, and field verification rates—each of which contribute to the unique deemed savings value assigned to each rebated measure.

Table ES-3. 2010 Gross Realization Rates by Measure

PY 2010	Energy RR	Summer Coincident Demand RR	Winter Demand RR[a]
Air source heat pump	100%	99%	7%
Central air conditioner	97%	101%	100%
Geothermal heat pump	96%	99%	NA
Level 1 HVAC tune-up	104%	108%	44%
Level 2 HVAC tune-up	95%	96%	91%
Duct sealing	106%	104%	218%
Windows	100%	109%	38%
Attic insulation	81%	90%	166%
HEIP Total	99%	103%	46%

Source: Navigant analysis

a. PEC retroactively updated the reported savings for PY 2010 using adjustment factors from Navigant's PY 2009 EM&V report. The adjustment factors for summer demand savings were also applied to winter demand savings, resulting in a low realization rate for winter demand savings. PEC could further adjust 2010 winter demand savings by applying "measure unit savings adjustments" that are specific to winter demand.

Table ES-4. 2011 Gross Realization Rates by Measure

PY 2011	Energy RR	Summer Coincident Demand RR	Winter Demand RR
Air source heat pump	99%	99%	95%
Central air conditioner	96%	101%	88%
Geothermal heat pump	96%	97%	NA
Level 1 HVAC tune-up	105%	107%	112%
Level 2 HVAC tune-up	95%	96%	91%
Duct sealing	97%	96%	94%
Windows	97%	96%	94%
Attic insulation	81%	92%	77%
HEIP Total	97%	98%	92%

Source: Navigant analysis

Net Savings

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

The evaluation team estimates free ridership across all measures for HEIP to be 41% of program savings, and spillover to be 9% of program savings. The resulting NTG ratio is 0.68, which implies that for every 100 kWh of realized savings, 68 kWh can be attributed to the program.

Table ES-5 and Table ES-6 show the verified net impacts for PY 2010 and PY 2011, respectively,

Table ES-5. 2010 Verified Net Impacts

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Verified Gross Savings	8,458	8.36	3.56
Net-to-Gross Ratio	0.68	0.68	0.68
Verified Net Savings	5,770	5.66	2.45

Source: Navigant analysis

Table ES-6. 2011 Verified Net Impacts

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Verified Gross Savings	7,989	7.81	3.39
Net-to-Gross Ratio	0.68	0.68	0.68
Verified Net Savings	5,460	5.30	2.34

Source: Navigant analysis

Table ES-7 shows a comparison of reported and verified net impacts for PY 2010 and PY 2011.

Table ES-7. Reported and Verified Net Energy Savings

Measure Category	PY 2010	PY 2011
Reported NTG Ratio	0.71	0.73
Reported Net Energy Savings (MWh)	6,030	6,002
Reported Net Summer Coincident Demand Savings (MW)	5.76	5.74
Verified NTG Ratio	0.68	0.68
Verified Net Energy Savings (MWh)	5,770	5,460
Verified Net Summer Coincident Demand Savings (MW)	5.66	5.30

Source: Navigant analysis

Process Findings

Process analysis findings are based on results of the 246 HEIP participant surveys, interviews with program staff and contractors, as well as high-level review of program documents and functionality.

Key findings are as follows:

- The relations among PEC, Honeywell (the implementation contractor), and HEIP prequalified contractors (or trade allies) are strong. Training and guidance provided by PEC and Honeywell to contractors appears to result in high-quality work and effective implementation.

- About 60% of program participants learned about HEIP directly from contact or marketing from prequalified contractors, which demonstrates the success of PEC and Honeywell's partnerships with these trade allies.

- Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP.

- A significant 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% of participants indicated 8-10 for satisfaction with overall program experience.
  - Over 90% of participants indicated 8-10 for satisfaction with the contractor's quality of work.
  - Almost 80% 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; however, more than half (56%) of level 2 HVAC tune-up participants report "no change" in their energy bill after participating (well above all other measures).

- During interviews with Navigant, prequalified contractors who perform level 2 HVAC tune-ups generally indicated that they expect increased participation in the HVAC audit measure over the next several years, and that continued training will be necessary to ensure proper use of the diagnostic tool used to identify the appropriate tune-up procedures.

Recommendations

HEIP continues to display strong participation and customer satisfaction. The decrease in overall participation and savings in 2011 was likely influenced by the expiration of many federal tax incentives that were part of ARRA.

The evaluation team recommends several discrete actions for improving the HEIP offering, based on insights gained through staff and contractor interviews, participant and prequalified contractor surveys, analysis of program records and assumptions, and review of field verification data. These recommendations provide PEC 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

Table ES-8 summarizes these program recommendations.

Table ES-8. Summary of Recommendations

Program Impacts	
1. Update the tracking database to reflect measure-level deemed savings from this report.	
Improving Program Cost-Effectiveness	
2. Tighten eligibility requirements for measures not meeting savings expectations	a. Consider adjusting the qualifying post-retrofit insulation R-values to be dependent on pre-retrofit R-value.
Improving Program Delivery	
3. Offer technical training and workshops for contractors, with particular emphasis on using the diagnostic tool for HVAC audits.	
4. Continue to offer marketing training for contractors.	
5. Increase direct marketing through PEC.	
6. Increase participant awareness regarding receipt of rebate payment.	
Enhancing Program Tracking and Evaluation Efforts	
7. Ensure that all information from rebate application forms is included in program tracking database extracts.	a. All measures: include square footage of home, year home was built, heating and cooling types from rebate application. b. HVAC audit: include fields in tracking database for before and after efficiency index % readings from Service Assistant, as well as unit SEER rating. c. Duct sealing: include field in tracking database for location of ducts that were sealed, and results of pressure testing if applicable.
8. Modify program processes to integrate data collection activities required for EM&V.	a. Require the "ARI" 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.
9. Reconsider using the term "NTG" for the 0.39 adjustment factor applied to the PY 2010 tracking database.	

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 PEC offerings address efficiency opportunities in new homes and commercial buildings. This report covers evaluation, measurement, and verification (EM&V) activities for HEIP for Program Years 2010 and 2011 (PY 2010 and PY 2011) projects, defined as those receiving rebates during the 2010 and 2011 calendar years. Navigant Consulting, Inc. (Navigant) chose to perform simultaneous EM&V efforts and reporting for PY 2010 and PY 2011 in order to leverage program budgets for additional field verification and survey sample sizes, and to align evaluation efforts more closely with program delivery.

EM&V is a term adopted by PEC and 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 2010 and 2011 HEIP activity. Secondary objectives included:

- Estimate net and gross impacts by measure
- Provide updated deemed savings values for each measure[4]
- 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, PEC can use these results for reporting impacts to the North Carolina Utilities Commission and the Public Service Commission of South Carolina 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 PEC staff to improve the design of HEIP to increase benefits delivered while remaining cost-effective, thus providing greater value to ratepayers.

[4] Deemed savings values 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.

1.2 *Reported Program Participation and Savings*

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

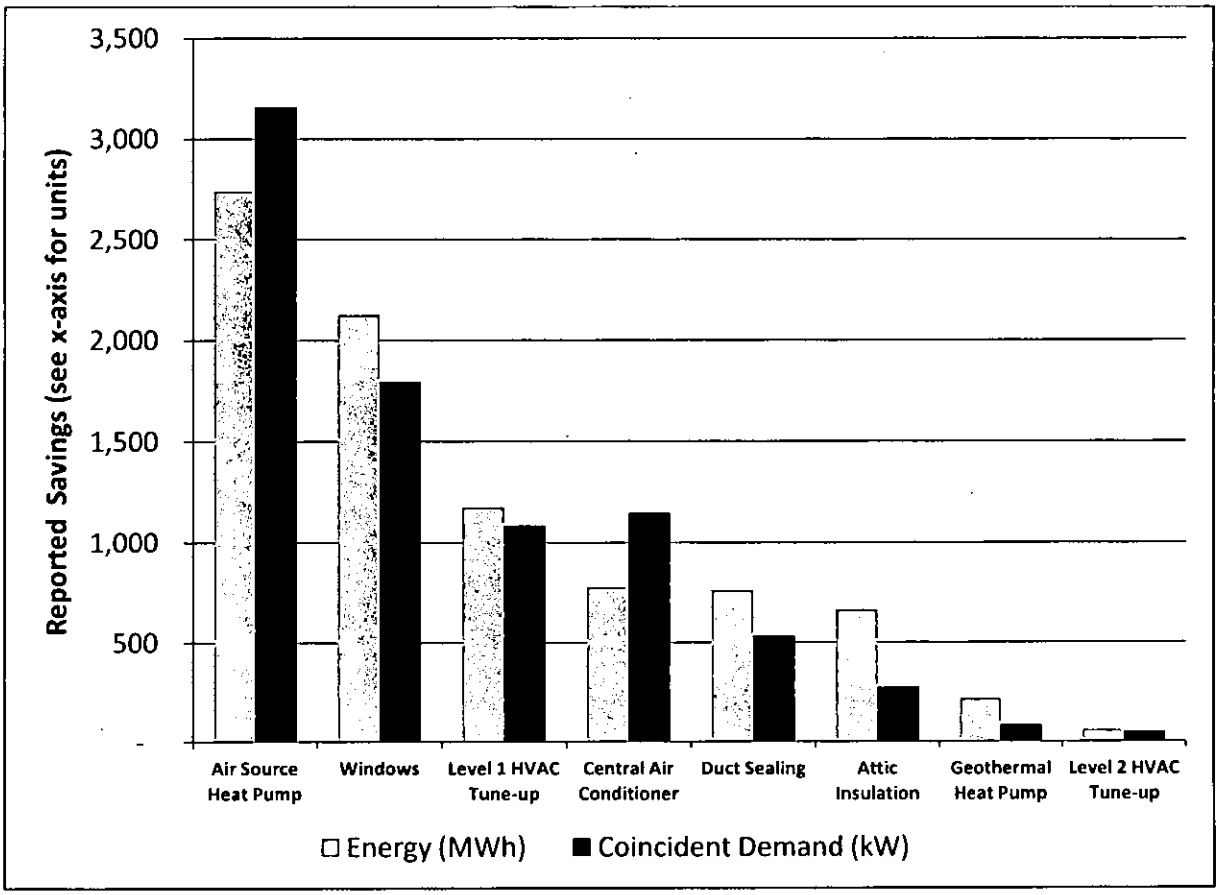
1. Heating, ventilation, and air conditioning (HVAC) equipment replacement (central air conditioner, air source, and geothermal heat pumps)
2. HVAC level 1 tune-up (condenser coil cleaning and general maintenance)
3. HVAC level 2 tune-up (same as level 1, plus correcting refrigerant charge and adjusting air flow)
4. Duct sealing
5. Window replacement
6. Attic insulation

PEC maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[5] based on assumed ("deemed") savings values.

[5] "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 PEC territory.

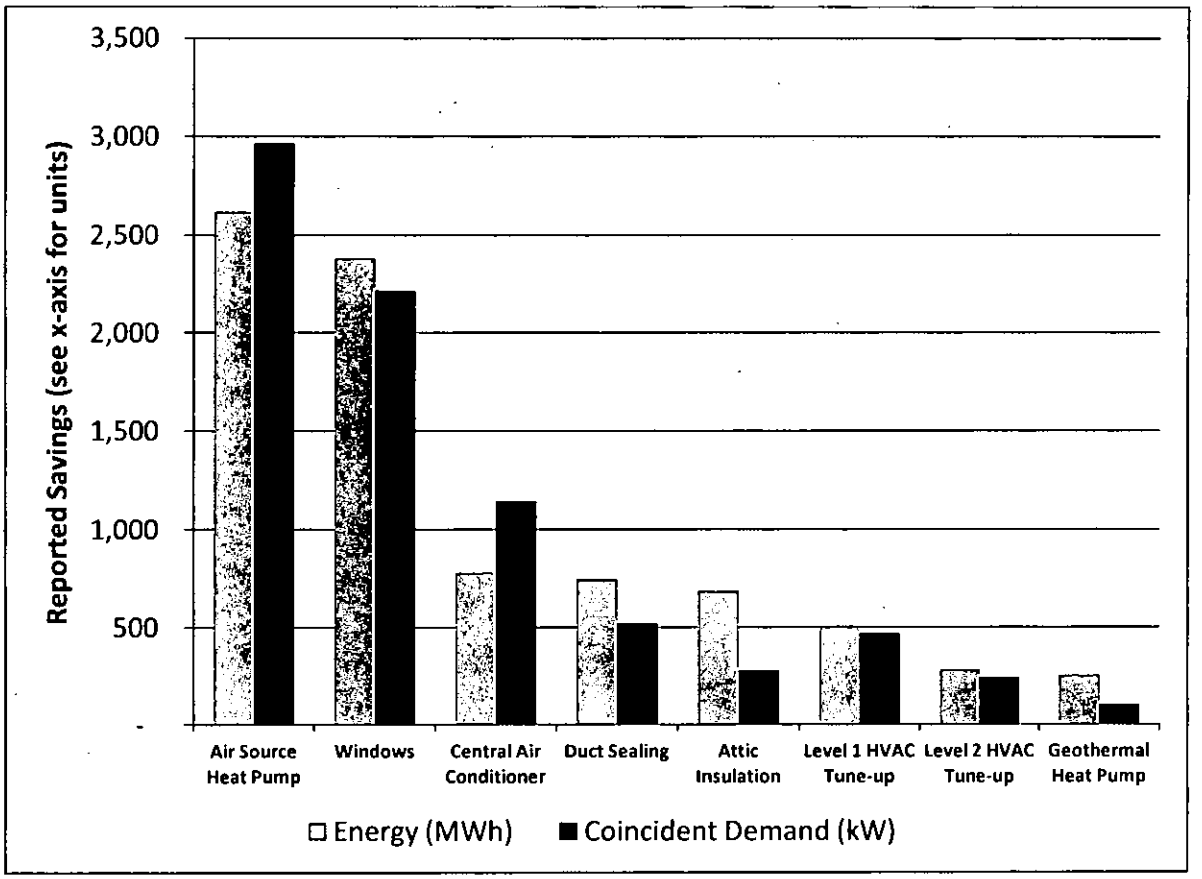
Reported gross savings from PY 2010 measures were over 8.5 gigawatt-hours (GWh) and 8.1 megawatts (MW). *Reported* gross savings from PY 2011 were approximately 8.3 GWh and 7.9 MW. In both 2010 and 2011, the air source heat pump replacement measure was the largest contributor to energy and summer demand savings, accounting for about one-third of the reported savings in those categories. In both years, there was negligible participation in the geothermal heat pump measure. Participation in the level 2 HVAC tune-up measure increased from 155 rebates in 2010 to 735 rebates in 2011. The share of peak demand reductions by measure was roughly the same as it was for total energy savings. Figure 1-1 and Figure 1-2 show the reported energy and demand savings by measure type for PY 2010 and PY 2011, respectively.

Figure 1-1. HEIP 2010 Reported Gross Savings by Measure



Source: Navigant analysis of HEIP tracking database

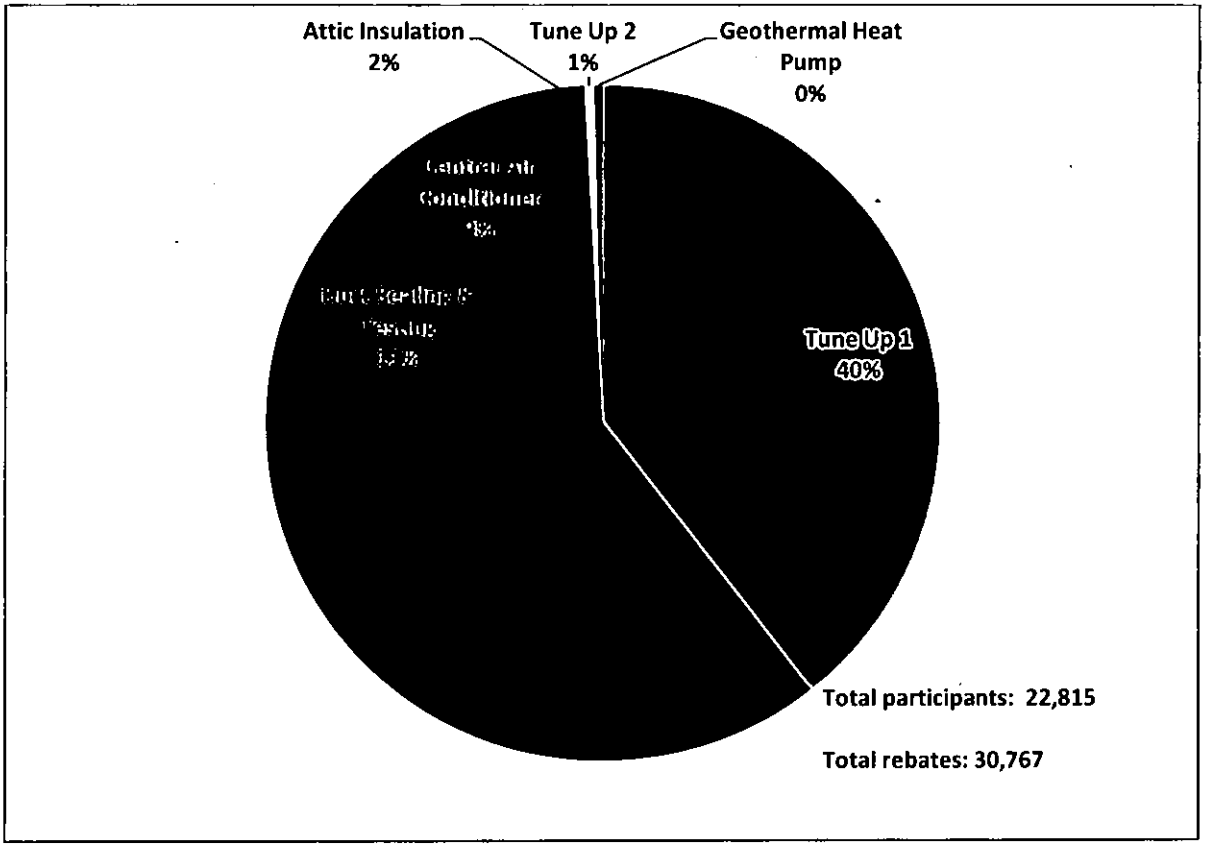
Figure 1-2. HEIP 2011 Reported Gross Savings by Measure



Source: Navigant analysis of HEIP tracking database

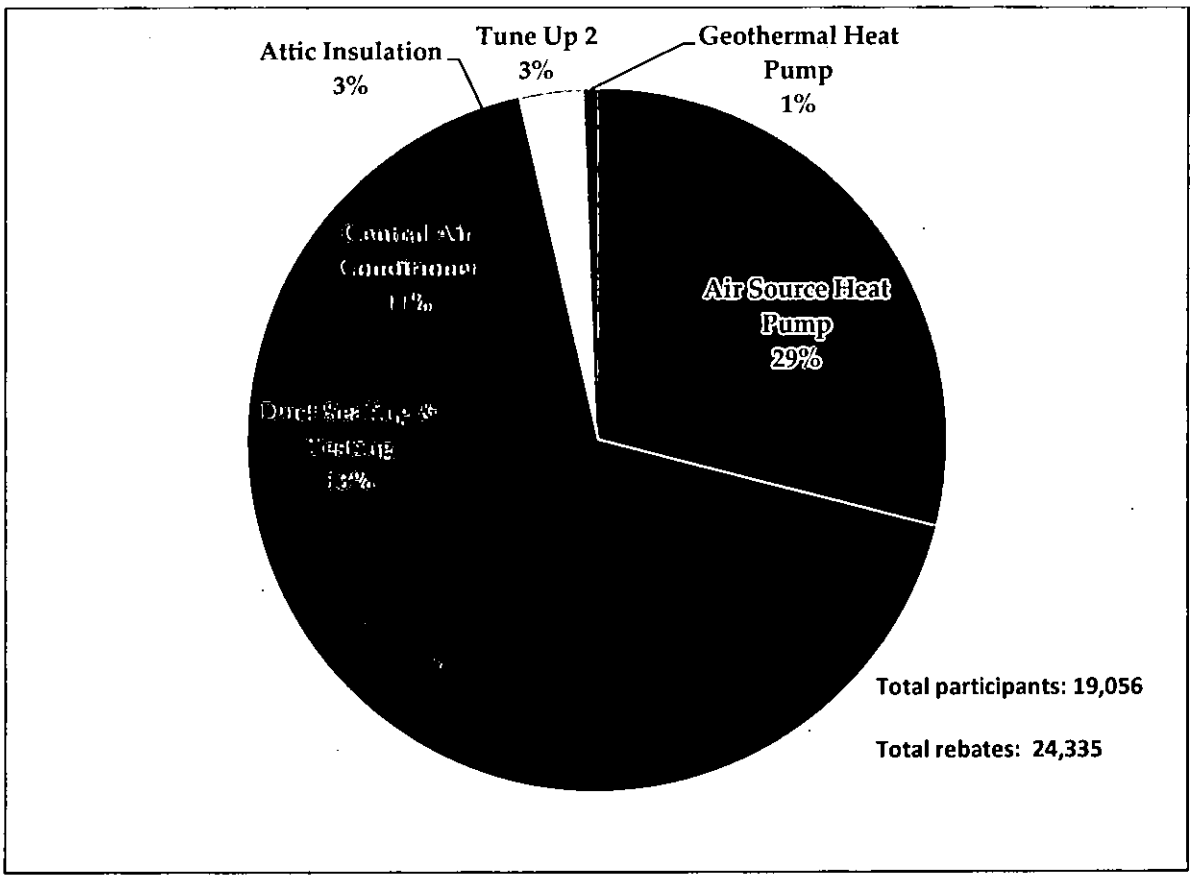
The number of rebates by measure for each program year is shown in Figure 1-3 and Figure 1-4.

Figure 1-3. HEIP 2010 Rebates by Measure



Source: Navigant analysis of HEIP tracking database

Figure 1-4. HEIP 2011 Rebates by Measure



Source: Navigant analysis of HEIP tracking database

Table 1-1 and Table 1-2 present a summary of participation and gross savings reported by measure. Participation in (and total savings from) the level 1 HVAC tune-up measure decreased significantly between 2010 and 2011. Navigant believes the measure was being phased out in favor of the more comprehensive HVAC audit and level 2 HVAC tune-up measure.

