

The Evaluation Team identified no spillover for each of the Home Performance Program components.

3.4 Process Evaluation

The following section presents key findings from the process evaluation conducted for the 2017 Residential Home Performance Program. This process evaluation is based on surveys conducted with customers who participated in the 2017 Home Performance Program through the Company, in-depth interviews with Company staff and implementation contractor staff, and an analysis of program tracking data.

The participant survey was designed to capture information related to the decision making behaviors and perspectives of Home Performance participants. The survey focused on aspects of the customer program experience including their implementation of energy efficient measures and behaviors, perspectives on saving energy, and satisfaction with the program.

Data collected via participant surveying are used in evaluating:

- Customer awareness of the program;
- Customer installation of energy efficient measures and behaviors;
- Customer decision making behaviors;
- Customer satisfaction with the program; and
- Overall customer perceptions and feedback across program years.

The Evaluation Team conducted these surveys with multiple groups of customer participants. The Home Performance Program is structured such that some participants receive energy efficiency kits via mail after completing an Online Energy Checkup, while others receive direct install measures through an in-home visit from a specialist. Additionally, participants are informed of existing energy efficiency rebates which they can pursue after they have completed participation in the Home Performance Program. The Evaluation Team attempted to survey each of these groups, as they involve varying levels of decision making and interaction with the Home Performance Program. However, only one of the twenty-eight program participants who received rebates for major measures through the Home Performance Program responded to survey requests.

Table 3-8 displays each of these participant types, along with the total survey respondents in each group and the percentage of participant population surveyed.

Table 3-8 Distribution of Survey Respondents by Participant Type

<i>Participant Type</i>	<i>Number of Survey respondents</i>	<i>Number of Completions in Total Program</i>	<i>Percentage Surveyed</i>
Online Energy Checkup Participants	72	1,863	4%
In-home Assessment Participants (Did not install major measure)	125	1,989	6%
Installed Major Measure	1	28	4%
Total	198	3,880	5%

3.4.1 Program Database Findings

This section presents the results of the program database review conducted by the Evaluation Team. Program tracking data exports were provided by the Company throughout the program year, and this analysis is based on an end-of-year tracking data file containing all projects completed during 2017.

3.4.1.1 Online Energy Checkup Analysis

The program database indicated that a total of 1,863 were mailed out to customers who completed the online kit assessment (Table 3-9). Of note, the kits with CFLs accounted for 57 percent of those distributed to online customers while LED bulbs were in 43 percent of the kits. Overall, 89 percent of these kits were distributed to customers with electric domestic hot water.

Table 3-9 Type of Online Kits Sent Out

<i>Type</i>	<i>Number of Units</i>
CFL-Electric DHW	966
CFL- Non Electric DHW	99
LED-Electric DHW	688
LED-Non Electric DHW	110
Total	1,863

As Table 3-10 shows, 52 percent of the online kits were distributed to the Company's customers who lived in the following cities. Together, Roanoke and Lynchburg VA accounted for 31% of customers who received online kits in PY2017.

Table 3-10 Distribution of Online Kits by Top 10 Cities

City	Number of Kits	% of Total
Roanoke	332	18%
Lynchburg	243	13%
Blacksburg	105	6%
Christiansburg	74	4%
Forest	47	3%
Abingdon	46	2%
Vinton	34	2%
Salem	32	2%
Madison Heights	30	2%
Galax	28	2%

As Figure 3-1 shows, online kit distributions were highest in January, July and December.

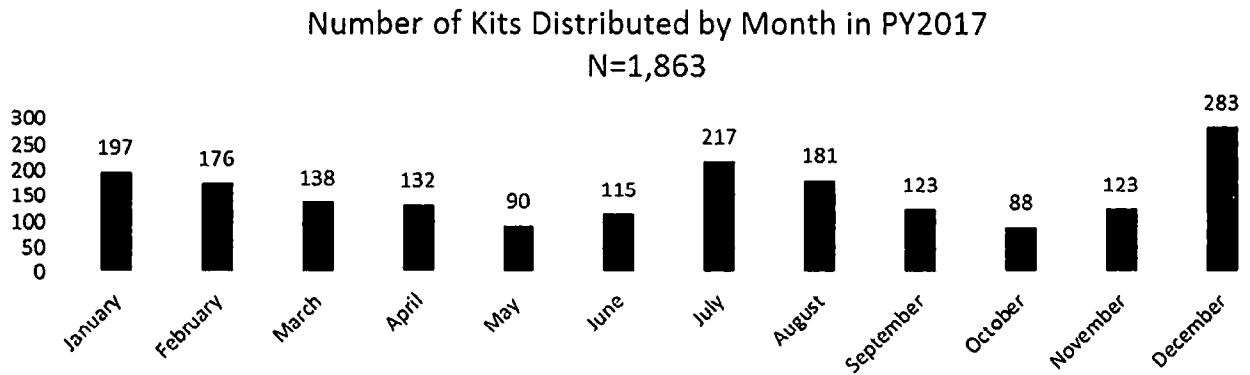


Figure 3-1 Number of Kits Distributed by Month in PY2017

3.4.1.2 In-Home Assessment Analysis

Honeywell manages the in-home assessments, which are completed by approved participating contractors. According to the program database, the 11 participating contractors completed a total of 2,015 in-home assessments in 2017. As Table 3-11 shows, approximately 70% of the in-home assessments were completed by two firms: Zerodraft (42%) and NDS Energy (28%). The other nine firms completed significantly fewer in-home assessments.

Table 3-11 Total Number of In-Home Assessments Completed by Contractor

<i>Contractor</i>	<i>Number of In-Home Assessments</i>	<i>Percent of Total</i>
Zerodraft	850	42%
NDS Energy	565	28%
Imago Green	405	20%
New Life Contracting	62	3%
Better Building Works	38	2%
Energy Check	35	2%
Browns Heating & Air	34	2%
Greenscape Environmental	15	1%
Leap - Local Energy Alliance Program	9	0%
Jk Contracting	1	0%
Tap - Total Action Against Poverty	1	0%
Total	2,015	100%

The activity level of in-home assessments peaked in the summer months, with the most being conducted in June through October, as shown in Figure 3-2.

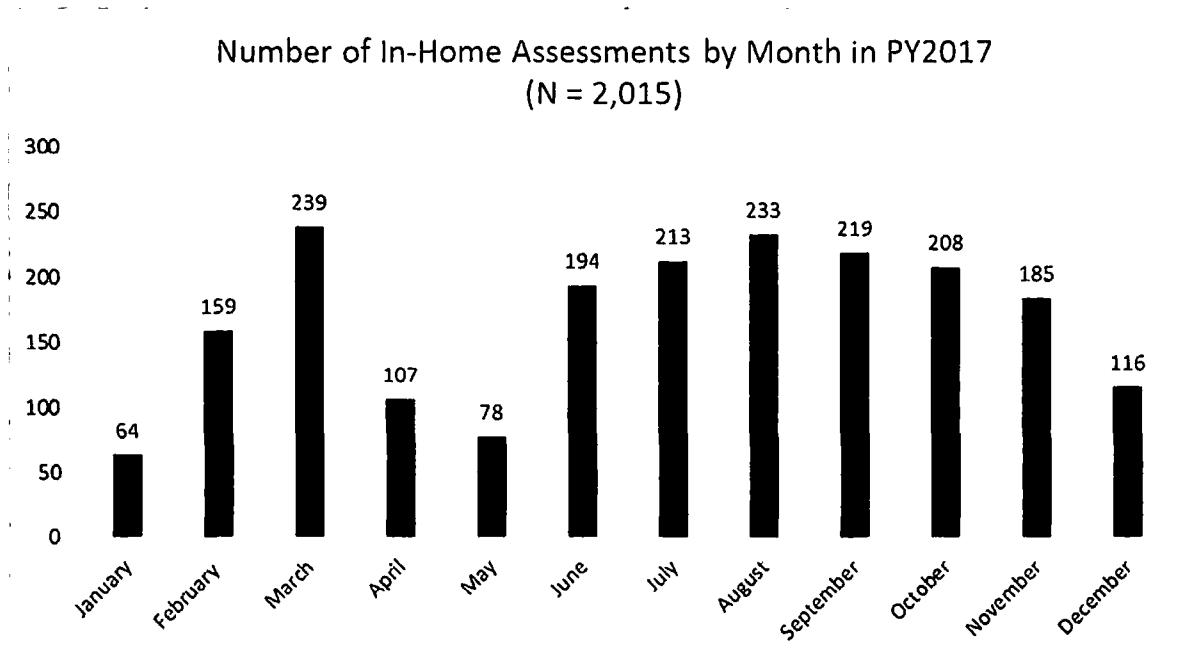


Figure 3-2 Number of Assessments Conducted by 2017 by Month

The majority of the measures installed during the assessment were lighting (36%) followed by low-flow showerheads (26%) and hot water pipe insulation (13%). These findings are illustrated in Figure 3-3.

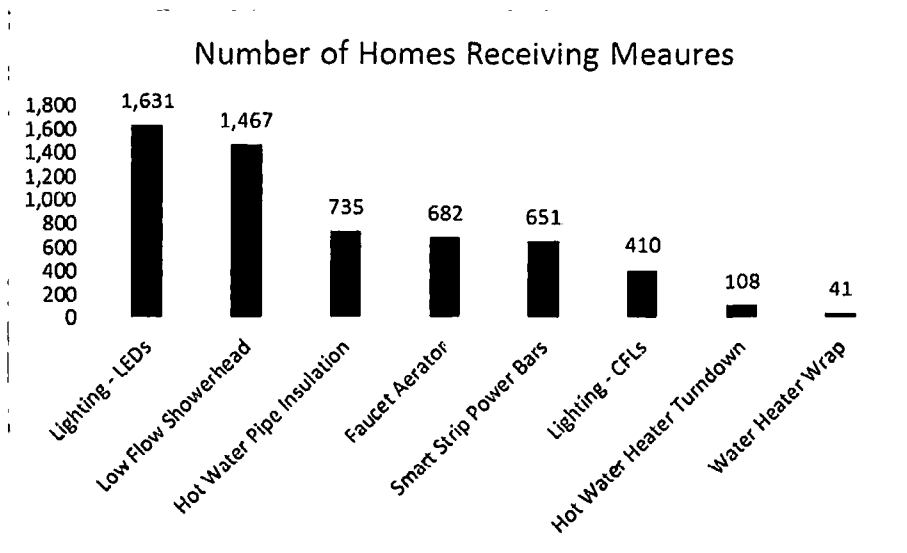


Figure 3-3 Distribution of Measures Installed by Category During In-Home Assessments

The top 10 cities displayed in Table 3-12 accounted for 77% of the customers who received in-home assessments in PY2017. As this table shows, nearly half of all customers receiving in-home assessments lived in either Roanoke or Lynchburg.

Table 3-12 Top 10 Cities Receiving In-Home Assessments

<i>City</i>	<i>Number of In-Home Assessments</i>	<i>% of Total</i>
Roanoke	580	29%
Lynchburg	357	18%
Vinton	148	7%
Martinsville	104	5%
Collinsville	70	3%
Goodview	62	3%
Axton	61	3%
Hardy	60	3%
Bassett	56	3%

Major Measures

A new program component added in PY2017 was to include rebates for insulation measures. A total of 28 customers received a total of \$9,436.20 in rebates for air sealing, duct sealing, and insulation measures. The total number of installations by type is summarized in the Table 3-13. Attic insulation accounted for the majority (80%) of these installations.

Table 3-13 Major Measures Installed Receiving In-Home Assessments

<i>Type of Major Measure</i>	<i>Number Installed</i>	<i>% of Total</i>
Attic Insulation	28	80%
Air Sealing	3	9%
Duct Sealing	3	9%
Wall Insulation	1	3%
Total	35	100%

3.4.2 In-Home Assessment Survey Results

The Evaluation Team conducted surveys with 125 customers who had received an in-home assessment through the Home Performance Program in 2017. Among these customers, 1 received a rebate for a major measure. This section presents key findings from this participant survey effort.

3.4.2.1 Customer Awareness of Program

Survey participants were first asked how they learned about the Home Performance Program.¹⁵ As shown in Figure 3-4, respondents most commonly heard about the program from friends or colleagues (37%), followed by a program representative (28%), and program brochures (22%).

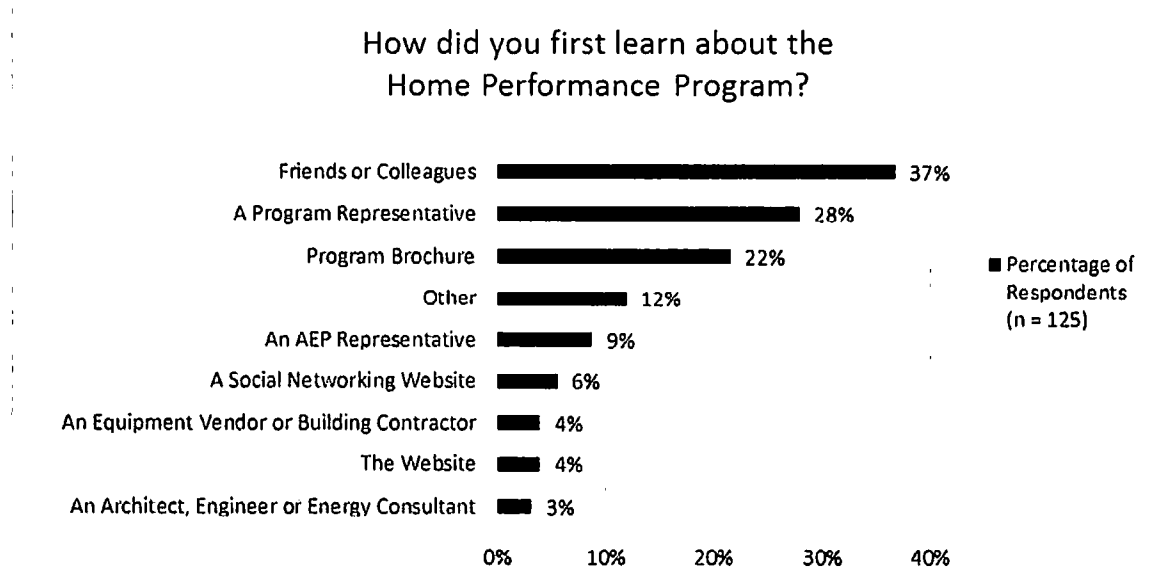


Figure 3-4 How Customers Learned about the Program

3.4.2.2 Additional Audit Recommendations

In addition to the measures provided in the Home Performance kits, many participants received recommendations related to reducing their residential energy usage. To gauge how effective these recommendations were in motivating participants to reduce their residential energy usage, respondents were asked whether they had implemented any of the various recommendations they received.