Table 1-1. HEIP 2010 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
Air Source Heat Pump	7,495	2,741	32%	3,161	39%	3,550	45%
Central Air Conditioner	2,686	776	9%	1,148	14%	0	0%
Geothermal Heat Pump	126	217	3%	85	1%	0	0%
Level 1 HVAC Tune-up	12,137	1,177	13%	1,085	13%	1,266	16%
Level 2 HVAC Tune-up	155	60	1%	51	1%	59	1%
Duct Sealing	3,400	761	9%	532	7%	591	8%
Windows	4,028	2,126	25%	1,797	22%	2,016	26%
Insulation	740	661	8%	273	3%	334	4%
Total	**30,767**	**8,518**	**100%**	**8,133**	**100%**	**7,816**	**100%**

Source: Navigant analysis of HEIP tracking database

Table 1-2. HEIP 2011 Reported Gross Annual Energy and Peak Demand Savings by Measure

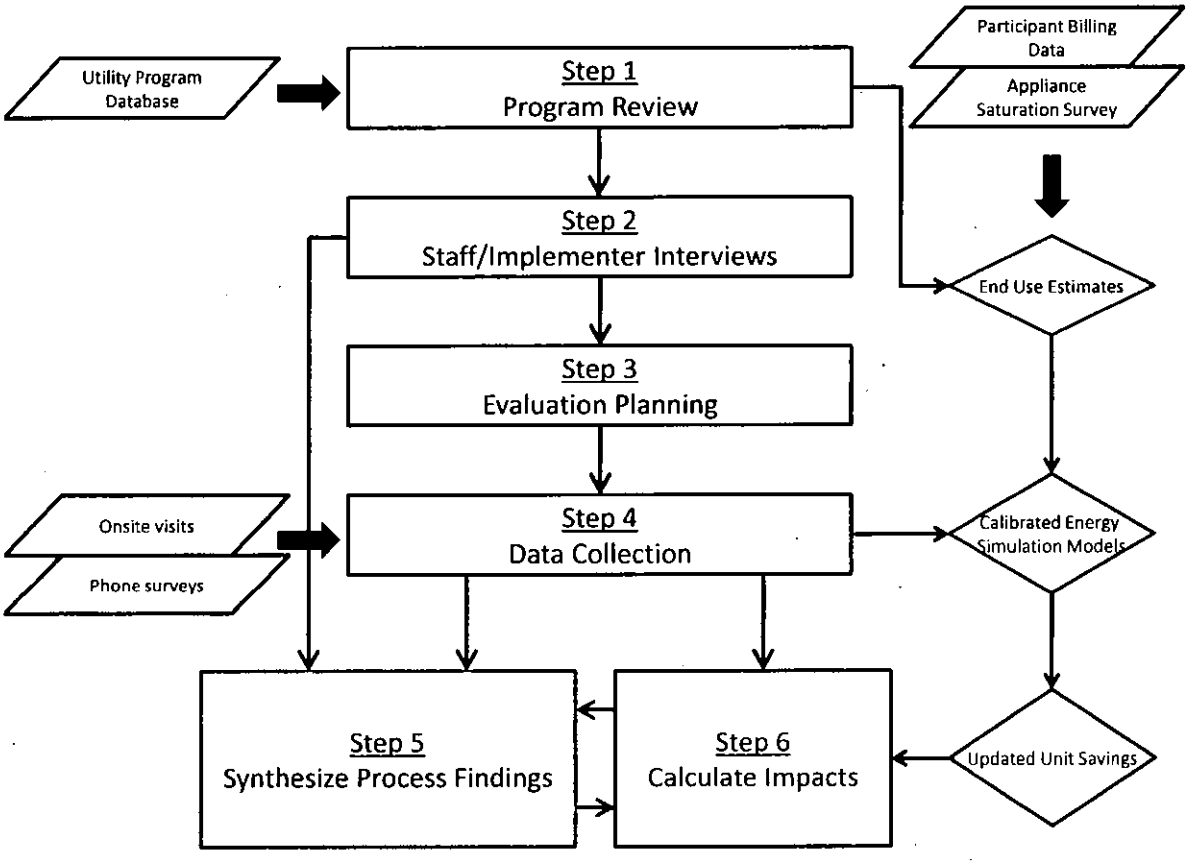
Measure	Rebate Count	Annual Energy Savings (MWh)	Fraction of Annual Energy Savings	Coincident Summer Demand Savings (kW)	Fraction of Coincident Summer Demand Savings	Coincident Winter Demand Savings (kW)	Fraction of Coincident Winter Demand Savings
Air Source Heat Pump	7,064	2,621	32%	2,967	37%	283	8%
Central Air Conditioner	2,665	781	9%	1,146	14%	107	3%
Geothermal Heat Pump	148	255	3%	102	1%	0	0%
Level 1 HVAC Tune-up	5,215	501	6%	469	6%	209	6%
Level 2 HVAC Tune-up	735	282	3%	243	3%	279	8%
Duct Sealing	3,060	747	9%	520	7%	1,224	33%
Windows	4,616	2,382	29%	2,216	28%	877	24%
Insulation	832	687	8%	282	4%	720	19%
Total	**24,335**	**8,256**	**100%**	**7,944**	**100%**	**3,699**	**100%**

Source: Navigant analysis of HEIP tracking database

2. Evaluation Methods

Navigant used a similar approach to evaluate PY 2010 and PY 2011 as was used in PY 2009. 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 2-1.[6]

Figure 2-1. Evaluation Process Flow Diagram



Source: Navigant

[6] 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:

- Program tracking database as provided by PEC
- 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.

2.2 *Step 2: Staff/Implementer Interviews*

The evaluation team conducted interviews with the HEIP Program Manager and several prequalified contractors 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:

- How program data is tracked from the customer installation through to PEC's reporting system
- Data quality control procedures in place to ensure the integrity of application data and quality of contractor work
- Measures of particular interest to PEC staff, such as increased focus on the attic insulation and air sealing measure
- Contractor training provided by PEC and Honeywell

2.3 *Step 3: Evaluation Planning*

For PY 2010 and PY 2011, Navigant focused on field verification for the top measures with regards to energy savings. Due to the expense related to field verification, a small amount of value would have been added by focusing on the smaller contributing measures, as they were sufficiently assessed in PY 2009. Navigant expects future field verification efforts to shift according to heightened focus on some measures by PEC and the addition of new program measures.

The PY 2009 evaluation team performed a comprehensive assessment of the per-unit energy and demand savings values for each measure (i.e. 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 measure in PY 2010 and PY 2011to 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 analysis.

The **telephone sample** was stratified primarily by measure and secondarily by region to give an accurate representation of measure-level results. As shown in Table 2-1, 246 participating customers responded to the telephone survey and each measure was represented by at least 25 respondents.

Table 2-1. Sample Sizes for Participant Telephone Surveys

	# Respondents	# of rebates in 2010 and 2011[a]
Heat pump/AC	62	19,910
Level 1 HVAC tune-up	30	17,352
Level 2 HVAC tune-up	25	890
Duct sealing	31	6,460
Windows	42	8,644
Attic insulation	27	1,572
Geothermal heat pump	29	274
Total	**246**	**55,102**

Source: Navigant analysis

a. Includes rebates paid in calendar years 2010 and 2011.

The **field verification** sample was stratified by measure and region, with the objective of getting a significant verification sample for each measure, spread across all regions, and 90/10 confidence and precision at the program level. The fieldwork addressed heat pump and AC installations, windows, and duct sealing—measures accounting for more than 75% of energy savings in 2010 and 2011.[7]

[7] Field verification was not conducted for attic insulation or geothermal heat pumps due to lower contribution to overall savings. Furthermore, the evaluation team concluded that on-site verification of level 1 and level 2 HVAC tune-ups would be unreliable and potentially misleading without conducting expensive and difficult-to-achieve pre-post measurement of equipment performance; thus, these measures were not included in the on-site verification sample.

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

Table 2-2. Field Verification Sample

Measure Category[a]	# Measures	# of rebates in 2010 and 2011[b]
Heat pump/AC	30	19,910
Windows	17	8,644
Duct sealing	17	6,460
Total[c]	**64**	**35,014**

Source: Navigant analysis

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 40, but many sites had multiple measures.
c. Participants include all those receiving rebates in calendar years 2010 and 2011.

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 2010 and 2011 tracking database and by reviewing secondary literature, 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 home with rebated windows, the number of verified windows was compared to the number of reported windows.

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**.[8] A detailed description of this process can be found in Navigant's 2009 EM&V report for HEIP.[9] Navigant updated the deemed savings values for each measure in PY 2010 and PY 2011 by applying the 2009 simulation outputs to the 2010 and 2011 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 results of the participant survey to estimate a net-to-gross 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. 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: those involved in the program's day-too-day management; the program prequalified contractors who deliver program services; and the customers who received those services. The evaluation team interviewed internal PEC staff, and conducted surveys with program participants as well as discussions with prequalified contractors that participated in the program in 2010 and 2011.The evaluation team analyzed survey results to determine what portions of the program are working well, and where PEC might be able to make improvements.

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[8] "Unit energy savings" refers to the assumed savings for the unit basis of each measure (e.g., per ton of central air conditioning system, per square foot of attic insulation).

[9] *2009 EM&V Report for the Home Energy Improvement Program, Final Report,* Prepared by Navigant Consulting, April 11, 2011.

3. Program Impacts

PEC's program tracking database provided savings values for energy and peak demand ("**reported gross savings**") based on program participation data and assumed **"deemed savings"** values for each measure.[10] As discussed in Section 2.5, the EM&V team verified the accuracy of these reported savings values for each measure category using 1) on-site data collection to conduct field verification of measure installations, and 2) program participant characteristics.[11] 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 definitions 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.[12] Table 3-1 and Table 3-2 compare the **verified gross savings** to the **reported savings** for 2010 and 2011, respectively. The relationship between these two values is the "gross realization rate," shown here to be 99% for energy savings and 103% for summer peak demand reductions in 2010, and 97% for energy savings and 98% for summer peak demand reductions in 2011.

Table 3-1. 2010 Annual Energy and Demand Reductions

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Reported Gross Savings	8,518	8.13	7.82
Verified Gross Savings	8,458	8.36	3.56
Gross Realization Rate	99%	103%	46%[a]

Source: Navigant analysis

a. PEC retroactively updated the reported savings for PY 2010 using adjustment factors from Navigant's PY 2009 EM&V report. The adjustment factors for summer demand savings were also applied to winter demand savings, resulting in a low realization rate for winter demand savings. PEC could further adjust 2010 winter demand savings by applying "measure unit savings adjustments" that are specific to winter demand.

[10] PEC retroactively adjusted the PY 2010 reported savings to include recommendations from Navigant's EM&V report from PY 2009. All reported values for PY 2010 shown in this report reflect those adjustments. The program tracking database was adjusted at the annual summary level; therefore, individual entries in the tracking database for PY 2010 still reflect the pre-adjustment deemed savings values.

[11] The PY 2009 evaluation team used billing data, appliance saturation data, and energy simulation modeling to assess the most appropriate unit savings values.

[12] 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.

Table 3-2. 2011 Annual Energy and Demand Reductions

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)	Winter Coincident Demand Savings (MW)
Reported Gross Savings	8,256	7.94	3.70
Verified Gross Savings	7,989	7.81	3.39
Gross Realization Rate	97%	98%	92%

Source: Navigant analysis

The remainder of this chapter presents the detailed impact findings broken down into the component parts:

1. **Field verification rate:** ratio of savings from measures verified on-site to that reported in the program database
2. **Updated deemed savings values:** estimated savings for each measure determined by annual mix of tracking database
3. **Verified gross savings:** gross reductions in energy consumption and peak demand verified through EM&V activities; and **Gross realization rate:** ratio of verified gross savings to reported savings
4. **NTG ratio and net savings:** 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 measure category using on-site verification of size, quantity, and efficiency characteristics, 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 windows, 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., *U-value and solar heat gain coefficient of new windows, 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 40 field verification site visits for HEIP participants who received rebates through the program in 2010 and the first half of 2011. The 40 site visits included verification of 64 measures, as some of the participants received rebates for more than one measure.

Navigant performed field verification for the top four contributing measures with respect to program-level energy savings: air source heat pumps and central air conditioners (combined into one category for sampling purposes), windows, and duct sealing.[13] Table 3-3 shows the quantities of field verification measures assessed.

Table 3-3. Evaluated Measures for 2010 and 2011

	Evaluated Measures (PY 2010)	Evaluated Measures (PY 2011)	Total
ASHP / CAC	18	12	30
Duct Sealing	10	7	17
Windows (sites)	12	5	17

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 well the verified characteristics match up with 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% for both energy and demand.

- **Duct sealing:** Navigant conducted verification visits at 14 sites for a total of 17 duct sealing measures. Of the 17 evaluated measures, 15 achieved Navigant's criteria for properly sealed ducts. The duct sealing work was inadequate at one of the sites, which contained two measures (one attic, one vented crawl, rebated in separate years). Verification rates were determined on a pass/fail basis.

- **Windows:** The reported window quantity was fairly accurate for the sample sites. Navigant found the verified window count to be 101% of the reported window count for the PY 2010 sample participants, and 94% for PY 2011 sample participants. The combined total was 99%, although some variation existed among individual sites.

[13] Navigant did not perform field verification for level 1 and level 2 HVAC tune-up measures due to complications and expense related to accurate assessment, or to attic insulation and geothermal heat pumps due to low overall contribution to program savings.

- Navigant found the verified window square footage to be significantly different from the reported window square footage. The PY 2009 evaluation team discovered the same trends during the previous evaluation cycle. Navigant believes the discrepancy in square footage may be linked to the way in which windows are tracked in the database. For some sites, it appears that the tracking database reports the total square footage per window *model*, and for other sites the database reports the square footage for each window. As an illustrative example, one site reported 15 windows and a square footage of 9.8 (presumably 9.8 sq. ft. *each*), and another site reported 9 windows for a square footage of 95 (presumably 95 sq. ft. *total*).

- To obtain the final field verification rates for windows, Navigant averaged the verification rates for window count and window square footage. Navigant also applied an algorithm to the tracking database as an attempt to identify square footage values that appeared "extreme" and probably due to participants who reported total square footage instead of per-window square footage values. The default assumption is that square footage was reported on a per-window basis.

» **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. Navigant believes that investing in M&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 3-4 below.

Table 3-4. PY 2010 Field Verification Rates by Measure

Measure	Annual Energy Savings	Peak Demand Reductions[b]	Winter Demand Reductions[b]
Air source heat pump	100%	100%	100%
Central air conditioner	100%	100%	100%
Geothermal heat pump[a]	96%	97%	97%
HVAC level 1 tune-up[a]	96%	97%	97%
HVAC level 2 tune-up[a]	96%	97%	97%
Duct sealing	90%	90%	90%
Windows	92%	92%	92%
Attic insulation[c]	100%	100%	100%
Program Average[d]	**96%**	**97%**	**97%**

Source: Navigant analysis

a. On-site verification was not performed for level 1or level 2 tune-ups, due to the difficulties and expense involved in accurate measurement, or for geothermal heat pumps, due to the small number of available sites (25) and the fact that geothermal heat pumps accounted for a small portion of reported savings. To be conservative, these measures were assigned the program average field verification rate of 96% for energy, 97% for coincident demand, and 97% for winter demand.

b. The energy and demand field verification rates can be different due to a measure's contribution to overall energy or demand savings.

c. Rather than assign the program average to the insulation measure, Navigant assigned a rate of 100% due to the high verification rate found during PY 2009 EM&V.

d. Program Average represents the weighted average field verification rate from the measures assessed during site visits for PY 2010 and PY 2011, which includes: air source heat pump, central air conditioner, duct sealing, and windows. 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.

Table 3-5. PY 2011 Field Verification Rates by Measure

Measure	Annual Energy Savings	Peak Demand Reductions[b]	Winter Demand Reductions[b]
Air source heat pump	100%	100%	100%
Central air conditioner	100%	100%	100%
Geothermal heat pump[a]	95%	96%	90%
HVAC level 1 tune-up[a]	95%	96%	90%
HVAC level 2 tune-up[a]	95%	96%	90%
Duct sealing	86%	86%	86%
Windows	91%	91%	91%
Attic insulation[c]	100%	100%	100%
Program Average[d]	**95%**	**96%**	**90%**

Source: Navigant analysis

Note: See table footnotes from Table 3-4 above.

Field verification rates were generally high, indicating successful implementation and quality control.

3.1.2 Combined Verification Rates

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 3-6. The corresponding values for summer coincident demand and winter demand can be found in Appendix C. These results demonstrate that field verification rates are fairly consistent each year, and a combined value provides the best representation of program performance.

Table 3-6. Weighted Field Verification Rates for Energy across PY 2009-2011

Measure	2009	2010	2011	Weighted
Air source heat pump	99%	100%	100%	100%
Central air conditioner	99%	100%	100%	100%
Geothermal heat pump	100%	96%	95%	96%[a]
Level 1 HVAC tune-up	100%	96%	95%	97%
Level 2 HVAC tune-up	NA	96%	95%	95%
Duct sealing	92%	90%	86%	89%
Windows	102%	92%	91%	93%
Attic insulation	110%	100%	100%	100%[b]

a. Geothermal heat pumps were not assessed for PY 2010 and PY 2011, and Navigant assigned the program average verification rates.

b. A combined verification rate of 100% was applied to insulation, due to the high values encountered during PY 2009 EM&V efforts.

3.2 *Updated Deemed Savings Estimates*

During EM&V activities for PY 2009, Navigant's evaluation team determined the most appropriate **deemed 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.[14]

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 2010 and 2011 program

[14] *2009 EM&V Report for the Home Energy Improvement Program, Final Report*, Prepared by Navigant Consulting, April 11, 2011.

tracking databases. For example, a participant who installed an air source heat pump of a given efficiency in PEC'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 2010 and 2011.[15] 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 window square footage, and PEC service region). Some values increased, (e.g., kWh savings for windows increased from 516 kWh per window participant in 2009 to 572 kWh per window participant in 2010), while other values decreased (e.g., summer demand savings for air source heat pumps decreased from 0.424 kW in 2009 to 0.419 kW in 2010).

3.2.1 Measure-specific Deemed Savings Values

The 2009 simulation results were applied to the 2010 and 2011 program data to determine updated deemed savings values that are representative of the actual mix of efficiencies and regional distribution of rebated measures during those years. Once each rebated measure was matched with the appropriate savings estimate, the field verification rates were applied to estimate updated deemed savings values. The deemed savings values for 2010 and 2011 differ from 2009 due to differences in these installation trends and in field verification rates. Updated deemed savings values for energy are found in Table 3-7. The corresponding values for summer coincident demand and winter demand can be found in Appendix C.

Table 3-7. Deemed Energy Savings for each Measure in PY 2009-2011

Energy	2009 (kWh)	2010 (kWh)	Change from 2009	2011 (kWh)	Change from 2009
Air source heat pump	371	366	-1.5%	367	-1.1%
Central air conditioner	293	279	-4.7%	283	-3.5%
Geothermal heat pump	1725	1725	0.0%	1725	0.0%
Level 1 HVAC tune-up	96	104	8.1%	104	8.1%
Level 2 HVAC tune-up	N/A	384	N/A	384	N/A
Duct sealing	244	265	8.6%	265	8.6%
Windows	516	572	10.8%	543	5.2%
Attic insulation	830	727	-12.5%	669	-19.4%

Source: Navigant analysis

[15] Navigant assumed that the energy model characteristics used in the PY 2009 evaluation remained valid for 2010 and 2011 participants. There were no major program changes within the time span that would suggest a significant difference in the "typical" participant.

3.2.2 Discussion of Deemed Savings Adjustments

In the previous section, several savings values were presented for PY 2010 and PY 2011 that differ from those found during the 2009 EM&V analysis. 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 primary drivers affecting the change in annual deemed savings values are:

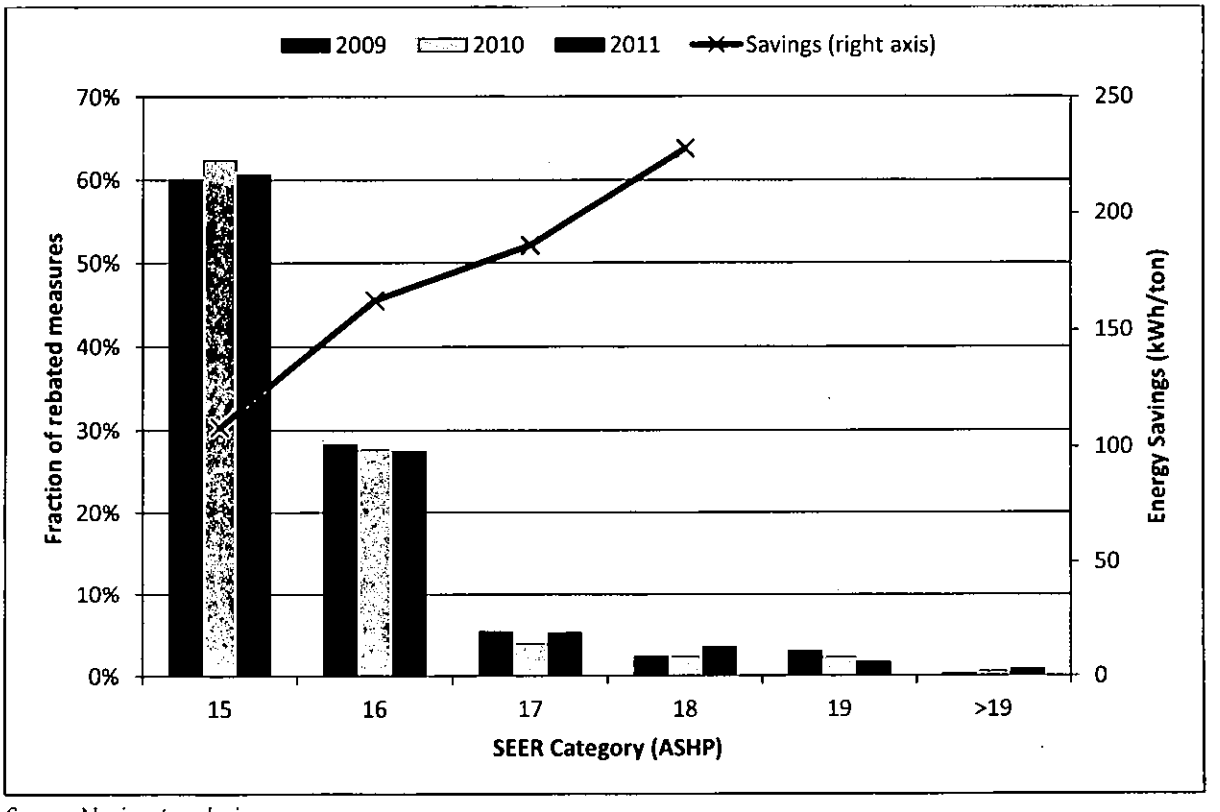
1. Annual mix of rebated measure efficiencies
2. Annual mix of baseline measure efficiencies
3. Annual trends in geographic location, as defined by PEC's northern, southern, eastern, and western regions
4. Measure location (i.e., vented crawlspace vs. attic for duct sealing)

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 HVAC replacement, attic insulation, and level 2 HVAC tune-up measures.

HVAC Replacement:

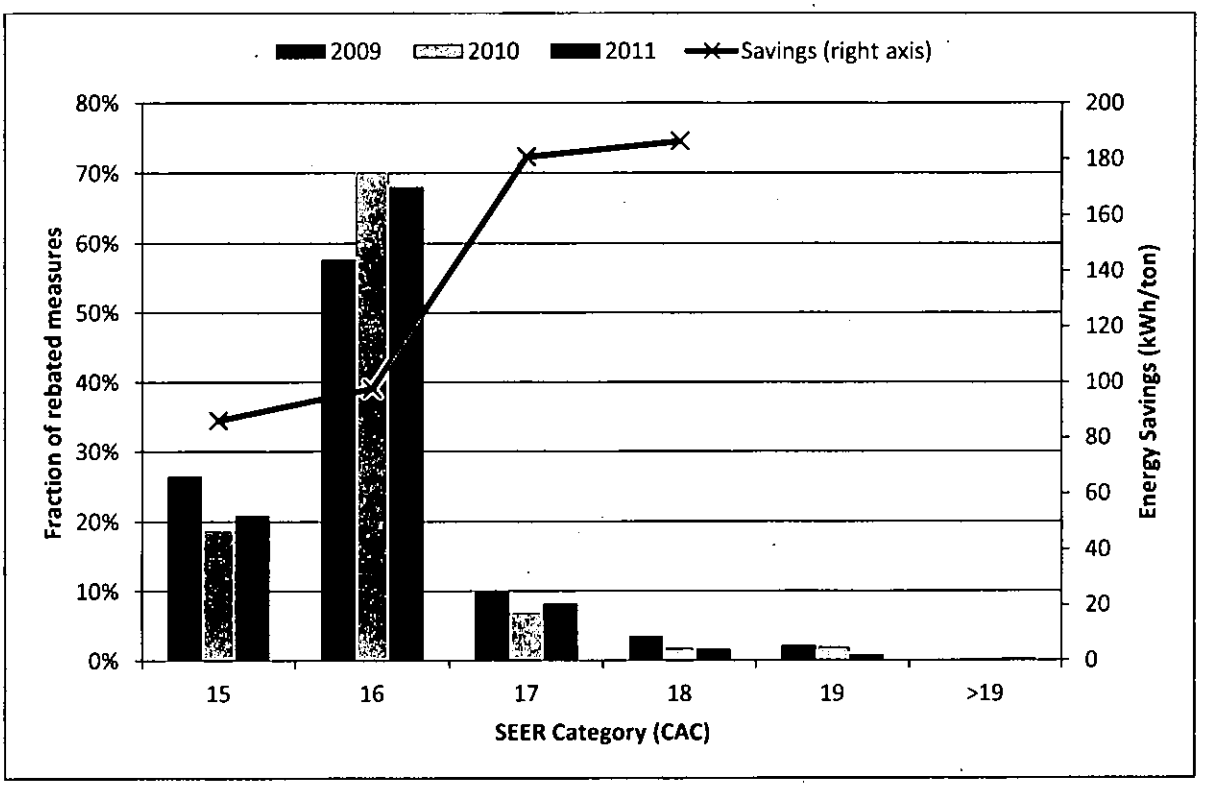
Annual energy and demand savings estimates for HVAC replacement measures were driven primarily by the annual trends in *rebated measure efficiency* (SEER value), *rebated measure size* (tons), and geographic location. Figure 3-1 and Figure 3-2 show the annual efficiency installation trends for the air source heat pump and central air conditioner replacement measures, respectively, along with the associated energy savings for each level. Most heat pump rebates fall into the SEER 15 category, and most central air conditioner rebates fall into the SEER 16 category, which aligns with qualifying levels for the ARRA rebates. There was little change in the average SEER rating, tonnage, and geographic distribution between 2009, 2010, and 2011; hence, the relatively small adjustments to deemed savings shown in 3.2.1. However, the purpose of Figure 3-1 and Figure 3-2 is to demonstrate the sensitivity of energy savings to unit efficiency, and to highlight the potential for added savings.

Figure 3-1. Trends in Replacement Efficiency for Air Source Heat Pump



Source: Navigant analysis

Figure 3-2. Trends in Replacement Efficiency for Central Air Conditioner



Source: Navigant analysis

Attic Insulation:

The energy savings per site for attic insulation in 2010 were 12.5% lower than they were 2009, and the 2011 savings per site were 19.4% less than 2009. Table 3-8 summarizes the annual differences in the installation trends for attic insulation. The decrease in savings was driven by three factors:

1. Changes in pre- and post-retrofit R-values.
2. A decrease in the average square footage of insulation installed by participants.
3. The field verification rate for attic insulation in 2009 was 110%. For PY 2010 and 2011, Navigant assumed a rate of 100% to be conservative, because attic insulation was not assessed during field verification.

Table 3-8. Annual Trends in Attic Insulation Characteristics

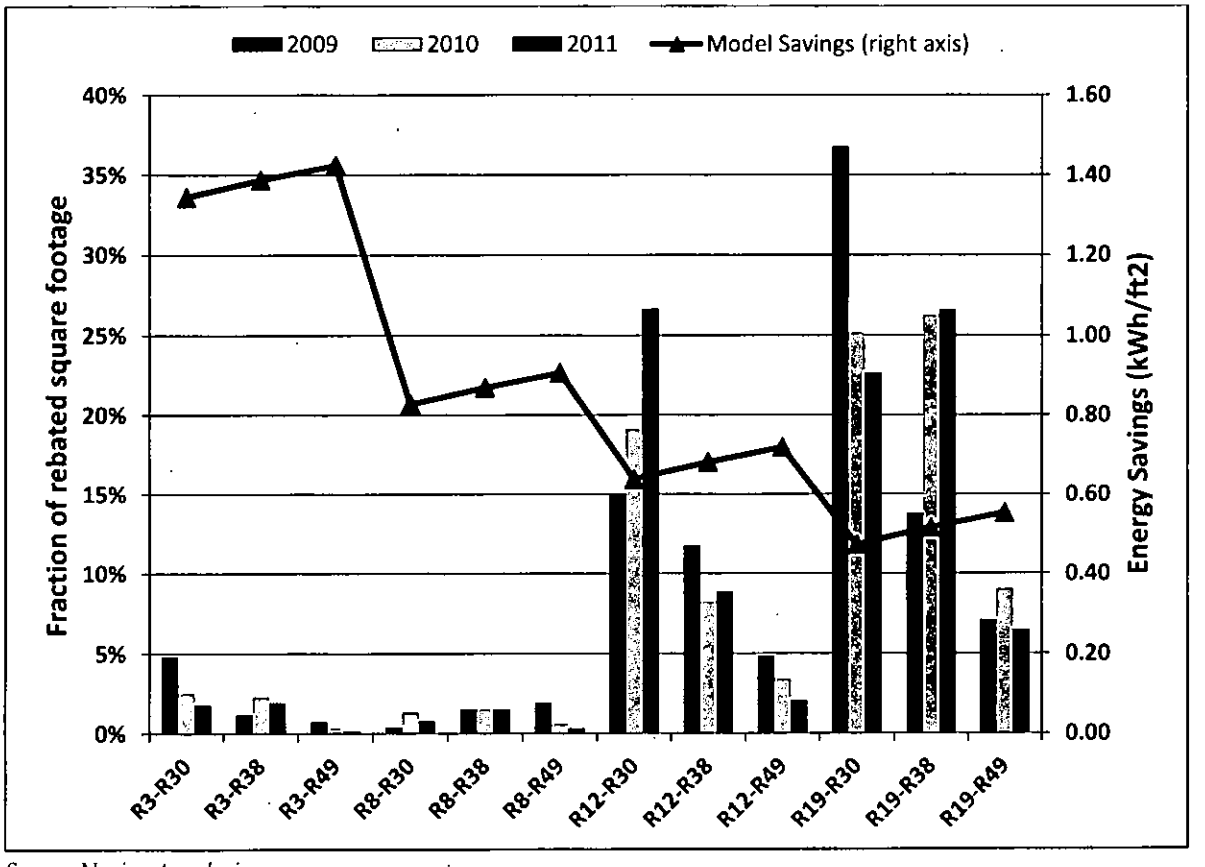
	2009	2010	2011
kWh savings per site	830[a]	727	669
Average Base R-Value	15.2	14.9	14.7
Average Rebated R-Value	35.2	36.2	35.0
Average ft² installed	1,356	1,337	1,265
Field Verification Rate	110%	100%	100%

Source: Navigant analysis

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

Figure 3-3 shows graphically the annual trends in attic insulation efficiency levels and the associated energy savings. This figure shows that most participants with a baseline R-value of 12 are upgrading to R-30, and most participants with a baseline R-value of 19 are upgrading to R-30. Increased savings could be achieved by convincing these customers to achieve a higher post-retrofit R-value.

Figure 3-3. Annual Trends in Attic Insulation Efficiency and Associated Energy Savings



Source: Navigant analysis

Level 2 HVAC Tune-up:

To evaluate the level 2 HVAC tune-up measure, Navigant conducted secondary research and performed interviews with several of PEC's prequalified contractors that perform a high number of level 2 HVAC tune-ups, or the HVAC audit measure. At this time, there is no basis to adjust the deemed savings for the level 2 tune-up measure; however, PEC should work carefully with Honeywell to ensure that contractor training is comprehensive so that energy and demand savings can be achieved. In PY 2011, the level 2 measure accounted for about 3% of the verified savings for HEIP; however, participation is poised to grow in future years. Contractors predict increased participation in the HVAC audit and tune-ups over the next year.

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 81% for insulation to as high as 106% for duct sealing. Realization rates for most measures were in the 95% to 100% range. The deemed savings adjustments discussed in Section 3.2 drove the gross energy realization rates in all cases since the field verification rates were all close to 100%.

Table 3-9 and Table 3-10 present gross energy realization rates for all measure categories in 2010 and 2011, respectively. The associated values for summer and winter demand are presented in Appendix C.

Table 3-9. Verified Gross Energy Savings by Measure for PY 2010

Measure	Reported Energy Savings (MWh)	Verified Gross Energy Savings (MWh)	Gross Realization Rate
Air source heat pumps	2,741	2,737	100%
Central air conditioners	776	749	97%
Geothermal heat pump	217	208	96%
Level 1 HVAC tune-up	1,177	1,229	104%
Level 2 HVAC tune-up	60	57	95%
Duct sealing	761	807	106%
Windows	2,126	2,133	100%
Attic insulation	661	538	81%
Total	**8,518**	**8,458**	**99%**

Source: Navigant analysis

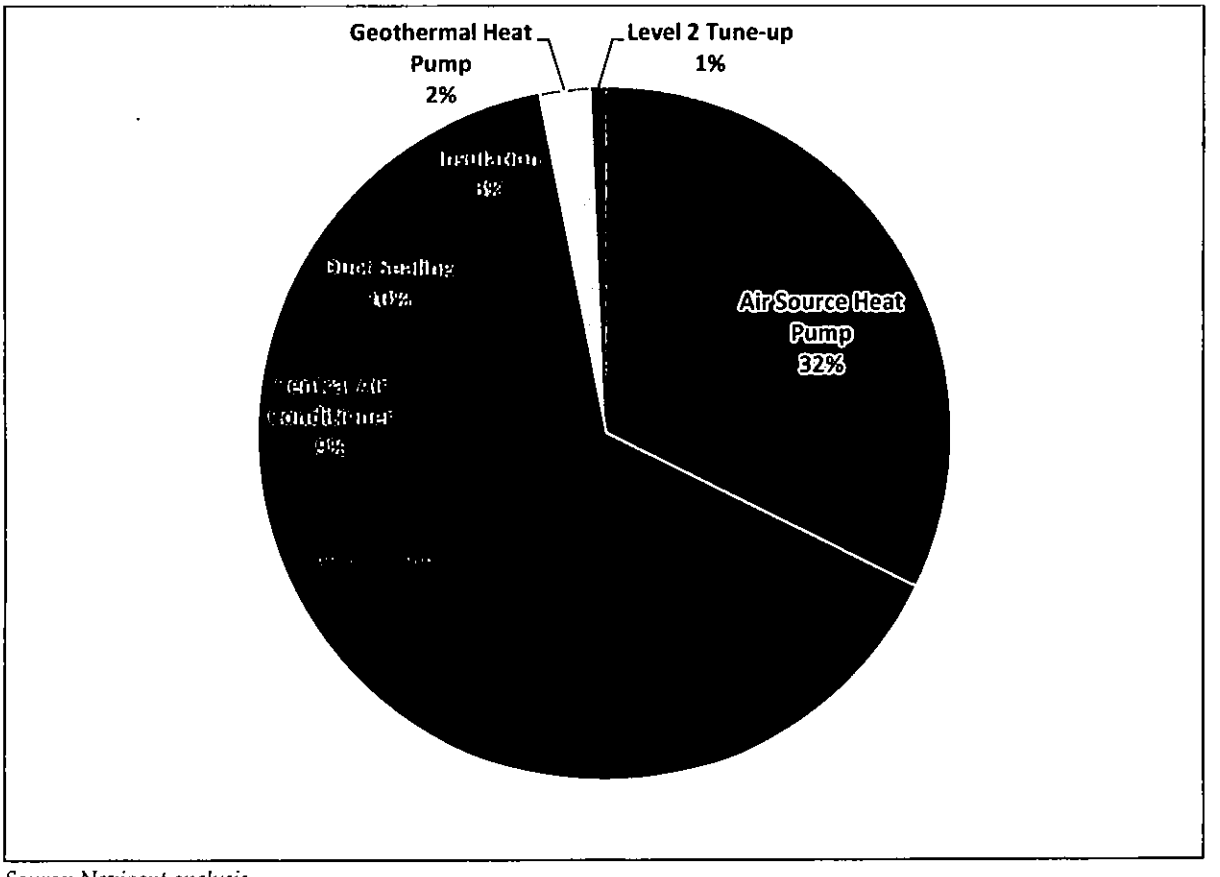
Table 3-10. Verified Gross Energy Savings by Measure for PY 2011

Measure	Reported Energy Savings (MWh)	Verified Gross Energy Savings (MWh)	Gross Realization Rate
Air source heat pumps	2,621	2,592	99%
Central air conditioners	781	752	96%
Geothermal heat pump	255	245	96%
Level 1 HVAC tune-up	501	527	105%
Level 2 HVAC tune-up	282	268	95%
Duct sealing	747	725	97%
Windows	2,382	2,322	97%
Attic insulation	687	557	81%
Total	**8,256**	**7,989**	**97%**

Source: Navigant analysis

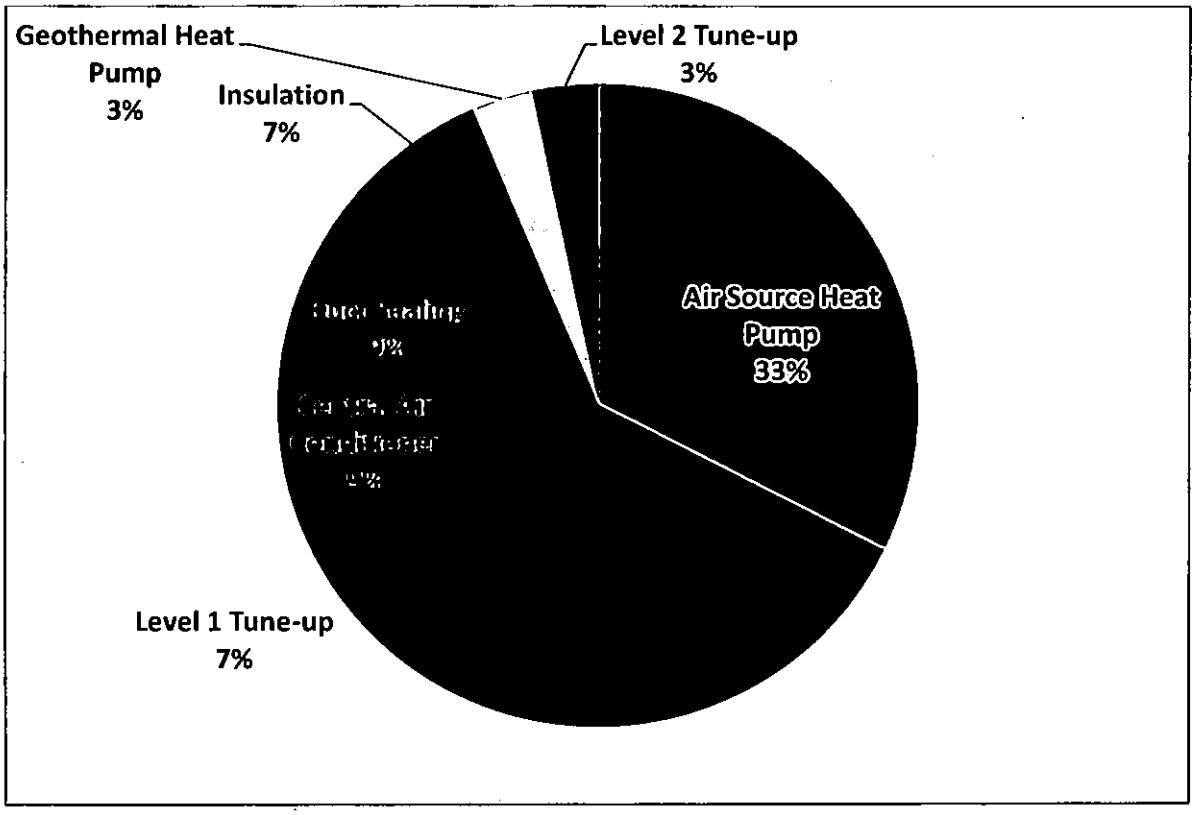
Figure 3-4 and Figure 3-5 show each measure's contribution to overall gross energy savings for PY 2010 and 2011, respectively. In both years, the air source heat pump measure contributed about one-third of verified energy savings, and windows were not far behind. A notable decrease in verified energy savings from level 1 HVAC tune-ups can been seen between 2010 and 2011, due to a decrease in customer participation. Navigant believes this measure was being phased out in favor of the more comprehensive level 2 HVAC tune-ups associated with the HVAC audit measure.

Figure 3-4. Measure-level Contribution to Verified Gross Energy Savings for PY 2010



Source: Navigant analysis

Figure 3-5. Measure-level Contribution to Verified Gross Energy Savings for PY 2011



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), and 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, and Appendix B provides definitions, methods, and further detail on the analysis and findings.

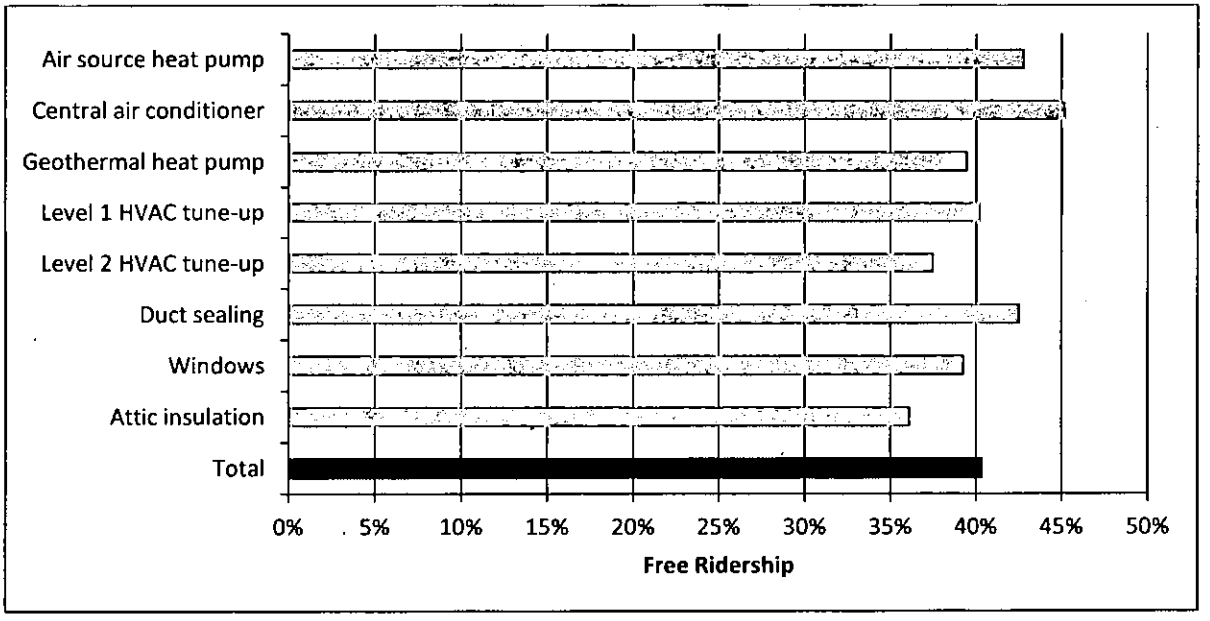
Free Ridership

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 3-6 as a free ridership estimate for each measure category. The free ridership scores range from 36% for attic insulation, to a high of 45% for central air conditioner replacement.