Twenty-six percent of respondents indicated that they had received energy saving tips and recommendations about possible energy saving behaviors or improvements that they could implement in their home, while 53% had not, and 20% didn't know.

The 26% of respondents that recalled receiving the recommendations or tips were asked to explain what kinds of recommendations they had received, and respondents reported having received a variety of recommendations, such as making energy efficient home upgrades (i.e.

¹⁵ The percentages shown are percentages of responses to all respondents rather than percentages of responses to all responses. As respondents were able to select more than one response, the sum of percentages shown in the figure exceeds 100%.

adding insulation to walls) as well as making behavioral changes (i.e. changes to the thermostat setting). Examples of specific comments regarding recommendations received are as follows:

“He had mentioned doing some extra insulation in our attic and replacing some of our older windows.”

“[They told] me about a programmable thermostat and shower heads.”

“[They informed me that I] needed a new heat pump.”

“[They recommended for me] to start getting more of the bulbs.”

As shown in Table 3-14, when asked whether they had implemented any of these recommendations, 6% reported that they had implemented all of the auditor’s recommendations, while 9% reported that they had implemented at least some of the recommendations.

Table 3-14 Implementation of Home Performance Recommendations

<i>Have you implemented any of these recommendations?</i>	<i>Percentage of Respondents (N = 32)</i>
Yes, all of them	6%
Yes, some of them	9%
No	78%
Don’t know	6%

Respondents who had implemented at least one of the auditor’s recommendations were asked which recommendations they had implemented. The recommendations implemented by respondents were primarily no-cost or low-cost measures, such as changing out lighting. Examples of verbatim recommendations implemented by respondents include:

“Yes, we replaced our light bulbs.”

“[I added] some weather stripping.”

3.4.2.3 Customer Satisfaction

Survey respondents were asked about their levels of satisfaction with selected elements of the Online Energy Checkup Program experience. Results were provided on a scale of 1 to 5, with 1 representing “very dissatisfied” and 5 representing “very satisfied”. Table 3-15 shows that respondents were generally satisfied with each of the selected program elements, with few instances of dissatisfaction in any category. Ninety-three percent of respondents indicated that they were either satisfied or very satisfied with their overall experience in the program.

Among the other program elements, respondents reported being the most satisfied with the professionalism of the auditor (95%), followed by the selection of items installed by the energy specialist (92%), and the performance of the items installed (91%). Respondents were least satisfied with the savings on their monthly bill (59%).

Table 3-15 Customer Satisfaction with Selected Program Elements

Program Element	Satisfaction Rating						N	Overall % Satisfied	Overall % Dissatisfied
	Very satisfied (5)	Somewhat satisfied (4)	Neutral (3)	Somewhat dissatisfied (2)	Very dissatisfied (1)	Don't know			
Professionalism of the auditor	89%	6%	1%	0%	2%	2%	125	95%	2%
The selection of items installed by the energy specialist	75%	17%	2%	0%	2%	5%	124	92%	2%
Performance of the items installed	76%	15%	2%	0%	2%	6%	125	91%	2%
Savings on your monthly bill	42%	17%	18%	2%	2%	19%	125	59%	4%
Information provided by [the Company]	72%	14%	6%	1%	2%	6%	125	86%	3%
The effort required by the application process	70%	19%	2%	0%	2%	7%	125	89%	2%
Overall program experience	76%	16%	2%	0%	2%	4%	123	93%	2%

Respondents who reported being dissatisfied with the program were asked to elaborate on this rating. Examples of commentary provided by these respondents include:

"[I am dissatisfied] because of the bill and would like to have another shower head in other bathroom and more light bulbs."

"I have not seen savings."

"[I am dissatisfied] because [my bill] price went up monthly."

The instances of dissatisfaction were infrequent, however, for all program elements. Nevertheless, the savings on the monthly bill was the aspect of the program with which participants were most often dissatisfied (4% were dissatisfied with this aspect). As none of these respondents completed the major measures component of the program, which would likely result in more significant energy savings per home, seasonal fluctuations in energy use may have obscured the monthly savings achieved for some customers. Overall, 93% of respondents reported being satisfied or very satisfied with their program experience.

3.4.3 Online Energy Checkup Survey Results

The Evaluation Team conducted surveys with 72 customers who had received an energy conservation kit through the Online Energy Checkup component of the program during 2017. This survey focused on many of the same topics as the In-home Assessment survey, with additional specific questions regarding the items that were provided in the conservation kits.

3.4.3.1 Customer Awareness of Program

Survey participants were first asked how they learned about the Online Energy Checkup component of the program.¹⁶ As shown in Figure 3-5, the majority of respondents most commonly reported that they heard about the program from the utility website (51%), as well as from friends or colleagues (15%). Other common sources of awareness were email (8%)¹⁷, direct shipment of the kits without prior notice (8%)¹⁸, or social networking sites such as Facebook or Twitter (4%).

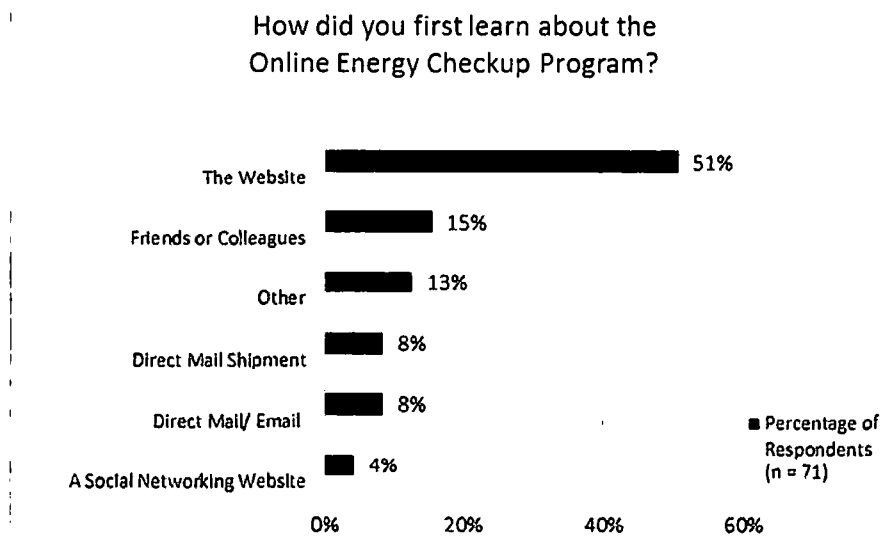


Figure 3-5 How Customers Learned about the Online Energy Checkup

¹⁶ The percentages shown are percentages of respondents rather than percentages of responses. As respondents were able to select more than one response, the sum of percentages shown in the figure exceeds 100%.

¹⁷ This was not a survey response option but was commonly provided through open-ended responses.

¹⁸ This was not a survey response option but was commonly provided through open-ended responses. Some participants became aware of the program only when the kit had arrived at their residence with no prior notice.

3.4.3.2 Customer Installation of Measures

Seventy-three percent of respondents indicated that there was at least one item included with the Online Energy Checkup kit that they chose not to install. Respondents who reported that they had not installed all of the available measures from the kits were asked why they had chosen not to install these measures. Respondents were able to select more than one response. As shown in Table 3-16, respondents most commonly reported that the item was not compatible with their fixtures (40%), or that they already had the item (27%).¹⁹

Additionally, 15% of these respondents indicated that they had not had time to install the measures and, 10% said they did not like the items. At 4% of the total respondents each program element, there was an even distribution of respondents reporting that they chose not to install the measures because they were unable to install the measures themselves, the items were broken, as well as that items were missing from the kit. Respondents reporting missing items may have been expecting a different measure mix in their kits; this may have occurred because customers receive kits with different contents based on whether they possess gas water heating or electric water heating.

Table 3-16 Reasons for Choosing not to Install Measures

<i>Reason</i>	<i>Percentage of Respondents (N = 45)</i>
They were not compatible with my fixtures	40%
Already had item installed	27%
Did not have time to install them	15%
I did not like the items	10%
Other	10%
Was not able to install them on my own	4%
The items were broken	4%
The items were missing from the kit	4%

3.4.3.3 Factors Affecting Customer Decision Making

Survey respondents were asked a series of questions related to their decision making behaviors involving energy efficiency. These responses can be used to provide insight into customer preferences, objectives, and primary motivations towards the Online Energy Checkup Program. These questions were mainly used to inform the free-ridership and spillover analysis of program

¹⁹ This was not a survey response option but was commonly provided through open-ended responses.

savings, which is further discussed in detail in the Savings Estimation Methodologies chapter of this report.

As a part of this series of decision making questions, respondents were asked to provide the specific reasons that they decided to participate in the program.²⁰ Figure 3-6 displays customer responses to this item for the 2017 program year. The majority of respondents (56%) indicated that they chose to use the energy efficient equipment in order to save money on their energy bills.

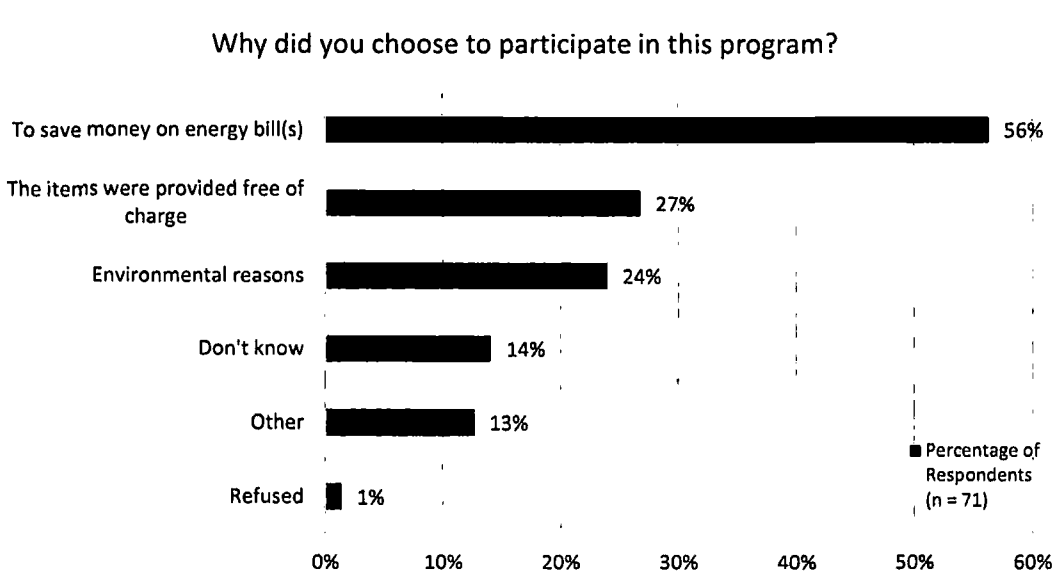


Figure 3-6 Reported Reasons for Participating in Online Energy Checkup Program

3.4.3.4 Customer Satisfaction

Survey respondents were asked about their levels of satisfaction with selected elements of the Online Energy Checkup Program experience. Results were provided on a scale of 1 to 5, with 1 representing “very dissatisfied” and 5 representing “very satisfied”. Table 3-17 shows that respondents were generally satisfied with each of the selected program elements, with few instances of dissatisfaction in any category.

Among the program elements, respondents reported being most satisfied with the performance of the energy efficiency items installed (88%), followed by the contents of the Online Energy Checkup kit (86%).

²⁰ The percentages shown are percentages of responses to all respondents rather than percentages of responses to all responses. As respondents were able to select more than one response, the sum of percentages shown in the figure exceeds 100%.

Table 3-17 Customer Satisfaction with Selected Program Elements

Program Element	Satisfaction Rating						N	Overall % Satisfied	Overall % Dissatisfied
	Very satisfied (5)	Somewhat satisfied (4)	Neutral (3)	Somewhat dissatisfied (2)	Very dissatisfied (1)	Don't know			
Contents of the Online Energy Checkup kit	70%	16%	4%	3%	1%	6%	69	86%	4%
Performance of the items installed	74%	14%	1%	0%	1%	9%	70	88%	1%
Savings on your monthly bill	26%	27%	17%	6%	3%	21%	70	53%	9%
Information provided by utility	64%	19%	7%	0%	3%	7%	69	83%	3%
The effort required for the program application process	69%	14%	3%	0%	3%	11%	70	83%	3%
Overall program experience	77%	9%	4%	0%	3%	7%	70	86%	3%

Respondents who reported being dissatisfied with other aspects of the program were asked to elaborate on this rating. Examples of commentary provided by these respondents include:

"I thought it would make some type of difference and it hasn't."