Free ridership for the HEIP program (i.e., across all measures) is estimated at 41% of program-reported savings when the measure-specific free ridership values are weighted according to the measure category's share of total reported savings. The window and air source heat pump measures (representing the largest projects) represent over 60% of all savings and have near-average free ridership.

Figure 3-6. Free Ridership by Measure Category



Source: Navigant analysis

Spillover

The HEIP program influenced approximately 23% of participants to install additional energy efficiency measures that were not rebated or included in program records. Over 63% 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). Based on the survey findings, the EM&V team estimates the overall program spillover to be 9% of program-reported savings. See Appendix B for additional explanation, including methods.

Net-to-Gross Ratio

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

$$NTG = 1 - Free\ ridership + Total\ Spillover$$

Using the overall free ridership value of 41% and the overall spillover value of 9%, the net-to-gross ratio is then 1 – 0.41 + 0.09 = 0.68. The estimated net-to-gross ratio of 0.68 implies that for every 100 kWh of realized savings recorded in HEIP records, 68 kWh can be attributed to the program.

Table 3-11 displays the free ridership scores by measure category and the free ridership, spillover, and NTG scores for the program as a whole.

Table 3-11. NTG for the HEIP Program

Measure Category	Free Ridership	Spillover[b]	NTG Ratio
Air source heat pump	42%	9%	0.67
Central air conditioner	45%		0.64
Geothermal heat pump	39%		0.70
Level 1 HVAC tune-up	40%		0.69
Level 2 HVAC tune-up	37%		0.72
Duct sealing	43%		0.66
Windows	39%		0.70
Attic insulation	36%		0.73
HEIP Total[a]	**41%**	**9%**	**0.68**

[a] HEIP Total value for free ridership and spillover are weighted to reflect each measure category's share of total reported energy savings and population.
[b] The Total spillover value is applied to each measure category to obtain the measure-specific NTG ratios.

Source: Navigant analysis

Navigant calculated the verified net energy and demand savings for each measure category by multiplying the measure's NTG ratio by its verified gross savings. Verified net energy savings are shown in Table 3-12 and Table 3-13 for PY 2010 and PY 2011, respectively. The corresponding tables for net demand impacts can be found in Appendix C.

Table 3-12. Verified Net Energy Impacts for PY 2010

Measure	Verified Gross Energy Savings (MWh)	Net-to-Gross Ratio	Verified Net Energy Savings (MWh)
Air source heat pumps	2,737	0.67	1,835
Central air conditioners	749	0.64	477
Geothermal heat pump	208	0.70	145
Level 1 HVAC tune-up	1,229	0.69	850
Level 2 HVAC tune-up	57	0.72	41
Duct sealing	807	0.66	536
Windows	2,133	0.70	1,492
Attic insulation	538	0.73	395
Total[a]	**8,458**	**0.68**	**5,770**

Source: Navigant analysis

a. Totals may differ from sum of respective columns due to rounding.

Table 3-13. Verified Net Energy Impacts for PY 2011

Measure	Verified Gross Energy Savings (MWh)	Net-to-Gross Ratio	Verified Net Energy Savings (MWh)
Air source heat pumps	2,592	0.67	1,738
Central air conditioners	752	0.64	479
Geothermal heat pump	245	0.70	171
Level 1 HVAC tune-up	527	0.69	362
Level 2 HVAC tune-up	268	0.72	193
Duct sealing	725	0.66	482
Windows	2,332	0.70	1,623
Attic insulation	557	0.73	409
Total[a]	**7,989**	**0.68**	**5,460**

Source: Navigant analysis

a. Totals may differ from sum of respective columns due to rounding.

Table 3-14 shows a comparison of reported and verified net impacts for both program years.

Table 3-14. Reported and Verified Net Energy Savings

Measure Category	PY 2010	PY 2011
Reported NTG Ratio	0.71	0.73
Reported Net Energy Savings (MWh)	6,030	6,002
Reported Net Summer Coincident Demand Savings (MW)	5.76	5.74
Verified NTG Ratio	0.68	0.68
Verified Net Energy Savings (MWh)	5,770	5,460
Verified Net Summer Coincident Demand Savings (MW)	5.66	5.30

Source: Navigant analysis

4. Process Findings

Process analysis findings are based on results of the 246 customer surveys, interviews with program staff and contractors, as well as 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, and the program is poised to grow with the addition of new measures for PY 2012 and increased marketing efforts to target key measures. Additional survey findings can be found in Appendix E.

Key findings are as follows:

- The relations among PEC, Honeywell (the implementation contractor), and HEIP prequalified contractors (or trade allies) are strong. Training and guidance provided by PEC and Honeywell to contractors appears to result in high-quality work and effective implementation.
- About 60% of program participants learned about HEIP directly from contact or marketing from prequalified contractors, which demonstrates the success of PEC and Honeywell's partnerships with these trade allies.
- Participants listed the rebates and reduced energy bills as the primary reasons for participating in HEIP.
- A significant 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% of participants indicated 8-10 for satisfaction with overall program experience.
  - Over 90% of participants indicated 8-10 for satisfaction with the contractor's quality of work.
  - Almost 80% 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; however, more than half (56%) of level 2 HVAC tune-up participants report "no change" in their energy bill after participating (well above all other measures).
- During interviews with Navigant, prequalified contractors who perform level 2 HVAC tune-ups generally indicated that they expect increased participation in the

HVAC audit measure over the next several years, and that continued training will be necessary to ensure proper use of the diagnostic tool used to identify the appropriate tune-up procedures.

4.1 *Program Staffing and Contractor Network*

PEC's project manager oversees the program, and Honeywell manages the implementation, which includes maintaining the contractor network and inspecting completed contractor work. The two work jointly to administer contractor training. PEC indicated that it is working with Honeywell to focus on contractor training for the attic insulation and air sealing, as well as HVAC audit measures over the next two program years.

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

4.2 *Program Goals*

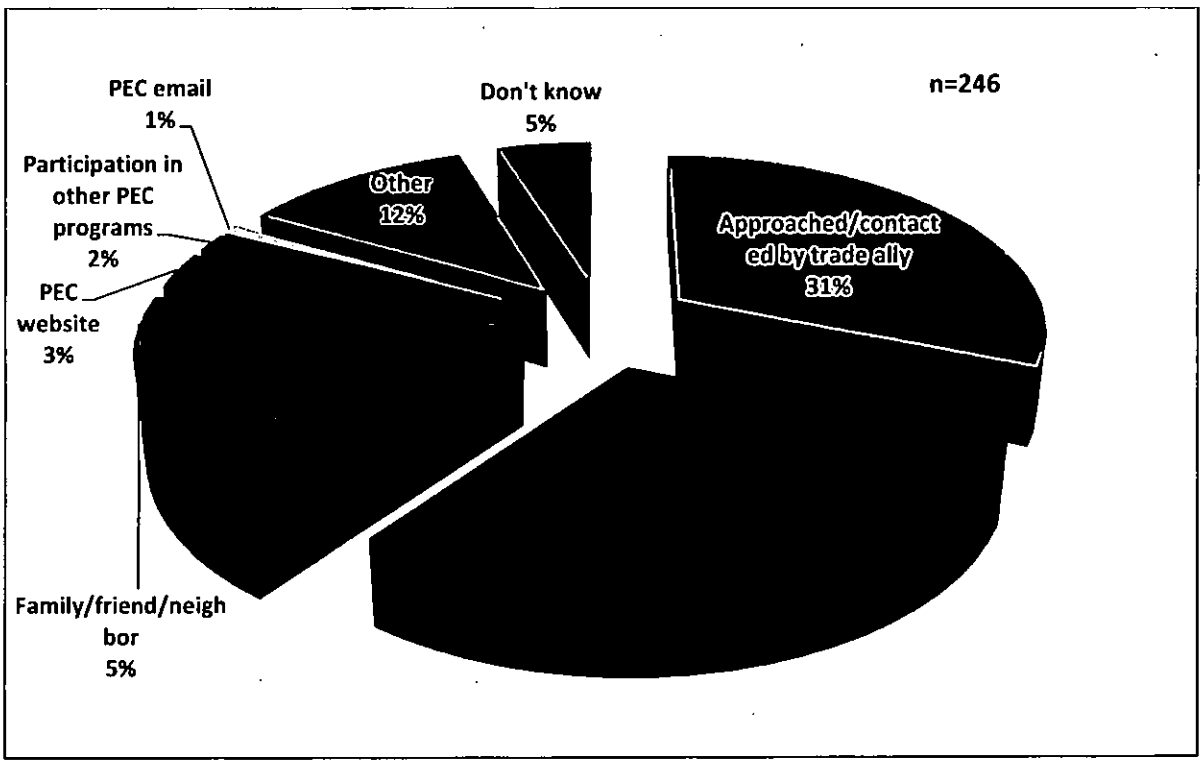
HEIP experienced significant growth between 2009 and 2010 in customer participation, energy savings, and demand savings. Participation levels and savings fell in PY 2011, presumably in part due to expiring federal tax credits for many of the measures. It is possible that the perceived lull in PY 2011 participation is due to a "rush" of participation in PY 2009 and PY 2010 to take advantage of the federal credits. PEC should expect a shift in participation and savings during PY 2012 due to the changes in the qualifying measures. Energy-efficient windows have been removed from the program due to changes in building codes and cost-effectiveness reasons. The windows measure accounted for 25% of the energy savings and 13% of the rebated measures in 2010, and 29% of energy savings as 19% of rebated measures in 2011. It is possible that participation in the HVAC audit measure will greatly increase. One of the contractors interviewed during the 2011 evaluation indicated that the company was expecting "upwards of 20,000" HVAC audits during 2012.

4.3 *Overall Marketing and Outreach*

PEC markets the program primarily through bill stuffers, bill envelopes, e-mail blasts, and through the contractor network. Honeywell helps recruit contractors into the program, and the contractors then market to customers.

Customer survey results indicate that the program is working as designed, and that contractors play a very important role in the program process. Participants were asked to indicate all the sources through which they learned about the program, and about 60% indicated they had learned about HEIP through a contractor (31% through direct contact from a contractor, 29% through contractor marketing). Figure 4-1 shows the range of ways in which customers found out about the program.

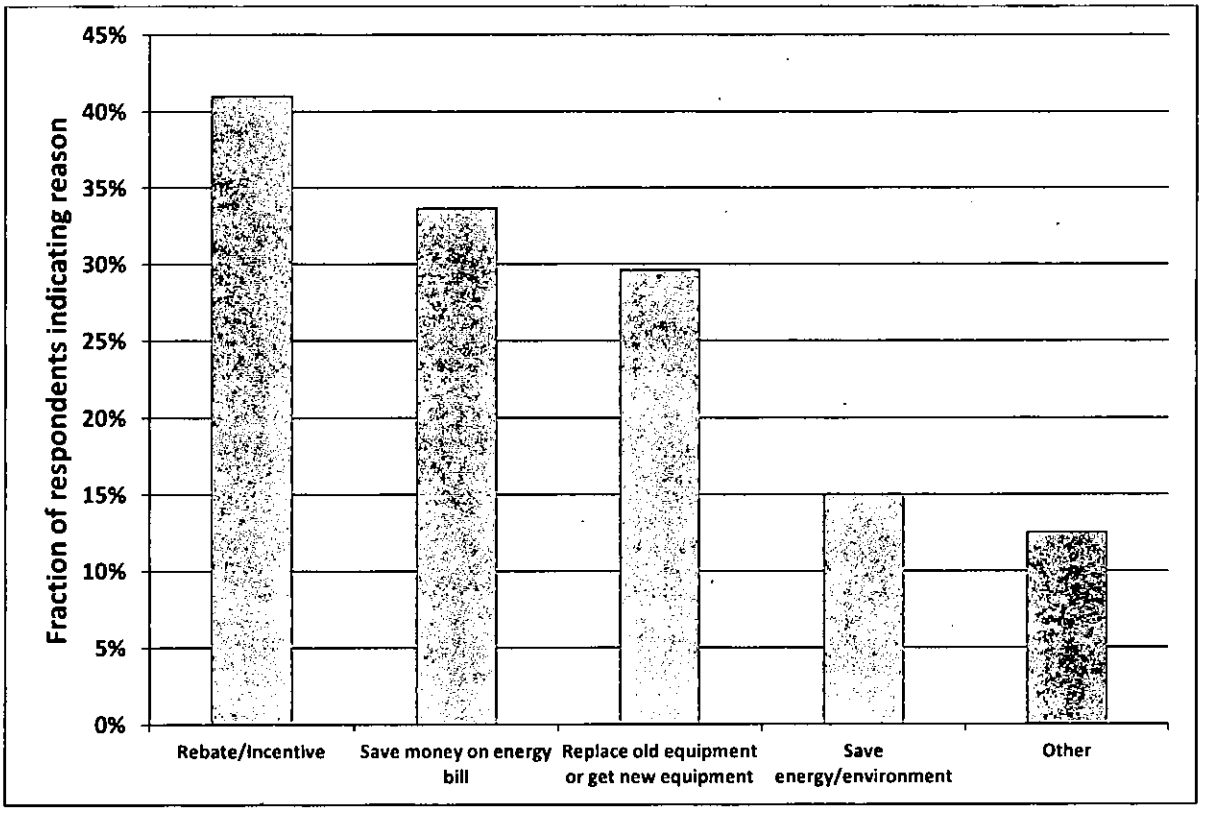
Figure 4-1. Where Program Participants First Learned About HEIP



Source: Navigant analysis

When asked why they chose to participate in the program, more than 40% of survey respondents cited the rebate as a reason (see Figure 4-2).

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



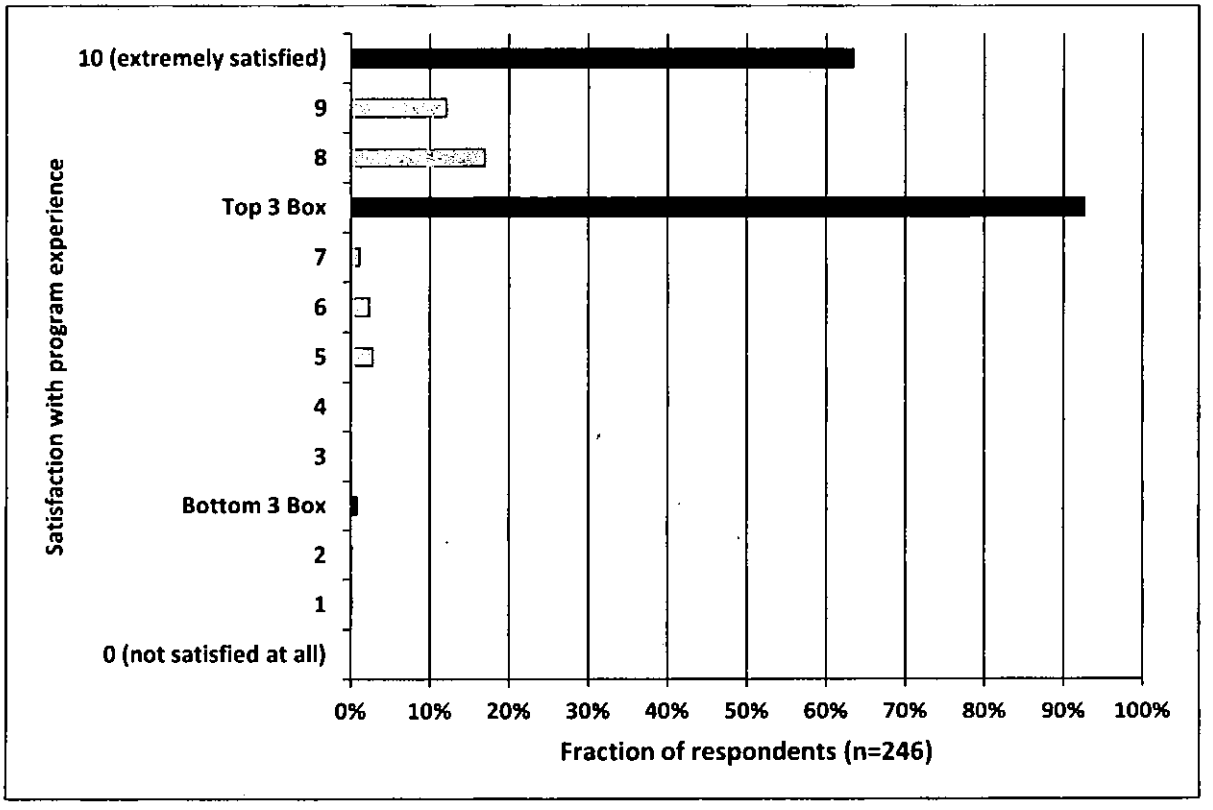
a. Totals exceed 100% because respondents were allowed to offer more than one answer.

Source: Navigant analysis

4.4 *Customer Experience*

Customers reported very high satisfaction with their overall program experience during 2010 and 2011. On a scale of 0 to 10 where 0 is "not satisfied at all" and 10 is "extremely satisfied", 93% of participants ranked their overall experience with the program as an 8, 9, or 10, with 63% responding that their experience was a "10" (see Figure 4-3). Participants who ranked their overall experience low did so because they were not aware of having received the rebate and weren't sure what the rebate was actually for.

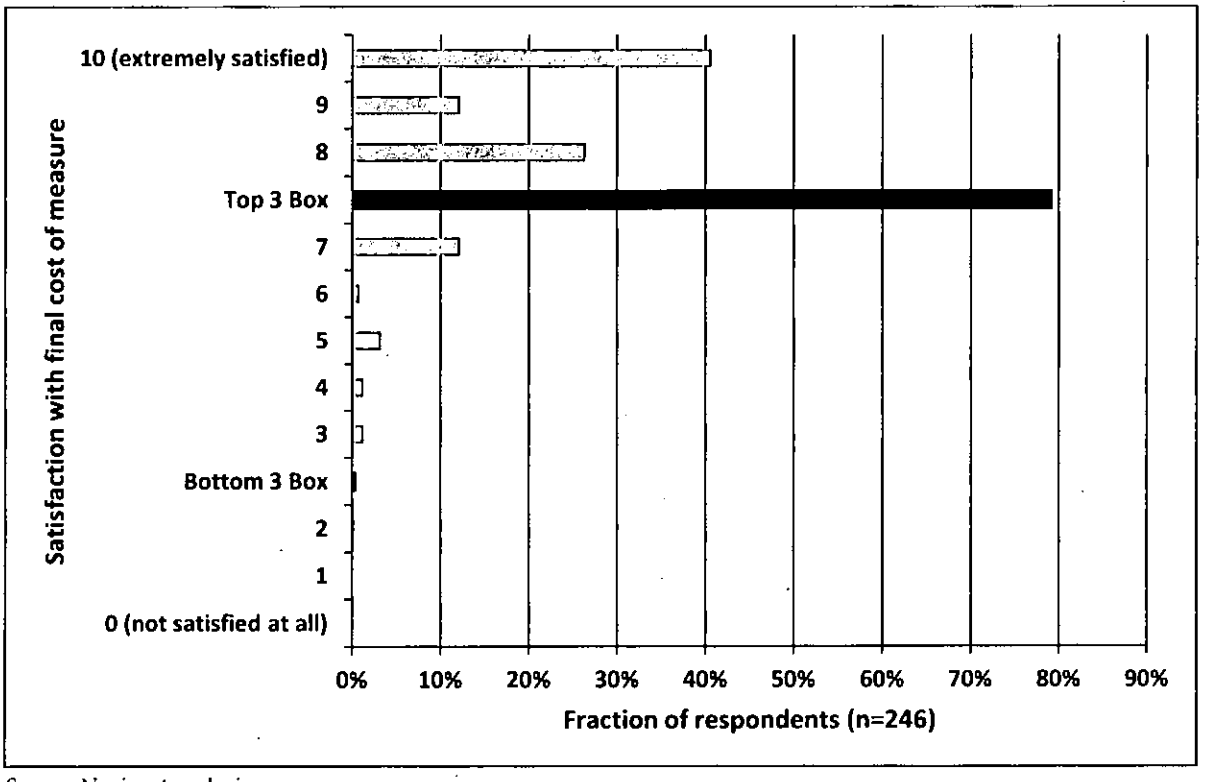
Figure 4-3. Customer Satisfaction with Overall Program Experience



Source: Navigant analysis

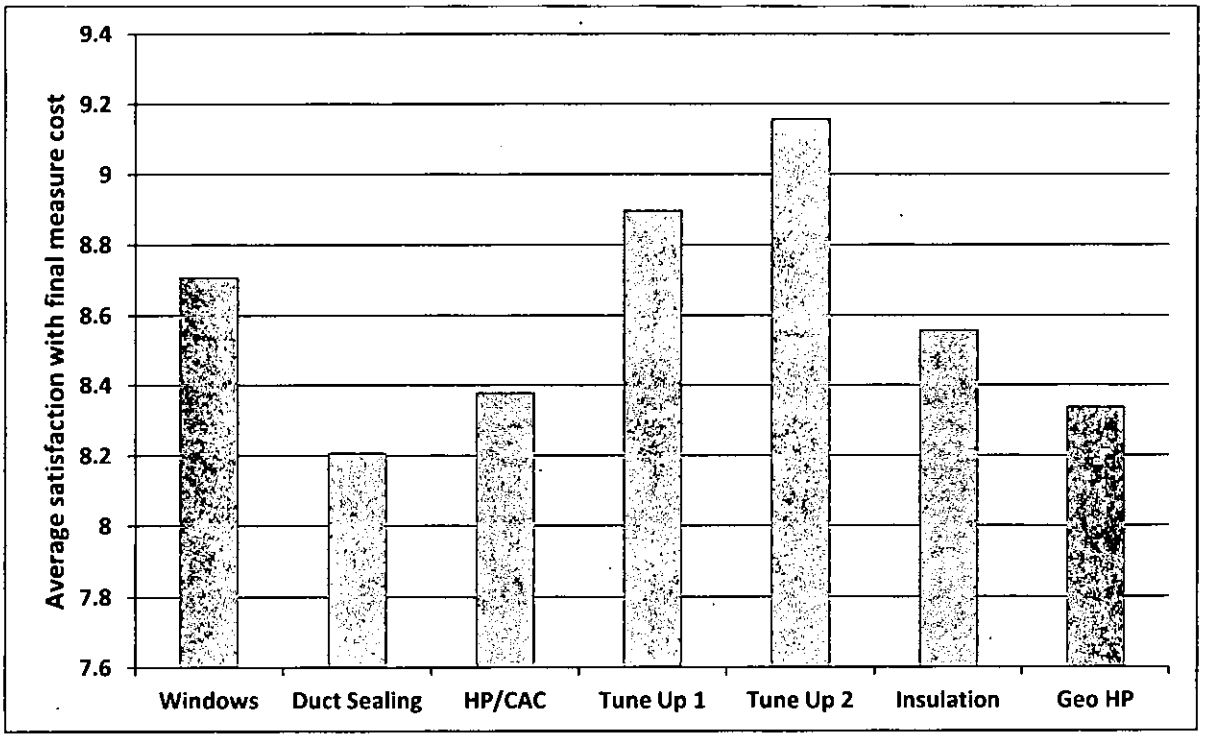
Customers also were satisfied with program costs. When aggregated by measure, at least 70% of the customers who installed each measure were satisfied or very satisfied with the measure's final cost, ranking an 8, 9, or 10 on the 0-10 scale (see Figure 4-4). On a measure basis, cost satisfaction was lowest for duct sealing and highest for the HVAC tune-up measures (see Figure 4-5). Reasons for low ratings in cost satisfaction included the measure being too expensive, and an increase in operating costs from the new measure.