"The water is coming out too slow."

Although there were some instances of dissatisfaction, the survey results overall indicate that respondents were generally satisfied with each of the selected program elements, and there were few instances of dissatisfaction in any category. Eighty-six percent of respondents indicated that they were either satisfied or very satisfied with their overall experience in the program.

3.4.4 In-depth Interview Results

As part of the PY2017 process evaluations, the team also conducted in-depth interviews with the Company program staff and the implementation staff responsible for delivering the Home Performance Program. These interviews provided an update on respondents' roles and responsibilities, program operations, assessed the effectiveness of current program components, such as marketing and outreach and data tracking, and identified areas for program improvement.

3.4.4.1 Roles and Responsibilities

The program is overseen by one Company staff member; however, the third-party implementer, Honeywell, is in charge of contractor recruitment, training, and management. The Company program staff has been working with Honeywell staff since the program began in PY2016. However, there has been some internal changes within Honeywell in the last year. A new

account manager started working with the program in mid-2016 and a new operational coordinator started processing customer rebates and assisting trade allies in April 2017.

3.4.4.2 Program Operations

This program has three separate components. The first component is completed by customers who visit the program website and complete an online energy audit. The Company manages this portion of the program and is responsible for mailing out the online kits to qualifying customers. The Company has been responsible for that program component since program inception.

Customers may also sign up to receive an in-home energy assessment, conducted by third-party contractors. The contractors conduct an in-home energy audit and install several energy savings measures, as appropriate. These direct install measures are similar to those available from the online kits, and are installed only if these measures are currently not in place in the customer's homes. However, customers may refuse to have some measures installed. According to the program implementer, the most frequently refused measures are the faucet aerators.

3.4.4.3 Program Performance

The Company staff reported that 1,863 customers participated in the online check-up and received an energy savings kit. While the staff is pleased with the program activity, it is slightly below the PY2017 program goal.

The in-home energy assessment program component is doing well, according to the program staff. The program implementer reported that the number of in-home energy assessments is tracking very closely to the program goals. They attribute this to the successful recruitment of contractors who specialize in conducting energy audits. As the program database showed, most of the energy audits are performed by just a few of the participating contractors.

Although this program component was designed to encourage participants to install more comprehensive measures, so far the major measures installed through the program have been limited to air sealing and insulation.

“Some contractors have partnerships with HVAC contractors or weatherization providers. But some contractors are just on the energy assessment side...not all of them are trying to sell beyond the energy audits.” (Program Implementer)

In addition, most of the contractors recruited for this program focus nearly exclusively on conducting energy assessments, rather than offering a comprehensive suite of weatherization services. So, although the program was changed to attract more HVAC contractors, this program objective is not likely to be met. The program implementer also explained that because there are limited incentives for HVAC measures, it is difficult to recruit these contractors into the program.

3.4.4.4 Program Outreach Activities

This program has relied on a variety of outreach activities to encourage customer participation. The Company's outreach activities include direct mail, bill inserts, television advertising and Search Engine Optimization (SEO).

The utility staff explained that the neighborhood canvassing activities were discontinued because they were both ineffective and led to a number of customer complaints. Rather, the utility gave cooperative advertising dollars to support local contractor outreach activities.

The Company also increased its direct mail, targeting specific neighborhoods which also helped to increase overall program participation.

In addition, the program implementer also increased its outreach to qualified contractors, especially those who provide the in-home energy assessments. The utility staff is pleased with these current contractor outreach activities conducted by Honeywell. Overall, the program's performance has improved since last year, largely due to the increased number of participating contractors.

Both the utility and program implementation staff plan on continuing their targeted direct mailing activities to promote continue the momentum. The focus will be on "helping the contractors help themselves," as the program implementer explained.

3.4.4.5 Quality Assurance/Quality Control

Both the utility staff and program implementer are pleased with the current database. It captures all of data required by program staff. However, the database is currently not tracking the customers' reasons for refusing to install any of the direct measures. There is also no follow-up with customers after the energy audit directly to encourage them to install the recommended measures.

The program implementer does maintain a robust Quality Control/Quality Assurance (QA/QC) requirement of inspecting the 100% of the first five in-home energy assessments completed by each contractor and then at least five percent of all jobs completed thereafter. According to the program implementer, the actual inspection rate is approximately 10% to 20% of the completed jobs.

3.4.4.6 Contractor and Customer Feedback

Overall, contractor feedback has been positive according to both the utility staff and the program implementer. There are currently approximately 20 contractors, but 11 account for the majority of the completed jobs.

The program implementer also reported that customer satisfaction is high, at nearly 100% based on post-audit customer surveys conducted by the implementation contractor.

3.4.4.7 Barriers to Participation

While the program design now includes a pathway to encourage customers to install more major measures, this change has still not addressed a major barrier to program participation—the lack of incentives for HVAC measures. Currently, HVAC incentives are only available for customers with electric baseboard heat or furnaces with heat pumps. But, as the program implementer explained, these are not commonly installed measures, so there is little demand for these products. In addition, most of the trade allies currently in the program do not perform heat pump replacements. As the program implementer explained, “The incentives are not aligned to market demand.”

3.4.4.8 Areas for Program Improvement

In the next filing, the utility staff would like to expand this program to also include customers who live in multifamily homes, as they believe this is a missed opportunity in the current filing.

3.4.5 Conclusions and Recommendations

The following conclusions are based on the process evaluation and impact evaluation activities conducted for the 2017 program year:

- Participant satisfaction with the program was high. Ninety-three percent indicated that they were satisfied with the home assessment track of the program overall by rating their satisfaction as a four or a five on a five point scale. Similarly, 86% were satisfied with their overall experience with the online audit component.
- Participants most often learned of the program from friends or colleagues (37%), a program representative (28%), or a program brochure (22%). In comparison, participants in the online component most often learned of RHPP from the program website (51%) or friends and colleagues (15%).
- Overall, two of the three program components are operating effectively. Both the online and in-home assessments have seen high levels of participation. However, comparatively fewer customers have implemented major measures such as insulation, air sealing, duct sealing, or heat pumps. Regarding the HVAC component, staff indicated that the current program design does not attract HVAC contractors to participate in the program and the requirement that heat pumps replace electric baseboard or electric furnaces limits participation.
- Honeywell should continue program activities to recruit and support participating trade allies, particularly those who sell and install HVAC equipment.
- The Company staff should continue its customer outreach to promote the online kit assessment.
- Honeywell staff should start tracking and reporting on customers’ reasons for refusing the direct install measures, as a way to more accurately gauge energy savings.

- The Company and Honeywell staff should work together to explore ways to encourage customers to implement major measures. Possible actions include developing more robust follow-up activities to all customers who received an in-home energy assessment, increasing incentives for duct and air sealing, or offering bonus incentives to contractors for completing projects with these measure types.
- For the next program cycle, the Company staff should consider adding HVAC incentives, as way to encourage customers to install additional energy savings measures.

4 Low-Income Weatherization Program

4.1 Program Description

The Residential Low-Income Weatherization Program (RLIWP) provides weatherization products and services to residential customers in need to help reduce their energy bills and improve their homes' comfort. The Company provides funding for this program through Community Housing Partners (CHP) to help supplement the State and Federal income qualified Weatherization Programs.

To qualify for the program, a household's income cannot exceed 60% of State Median Income. Appalachian Power does not offer this Program directly; it is managed by the CHP in conjunction with the Weatherization Service Providers. When a customer applies for an energy assistance program through an agency, they are also applying for this program.

The weatherization service providers use the Weatherization Assistant National Energy Audit Tool (NEAT) and Mobile Home Energy Audit (MHEA) software to calculate savings for the program. The program weatherized 247 homes during PY2017.

4.2 Impact Evaluation

This chapter addresses the impacts of kWh savings and peak kW reductions resulting from measures installed in facilities of customers that obtained incentives under the Residential Low-Income Weatherization Program during the period January 2017 through December 2017.

4.2.1 Methodology for Estimating Gross Savings

The M&V approach for the 2017 Residential Low-Income Weatherization Program is aimed at the following:

- Determining the number of weatherization measures reported as being installed through the program;
- Verifying the extent to which the reported weatherization measures are currently installed;
- Estimating annual kWh savings for measures implemented; and
- Estimating annual kW reduction for measures implemented.

Table 4-1 below summarizes the inputs needed for gross savings calculations and the source of each input.

Table 4-1 Data Sources for Gross Impact Parameters – Low-Income Weatherization Program

<i>Parameter</i>	<i>Source</i>
Number of Participants	Program Tracking Data
Measures Installed	Program Tracking Data/ Telephone Surveys/ On-Site Visits
Measures Still In Use	Participant Surveying/ Telephone Surveys/ On-Site Visits
Home characteristics	Program Tracking Data / Telephone Surveys/ On-Site Visits

4.2.1.1 Verification of Weatherization Measures Installation

The initial step in conducting measurements of program activity is to verify the number of weatherization measures installed. The Evaluation Team takes several steps in verifying the number of weatherization measures installed which consists of the following:

- Validating Program tracking data provided by CHP by checking for duplicate or erroneous entries;
- Verifying that participants were part of the program according to the agreed-upon process between CHP and the Company;
- Conducting verification surveys with a statistically valid sample of program participants (the focus of these verification surveys is to confirm that customers listed in the program tracking database did indeed participate and that the number of measures installed was accurate); and,
- Conducting on-site visits constituting a verification inspection of installed measures (field technicians verify the implementation status of the installed measures customers received, that the measures are indeed installed, and that they were installed correctly and are functioning properly).

4.2.1.2 Sampling

Sampling is necessary to evaluate savings for the Company's RLIWP, as verification of a census of program participants is typically cost-prohibitive. Samples are drawn in order to ensure 90% confidence at the +/- 10% precision level. The RLIWP is evaluated on the Simple Random Sample basis.

4.2.1.2.1 Simple Random Sampling

For the RLIWP, the Evaluation Team conducted a simple random sample of participants for surveying. The sample size for verification surveys is calculated to meet 90% confidence and 10% precision. The sample size to meet 90/10 requirements is calculated based on the coefficient of variation of savings for Program participants. Coefficient of Variation (CV) is defined as:

$$CV(x) = \frac{\text{Standard Deviation}(x)}{\text{Mean}(x)}$$

Where x is the average kWh savings per participant. Without data to use as a basis for a higher value, it is typical to apply a CV of 0.5 in residential Program evaluations. The resulting sample size is estimated at:

$$n_o = \left(\frac{1.645 \cdot CV}{RP} \right)^2$$

Where,

1.645 = Z Score for 90% confidence interval in a normal distribution

CV = Coefficient of Variation

RP = Required Precision, 10% in this evaluation

With 10% required precision (RP), this calls for a sample of 68 surveys to be performed for the RLIWP. For the RLIWP, the Evaluators were only able to obtain 30 participant survey completions, but conducted on-site visits to 30 participant homes to verify measure installation.

4.2.1.3 Data Collection

This subsection provides descriptions of the Evaluation Team's data collection procedures, including:

- Telephone Surveys; and
- Home Visits.

4.2.1.3.1 Telephone Surveys

The Evaluation Team conducted telephone surveys as part of the evaluation of the Company's 2017 Residential Low-Income Weatherization Program. These surveys were designed to collect a variety of data needed to perform an in-depth evaluation effort, including:

- Verification of implemented measures completed by Weatherization Service Providers;
- Parameters used in gross savings calculations; and
- Feedback from participants regarding their experiences with the program.

The Evaluation Team was able to reach 30 of the 247 participants through telephone surveying. Surveys with residential program participants were conducted by VuPoint Research, an

experienced survey firm, with the Evaluation Team performing quality control checking on the collected data.

4.2.1.3.2 Home Visits

In addition to telephone surveying, the Evaluation Team's verification efforts consisted of a sample of on-site visits to participant homes. Participants were given \$25 gift cards for their time. During the on-site visits, Evaluation Team field technicians accomplished the following:

- Verified the implementation status of the measures; verified that the measures were indeed installed, that they were installed correctly, and that they were functioning properly. Photographs were taken of installed measures.
- Data collected at each site focused on obtaining more specific information regarding the characteristics of the home where the measures were implemented.

The Evaluation Team conducted on-site visits to 30 participant homes as part of this verification effort. Of these 30 customers, 5 also responded to the participant survey effort. Thus, the Evaluation Team conducted measure verification checks with 55 unique participants.

4.2.1.4 Gross Annual kWh Savings and Peak kW Reduction Estimates

During the 2015 evaluation, the Evaluation Team conducted an analysis of the National Energy Audit Tool that the weatherization service providers use to calculate expected savings for the program. Based on this analysis, the Evaluation Team deemed the software to be a sufficient way to calculate expected savings for the measures implemented through the program. For the 2017 evaluation, the Evaluation Team analyzed a series of NEAT input reports provided by CHP in order to verify that the NEAT-reported savings continue to produce reliable savings estimates.

This analysis consisted of two phases. The first phase involved inputting customer information for a small sample of NEAT reports into a default version of the NEAT software. This portion of the analysis served to verify that the savings reported within program tracking data matched the savings generated by NEAT. The Evaluation Team did not identify any significant differences between the reported savings and NEAT-generated savings for this sample of customers, which indicates that the reported savings are based on the algorithms and assumptions that the Evaluation Team validated during the 2015 evaluation.

Although the Evaluation Team found the NEAT system to be sufficient for calculating savings under the RLIWP, the preferred source for deemed residential savings calculations within the Company's portfolio of residential programs for 2017 is the Mid-Atlantic TRM. In order to maintain consistency across the Company's portfolio of residential programs, the Evaluation Team identified RLIWP measures for which sufficient information was provided to calculate savings using TRM algorithms. These measures included air sealing, heat pump replacement,

CFLs, and water heater tank wraps.²¹ For these measures, the Evaluation Team referenced the Mid-Atlantic TRM in the calculation of realized energy savings and peak demand reductions.

To calculate energy savings and demand reductions resulting from the installation of CFLs, the Evaluation Team referenced multiple sources as the Mid-Atlantic TRM did not completely characterize this measure. Baseline wattages of installed lamps were determined from lumens lookup tables provided in the Illinois Statewide TRM V6.0 (Illinois TRM), the average annual hours of use for installed CFLs was obtained from the residential LED savings section found in the Mid-Atlantic TRM, and Virginia weather data was used for estimating the heating and cooling interactive effects from installing these measures.

For measures for which insufficient information was provided within NEAT reports or program tracking data to calculate savings using either the Mid-Atlantic TRM or the Illinois TRM, or for measures that are not addressed within the appropriate TRM, the Evaluation Team continued to reference the NEAT-reported savings. Table 4-2 lists each measure category for the 2017 RLIWP, along with the source referenced by the Evaluation Team to calculate realized energy savings and demand reductions.

²¹ The Mid-Atlantic TRM is the preferred deemed savings source for the Company's programs in Virginia and was referenced for each of these measures.

Table 4-2 Data Sources Referenced by Measure Category

<i>Measure Type</i>	<i>Calculation Method</i>
Air Sealing	Mid-Atlantic TRM
CFLs	IL TRM / Mid-Atlantic TRM
Duct Insulation	NEAT
Duct Sealing	NEAT
Electric Furnace Replacement	NEAT
Faucet Aerator	NEAT
Heat Pump Installation	Mid-Atlantic TRM
HVAC Tune-Up	NEAT
Insulation	NEAT
Low Flow Showerhead	NEAT
Refrigerator Replacement	NEAT
Water Heater Pipe Wrap	NEAT
Water Heater Tank Wrap	Mid-Atlantic TRM
Water Heater Temperature Setback	NEAT

4.2.1.5 Net Energy (kWh) and Peak Demand (kW) Impacts

The purpose of the Residential Low-Income Weatherization Program is to assist income-qualified customers who would benefit from higher level standard home weatherization measures such as ceiling insulation, home infiltration, and duct sealing. Because the program is offered to customers whose income is below 200% of the federal poverty level, and who would be unlikely to implement the measures without the program, the Evaluation Team applied a NTGR of 100% to the program.

4.2.2 Results of Gross and Net Savings Estimation

The following subsections summarize the results of the impact evaluation conducted for the 2017 Low-Income Weatherization Program.

4.2.2.1 Database Review Results

The Evaluation Team first examined the tracking database for systemic entry errors for each channel, i.e., duplicate entries and/or erroneous entries (such as data entered into improper columns). Upon receiving final program tracking databases, the Evaluation Team found quantities and unit specifications to match the implementer's records.

4.2.2.2 Results of Verification of Weatherization Measures Installation

To verify that the number of homes in the program tracking database claiming to have weatherization measures installed through the program was accurate, the Evaluation Team administered a telephone survey with program participants and performed on-site visits at participant homes.

All 30 respondents who completed the participant survey verified that they had participated in the Residential Low-Income Weatherization Program during 2017. Nearly all survey respondents also indicated that the measures matched up to what was claimed by the implementer's tracking database. Respondents were also asked whether they had removed or replaced any of the items that were installed by the agencies, and nearly all respondents indicated that they had not removed any items. The only exception was that the Evaluation Team was unable to verify two instances of air sealing being performed, thirteen faucet aerators, and seven low flow showerheads. Other than an expected rate of removal of CFLs, no other differences in measure documentation provided versus measures found on-site or verified through the survey were found. The in-service rates applied to the 2017 program year by measure are displayed in Table 4-3.²²

²² The in-service rate applied to CFLs is based on the Illinois TRM stipulated in-service rate for this measure.

Table 4-3 In-Service Rates Applied by Measure Category

<i>Measure Type</i>	<i>In-Service Rate</i>
Air Sealing	90%
CFLs	98%
Duct Insulation	100%
Duct Sealing	100%
Electric Furnace Replacement	100%
Faucet Aerator	59%
Heat Pump Installation	100%
HVAC Tune-Up	100%
Insulation	100%
Low Flow Showerhead	53%
Refrigerator Replacement	100%
Water Heater Pipe Wrap	100%
Water Heater Tank Wrap	100%
Water Heater Temperature Setback	100%

4.2.2.3 Gross Annual kWh Savings and Peak kW Reduction Results

The 2017 Residential Low-Income Weatherization Program contributed to the weatherization of 247 homes. The program-level realized energy savings of the program for the period January 2017 through December 2017 are summarized in Table 4-4 below. During this period, realized gross energy savings totaled 1,045,124 kWh. The gross realization rate for the program is 92%. The program assumed no free-ridership; therefore, net savings are equal to gross savings.

Table 4-4 Weatherization Component Gross Realization Summary

<i>Low-Income Weatherization Program</i>			
	<i>Expected</i>	<i>Realized</i>	<i>Realization Rate</i>
Annual Energy Savings (kWh)	1,136,577	1,045,124	92%
Annual Energy Savings (kW)	147.76	135.87	92%
Lifetime Energy Savings (kWh)	-	15,667,444	-

Lifetime savings for weatherization measures were calculated using Effective Useful Life (EUL) values for each measure as specified in the appropriate TRM.

4.3 Process Evaluation

This chapter presents key findings from the limited process evaluation conducted for the 2017 Residential Low-Income Weatherization Program through the Company. The 2017 process findings are based on surveys of a sample of participating customers, a review of the program database, and interviews with staff from the Company and the implementation contractor.

4.3.1 Program Participation

The program database contained a complete set of program records for all of the activity that was completed during PY2017. Table 4-5 summarizes the total cost paid by the Company for the installed measures and also provides the total number of measures installed by type. Overall, the total cost of the installed measures was \$795,015.53. The program recorded a total of 1,146 actions that were completed in 247 residences. This number included energy audit actions as well as the installation of energy efficiency measures.

As this table shows, heat pump replacements were the costliest measure, accounting for nearly 50% of the total program measure costs. Other commonly installed measures included air sealing (7%) and insulation in mobile homes (9%). The table also captures those activities that are conducted as part of the in-home energy audit, including blower door testing.

Table 4-5 Summary of Measures Installed Through 2017 by Cost and Number

<i>Measure Installed</i>	<i>Total Measure Cost</i>	<i>% of Measure Cost</i>	<i>Number of Measures Installed</i>	<i>% of Total</i>
BL 1 - Energy Audit	\$55,648.48	7.0%	157	13.7%
BL 2 - Replace Refrigerator	\$5,387.79	0.7%	11	1.0%
BL 3 - CFL Bulbs - 13 Watt CFL	\$1,432.70	0.2%	52	4.5%
BL 4 - Low-Flow Showerheads	\$743.46	0.1%	29	2.5%
BL 5 - Faucet Aerator	\$137.94	0.0%	20	1.7%
BL 6 - Water Pipe Insulation	\$1,718.00	0.2%	76	6.6%
BL 7 - Electric Water Heater Wraps	\$2,797.95	0.4%	58	5.1%
BL 8 - Lower DHW Temperature		0.0%	0	0.0%
BL 9 - Electric Furnace Clean/Tune Following VA Field Guide and HVAC Training	\$950.00	0.1%	3	0.3%
BL 10 - Heat Pump Clean/Tune Following VA Field Guide and HVAC Training	\$12,284.76	1.5%	23	2.0%
BL 11 - Heat Pump Installation - Replacement of Electric Furnace or Heat Pump	\$395,557.28	49.8%	117	10.2%
BL 12 - Electric Furnace Repair or Replacement	\$3,188.00	0.4%	6	0.5%
EE 1 - Blower Door Guided Air Sealing	\$56,835.82	7.1%	170	14.8%
EE 2 - Insulate Sidewalls	\$10,268.00	1.3%	13	1.1%

<i>Measure Installed</i>	<i>Total Measure Cost</i>	<i>% of Measure Cost</i>	<i>Number of Measures Installed</i>	<i>% of Total</i>
EE 3 - Insulate Attic	\$38,863.65	4.9%	60	5.2%
EE 4 - Foundation Insulation	\$1,315.60	0.2%	2	0.2%
EE 5 - Floor Insulation for Site Built Home	\$15,431.08	1.9%	18	1.6%
EE 6 - Duct Sealing	\$23,451.00	2.9%	76	6.6%
EE 7 - Duct Insulation	\$2,541.26	0.3%	9	0.8%
EE 8 - Mobile Home Floor or Attic Insulation	\$68,505.61	8.6%	58	5.1%
EE 9 - Mobile Home Roof Coat to Protect integrity of Existing or Added Insulation	\$2,652.15	0.3%	8	0.7%
EE 10 - Mobile Home Roof Patch to Seal Holes after Insulating	\$3,267.60	0.4%	5	0.4%
EE 11 - Mobile Home Belly Patch	\$1,349.00	0.2%	14	1.2%
HS 1 - Electric Upgrade - Grounding or Panel Upgrade, Knob & Tube by Licensed Electrician	\$700.00	0.1%	2	0.2%
HS 2 - Bathroom Fan	\$4,093.00	0.5%	8	0.7%
HS 3 - Kitchen Exhaust Fan / Vent	\$8,949.00	1.1%	24	2.1%
HS 4 - ASHRAE Continuous Ventilation Fan	\$73,216.40	9.2%	123	10.7%
HS 6 - Domestic Hot Water Tank Replacement	\$3,730.00	0.5%	4	0.3%
Total	\$795,015.53	100.0%	1,146	100.0%

The program activity was relatively consistent throughout the year, as Table-4-6 and Figure 4-1 illustrate. The busiest times were in November (16%) and the Spring months (April, May and June; 33%). However, activity was fairly consistent throughout most of the program year.

Table-4-6 2017 Program Activity by Month

Month	# of Homes	% of Total
January	12	5%
February	8	3%
March	9	4%
April	29	12%
May	25	10%
June	27	11%
July	17	7%
August	26	11%
September	21	9%
October	18	7%
November	39	16%
December	16	6%
Total	247	100%

**Number of Homes Treated by Month in PY2017
(N=247)**

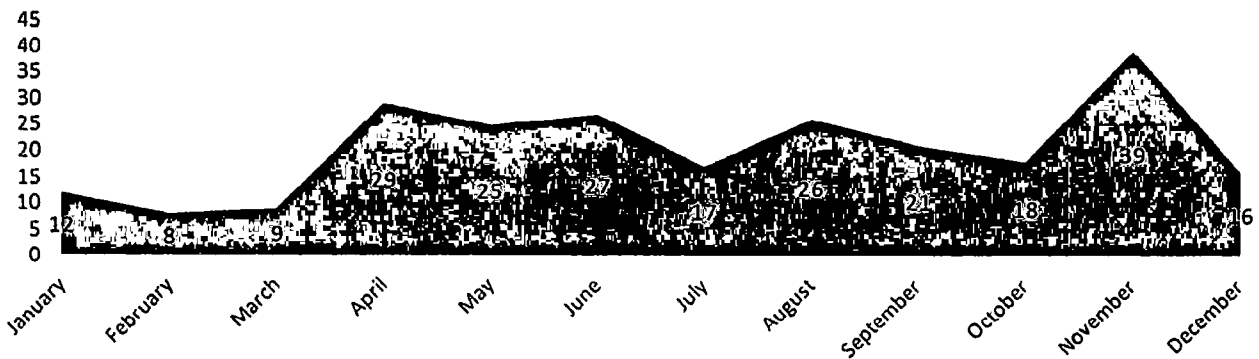


Figure 4-1 Number of Homes Treated by Month

CHP is not only the program implementer, but also the most active weatherization contractor, accounting for 43% of all completed projects. STEP Inc. accounted for 10% of the program

activity while the other weatherization contractors each accounted for less than 10% of the total number of completed projects.

Table 4-7 Distribution of Treated Homes Weatherization Contractor

<i>Program Activity by Weatherization Contractor</i>		
<i>Contractor</i>	<i>Number of Projects</i>	<i>% of Total</i>
Community Housing Partners	106	43%
STEP, Inc.	25	10%
Clinch Valley Community Action	19	8%
People, Inc. of Virginia	18	7%
Appalachian Community Action Agency	16	6%
Central Virginia AAA	16	6%
Rooftop of Virginia	14	6%
Total Action for Progress	14	6%
Lynchburg Community Action Group	14	6%
Pittsylvania County CAA	5	2%
Total	247	100%

Most program activity was concentrated in three counties: Pulaski, Montgomery and Franklin County which accounted for one-third (34%) of the total homes served in PY2017. The other projects were spread more evenly across the remaining counties as Table 4-8 shows.

Table 4-8 Distribution of Treated Homes by Top 10 Counties

2017 Virginia Low-Income Weatherization - Top Counties Served		
County	Total Homes Served	% of Total (N=247)
Pulaski	31	13%
Montgomery	26	11%
Franklin	23	10%
Bedford	13	6%
Tazewell	15	6%
Campbell	12	5%
Giles	12	5%
Scott	12	5%
Amherst	11	5%
Buchanan	10	4%

The database review noted some duplications in county listings, as well as some missing records. Nine records did not capture the county where the home was treated and several entries contained duplications, including Grayson County, Tazewell (also abbreviated as TZ) and Franklin counties.