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



Source: Navigant analysis

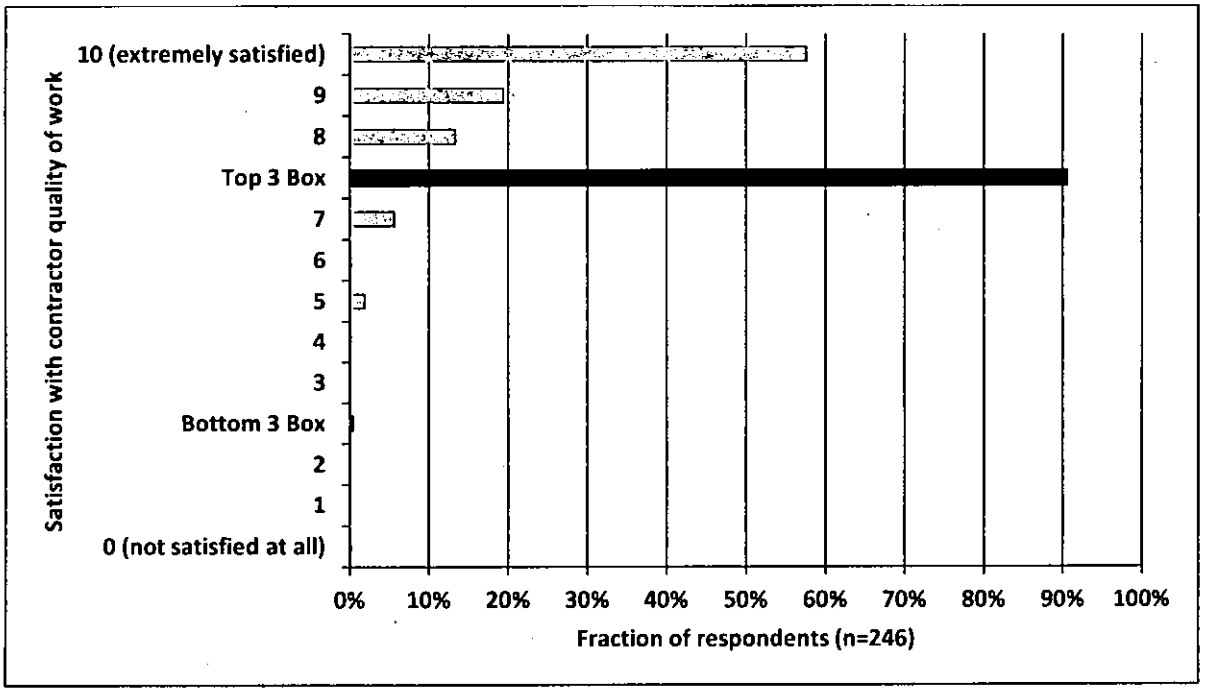
Figure 4-5. Average Satisfaction with Final Measure Cost on 0-10 Scale (note scale of y-axis, n=246)



Source: Navigant analysis

Customer satisfaction with contractor quality of work is very high. This is one of the most significant findings of the process evaluation, given that program success and energy savings rely heavily on the quality of contractor work. Figure 4-6 shows that over 90% of survey respondents ranked their satisfaction with contractor work as an 8, 9, or 10. Duct sealing and geothermal heat pumps had the lowest average ratings for customer satisfaction with contractor quality of work.

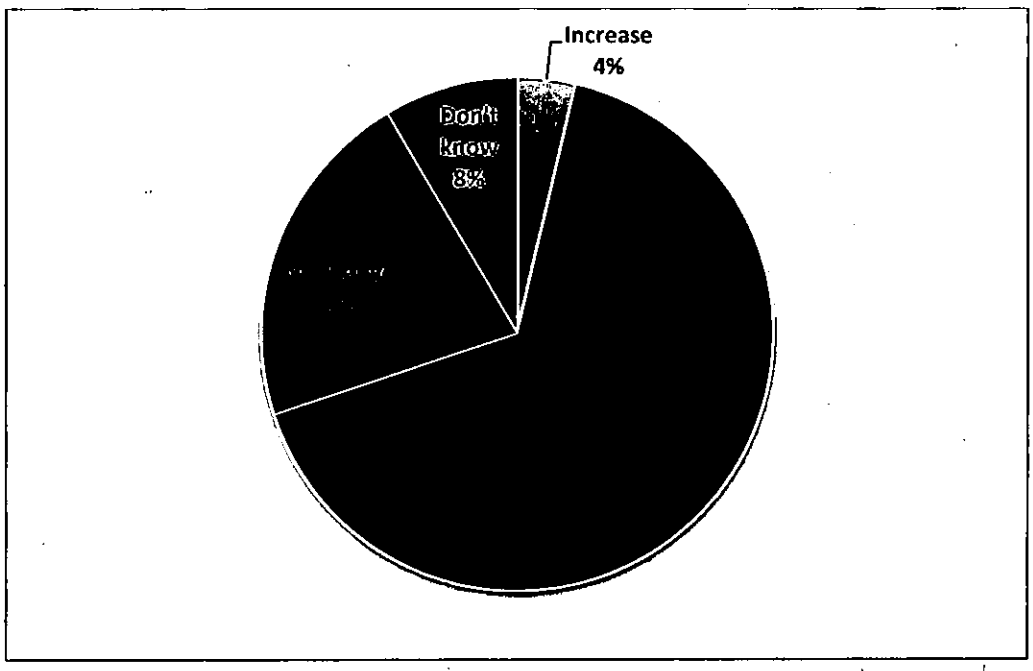
Figure 4-6. Customer Satisfaction with Contractor Quality of Work



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 4-7).

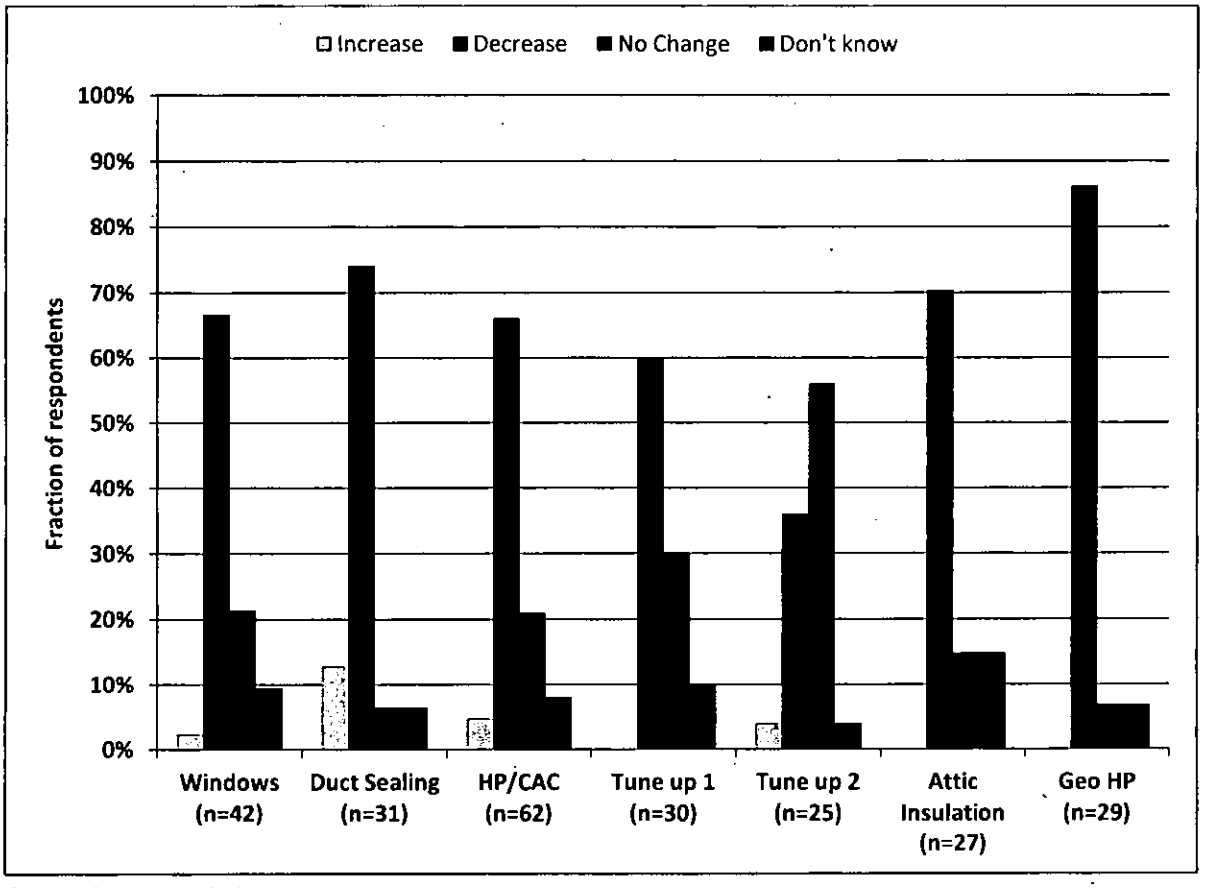
Figure 4-7. Participants Who Noticed a Change in Their Energy Bill After Installing the New Measure (n=246)



Source: Navigant analysis

Figure 4-8 shows the measure-level fraction of survey participants who noticed a change in their energy bill after installing the rebate measure. It should be noted that participants who received the level 2 HVAC tune-up reported a much higher incidence of noticing *no change* in their energy bill after receiving the measure. This finding should be considered along with the impact discussion in Section 3.2.2.

Figure 4-8. Participants Who Noticed a Change in Their Energy Bill, by Measure Type



Source: Navigant analysis

4.5 *Interviews with Prequalified Level 2 HVAC Tune-up Contractors*

Navigant conducted interviews with several prequalified contractors regarding the level 2 HVAC tune-up measure. During those interviews, contractors generally predicted an increase in the HVAC audit and level 2 HVAC tune-up participation over the coming year or two. Some of the contractors reported that customers come to them regarding the HVAC audit measure, and that marketing for that measure is relatively low or sometimes used to recruit customers for more profitable jobs. One contractor stated that some companies do not market the tune-ups because they can make more money doing HVAC replacements. However, another contractor reported sending out advertisements for HVAC audits with

nearly all of their mailings. Every contractor interviewed by Navigant believed that the HEIP rebates help drive participation in HVAC tune-ups, and that business would suffer if rebates were dissolved. One contractor requested that PEC could improve the program by providing more marketing for the "service-type" measures instead of replacement measures.

Every contractor also ranked their experience with HVAC training provided by PEC and Honeywell as "very satisfied." However, there seems to be general agreement that the diagnostic tool used for the HVAC audit measure is difficult and time consuming to use, and that further training is necessary for successful operation and energy savings. One contractor stated that he supervises four or five technicians, and all of them have expressed difficulties in using the diagnostic tool. Complaints include readings that "jump around a lot" and "give varying results because [the diagnostic tool] is interpreting a number of parameters at once." Another complaint was that the diagnostic tool reports directly to Honeywell and PEC, and technicians have to submit a separate paper copy, which is more time consuming.

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

5. Conclusions and Recommendations

HEIP continued to be a well-run program in PY 2010 and PY 2011, with the strong relationships among PEC, Honeywell, and prequalified contractors being the backbone of program success. Customer satisfaction is 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 8.5 GWh in 2010 and approximately 8.0 GWh in 2011. Verified gross summer coincident demand savings were approximately 8.4 MW in 2010 and approximately 7.8 MW in 2011. The decrease in savings and participation between the two years was likely due in part to the expiration of ARRA tax credits. Navigant found free ridership to be 41% for HEIP, which is quite high. Spillover was found to be 9%, which resulted in a final NTG ratio of 0.68.

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 was 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.

5.2 *Recommendations*

The evaluation team recommends several discrete actions for improving the HEIP offering, based on insights gained through staff and contractor interviews, participant and prequalifed contractor surveys, analysis of program records and assumptions, and review of on-site verification data. These recommendations provide PEC 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

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

Table 5-1. Summary of Recommendations

Program Impacts	
1. Update the tracking database to reflect measure-level deemed savings from this report.	
Improving Program Cost-Effectiveness	
2. Tighten eligibility requirements for measures not meeting savings expectations	a. Consider adjusting the qualifying post-retrofit insulation R-values to be dependent on pre-retrofit R-value.
Improving Program Delivery	
3. Offer technical training and workshops for contractors, with particular emphasis on using the diagnostic tool for HVAC audits.	
4. Continue to offer marketing training for contractors.	
5. Increase direct marketing through PEC.	
6. Increase participant awareness regarding receipt of rebate payment.	
Enhancing Program Tracking and Evaluation Efforts	
7. Ensure that all information from rebate application forms is included in program tracking database extracts.	a. All measures: include square footage of home, year home was built, heating and cooling types from rebate application. b. HVAC audit: include fields in tracking database for before and after efficiency index % readings from Service Assistant, as well as unit SEER rating. c. Duct sealing: include field in tracking database for location of ducts that were sealed, and results of pressure testing if applicable.
8. Modify program processes to integrate data collection activities required for EM&V.	a. Require the "ARI" 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.
9. Reconsider using the term "NTG" for the 0.39 adjustment factor applied to the PY 2010 tracking database.	

Several of the recommendations from Navigant's 2009 EM&V report were meant to help inform cost-effectiveness testing. These continue to apply, and are summarized by the following bullet points:

- Tighten eligibility requirements for measures that are not meeting average savings expectations:
  - Consider requiring electric heating for participation where a measure does not meet cost-effectiveness requirements.
  - Consider limiting eligibility for duct sealing to systems where at least half of the ducts are located in the attic.

» Add program elements and incentivize bundled measures:

- Offer a rebate for HVAC quality installation (verified refrigerant charge and airflow).
- Offer a rebate for combining duct sealing and envelope measures with new downsized HVAC equipment.

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 2010 and 2011 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 may suggest 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%.[16]
    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%.[16]
2. **Tighten eligibility requirements for measures that are not meeting average savings expectations.** If a measure is not cost-effective based on the 2010 and 2011 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

[16] PEC 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.

requirements for the measure on the whole. If cost-effectiveness requirements for a given measure can be met without restricting participation, then there is no need to make changes.[17]

Options include:

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.

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. During interviews with Navigant, contractors indicated that the diagnostic tool is difficult to use and cited enhanced training as necessary for successful implementation. Proper use is critical for achieving actual savings, and contractor training will reduce the site time for each audit and tune-up. About 56% of surveyed participants have noticed no change in their energy bill after having a level 2 HVAC tune-up, a number significantly higher than every other measure.

4. **Continue to offer marketing training for contractors.** Program marketing and promotion by contractors is a key component of PEC's marketing strategy, and as such, a continued and greater focus on marketing tactics and program sell points is likely to increase participation. About 60% 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 PEC.** About 40% of surveyed customers cited PEC's rebate as one factor in their decision to install the program measure, and about 18% of surveyed customers reported finding out about HEIP through PEC. As a whole, contractors are performing well at recruiting customers via the strong partnership with PEC; however, there may still be an untapped market of potential participants who may not have interaction with or even hesitate to trust a trade ally. An increase in direct marketing from PEC could be an effective way to gain additional participants.

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 PEC. In general, this is probably because the

[17] 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.

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. PEC 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 PEC.

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 V-TECH 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 extract provided to Navigant from the V-TECH website:

    a. All measures: include fields in the V-TECH database extract to Navigant for square footage of home, year home was built, heating type, and cooling type.

    b. HVAC audit: include fields in the V-TECH database extract to Navigant for the energy index efficiency readings 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 V-TECH 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. Also include results of any pre- and post-installation pressure testing.

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. PEC 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:

    a. Require the "ARI" 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 PEC or its implementation contractor.

5.2.4 Previous Recommendations

9. **Add program elements in combination with providing incentives for bundled measures to increase customer and program return on investment.** Transaction costs are high for residential downstream rebate programs with small measures, and many measures may have borderline cost-effectiveness by themselves. When measures are bundled together, however, those transaction costs are spread over greater savings, and the resulting cost-effectiveness of the group of measures is likely to be greater than for individual measures. An example of this is combining new HVAC equipment with quality installation, which includes duct sealing, proper refrigerant charge, proper airflow, and proper sizing. This generates higher savings while costing less by encouraging contractors to install smaller equipment after they have upgraded the ducts. Similarly, HVAC equipment can be bundled with building envelope upgrades (e.g., attic insulation) to further reduce system size and increase savings. Even if rebates and measures are not bundled together, contractors should be encouraged to assess multiple measures at a given site and promote the idea that a house is a system. For example, during field verification, several HVAC replacement participants indicated that contractors had not inspected the duct work. Navigant recognizes that some contractors specialize in HVAC replacement only; however, efforts to promote multiple measures may increase savings and cost-effectiveness.

NAVIGANT

2010 AND 2011 EM&V REPORT

FOR THE HOME ENERGY IMPROVEMENT PROGRAM

Appendices

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June 27, 2012

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NAVIGANT

Table of Contents

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 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 given 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.

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 Reductions: 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.

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, or peak kW per square foot of window installed.

Verification Rate: See Field Verification Rate.

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 Program Attribution

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

1. Defining Free ridership, Spillover, and Net-to-Gross Ratio
2. Methods for Estimating Free Ridership and Spillover
3. Results for Free ridership, Spillover, and Net-to-Gross Ratio

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

The methodology for assessing the energy savings attributable to a program is based on a net-to-gross (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 HEIP Program and most other Progress Energy programs cover a wide range of energy efficiency measures and are designed to move the overall energy efficiency market forward. However, it is likely that some participants would have wanted to install, for various reasons, some high efficiency measures (possibly a subset of those installed under the HEIP Program) 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 (*e.g.*, 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 basic equation is:

$$NTG = 1 - Free\ ridership + Spillover$$

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

B.2 *Methods for Estimating Free ridership and Spillover*

Estimating Free Ridership

Data to assess free ridership were gathered through the self-report method using a series of survey questions asked of 246 HEIP participants. The survey was stratified by measure-level energy savings, and to be representative of the distribution within Progress Energy Carolinas's (PEC's) geographic regions. The survey assessed free ridership using both direct questions – aimed at obtaining respondent estimates of the appropriate free ridership rate that should be applied to them – and using supporting, or influencing, questions that could be used to verify whether the direct responses are 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.*, heating, ventilation, and air conditioning (HVAC) replacement, duct sealing etc.). 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 the HEIP Program. 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 gave 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. Details follow:

- **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 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 anyways, 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,[1] and then averaged and divided by 10 to convert the scores into a free ridership percentage. Then, a timing multiplier was applied to the

[1] 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 2 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 how far along your plans were." On a scale of 0 to 10, where 0 means "Had not yet budgeted or considered

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, without the program, when they would have installed the equipment. Respondents who indicated that they would not have installed the equipment for at least two years were not considered free riders, and had a timing multiplier of "0". If they would have installed at the same time as they did, they had a timing multiplier of "1"; within one year, "0.67"; and between one and two years, "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 had a timing multiplier of "1."

Estimating Spillover

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

- *Whether spillover exists at all.* These were yes/no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records.
- *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 method of assigning savings).
- *Program attribution.* Estimates were derived from a question asking the program importance, on a 0 t o10 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 1) the spillover savings, as estimated below, multiplied by 2) the program influence score.

Navigant Consulting, Inc. (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. windows, attic insulation, etc.). If a participant indicated a spillover measure that matched an existing HEIP measure, Navigant assigned 50% 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 would have received

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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 Appendix E for survey questions) and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free-ridership).

the rebate. The 50% 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, and a variety of technical reference manuals (TRMs) from other utility programs for other measures.

Combining Results across Respondents

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

- Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above.
- Measure categories:
  - For free ridership: by taking the average of each respondent's score within each category
  - For spillover: by taking the sum of the individual spillover results for each measure category, and weighting each category by the population.
- The program as a whole, by combining measure-level results.
  - For free ridership: measure category results were subsequently weighted by each category's share of total savings.
  - For spillover: measure category results were summed and then weighted by the sum of the reported savings for the sample (which were also weighted 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 the HEIP Program. Specifically, results are presented for free ridership and spillover, which are used collectively to calculate a NTG ratio.