In addition, one record was listed as blank which reduced the overall number of completed projects in the program database to 247.

4.3.2 Participant Survey Results

As with prior evaluation years, the Evaluation Team conducted surveys with program participants as part of the evaluation effort for the 2017 RLIWP. These surveys were designed to gather information related to both the impact and process components of the program evaluation. Data collected via participant surveying is used in evaluating:

- Customer awareness of the program;
- Customer purchasing behaviors and energy efficiency; and
- Customer satisfaction with the program.

Customers were recruited through telephone surveying. In order to assuage customer concerns regarding the legitimacy of the process, phone number for the Company's program manager are provided, explaining the Evaluation Team's role and the purpose of the onsite visit. The survey questionnaire can be found in Appendix A.

In total, 30 customer participants who received weatherization measures through the program responded to the survey.

4.3.2.1 Customer Awareness of Program

Survey participants were first asked how they learned about the Residential Low-Income Weatherization Program.²³ As shown in Figure 4-2, respondents most commonly reported that they had learned of the program through word-of-mouth from friends and colleagues (47%). This is consistent with the results from the prior program year.

Twenty-three percent of respondents reported learning about the program through community programs or social service organizations, such as the local Community Actions Partnership (CAP). Few respondents cited any of the other listed options.

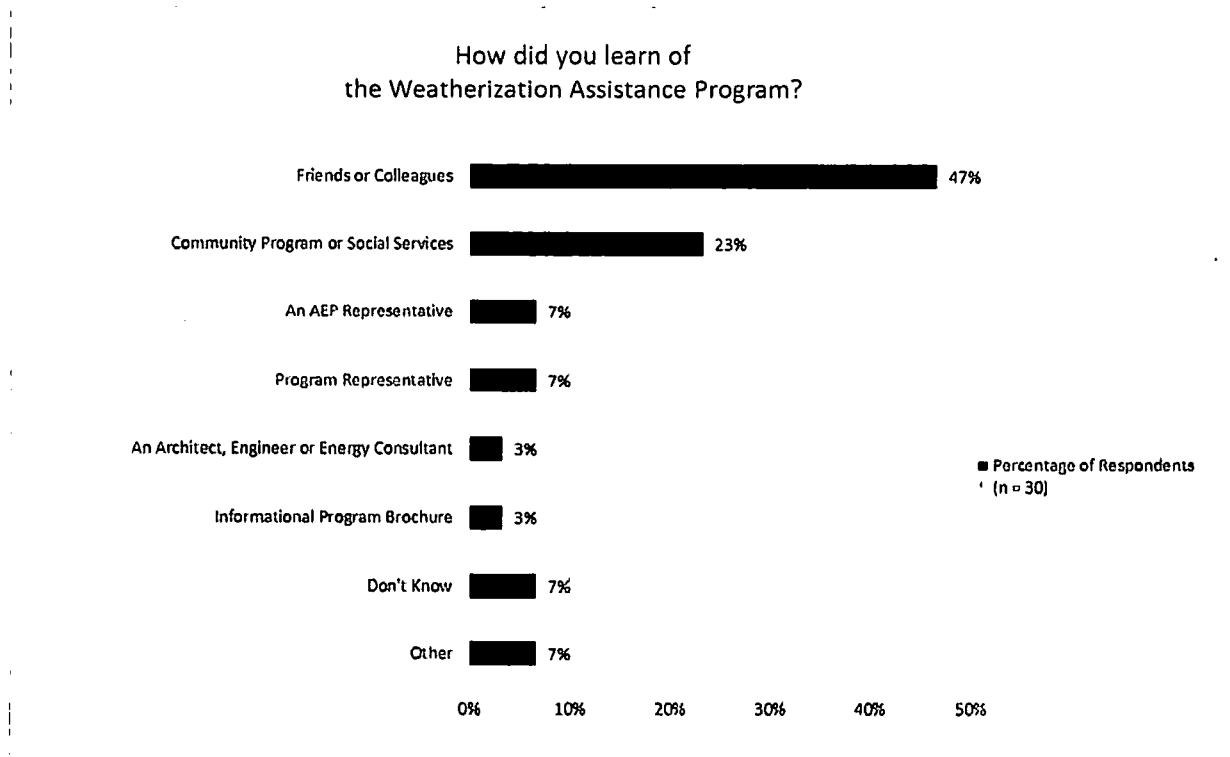


Figure 4-2 How Customers Learned about the Program

Next, survey respondents were asked why they chose to participate in the program.²⁴ Most respondents (43%) cited the desire to save money on energy bills as one of their reasons for

²³ The percentages shown are percentages of responses to all respondents rather than percentages of responses to all responses. As respondents were able to select more than one response, the sum of percentages shown in the figure exceeds 100%.

²⁴ The percentages shown are percentages of responses to all respondents rather than percentages of responses to all responses. As respondents were able to select more than one response, the sum of percentages shown in the figure exceeds 100%.

participating, followed by the desire to make improvements or repairs to their homes²⁵ (30%). Among respondents, that the services were provided free of charge was also a common reason for program participation. Several respondents specifically mentioned participating in the program to address heating issues in their home. Results to the question are displayed in Table 4-9.

Table 4-9 Why Customers Participated In the Program

<i>Why did you choose to participate in the program? (Select all that apply)</i>	<i>Response</i>	<i>Percent of Respondents*</i> (N=30)
		To save money on energy bill(s)
	Home needed improvement or repairs	30%
	The services were provided free of charge	20%
	Other	10%
	Environmental reasons	3%

Participants were also asked to identify their primary motivation for deciding to participate in the program. Responses were fairly evenly split between the desire to save money on energy bills and the desire to obtain home improvements or repairs; both reasons were cited by approximately one-third of respondents. Responses are summarized in Table 4-10. These results show that there are several important factors which encourage program participation.

Table 4-10 Primary Reason Customers Participated in the Program

<i>Of all the things that interested you about the program, what was the most important reason for your decision to participate in the program?</i>	<i>Response</i>	<i>Percent of Respondents*</i> (N=25)
		To save money on energy bill(s)
	Home needed improvement or repairs ²⁶	27%
	Other	13%
	The services were provided free of charge	7%
	Environmental reasons	3%

4.3.2.2 Experience with Audit

Eighty percent of respondents who recalled the visit with the energy auditor reported that their appliances or building structure were examined for energy efficiency. When asked which parts of their home were evaluated, the most common responses were water heater (35%), refrigerator (35%), insulation (25%), and windows (25%).

²⁵ This was not a survey response option but was commonly provided through open-ended responses.

²⁶ This was not a survey response option but was commonly provided through open-ended responses.

In addition, more than 70% of participants recalled discussing measure options and energy efficiency benefits with an energy auditor prior to receiving the measures through the program. When asked to provide examples of what types of energy efficiency recommendations had been relayed during this audit, participants supplied a wide range of comments including:

“[They recommended] keeping power strips off [and] using lights only when you need them.”

“[They recommended to] turn the water heater down as well as gave me [a] little information about energy efficient light bulbs.”

“[They taught me] how to keep [the temperature on the thermostat] set on the computer.”

“They told [me] to keep all the doors [to the bedrooms] open.”

Respondents were then asked whether these recommendations had caused them to change their home energy usage. Sixty-three percent of respondents believe that they have changed their home energy usage as a result of the program, while 11% did not believe so and 26% did not know if they did.

As with the prior program year, the majority of these improvements were fairly low-cost or no-cost, and mainly related to behavioral changes such as turning off lights, lowering thermostat or water temperatures, and unplugging appliances when not in use.

4.3.2.3 Customer Satisfaction

Survey respondents were asked about their levels of satisfaction with selected elements of the 2017 Residential Low-Income Weatherization Program experience. Results were provided on a scale of 1 to 5, with 1 representing “very dissatisfied” and 5 representing “very satisfied”. As displayed in Table 4-11, respondents generally reported high satisfaction levels with the majority of program elements.

Respondents reported being highly satisfied with the quality of work conducted by the energy auditor (93%). Additionally, the information provided by the Community Action Agency, the performance of items installed, and the effort required to by the application process all displayed strong participant satisfaction rates, at 83% for each program element.

Few respondents provided specific reasons for their dissatisfaction with any of the program elements. Examples of commentary provided through the satisfaction section of the survey are as follows:

“Well, my dissatisfaction was with AEP because I did not receive any information from them.”

“The person who installed the equipment didn't know what they were doing, because when they installed the furnace it was leaking in my attic and it [caused] water damage to my property. I had to file a claim on my homeowner's insurance.”

Table 4-11 Customer Satisfaction with Selected Program Elements

Program Element	Satisfaction Rating						N	Overall % Satisfied	Overall % Dissatisfied
	Very satisfied -5	Somewhat satisfied -4	Neutral -3	Somewhat dissatisfied -2	Very dissatisfied -1	Don't know			
Professionalism of the auditor	83%	10%	0%	0%	7%	0%	30	93%	7%
Information provided by the Community Action Agency	73%	10%	7%	0%	7%	3%	30	83%	7%
Performance of the items installed	70%	13%	7%	0%	10%	0%	30	83%	10%
Savings on your monthly bill	48%	24%	14%	3%	7%	3%	29	72%	10%
Information provided by company representatives	53%	13%	13%	0%	10%	10%	30	66%	10%
The effort required by the application process	73%	10%	7%	0%	3%	7%	30	83%	3%
Overall program experience	90%	3%	0%	0%	7%	0%	30	93%	7%

Respondents also provided a variety of open-ended commentary regarding their experiences with the Low-Income Weatherization Program. Some participants used this opportunity to provide recommendations for the program, to point out issues, or recommend anything additional that they would have liked to receive from the program. Such comments included:

“Maybe they should help out on all the other stuff. They didn't go over my appliances. They are eating up a lot of energy and I can't afford a new one.”

“If the program can focus on windows and doors as well.”

“No, I just had other things that I wanted to get done but they stated that there wasn't enough money around to do it. I wanted to get my roof coated on my mobile home.”

“[The work] I was shown [that] was supposed to [be done] compared [to] what I received was not good. They basically threw a bunch of rolls of plastic on stuff.”

As with the prior year, some of these comments suggest that there is still additional work that could be done to improve participant homes. However, these comments represent a small percentage of total respondents.

Many of the comments were positive in nature, with participants praising the program for its high-quality services and kind, informative staff members. Specific positive commentary from participants surveyed during the 2017 program year included:

“No none at this time. It is a very helpful program when you don't have money to do it yourself.”

“Tell them they are very good, I am very happy with everyone. I really appreciate everything they've done.”

“No, I think it is a very good program. It gives people the opportunity to have better heating and cooling.”

“Just that the people who came to my home... were all wonderful and professional.”

Overall, the survey responses suggest that participants continue to value the services and measures provided by the program.

4.3.3 In-Depth Interviews

As part of the 2017 process evaluations, the Evaluation Team conducted in-depth interviews with one staff member from the Company and with four staff members from the third-party implementer, Community Housing Partners (CHP). These interviews provided an update on respondents' roles and responsibilities, program operations, assessed the effectiveness of current program components, such as marketing and outreach and data tracking, and identified areas for program improvement. The findings are summarized by topic area in this section.

4.3.3.1 Roles and Responsibilities

The Company has one program manager who works with the non-profit third-party implementer, Community Housing Partners (CHP). However, CHP is responsible for the recruiting and training of the contractors, and all aspects of program operations.

CHP has four staff members who are directly involved in the daily program activities. Their responsibilities include contractor training and outreach, quality assurance/quality control, and tracking and recording completed energy audits and installed measures. CHP's staff includes a

utility program manager, who supervises similar weatherization programs for several Virginia utilities, a program administrator and additional support staff.

In addition, CHP also serves as an aggregator of programs and services for weatherization contractors across the state, which makes it an ideal partner to reach and recruit contractors to participate in this program.

The utility staff is pleased with work performed by CHP and believe they are a “great partner to have because they are very familiar with the territory and are experts at weatherization.”

As the implementer noted, the Company’s program is focused on collaboration with its weatherization partners.

4.3.3.2 Program Operations

Both the program staff and the implementer reported that the program has surpassed its kilowatt hour goals in PY2017, estimating that the program will save more than 1 million kilowatt hours this year. This is significantly higher than the program’s annual goal of 679,884 kilowatt hours. In addition, CHP has completed one-third to one-half of the total jobs completed in PY2017.

While the program did not install measures in targeted number of houses (n=325), the program was able to exceed its savings goals because the installed measures were targeted to electric heating homes, which increased the overall savings. As the program implementer explained, the focus was to do a “deeper dive on the households,” which would generate larger energy savings.

The program implementer attributes this success to the program design, which “marries so well with the existing weatherization programs.” The program implementer added that the program design is “exceptional” because it fits so well with the existing Weatherization Assistance Program (WAP) offered through the Department of Energy (DOE).

The program has also met its spending allotment. According to the program implementer, the average cost per job was \$3,100 for PY2017, which is consistent with the average costs in the previous program years.

The program implementer estimates that there are about 20 Company customers on the waiting list.

The Company’s program manager also noted that CHP is effective in spending its funds evenly throughout the year. The program manager added that CHP has been very proactive in communicating with the utility staff and providing updates relative to the savings and goals.

4.3.3.3 Program Participation Process

Customers participate in the program by working with a participating weatherization agency, who verifies their eligibility, completes the energy audit, and develops a proposed work scope. Customers must meet the state income guidelines, which are identical to the federal standards. Additionally, customers of the Company must have electricity as a main source of heat in order to receive the utility funds. CHP staff noted that limiting the program to electric-heat only customers does limit the program's reach; however, the program has about 20 customers on its waiting list.

4.3.3.4 Program Outreach Activities

This type of program really does not require any program marketing, as it "markets itself," according to the utility staff. Eligible customers are aware of the program and contact either the weatherization agency for the services.

4.3.3.5 Data Tracking and Quality Control

The program implementer performs ongoing QA/QC on the sub grantees. In addition to performing inspections of 10% of the completed jobs, CHP also inspects another 5% of completed jobs, randomly in order to meet the requirements for the federal program.

4.3.3.6 Contractor/Customer Feedback

Both the program staff and the implementer reported receiving positive feedback from the participating customers, noting that "we have good feedback from the clients." The implementer added that the program is designed so that it does not create any extra work for the participating weatherization agency.

4.3.4 Areas for Improvement

Developing a program to target multifamily housing units and increasing the overall program budgets were the only suggestions for program improvement made by the implementer. However, these program changes would require modifying the program requirements as well.

The program implementer notes that more funds from the Company would serve to expand the program to more customers. But, given that the focus is on electric heating customers, they are happy to work within the current program guidelines.

These recommendations from PY2017 have either been implemented or are in process. One of the previous recommendations was to conduct a more in-depth review of the technical assumptions, including the assumptions used by the energy auditing tool. This review is in progress, and the implementer reports that the Company staff have been helpful in this process and are receptive to their suggestions.

4.3.5 Conclusions and Recommendations

The following conclusions and recommendations are based on findings from the impact and process evaluation of the 2017 Low-Income Weatherization Program:

- Reporting of measure quantities: The 2017 program tracking data included measure categories, expected savings, and measure costs per participant but did not include a field for measure quantities installed. While it is possible to estimate measure quantities by dividing the total measure cost by the per-measure costs provided in the program tracking data, this approach creates a margin of error for some measures. If possible, the Evaluation Team recommends that individual measure quantities be collected and reported within participant tracking data.
- Data collection procedures: The sample NEAT reports provided for the 2017 participant population typically contained detailed information for each implemented measure category, but there were some inconsistencies among the level of detail or specific data points collected. Optimally, there would be no blank fields for a given measure category or home characteristic in each NEAT report, or if a field is left blank, a comment would be added to indicate the reason for this. Specific data collection adjustments that would be beneficial to the EM&V process for future program years include:
 - Replaced HVAC age: The Evaluation Team requests that the specific age of baseline units such as refrigerators and HVAC systems be collected and reported.
 - CFM reduction detail: The NEAT reports do not appear to be consistent in differentiating between CFM reduction attributable to air sealing and CFM reduction attributable to duct sealing. In order to isolate savings for these measures, it would be preferable to have separate CFM reduction values reported for each of these measures.
 - Insulation R-value: The added inches or added R-value for insulation measures were not always present within NEAT reports. Clearly identifying the added insulation in these terms would allow for more accurate estimation of savings attributable to insulation improvements.
- The program is operating effectively, exceeding its savings goals and staying within the budget constraints, despite falling short on the overall participation goals.
- The program implementer continues to do an excellent job in both managing other weatherization subcontractors, as well as completing projects located within its service area.
- The design has contributed to the overall program success, and the Company and CHP have developed strong and effective partnership.
- Overall program satisfaction was high; 93% of customers reporting that they were somewhat or very satisfied with the program overall.

- Going forward, the Company may want to consider adding a multifamily program component, as a way to reach additional low-income customers in its next program filing.

5 Appliance Recycling Program

5.1 Program Description

The Residential Appliance Recycling Program (RARP) is designed to help customers reduce their energy consumption by removing old, working refrigerators and freezers from their homes for recycling. There is a limit of two refrigerators or freezers per household per calendar year. The RARP generates energy savings because the old appliances, which are generally inefficient, are permanently removed from the system. The environment also benefits from the recycling process through safe disposal of environmentally harmful material.

The goal of the program is to reduce the number of old, inefficient refrigerators and freezers that customers have moved to their garages or other locations such as basements and patios. Many areas in which spare units are placed are not space conditioned and most refrigerators used in that environment operate under a heavy thermal load during the summer. This is exacerbated by the fact that the appliances are usually quite old and inefficient. Previous studies by the Environmental Protection Agency (EPA), the Department of Energy (DOE) and other utilities have determined that removing these appliances, and properly recycling them, performs an energy saving service.

In 2017 the Company contracted with Appliance Recycling Centers of America (ARCA) to implement the program. The program operates as a turnkey, stand-alone energy efficiency initiative. The program targets existing multi- and single-family households, renters and homeowners who have old, inefficient refrigerators or freezers. Marketing for the program consists of newspaper, radio, direct mail, bill stuffers, a dedicated webpage, and TV ads. To be eligible for the program, appliances to be recycled must be in working condition, plugged in and cooling at the time of pick-up. The customer receives pick-up and removal service in addition to a \$50 rebate per recycled refrigerator or freezer.

Removing old, inefficient refrigerators and freezers prevents them from being resold or transferred to another utility customer. The program provides annual electric energy savings for the remaining useful life (RUL) of the unit by permanently removing the appliance from service. As an added environmental benefit, 95% of the materials from these units are able to be recycled (metals, plastic, glass, oil, etc.) and disposed of in an environmentally responsible manner, thus preventing the materials from reaching landfills and contaminating the environment.

5.2 Impact Evaluation

This chapter addresses the impacts of gross and net kWh savings and peak kW reductions resulting from appliances being recycled by customers that obtained rebates under the Residential Appliance Recycling Program during the period January 2017 through December 2017.

5.2.1 Methodology for Estimating Gross and Net Savings

The methodology used for estimating gross savings is described in this section.

The M&V approach for the 2017 RARP is aimed at the following:

- Numbers of refrigerators and freezers collected and recycled;
- Average annual kWh savings per collected appliance;
- Average kW reduction per collected appliance;
- Providing estimates of net-to-gross savings and free-ridership; and

Table 5-1 below summarizes the inputs needed for gross savings calculations and the source of each input.

Table 5-1 Data Sources for Gross Impact Parameters – Appliance Recycling Program

<i>Parameter</i>	<i>Source</i>
Number of Units Recycled	Program Tracking Data, Participant Surveying
Unit Energy Consumption	Regression model developed in prior studies and the Uniform Methods Project, various appliance and household characteristics
Appliance and Household Characteristics	Participant Surveying
Net -to-Gross-Ratio	Participant Surveying

5.2.1.1 Verification of Units Recycled

An initial aspect of conducting measurements of program activity is to verify the number of refrigerators and freezers collected and recycled. The Evaluation Team takes several steps in verifying the number of refrigerators and freezers collected and recycled which consists of the following:

- Validating program tracking data provided by ARCA by checking for duplicate or erroneous entries;
- Verifying that refrigerators and freezers are recycled according to the agreed-upon process between ARCA and the Company; and
- Conducting verification surveys with a statistically valid sample of program participants. The focus of these verification surveys is to verify that customers listed in the program tracking database did indeed participate and that the number of appliances claimed to be recycled was accurate. Additionally, survey respondents are asked a series of questions to verify the working condition of their recycled appliances; it is a program requirement that collected units be in working condition at the time of pick-up.

5.2.1.2 Sampling

Sampling is necessary to evaluate savings for the Company's RARP, as verification of a census of program participants is typically cost-prohibitive. Samples are drawn in order to ensure 90% confidence at the +/- 10% precision level. The RARP is evaluated on the Simple Random Sample basis.

5.2.1.2.1 Stratified Random Sampling

For the RARP participant survey, the Evaluation Team stratified by appliance type recycled (refrigerator or freezer). The sample size for verification surveys was calculated to meet 90% confidence and 10% precision at the program level. Quotas were set based on the proportion of each appliance type in the program population to ensure the desired confidence and precision level was achieved.

The sample size to meet 90/10 requirements is calculated based on the coefficient of variation of savings for program participants. Coefficient of Variation (CV) is defined as:

$$CV(x) = \frac{\text{Standard Deviation}(x)}{\text{Mean}(x)}$$

Where x is the average kWh savings per participant. Without data to use as a basis for a higher value, it is typical to apply a CV of 0.5 in residential program evaluations. Using a CV of 0.5, sampling quotas were set at 60 surveys with customers who recycled refrigerators, and 24 surveys with customers who recycled freezers. The sample design, achieved sample size, and corresponding precision at the 90% confidence level is shown in Table 5-2 below.

Table 5-2 Participant Survey Sample Design

<i>Strata</i>	<i>Population Size</i>	<i>Survey Quota</i>	<i>Completed Surveys</i>	<i>Precision (90% CI)</i>
Refrigerators	996	60	67	9.70%
Freezers	396	24	30	14.40%
Totals	1392	84	97	8.20%

The Evaluation Team drew the sample of customers for the telephone survey effort by first organizing by appliance type recycled, then assigning a random number to each participant. The participant call list was then prioritized by the random number, making up to five call attempts per sampled customer. Ultimately, the telephone survey effort resulted in 97 completed surveys (67 from participants who recycled refrigerators and 30 from participants who recycled freezers).

5.2.1.3 Data Collection

This subsection provides a description of the Evaluation Team's data collection procedures.

5.2.1.3.1 Telephone Surveys

The Evaluation Team conducted a sample of telephone surveys in evaluating the Company's 2017 RARP. These surveys were designed to collect a variety of data needed to perform an in-depth evaluation effort, including:

- Verification of refrigerators and freezers recycled;
- Parameters used in gross savings calculations;
- Parameters used in net savings calculations; and
- Feedback from participants from their experiences with the program.

In total, 97 surveys were completed with customers who had at least one refrigerator or freezer recycled through the program in 2017. Surveys with program participants were conducted by VuPoint Research, an experienced survey firm, with the Evaluation Team performing quality control checking on collected survey data.

5.2.1.4 Gross Annual kWh Savings and Peak kW Reduction Estimates

Expected savings for the RARP were assumed to be 1,081 kWh per refrigerator and 919 kWh per freezer recycled. For the impact evaluation effort, these savings estimates were assessed by developing separate gross unit energy consumption (UEC) estimates for refrigerators and freezers recycled through the program using existing statistical models relating various appliance and household characteristics to estimated energy usage.

The Cadmus Group refined the use of linear regression methodology for estimating energy savings resulting from refrigerator recycling. This research consisted of a metering study of 472 refrigerators across five utilities to determine energy savings associated with refrigerators recycled through appliance recycling programs.²⁷

Cadmus used the data from this monitoring sample to develop a regression model that relates the annual unit energy consumption (UEC) of refrigerators - metered in situ operating conditions – to various characteristics of the appliance. The model is specified in the Uniform Methods Project (UMP), which is an effort by the U.S. Department of Energy to increase the consistency and transparency of how energy savings are determined. The protocols presented in the UMP provide a straightforward method for evaluating gross and net energy savings for common residential and commercial measures offered in ratepayer-funded initiatives in the United States.²⁸

²⁷ Source: Cadmus et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. April 2013.

²⁸ Office of Energy Efficiency & Renewable Energy, energy.gov/eere/about-us/initiatives-and-projects/uniform-methods-project-determining-energy-efficiency-progr-0, accessed: 12 January 2016.

The Evaluation Team used the UMP regression model developed by Cadmus to estimate the UEC for refrigerators recycled through the Company's program. The Cadmus regression model was developed using in situ monitoring data from 472 refrigerators. Specifically, the average characteristics of refrigerators recycled through the program were multiplied by the associated coefficients from the Cadmus model and summed to produce an estimated average in situ UEC for refrigerators recycled through the program.

It is important to note that the Cadmus model only considers refrigerators. Accordingly, the Evaluation Team used a refrigerator-to-freezer ratio factor to determine the average UEC for freezers. This refrigerator-to-freezer factor methodology is similar to that used by the NMR Group, Inc. in their recent evaluation of the Massachusetts Appliance Turn-in program.²⁹ Using relevant secondary sources, the Evaluation Team concluded that freezers on average use 15% less energy annually than refrigerators. This implies a refrigerator-to-freezer factor of 0.85. The analysis supporting this refrigerator-to-freezer factor is detailed in the previously mentioned Massachusetts Appliance Turn-In Program Evaluation performed by NMR Group, Inc.³⁰

Finally, a partial use factor was developed for refrigerators and freezers to adjust UEC estimates to reflect the gross savings of appliances that were recycled through the program. The partial use factor is designed to account for the fact that not all refrigerators and freezers are plugged in year round. Secondary appliances are more likely to be unplugged for a portion of the year than primary appliances, and since there was a large presence of secondary appliances in the program, the partial use factor is an important consideration when developing gross savings estimates.

Based on the proceeding discussion, the procedures used by the Evaluation Team to estimate gross energy savings (kWh) for the refrigerators and freezers recycled through the program can be summarized by the following steps:

- (1) The Cadmus UMP-based model was used to predict the average annual in situ UEC for participating refrigerators in 2017 based on the average refrigerator characteristics established from ARCA records and the participant survey.
- (2) The average freezer annual UEC was obtained by multiplying the estimated average refrigerator UEC by the refrigerator-to-freezer factor of 0.85.
- (3) Partial use factors were applied to the UEC estimates to account for the fact that some appliances are not used continuously throughout the entire year.