Review of Data Collection Efforts for Attribution Analysis

Surveys were conducted with HEIP participants to provide the information to estimate free ridership, spillover, and NTG ratios. 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

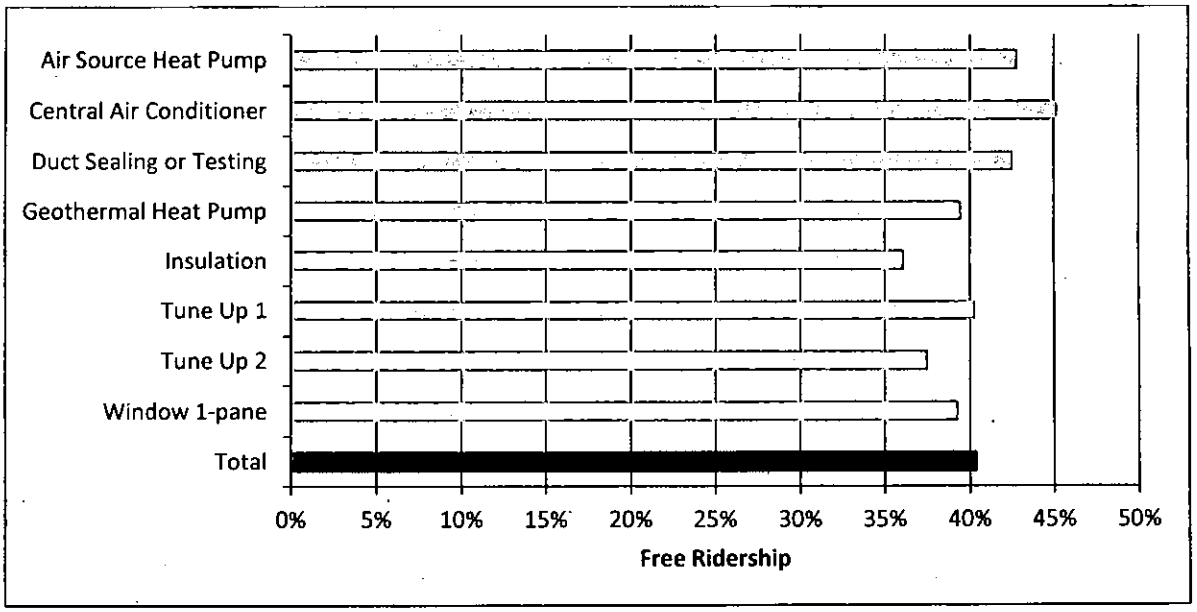
	= Respondents
Heat Pump	46
Central Air Conditioner	16
Level 1 HVAC Tune-Up	30
Level 2 HVAC Tune-Up	25
Duct Sealing	31
Windows	42
Attic Insulation	27
Geothermal Heat Pump	29
Total	**246**

Source: Navigant analysis

Free Ridership Results

As described in 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 range from 36% for Insulation, to a high of 45% for Central Air Conditioner.

Figure B-1. Free Ridership by Measure Category



Source: Navigant analysis (n=246)

Free ridership for the HEIP Program (*i.e.*, across all measures) was estimated at 41%, 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 the HEIP Program

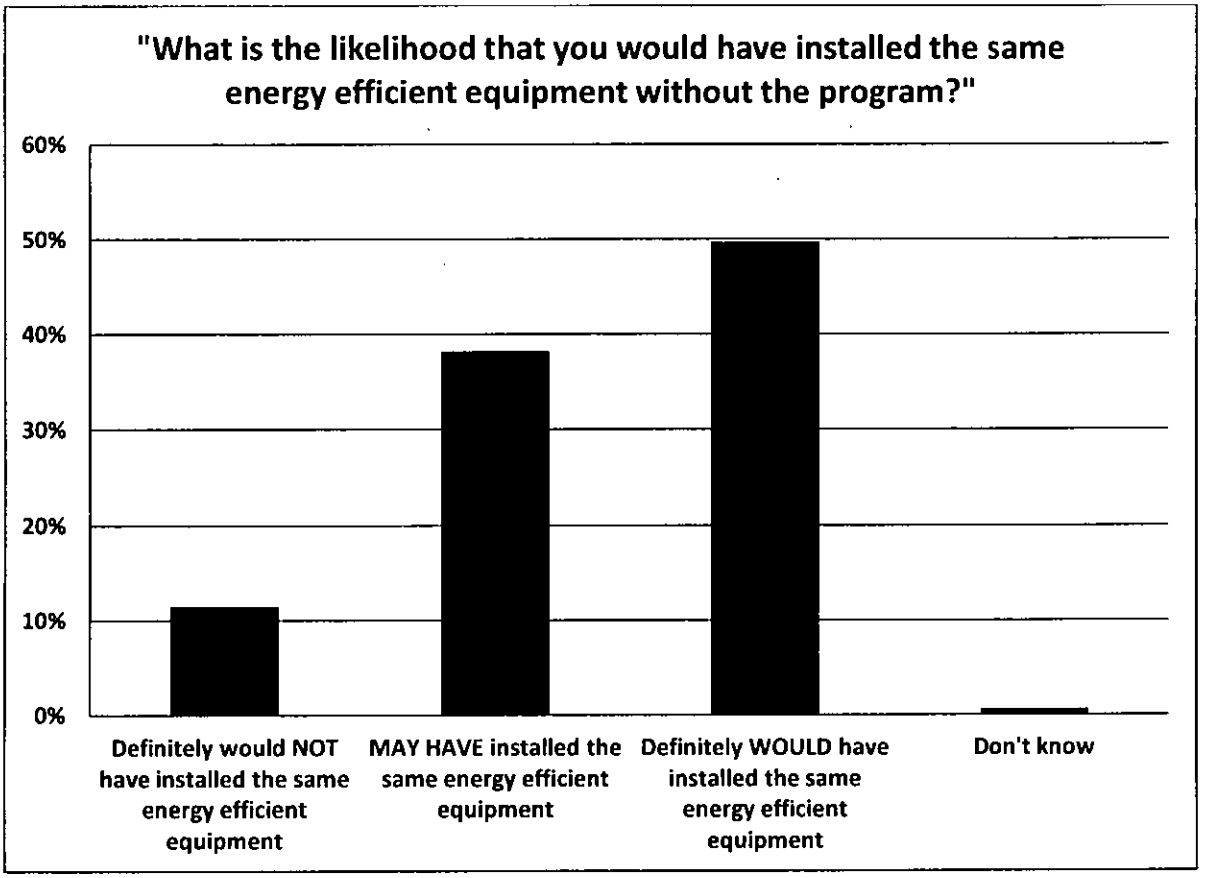
Measure Category	Reported Energy Savings (MWh)	Share of HEIP Energy Savings	FR Score[a]
Air Source Heat Pump	5,362	32%	42%
Central Air Conditioner	1,557	9%	45%
Geothermal Heat Pump	473	3%	39%
Level 1 HVAC Tune-Up	1,677	10%	40%
Level 2 HVAC Tune-Up	342	2%	37%
Duct Sealing	1,507	9%	43%
Windows	4,508	27%	39%
Attic Insulation	1,348	8%	36%
Total	16,774	100%	41%

[a] Total FR Score is calculated by summing the product of each categories' FR Score and their share of savings.

Source: Navigant analysis

Navigant developed the free ridership estimates presented above based on responses to a variety of questions 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 efficient equipment. 12% said they would not have installed the same equipment, while 50% said they would have. 38% said they "may have" installed the same equipment.

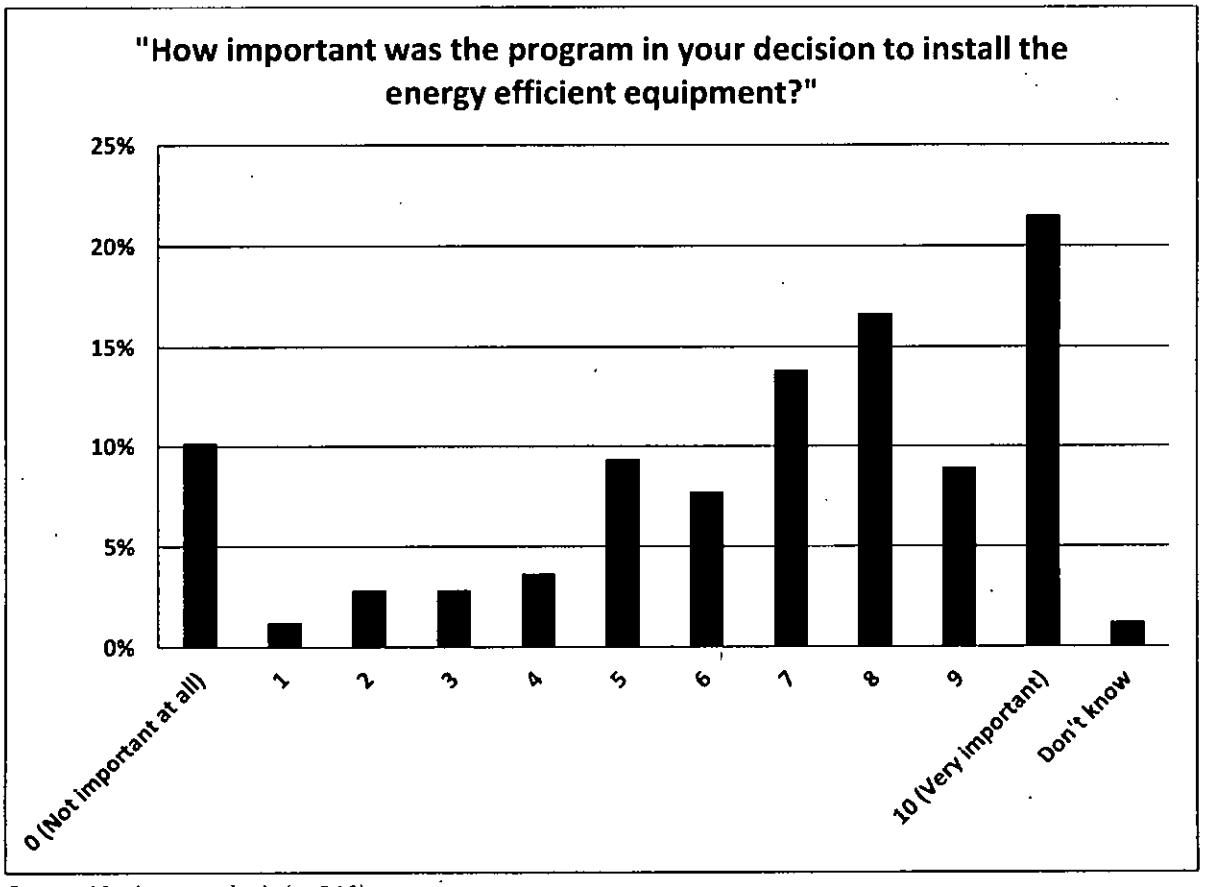
Figure B-2. Likelihood of Installing without the Program



Source: Navigant analysis (n=165)

Respondents indicated that the HEIP Program significantly influenced borrowers in selecting high-efficiency equipment. 47% of the customers said the program was very important in influencing their decision to install the high efficiency equipment (see Figure B-3, scoring of 8 and higher). A score of 0 indicates no program influence (*i.e.,* respondent replied "no" to the question about whether the program "in any way" influenced decisions regarding energy efficiency), and a score of 10 indicates that the HEIP was the primary reason for the selection of high-efficiency equipment. 30% gave a score of 5 or lower.

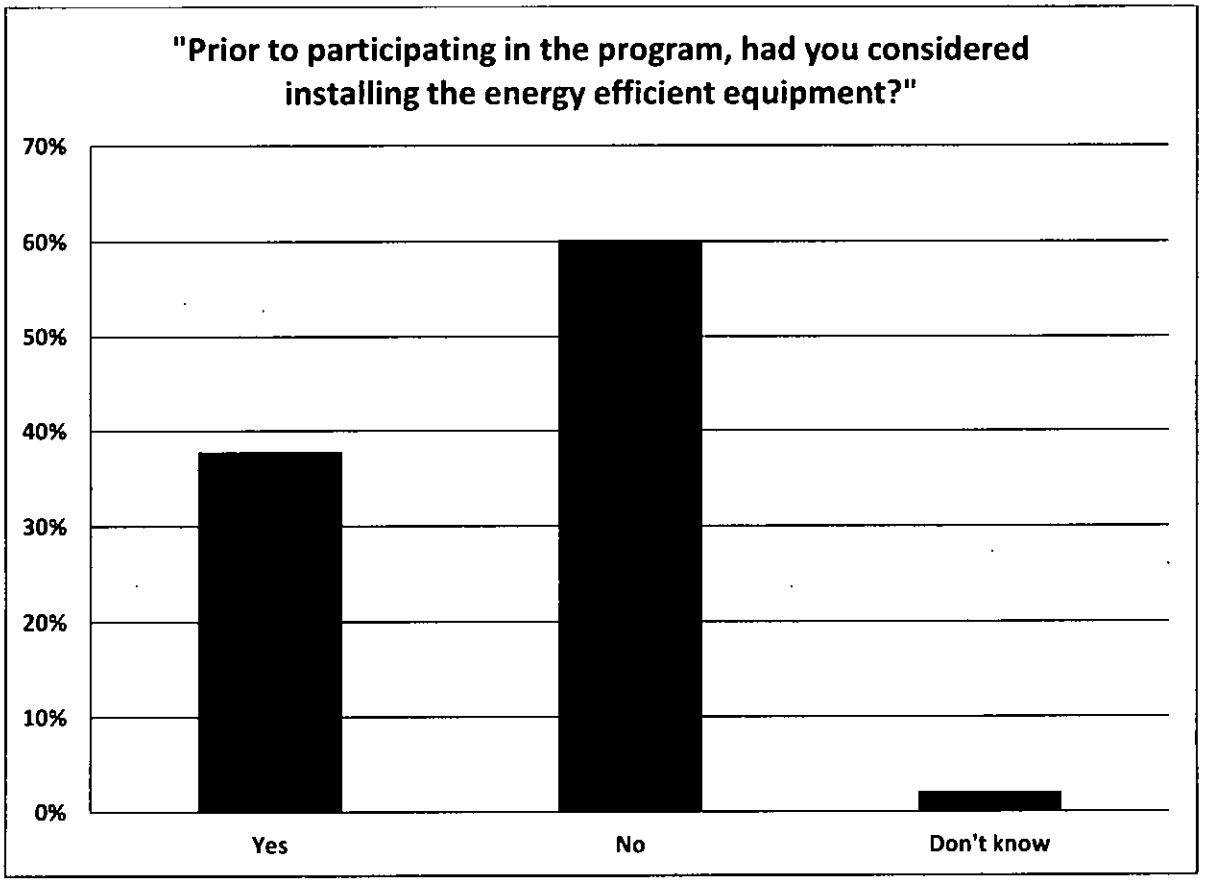
Figure B-3. Program Importance



Source: Navigant analysis (n=246)

Respondents indicated that some energy efficiency measures were being planned, at least in part, for 38% of all projects prior to participation in the HEIP Program (Figure B-4).

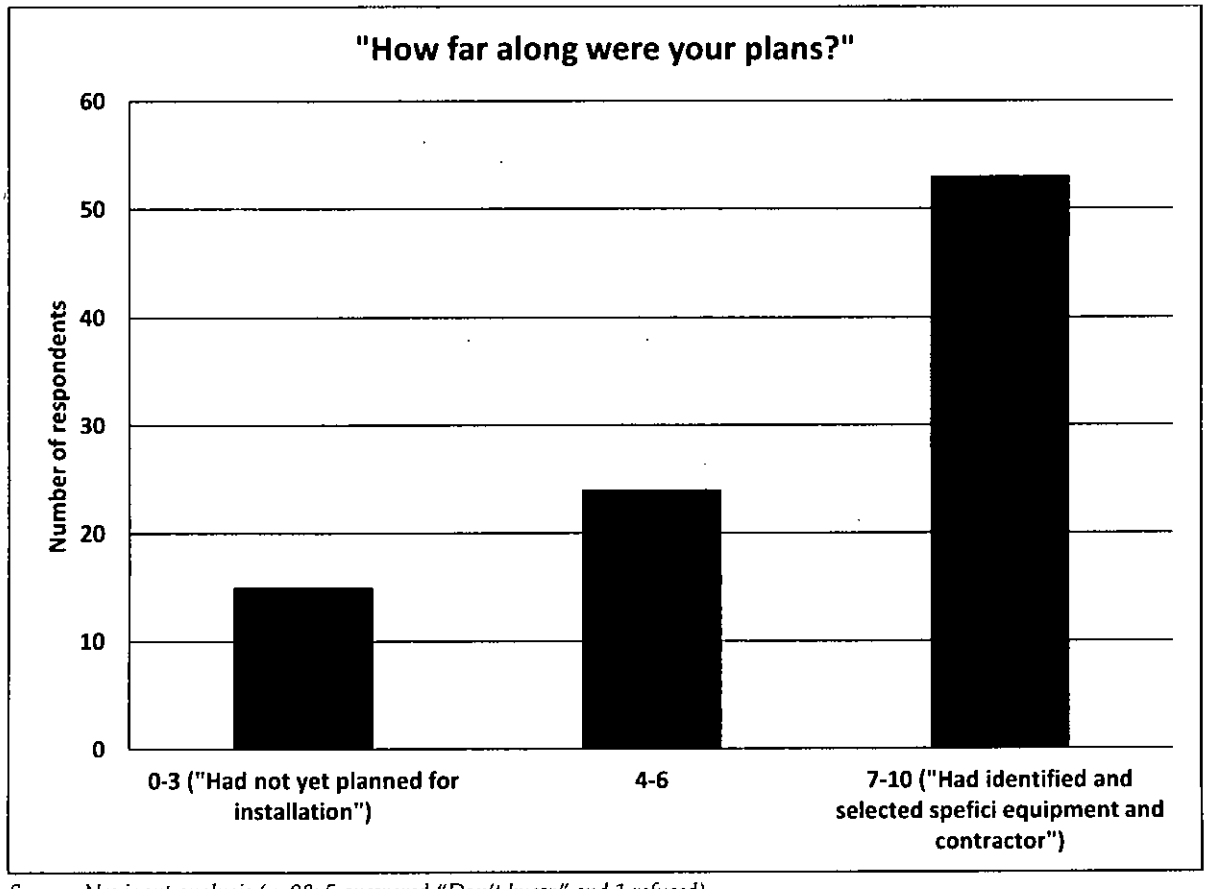
Figure B-4. Prior Planning



Source: Navigant analysis (n=246)

Figure B-5 shows that 15 of the 93 customers with plans, had little to no planning at all (16% of those with plans, 6% of all respondents). 24 customers had been planning to a moderate degree (4-6 on the 10-point scale), which generally indicates that the customers took some initial steps toward acquiring high-efficiency equipment—such as discussing energy efficiency alternatives with a contractor—but had not reviewed specific options in detail. 53 customers had more detailed plans to install the equipment (57% of those with plans, 22% of all respondents).

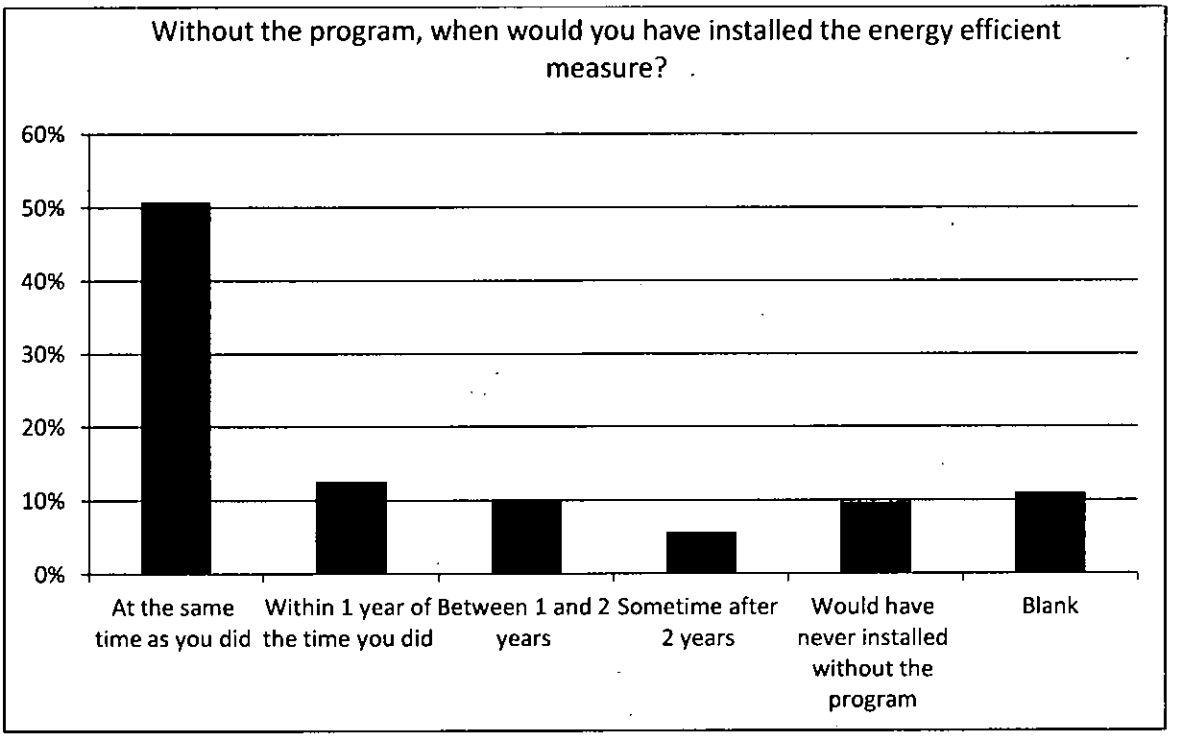
Figure B-5. Extent of Prior Plans



Source: Navigant analysis (n=98; 5 answered "Don't know" and 1 refused)

Figure B-6 provides further information on customers' prior plans by displaying the timeframe in which equipment was planned to be installed. 51% said they would have installed the equipment at the same time as they did, and another 13% said they would install within one year. 26% said they would not have installed for 2 or more years, never or did not answer.