²⁹ NMR Group, Inc. Massachusetts Appliance Turn-in Program Impact Evaluation, Final. June 15th, 2011. Available at: <http://ma-ceac.org/wordpress/wp-content/uploads/Impact-Evaluation-Final-Report.pdf>

³⁰ Ibid.

- (4) The estimated average UECs for refrigerators and freezers were extrapolated to the population of program participating units to obtain a program level estimate of gross kWh savings resulting from refrigerator and freezer recycling.

5.2.1.4.1 Calculating Gross Peak Demand (kW) Savings

Gross peak demand savings were calculated based on the critical peak demand definition provided by the Company. Specifically, the Company established a summer (June – August) on-peak period of 3:00 p.m. - 6:00 p.m. during weekdays. Measure specific normalized 8,760 hour load shapes were used to identify the average demand during this on-peak period. These load shapes assign a portion of estimated gross kWh savings to each hour of the year. After identifying the total kWh saving's that fall into the defined on-peak hours, dividing by the total number of hours in the peak period results in the average gross peak demand reduction. There is a total of 198 hours per year that meet the criteria of the Company's on-peak period definition. Appliance load shapes developed as part of the End-Use Load and Consumer Assessment program (ELCAP)³¹ were used to estimate the percentage of kWh savings occurring during those 198 on-peak hours.

5.2.1.5 Net Energy (kWh) and Peak Demand (kW) Impacts

This section will explain the net savings methodology in the context of the UMP protocol estimation of gross savings. The three effects discussed in this section are free-ridership, secondary market impacts, and induced replacement. Net savings are calculated relative to UMP gross savings using the formula below.

$$\text{Net Savings} = \text{Gross Savings} - \text{Freeridership} - \text{Secondary Market Impacts} \\ - \text{Induced Replacement}$$

Where:

Gross Savings = The evaluated in situ UEC for the average recycled unit, adjusted for part use (UMP definition of gross savings);

Free-ridership = Program savings from units that would have been destroyed even in the absence of the program;

Secondary Market Impacts = Program Savings that would have occurred in the absence of the program based on the estimated/assumed counterfactual actions of appliance acquirers.

³¹ Pratt RG, CC Conner, EE Richman, KG Ritland, WF Sandusky, and ME Taylor. 1989. Description of Electric Energy Use in Single-Family Residences in the Pacific Northwest. (End-Use Load and Consumer Assessment program [ELCAP]). DOE/BP-13795-21, prepared for Bonneville Power Administration by Pacific Northwest Laboratory, Richland, Washington.

Induced Replacement = Average additional energy savings consumed by replacement units purchased due to the program.

The following sections detail more thoroughly the free-ridership, secondary market effects, and induced replacement components of net savings. After each effect is discussed individually, a summary diagram is provided in Figure 5-2 to illustrate the complete net savings adjustment.

Free-ridership occurs when an appliance recycled through the program would have been taken off the grid even in the absence of the program. The first step of the free-ridership analysis was to ask participants if they had considered discarding the program appliance before learning about the program. If the participant indicated no previous consideration of unit disposal, they are categorized as non-free-riders and removed from the subsequent free-ridership analysis. Conceptually, this reflects the assumption that without prior consideration of disposal, the program induced the resulting decommissioning of the appliance.

Next, the remaining participants (i.e., those who had previously considered discarding the program appliance) were asked a series of questions to determine the distribution of program appliances that would have been kept within participant households versus those that would have been discarded. If one considers the counterfactual scenario where there is no program intervention, there are essentially three outcomes for participating appliances:

- The appliance would have been kept in use by the participant household.³²
- The appliance would have been discarded in such a way that it was transferred to another customer for continued use.
- The appliance would have been discarded in such a way that it would be taken out of service.

Of the three outcomes, one is indicative of free-ridership:

- Discarded and taken out of service (destroyed)

This outcome is indicative of free-ridership because the units would have been removed from the grid even without program intervention.

The participant surveys were used to estimate the percentage of program appliances that fall into each category. Participants were asked a series of questions about what they would have done with the appliance in the absence of the program. The distribution of likely discard outcomes was then calculated as a weighted average of the participant responses.

Secondary market impacts refer to the effect the program has on would-be acquirers of program participating units. In the event that a program unit would have been transferred to another customer (sold, gifted, donated), the question then becomes what other appliance acquisition

³² Note that units kept by participant households but *not* used are accounted for in the estimation of part-use factors and therefore discounted from gross savings.

decisions are made by the would-be acquirer of the program unit now that it is decommissioned and unavailable. The would-be acquirer could:

- Not purchase/acquire another unit.
- Purchase/acquire a different non-program used appliance.
- Purchase a new appliance instead.

Absent the program, if we consider the options of would-be acquirers at the market level, there are a range of possibilities as described below:

- None of the would-be acquirers would find another unit: This reflects a scenario where program participation results in a one-for-one reduction in the total number of appliances on the grid. In this case, the total UEC of avoided transfers would represent energy savings achieved.
- All of the would-be acquirers would find another unit: This reflects a scenario where program participation has no effect on the total number of appliances operating on the grid. Without the program units available, all acquirers simply purchase non-program units (whether new or used).
- Some of the would-be acquirers would find another unit, while others would not: This possibility reflects the most likely possibility, where some would-be acquirers who were in the market for an appliance acquire a unit. Other would-be acquirers, who perhaps would have only taken the unit opportunistically (for example, taking a neighbor's discarded unit to use as a secondary garage unit), do not acquire a new unit because of program intervention.

Ultimately, the true market level outcome in the absence of the program is difficult to assess. As a result, this evaluation takes a midpoint approach, as recommended by the UMP protocols. That is, 50% of would-be acquirers of program avoided transfers are assumed to find an alternate unit. The next question of interest is whether the alternative units acquired would be used (similar to those recycled by the program) or new. Again, this market distribution is difficult to estimate with any certainty. This evaluation takes the UMP recommendation and assumes that 50% of the alternative units would be used and 50% would be new, standard efficiency units.

Induced replacement refers to a scenario in which the RARP causes a program participant to purchase a replacement appliance. That is, the participant would not have replaced the refrigerator or freezer in the absence of the program. The purchase of a new appliance in conjunction with participating in the program does not necessarily indicate induced replacement. Older refrigerators and freezers are constantly being replaced with newer units, independent of any program effects.

However, if the program actually caused the decision to replace an older unit with a new unit (thus effectively putting another appliance on the grid) then the net program savings should account for this fact. This is the one scenario in which the energy usage of a replacement unit should be subtracted from energy savings produced by decommissioning the old unit.

The RARP offers an incentive and free pickup. This incentive is a small portion of the cost of purchasing a new appliance, and thus the likelihood of induced replacement can be reasonably assumed to be low. Indeed, past evaluations that have considered induced replacement effects have found that induced replacement is much less common than naturally occurring replacements unrelated to the program.

To account for induced replacement, the participant survey asked respondents a series of questions. First, if the respondent indicated the unit recycled was a primary refrigerator and that they would have discarded the unit even without the program, they were eliminated from consideration for induced replacement (because it is extremely unlikely a participant would choose to go without a refrigerator). All remaining respondents were asked the following questions:

- *“Did you replace the old [refrigerator, freezer] with a new unit?”* – Respondents who did not purchase a replacement appliance are removed from consideration.
- *“Would you have purchased a replacement [refrigerator, freezer] even if [Appalachian Power/AEP]’s recycling program had not been offered?”* – This is the primary question for determining whether the program induced replacement. However, because the question may cause confusion, those you indicate “yes” are then asked the following confirmation question:
 - *“Let me be sure I understand. Are you saying that you chose to purchase a new appliance because of [Appalachian Power/AEP]’s appliance recycling program, or are you saying you would have purchased a new appliance regardless of the program?”* – If a respondent again indicates the program caused the replacement, then the recycled appliance in question is considered to exhibit induced replacement.

For the small proportion of program participants that were induced to replace an appliance, it is assumed that they purchased a standard efficiency new unit. Energy consumption for a standard new refrigerator is assumed to be 444 kWh based on sales-weighted appliance data from the Association of Home Appliance Manufactures (AHAM).³³ Similarly, energy consumption for a standard new freezer is assumed to be 462 kWh. Figure 5-1 below provides an example of how the induced replacement factor is calculated. In the example, induced replacement causes a 17 kWh per-unit decrease in net savings.

³³ AHAM Energy Efficiency and Consumption Trends 2013

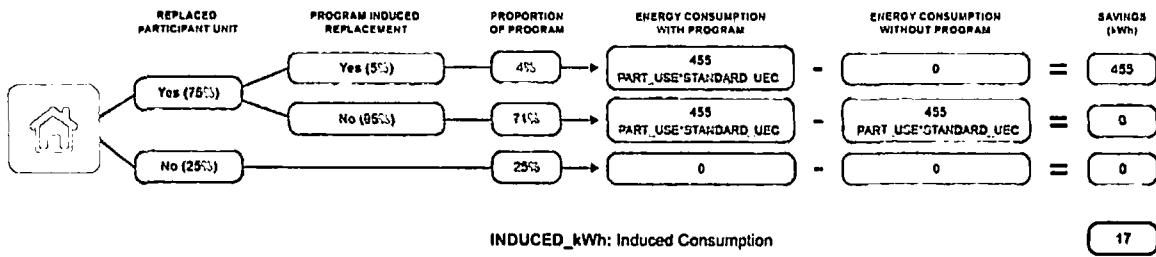


Figure 5-1 Induced Replacement Example³⁴

Figure 5-2 summarizes the complete net-to-gross calculation used in this evaluation. Note that this diagram depicts net savings as calculated under the UMP gross savings definition.

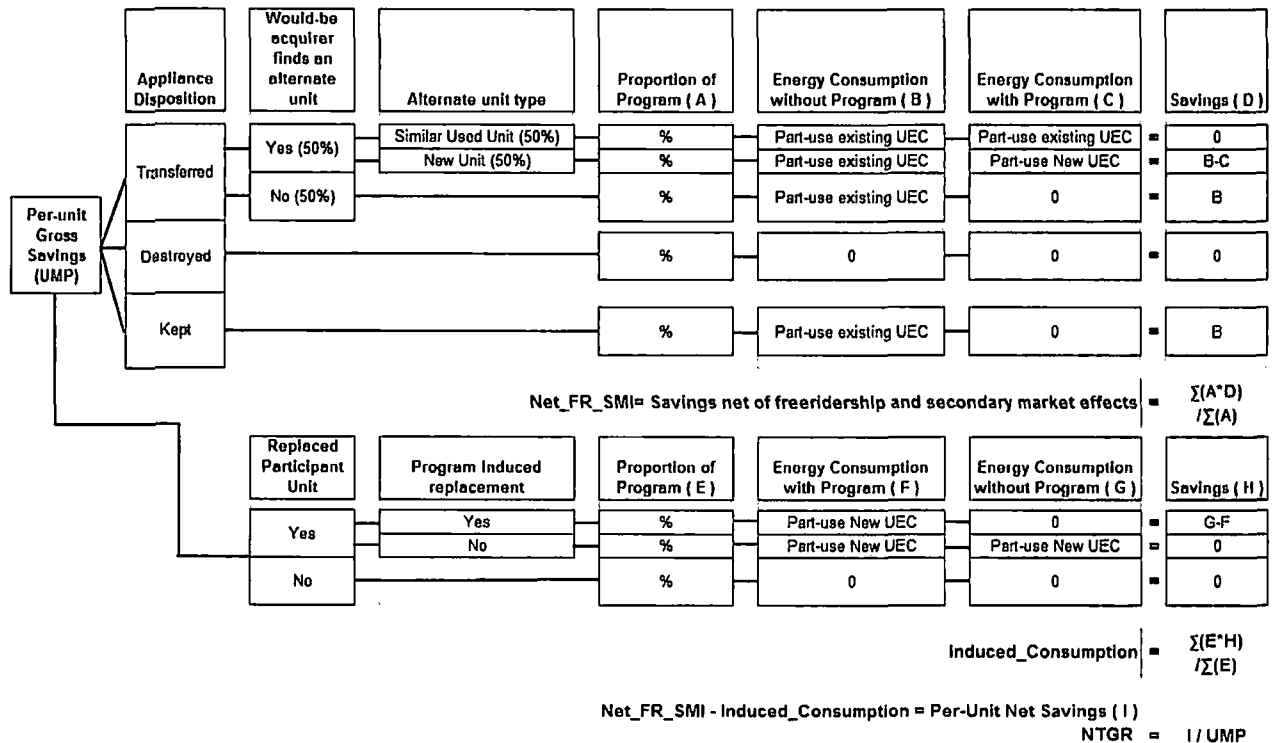


Figure 5-2 Net Savings Calculation Summary Diagram

5.2.2 Results of Gross and Net Savings Estimation

The Evaluation Team estimated realized gross electric savings and peak demand reductions through detailed analysis of program tracking data and participant survey data. The estimated

³⁴ Figure is taken directly from UMP protocol. Note that the values in the figure are just an example, and do not reflect the findings from this evaluation.

gross impacts resulting from the 2017 RARP are summarized in Table 5-3. The gross realization rate is 100%.

Table 5-3 Residential Appliance Recycling Program Gross Realization Summary

	<i>Expected</i>	<i>Realized</i>	<i>Realization Rate</i>
Annual Energy Savings (kWh)	1,254,846	1,253,520	100%
Annual Demand Reduction (kW)	148.14	148.10	100%
Lifetime Energy Savings (kWh)	10,038,768	10,028,158	100%

In addition to gross savings, the Evaluation Team estimated associated net-to-gross ratio (NTGR) for both refrigerators and freezers based on results from the participant survey. Applying the estimated NTGR of 45% for refrigerators and 55% for freezers to the gross savings reported in Table 5-3 results in the net savings detailed in Table 5-4 below. The net realization rate is 47%.

Table 5-4 Residential Appliance Recycling Program Net Realization Summary

	<i>Realized Gross</i>	<i>Net</i>	<i>Net-to-Gross Ratio</i>
Annual Energy Savings (kWh)	1,253,520	595,008	47%
Annual Demand Reduction (kW)	148.10	70.35	48%
Lifetime Energy Savings (kWh)	10,028,158	4,760,061	47%

5.2.2.1 Database Review

The program contributed to the recycling of 996 refrigerators and 396 freezers during the 2017 program year. The Evaluation Team first examined the tracking database for systemic entry errors for each channel, i.e., duplicate entries and/or erroneous entries (such as data entered into improper columns). The Evaluation Team confirmed that the tracking database included all necessary information to conduct the impact analysis, including appliance and household characteristics. The review did not identify any duplicate or obviously erroneous entries. Additionally, it was confirmed that no household recycled more than two appliances during the 2017 program year (a program requirement). Overall, the tracking database was well organized and complete.

5.2.2.2 Verification of Units Recycled

As a first step toward estimating program level kWh and kW impacts, the Evaluation Team reviewed program tracking data provided by ARCA for accuracy. No duplicate entries were discovered. To verify that the number of units claimed in the program tracking database was accurate, the Evaluation Team administered a telephone survey with a sample of program participants.

All 97 respondents who completed the participant survey verified that they had in fact participated in the program during 2017. However, in order for participating appliances to accrue energy savings by being taken out of service, the units must be in working condition at the time of pick-up. One respondent who recycled a refrigerator and one separate respondent who recycled a freezer reported that their units were not in working condition at the time they were collected for recycle. Based on these results, the verification rates shown in Table 5-5 for each appliance were determined:

Table 5-5 Verification Rates by Appliance Type

<i>Appliance Type</i>	
<i>Refrigerator</i>	<i>Freezer</i>
98.51%	96.67%

Based on these verification rates, Table 5-6 reports the numbers of refrigerators and freezers recycled through the program during 2017 that were verified as being in working condition when recycled and therefore program-eligible.

Table 5-6 Recycled Appliances Verified to be in Working Condition

<i>Unit Type</i>	<i>Quantity Reported as Recycled</i>	<i>Verification Rate</i>	<i>Quantity of Recycled Units Verified as program Eligible</i>
Refrigerator	996	98.51%	981
Freezer	396	96.67%	383

5.2.2.3 Gross Annual kWh Savings and Peak kW Reduction Estimates

Gross annual kWh savings were calculated as described in chapter 2.1.4 of this report. The details and results of these calculations are reported in this section.

For refrigerators, Unit Energy Consumption (UEC) estimates were derived using the DOE monitoring procedure based regression model developed by Cadmus in the development of the Uniform Methods Project Refrigerator Recycling Evaluation Protocol. The model specification and estimated coefficients of the Cadmus model are shown in Table 5-7.

Table 5-7 Uniform Methods Project UEC Regression Details³⁵
(Dependent Variable – UMP Estimated In Situ UEC)

<i>Independent Variables</i>	<i>Coefficient</i>
Intercept	0.582
Appliance Age (years)	0.027
Dummy: Manufactured Pre-1990	1.055
Appliance Size (square feet)	0.067
Dummy: Single-Door Configuration	-1.977
Dummy: Side-by-Side Configuration	1.071
Dummy: Primary Usage Type	0.6054
Interaction: Uncooled Space x CDDs	0.02
Interaction: Uncooled Space x HDDs	-0.045

The program tracking database included information regarding configuration, size, and age³⁶ for all refrigerators collected during 2017. Of these 996 refrigerators, 20.8% were side-by-side models and 2.1% were single-door models; the average size was 19.0 cubic feet and the average age was 21.3 years old. Finally, 21.3% of refrigerators were manufactured before 1990. Table 5-8 shows the relevant refrigerator characteristics used to estimate UEC.

³⁵ Source: Cadmus et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. April 2013.

³⁶ Model year is listed on refrigerator nameplates for many but not all units. As explained to the Evaluation Team staff, when model year is not listed on the nameplate it is estimated based on appliance characteristics common to certain vintages.

Table 5-8 2017 Refrigerator Characteristics

<i>Appliance Characteristics</i>	<i>Refrigerators</i>
Population Size	996
Appliance Age (years)	21.27
Manufacture Pre-1990	21.3%
Average Size (Cubic Feet)	19.00
Single-Door Configuration	2.1%
Side-by Side Configuration	20.8%
Primary Usage	42.6%
Interaction: Uncooled x CDD	1.26
Interaction: Uncooled x HDD	4.86

The refrigerator characteristics shown above were used in conjunction with the model coefficients in Table 5-7 to calculate annual energy consumption estimates for program participating refrigerators. The refrigerator-to-freezer factor of 0.85 was applied to develop annual energy consumption estimates for freezers. These calculations are shown below:

- Refrigerator UEC (kWh)

$$\begin{aligned}
 & (.582 + .027 * 21.27(\text{Age}) + 1.055 * .213 (\text{Pre} - 1990) + .067 * 19.00 (\text{Size}) \\
 & \quad - 1.977 * .021 (\text{Single Door}) + 1.071 * .208 (\text{Side by Side}) \\
 & \quad + .6054 * .426 (\text{Usage}) + .02 * 1.26 (\text{CDD Interaction}) - .045 \\
 & \quad * 4.86 (\text{HDD Interaction})) * 365.25 = 1,059 \text{ kWh}
 \end{aligned}$$

- Freezer UEC (kWh)

$$1,059 * 0.85 (\text{refrigerator} - \text{to} - \text{freezer factor}) = 900 \text{ kWh}$$

The UMP-based Refrigerator UEC model presented above is the best option to use when in situ metering is not available, or when a recently developed model from a comparable program cannot be identified.³⁷ Since the UEC estimate takes into account in situ operating conditions for refrigerators, the estimates of 1,059 kWh for refrigerators and 900 kWh for freezers can be considered in situ estimates.

³⁷ Source: Cadmus et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. April 2013.

A final adjustment was made to account for not all refrigerators and freezers being plugged in year-round. This partial use adjustment is based on participant survey responses regarding their usage of the recycled units, and assigns different “use factors” based on three categories into which recycled appliances fall:

- Some units that were recycled were not being used at all before being sent for recycling. The use factor for such units therefore would be zero. That is, these units were not being used and therefore had no baseline energy usage.
- Other units were being used, but for only part of the year. For these units, the use factor is calculated by dividing the number of months in the past year that the unit had been in use by the number of months in the year. Based on data collected through the survey of participants, the average number of months in use for a refrigerator that was being partly used was 5.125 months, implying a use factor of 0.43 (i.e., $5.125/12$). For freezers in this category, the use factor was calculated to be 0.25, reflecting an average of 3 months in use for freezers being partly used.
- Units which are constantly in use have a use factor of one (1).

The overall use factor and the corresponding overall Unit Energy Savings (UES) are calculated as a weighted average across the three categories, where the weights are determined by the percentages of units falling into the three categories. Table 5-9 shows the calculation of the overall UES for refrigerators and freezers when partial use is considered.

Table 5-9 Unit Energy Savings Adjusted for Partial Use

<i>Operating Status of Unit</i>	<i>Percentage of Recycled Units in Category</i>	<i>Use Factor</i>	<i>Calculation of UES to Adjust for Part Use</i>
<i>Refrigerators</i>			
Not running	1.37%	0	0
Running part time	10.96%	0.43	452
Running all time	87.67%	1	1,059
Weighted Average UES for Refrigerators			978
<i>Freezers</i>			
Not running	6.90%	0	0
Running part time	10.34%	0.25	225
Running all time	82.67%	1	900
Weighted Average UES for Freezers			768

Based on the findings detailed in this section, the realized gross per-unit annual kWh savings for refrigerators recycled through the program is estimated to be 978 kWh; the realized gross per-unit annual kWh savings for freezers recycled through the program is estimated to be 768 kWh.

5.2.2.3.1 Gross Peak Demand (kW) Savings per Appliance

Appliance load shapes for refrigerators and freezers were used to estimate the average kW reduction occurring during the Company's defined on-peak period. These load shapes were normalized versions of load shapes originally developed as part of the End-Use Load and Consumer Assessment program (ELCAP).³⁸ The average daily load profile for each appliance type recycled through the program is shown in Figure 5-3.

³⁸ Ibid.

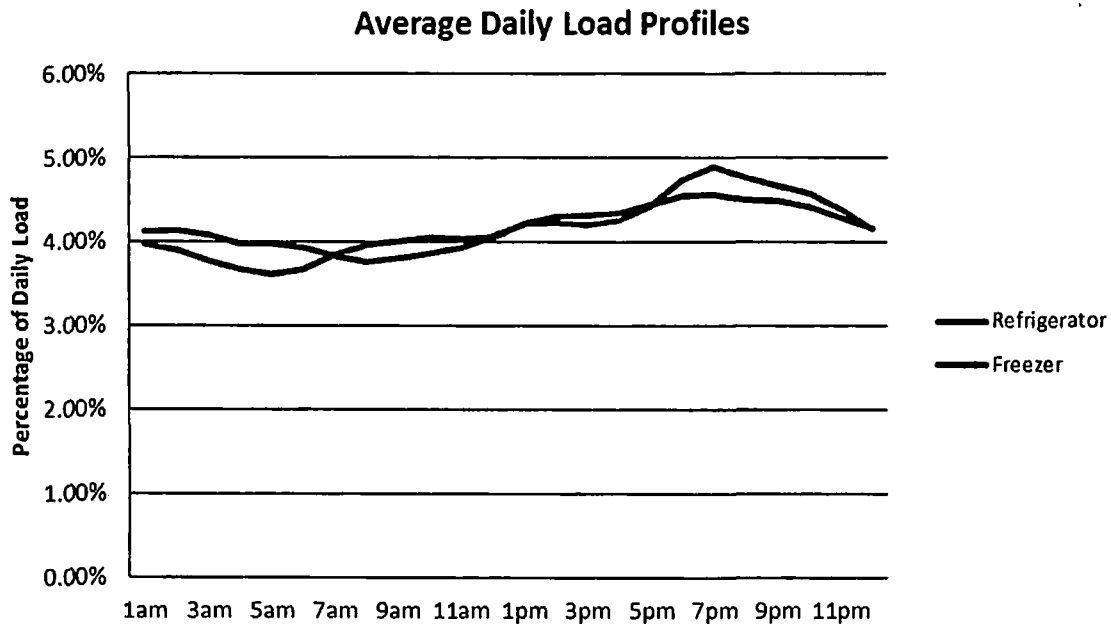


Figure 5-3 Average Daily Load Profiles

Using these normalized ELCAP load shapes, the Evaluation Team determined that approximately 2.3% of the annual gross kWh savings attributable to a recycled refrigerator occurs during the on-peak period. This is equivalent to 22.8 kWh; dividing by the number of on-peak hours (198) results in an average on-peak demand reduction of 0.12 kW per recycled refrigerator.

Similarly, it was determined that approximately 2.4% of a freezer's energy consumption occurs during on-peak hours (18.2 kWh). Average on-peak demand reduction is thus 0.09 kW per recycled freezer.

5.2.2.4 Net Energy (kWh) and Peak Demand (kW) Impacts

The Evaluation Team used the formula shown below to estimate net savings for recycled refrigerators and freezers. Note that this definition considers gross savings under the UMP definition. Each component of the net savings calculation is described in Section 5.2.1.5 of this report. Spillover effects were not considered as part of the net savings analysis for this evaluation.

Net Savings

$$= \text{Gross Savings} - \text{Freeridership} - \text{Secondary Market Impacts} - \text{Induced Replacement}$$

Where:

Gross Savings = The evaluated in situ UEC for the average recycled unit, adjusted for part use (UMP definition of gross savings);

Free-ridership = Program savings from units that would have been destroyed even in the absence of the program;

Secondary Market Impacts = Program Savings that would have occurred in the absence of the program based on the estimated/assumed counterfactual actions of appliance acquirers.

Induced Replacement = Average additional energy savings consumed by replacement units purchased due to the program.

Net savings are essentially calculated using a decision tree. The decision tree is populated with estimated percentages of appliance disposition in the absence of the program based on responses to the participant survey. In other words, participants' actions concerning discarded equipment are used to estimate savings values under all possible scenarios. The weighted average of savings under these scenarios is then used to calculate the net savings attributable to the program.

Participant survey respondents were first asked if they had considered discarding the program appliance before learning about the program. Respondent answers to this question are shown in Table 5-10.

Table 5-10 Prior Consideration of Disposal

	<i>Measure</i>	<i>Response</i>	<i>Percent of</i>
24. Had you already considered disposing of the [refrigerator, freezer] before you heard about [Appalachian Power/AEP]'s appliance recycling program?	Refrigerator	Yes	83.05%
		No	16.95%
		Don't know	0.00%
	Freezer	Yes	56.67%
		No	36.67%
		Don't know	6.67%

Respondents who indicated they had not considered disposal before learning about the program were considered non-free-riders. That is, for these respondents it was assumed they would have kept the appliance in use absent the program, since they hadn't considered disposal before learning about the program. Respondents who indicated they had considered disposal or "didn't know" if they had considered disposal were asked additional questions to determine whether the appliances they recycled were indicative of free-ridership.