Figure B-6. Timing

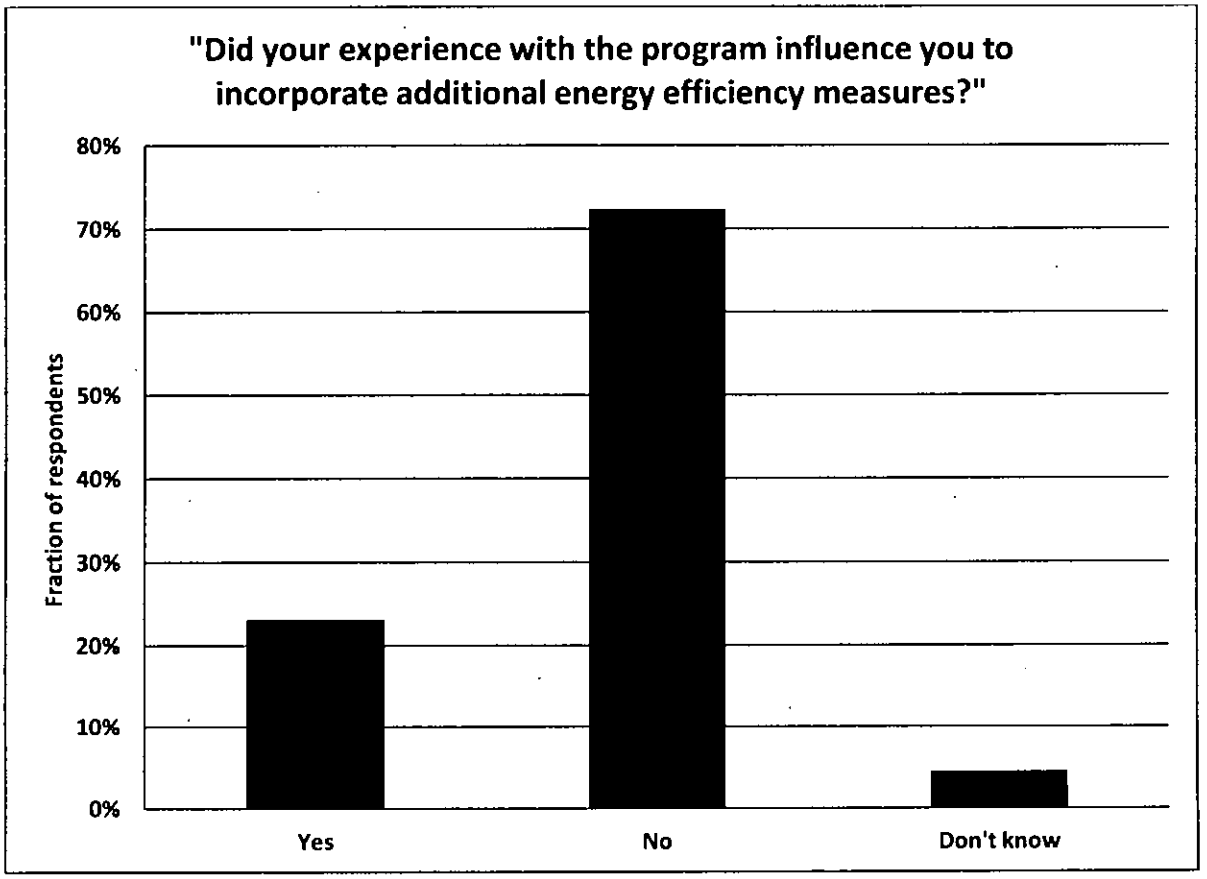


Source: Navigant analysis (n=246)

Spillover Results

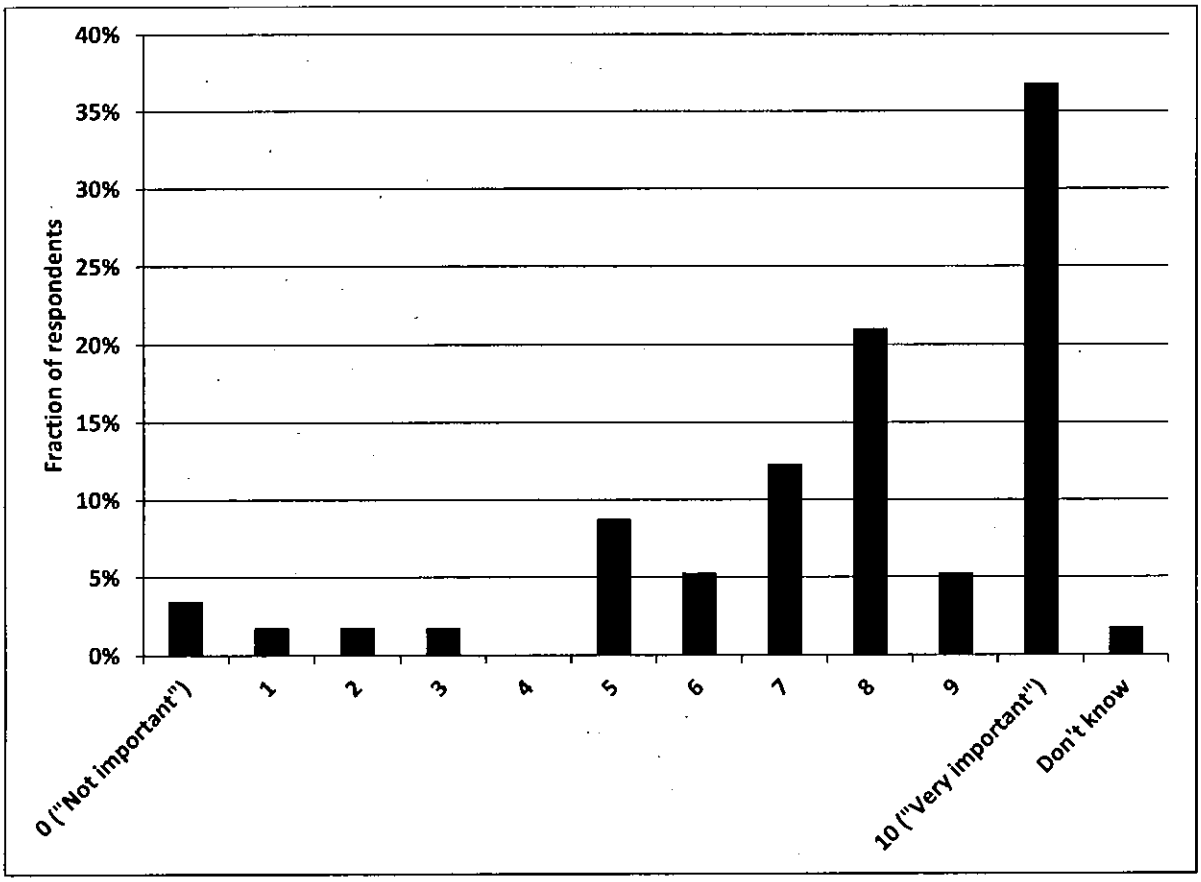
The HEIP Program influenced approximately 23% of participants to install additional energy efficiency measures (see Figure B-7). Over 63% of these respondents taking spillover actions indicated that the program was very important in influencing their decision to install the high efficiency equipment (8 or higher on a 10-point importance scale: see Figure B-8). A list of the spillover measures indicated by survey participants is shown in Table B-3. Based on the survey findings, the EM&V team estimates the overall program spillover to be 9% of program-reported savings. Spillover savings were calculated for each measure, and the program-wide value of 9% was calculated by weighting the spillover from each measure according to that measure's share of total reported energy savings.

Figure B-7. Spillover



Source: Navigant analysis (n=246)

Figure B-8. Program Importance for Respondents with Spillover



Source: Navigant analysis (n=57)

Table B-3. Spillover Measures Installed by Survey Participants

Program Measures	Appliances	Envelope	Other
Heat Pump	Refrigerator	Air Sealing	Lighting
Insulation	Freezer	Weatherization	Thermostat
Windows	Clothes Washer	Weather Stripping	Siding
Duct Sealing	Clothes Dryer	Doors	Metal Roof
	Dishwasher	Window Tint	
	Water Heater		
	Furnace		

Net-to-Gross Ratio
As stated in Section B.1, the NTG ratio defined as follows:

$$NTG = 1 - Free\ ridership + Total\ Spillover$$

Using the overall free ridership value of 41% and the overall spillover value of 9%, the NTG ratio is then 1 – 0.41 + 0.09 = 0.68. The estimated NTG ratio of 0.68 implies that for every 100 kWh of realized savings recorded in HEIP records, 68 kWh can be attributed to the program.

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	Spillover[b]	NTG Ratio
Air Source Heat Pump	42%		0.67
Central Air Conditioner	45%		0.64
Geothermal Heat Pump	39%		0.70
Level 1 HVAC Tune-Up	40%		0.69
Level 2 HVAC Tune-Up	37%	9%	0.72
Duct Sealing	43%		0.66
Windows	39%		0.70
Attic Insulation	36%		0.73
HEIP Total[a]	**41%**		0.68

[a] HEIP Total values for free ridership, spillover and NTG are weighted values, weighted for each measure category's share of total energy savings and/or population.
[b] The Total spillover value is applied to each measure category to obtain the measure-specific NTG ratios.

Source: Navigant analysis

Appendix C. Supplemental Information on Demand Impacts

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

C.1 Field Verification Rates (demand)

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

Table C-1. Weighted Field Verification Rates for Summer Coincident Demand across PY 2009-2011

Measure	2009	2010	2011	Weighted
Air Source Heat Pump	100%	100%	100%	100%
Central Air Conditioner	100%	100%	100%	100%
Geothermal Heat Pump	98%	97%	96%	97%[a]
Level 1 HVAC Tune-Up	98%	97%	96%	97%
Level 2 HVAC Tune-Up	NA	97%	96%	96%
Duct Sealing	95%	90%	86%	90%
Windows	93%	92%	91%	91%
Attic Insulation	110%	97%	96%	100%[b]

a. Geothermal heat pumps were not assessed for PY 2010 and PY 2011, and Navigant assigned the program average verification rates to be conservative.

b. A combined verification rate of 100% was applied to insulation, due to the high values encountered during PY 2009 EM&V efforts.

Table C-2. Weighted Field Verification Rates for Winter Demand across PY 2009-2011

Measure	2009[a]	2010	2011	Weighted
Air Source Heat Pump	NA	100%	100%	100%
Central Air Conditioner	NA	100%	100%	100%
Geothermal Heat Pump	NA	97%	90%	94%[b]
Level 1 HVAC Tune-Up	NA	97%	90%	96%
Level 2 HVAC Tune-Up	NA	97%	90%	91%
Duct Sealing	NA	90%	86%	88%
Windows	NA	92%	91%	92%
Attic Insulation	NA	97%	90%	100%[c]

a. Values were not included in PY 2009 analysis.

b. Geothermal heat pumps were not assessed for PY 2010 and PY 2011, and Navigant assigned the program average verification rates to be conservative.

c. A combined verification rate of 100% was applied to insulation, due to the high values encountered during PY 2009 EM&V efforts.

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

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

Table C-3. Deemed Summer Coincident Demand Savings for Each Measure in PY 2009-2011

Summer Demand	2009 (kW)	2010 (kW)	Change from 2009	2011 (kW)	Change from 2009
Air Source Heat Pump	0.424	0.419	-1.2%	0.416	-1.8%
Central Air Conditioner	0.429	0.430	0.2%	0.432	0.8%
Geothermal Heat Pump	0.690	0.690	0.0%	0.690	0.0%
Level 1 HVAC Tune-Up	0.092	0.099	7.6%	0.098	6.5%
Level 2 HVAC Tune-Up	N/A	0.33	N/A	0.33	N/A
Duct Sealing	0.167	0.182	9.0%	0.182	9.0%
Windows	0.480	0.532	10.8%	0.505	5.2%
Attic Insulation	0.344	0.332	-3.5%	0.311	-9.5%

Source: Navigant analysis.

Table C-4. Deemed Winter Demand Savings for Each Measure in PY 2009-2011

Winter Demand	2009 (kW)	2010 (kW)	Change from 2009	2011 (kW)	Change from 2009
Air Source Heat Pump	0.037	0.034	-8.1%	0.038	2.4%
Central Air Conditioner	0.038	0.034	-10.5%	0.035	-7.2%
Geothermal Heat Pump	0	0	0.0%	0	0.0%
Level 1 HVAC Tune-Up	0.039	0.048	23.1%	0.046	17.9%
Level 2 HVAC Tune-Up	N/A	0.38	N/A	0.38	N/A
Duct Sealing	0.397	0.432	8.8%	0.431	8.4%
Windows	0.190	0.206	8.4%	0.196	3.2%
Attic Insulation	0.869	0.749	-13.8%	0.668	-23.1%

Source: Navigant analysis.

C.3 *Verified Gross Savings and Gross Realization Rates (demand)*

The total verified gross demand reductions follow similar trends as energy. Table C-5 and Table C-6 present gross realization rates and peak demand reductions, by measure, for PY 2010 and PY 2011, respectively.

Table C-5. Verified Gross Peak Demand Reductions by Measure for PY 2010

Measure	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction(kW)	Gross Realization Rate
Air Source Heat Pump	3,161	3,140	99%
Central Air Conditioner	1,148	1,155	101%
Geothermal Heat Pump	85	84	99%
Level 1 HVAC Tune-Up	1,085	1,171	108%
Level 2 HVAC Tune-Up	51	49	96%
Duct Sealing	532	554	104%
Windows	1,797	1,957	109%
Attic Insulation	273	246	90%
Total	**8,133**	**8,356**	**103%**

Source: Navigant analysis

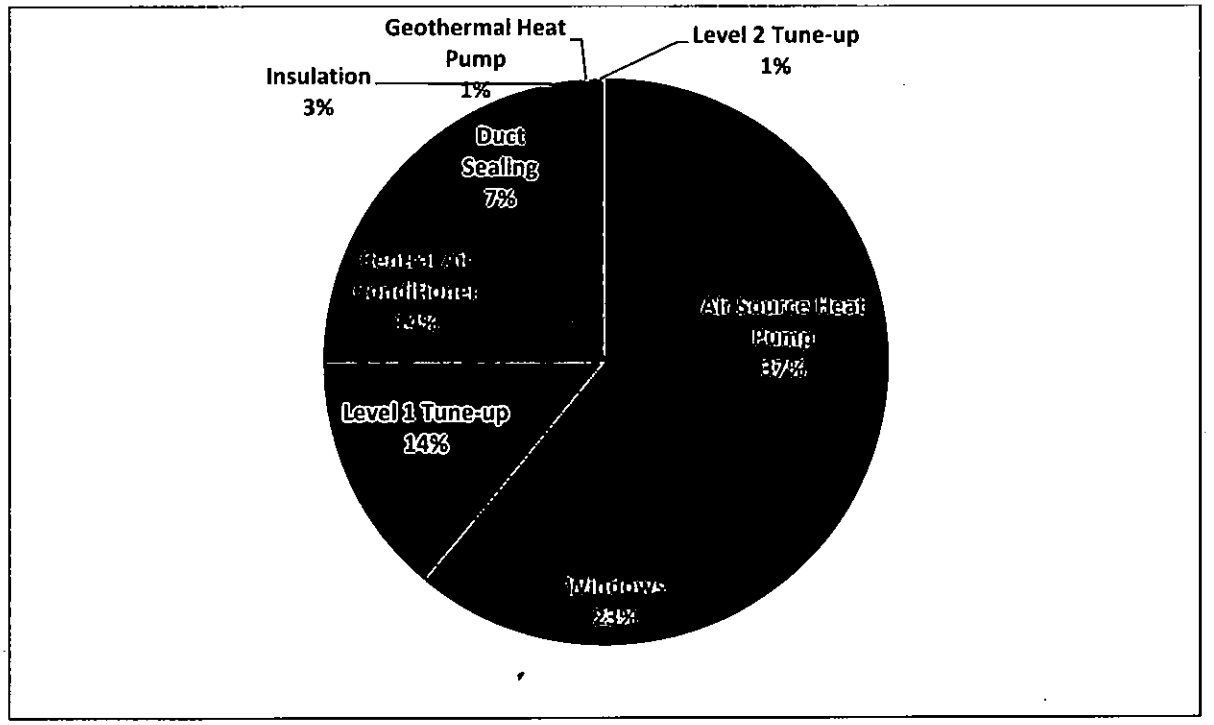
Table C-6. Verified Gross Peak Demand Reductions by Measure for PY 2011

Measure	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction(kW)	Gross Realization Rate
Air Source Heat Pump	2,967	2,941	99%
Central Air Conditioner	1,146	1,152	101%
Geothermal Heat Pump	102	99	97%
Level 1 HVAC Tune-Up	469	500	107%
Level 2 HVAC Tune-Up	243	233	96%
Duct Sealing	520	499	96%
Windows	2,216	2,129	96%
Attic Insulation	282	259	92%
Total	**7,944**	**7,811**	**98%**

Source: Navigant analysis

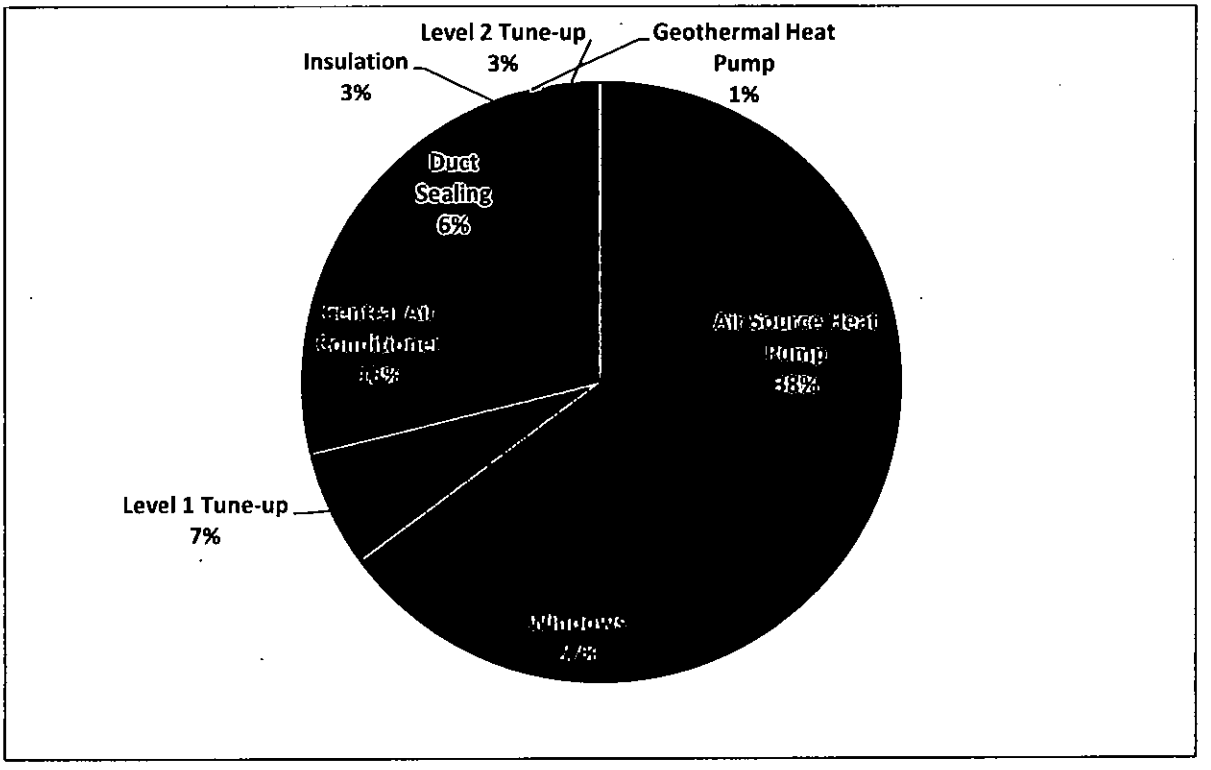
Figure C-1 and Figure C-2 show each measure's contribution to overall summer coincident demand reductions for PY 2010 and PY 2011, respectively. Again, air source heat pump was the largest contributor, and there was a notable decrease from level 1 tune-ups between the two years.

Figure C-1. Measure-Level Contribution to Verified Gross Summer Coincident Demand Savings for PY 2010



Source: Navigant analysis

Figure C-2. Measure-Level Contribution to Verified Gross Summer Coincident Demand Savings for PY 2011



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 2010 are summarized in Table C-7 and are summarized for 2011 in Table C-8.

Table C-7. Verified Gross Winter Peak Demand Reductions by Measure for PY 2010

Measure	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction(kW)	Gross Realization Rate
Air Source Heat Pump	3,550	255	7%
Central Air Conditioner	0	91	0%
Geothermal Heat Pump	0	0	100%
Level 1 HVAC Tune-Up	1,266	561	44%
Level 2 HVAC Tune-Up	59	54	91%
Duct Sealing	591	1,288	218%
Windows	2,016	760	38%
Attic Insulation	334	554	166%
Total	**7,816**	**3,563**	**46%[a]**

Source: Navigant analysis

a. PEC retroactively updated the reported savings for PY 2010 using adjustment factors from Navigant's PY 2009 EM&V report. The adjustment factors for summer demand savings were also applied to winter demand savings, resulting in a low realization rate for winter demand savings.

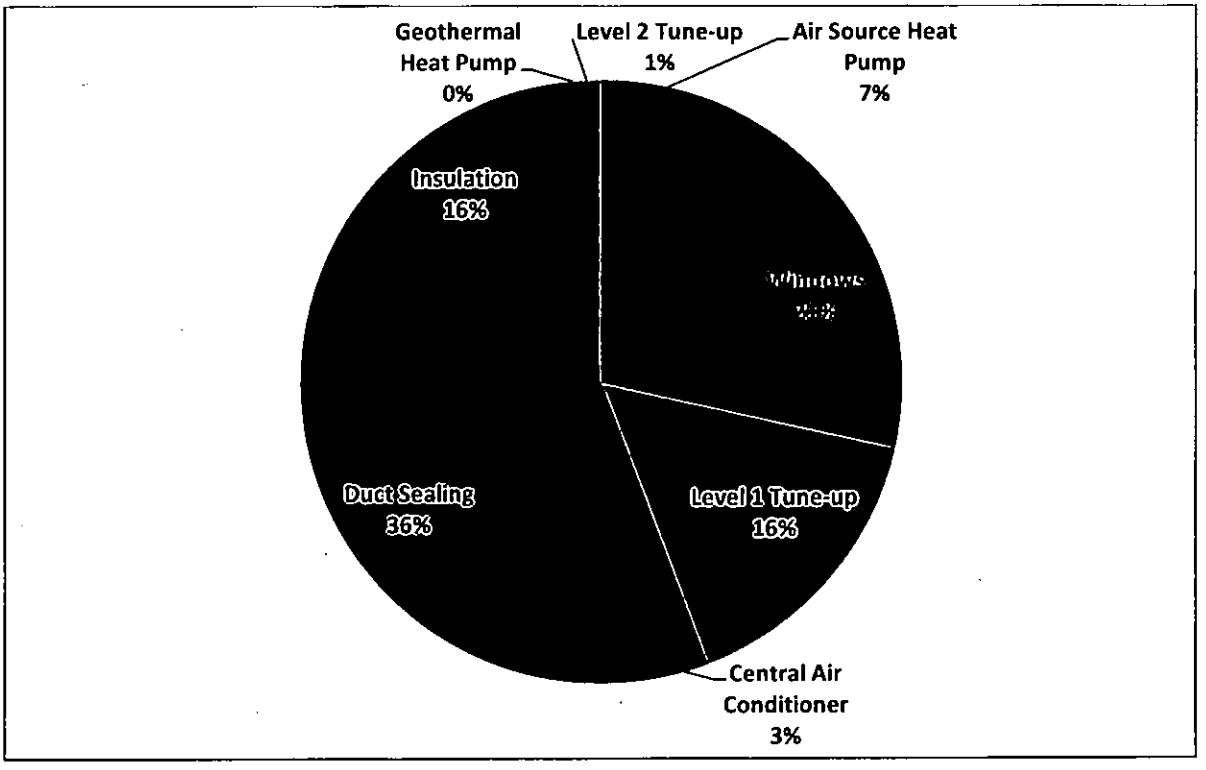
Table C-8. Verified Gross Winter Peak Demand Reductions by Measure for PY 2011

Measure	Reported Gross Demand Reduction (kW)	Verified Gross Demand Reduction(kW)	Gross Realization Rate
Air Source Heat Pumps	283	268	95%
Central Air Conditioners	107	94	88%
Geothermal Heat Pump	0	0	100%
Level 1 HVAC Tune-Up	209	233	112%
Level 2 HVAC Tune-Up	279	254	91%
Duct Sealing	1,224	1,155	94%
Windows	877	829	94%
Attic Insulation	720	556	77%
Total	**3,699**	**3,388**	**92%**

Source: Navigant analysis

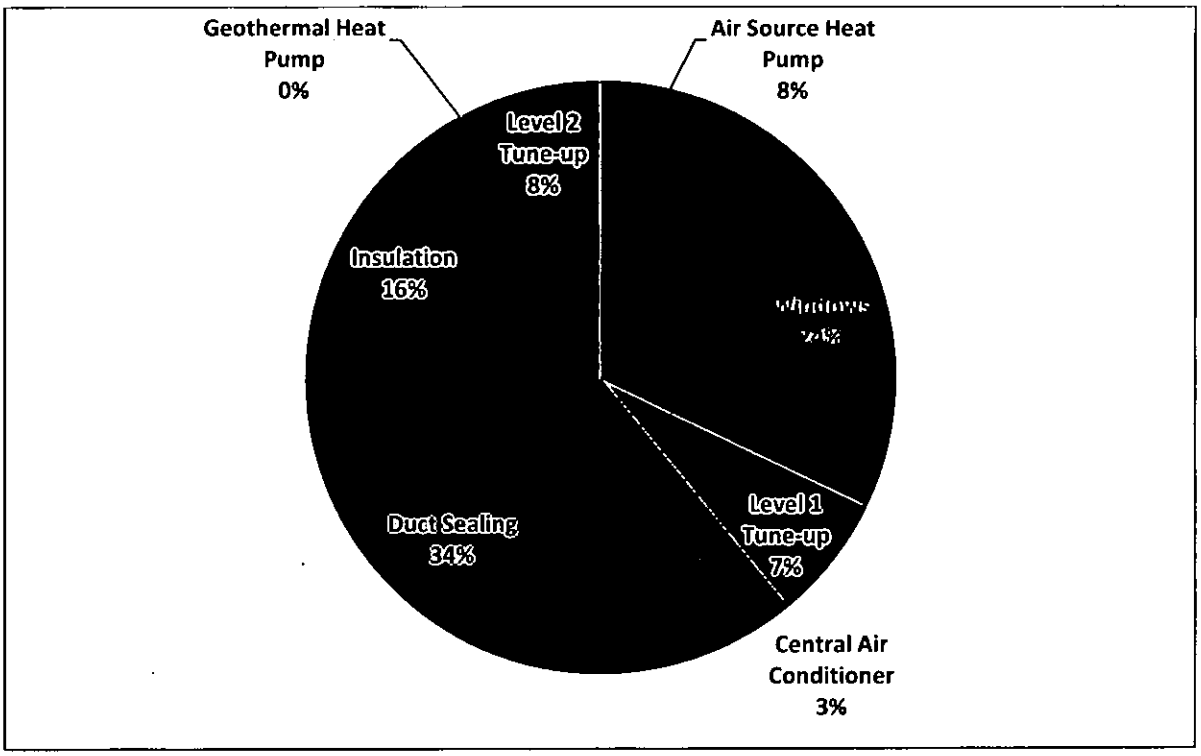
Each measure's contribution to overall verified winter demand reduction for 2010 is shown in Figure C-3, and for 2011 shown in Figure C-4. Duct sealing and windows provided the most winter demand savings, with insulation not far behind.

Figure C-3. Measure-Level Contribution to Verified Gross Winter Demand Savings for PY 2010



Source: Navigant analysis

Figure C-4. Measure-Level Contribution to Verified Gross Winter Demand Savings for PY 2011



Source: Navigant analysis

C.4 *Verified Net Savings (demand)*

The following set of tables present the verified net demand savings for PY 2010 and PY 2011.

Table C-9: Verified Net Summer Demand Impacts for PY 2010

Measure	Verified Gross Demand Reduction(kW)	Net-to-Gross Ratio	Verified Net Demand Reductions (kW)
Air Source Heat Pump	3,140	0.67	2,106
Central Air Conditioner	1,155	0.64	735
Geothermal Heat Pump	84	0.70	59
Level 1 HVAC Tune-Up	1,171	0.69	810
Level 2 HVAC Tune-Up	49	0.72	35
Duct Sealing	554	0.66	368
Windows	1,957	0.70	1,369
Attic Insulation	246	0.73	180
Total	**8,356**	**0.68**	**5,661**

Source: Navigant analysis

Table C-10: Verified Net Summer Demand Impacts for PY 2011

Measure	Verified Gross Demand Reduction(kW)	Net-to-Gross Ratio	Verified Net Demand Reductions (kW)
Air Source Heat Pump	2,941	0.67	1,971
Central Air Conditioner	1,152	0.64	733
Geothermal Heat Pump	99	0.70	69
Level 1 HVAC Tune-Up	500	0.69	346
Level 2 HVAC Tune-Up	233	0.72	168
Duct Sealing	499	0.66	332
Windows	2,129	0.70	1,488
Attic Insulation	259	0.73	190
Total	**7,811**	**0.68**	**5,297**

Source: Navigant analysis

Table C-11: Verified Net Winter Demand Impacts for PY 2010

Measure	Verified Gross Demand Reduction(kW)	Net-to-Gross Ratio	Verified Net Demand Reductions (kW)
Air Source Heat Pump	255	0.67	171
Central Air Conditioner	91	0.64	58
Geothermal Heat Pump	0	0.70	0
Level 1 HVAC Tune-Up	561	0.69	388
Level 2 HVAC Tune-Up	54	0.72	39
Duct Sealing	1,288	0.66	856
Windows	760	0.70	531
Attic Insulation	554	0.73	407
Total	**3,563**	**0.68**	**2,450**

Source: Navigant analysis

Table C-12: Verified Net Winter Demand Impacts for PY 2011

Measure	Verified Gross Demand Reduction(kW)	Net-to-Gross Ratio	Verified Net Demand Reductions (kW)
Air Source Heat Pumps	268	0.67	179
Central Air Conditioners	94	0.64	60
Geothermal Heat Pump	0	0.70	0
Level 1 HVAC Tune-Up	233	0.69	161
Level 2 HVAC Tune-Up	254	0.72	183
Duct Sealing	1,155	0.66	768
Windows	829	0.70	579
Attic Insulation	556	0.73	408
Total	**3,388**	**0.68**	**2,339**

Source: Navigant analysis

C.5 Statistical Significance of Impact Findings

Sampling precision for the field verification was determined for each sample stratum's verification rate using a 90% confidence interval. The analysis was conducted for the four measures for which onsite verification was performed (air conditioning [AC], heat pump, duct sealing, and windows), and AC 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.[2] 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 90/2 and 90/1, indicating a relative precision of +/- 2% for energy savings and +/-1% for summer peak demand savings at a 90% level of confidence. Precision levels for energy and summer demand were heavily affected by the 100% field verification rates for the air source heat pump and central air conditioner measures. Precision levels for winter demand were driven by the slightly lower verification rates for duct sealing. The verified gross and net savings, as well as relative precision for the energy and peak demand savings estimates are shown in Table C-13.

Table C-13. Statistical Significance of Verified Savings

	Annual Energy Savings (MWh)		Summer Coincident Peak Demand Savings (MW)		Winter Coincident Peak Demand Savings (MW)	
	2010	2011	2010	2011	2010	2011
Verified Gross Savings	8,458	7,989	8.36	7.81	3.56	3.39
Verified Net Savings	5,770	5,460	5.66	5.30	2.45	2.34
Relative Precision (+/-%) at 90% Level of Confidence	+/-2%		+/-1%		+/-7%	

Source: Navigant analysis

[2] 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 lowers the coefficient of variation.

Appendix D. Unit Savings Values

Chapter 3 of the report presents updated deemed savings values for each measure, which were based on the 2010 and 2011 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.[3] 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.[4]

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

Table D-1. Measure Unit Savings by Efficiency Level

Measure	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

[3] 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, April 11, 2011

[4] 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	Base Case	Efficient Case	Units	kWh	Summer kW	Winter kW
Duct Sealing	Ducts in Attic	Ducts in Attic, Visually Inspected	Site	638	0.491	1.126
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

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

Table D-2 shows unit savings by heating type.

Table D-2. Measure Unit Savings by Heating Type

Measure	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

Table D-3 shows measure unit savings by region.

Table D-3. Measure Unit Savings by Region

Measure	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

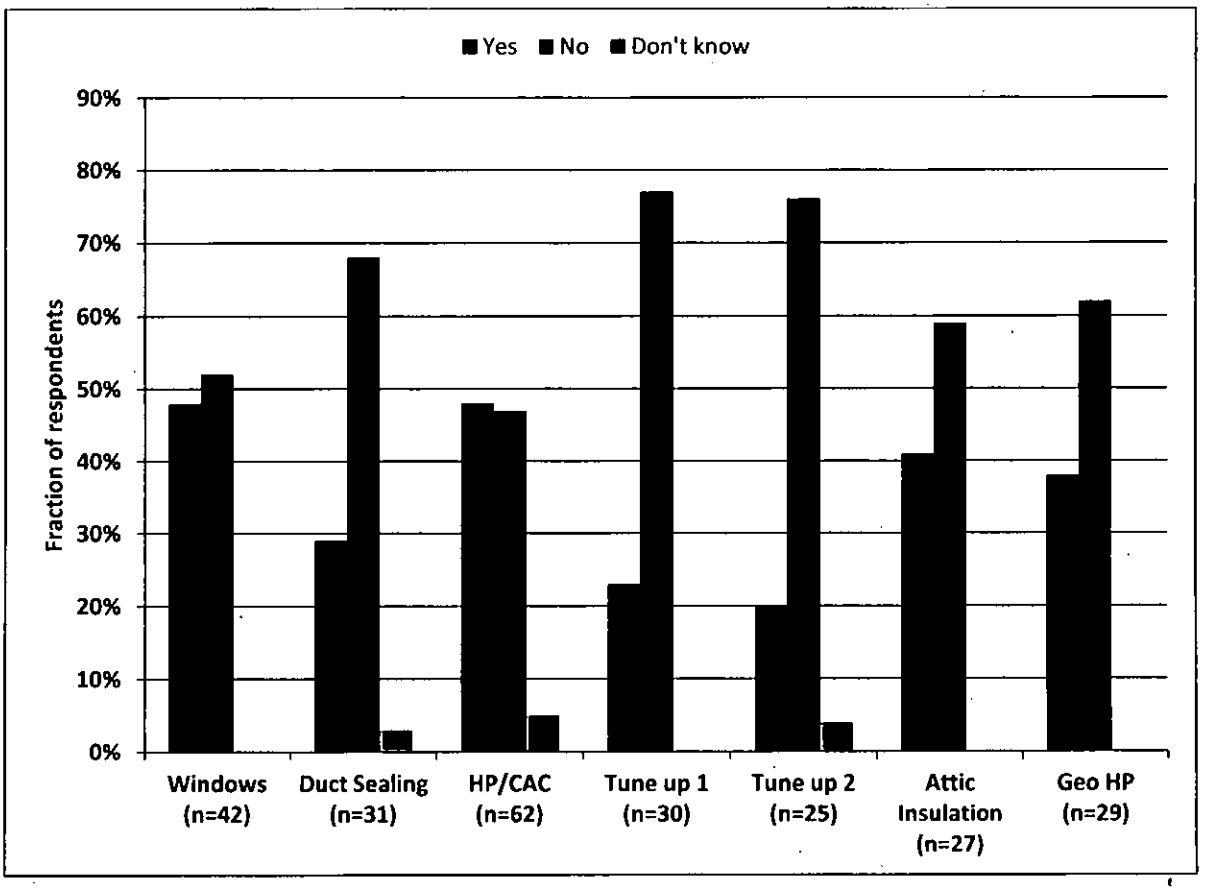
Appendix E. Additional Participant Survey Results

The evaluation team conducted telephone surveys with 246 HEIP participants 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 efficient windows. Chapter 4 of the 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 Chapter 4.

Prior to finding out about HEIP, participants indicated they were more likely to have considered equipment replacement measures such as purchasing a new heat pump than they were to have considered maintenance measures such as HVAC tune-ups or duct sealing (see Figure E-1).

Question: Prior to participating in the program, had you considered installing the energy efficient [measure] installed through the program?

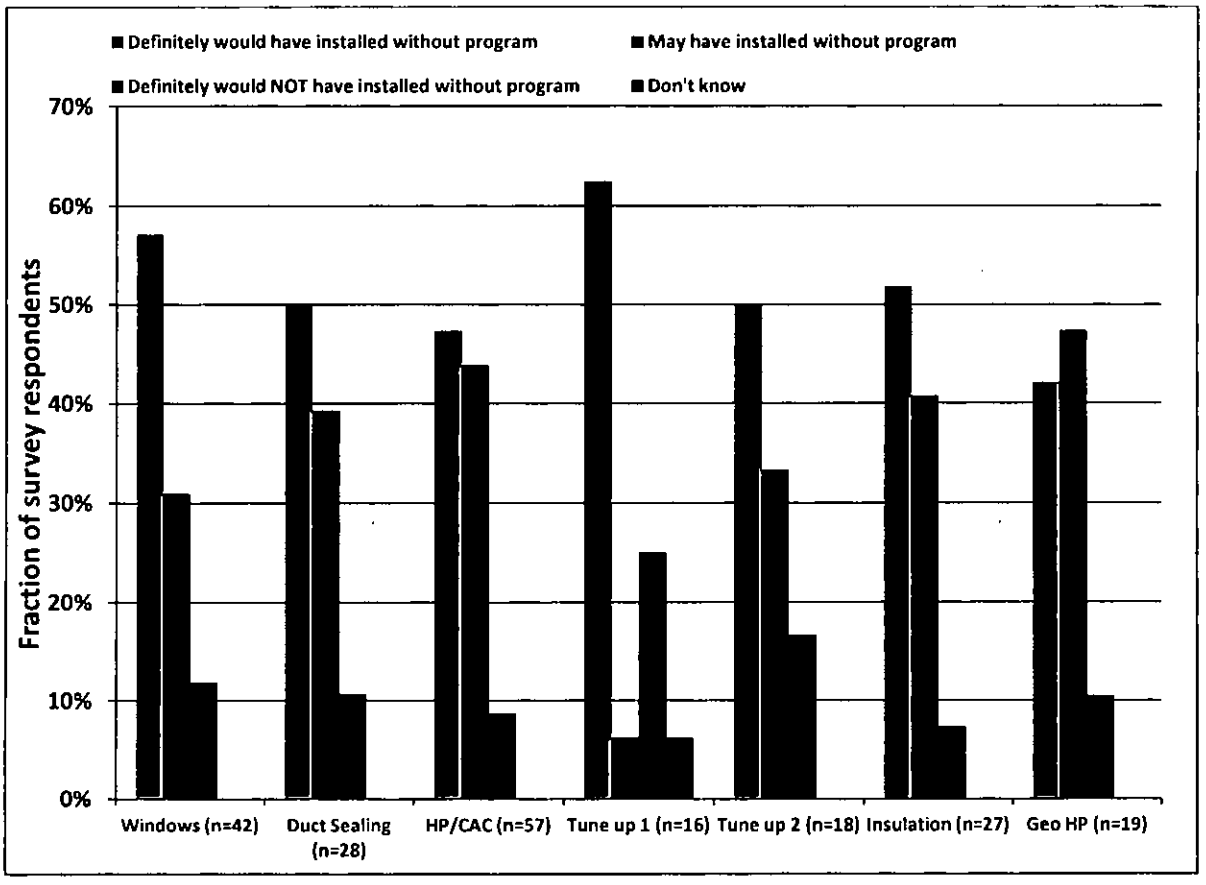
Figure E-1. Number of Participants That Had Considered Installing Measure Prior to HEIP



When asked if they would have installed the same measure in the absence of HEIP and its rebate, participants responded as shown in Figure E-2.

Question: Now I'd like you to think about this in a different way. Given everything you've just told me about the program, what is the likelihood that you would have installed the same energy efficient [INSERT MEASURE(S)] without the program and its financial and technical assistance?

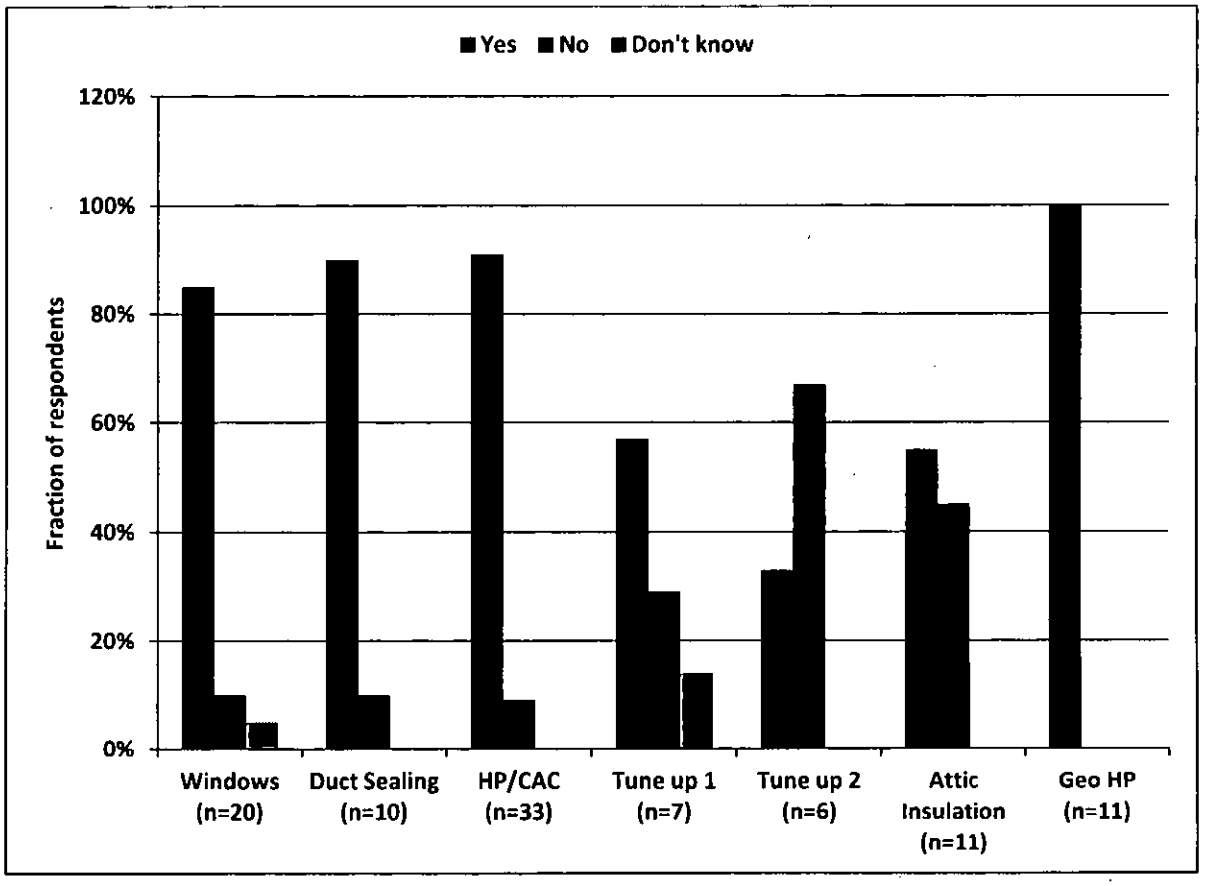
Figure E-2. Likelihood to Install Measure without Program



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 (see Figure E-3.

Question: Did an equipment vendor or contractor help you with your choice of the energy efficient [Insert Measures]?

Figure E-3. Participants Who Indicated the Contractor Aided in Their Final Equipment Choice, Despite Having Considered the Measure Prior to Participating in HEIP



Most participants were satisfied with the HEIP and had no suggestions for improvement, however the most commonly cited improvement was to increase advertising and customer communication (see Figure E-4).

Question: Is there anything you would suggest to improve the Home Energy Improvement Program?

Figure E-4. Participant Suggestions for Improving the Program