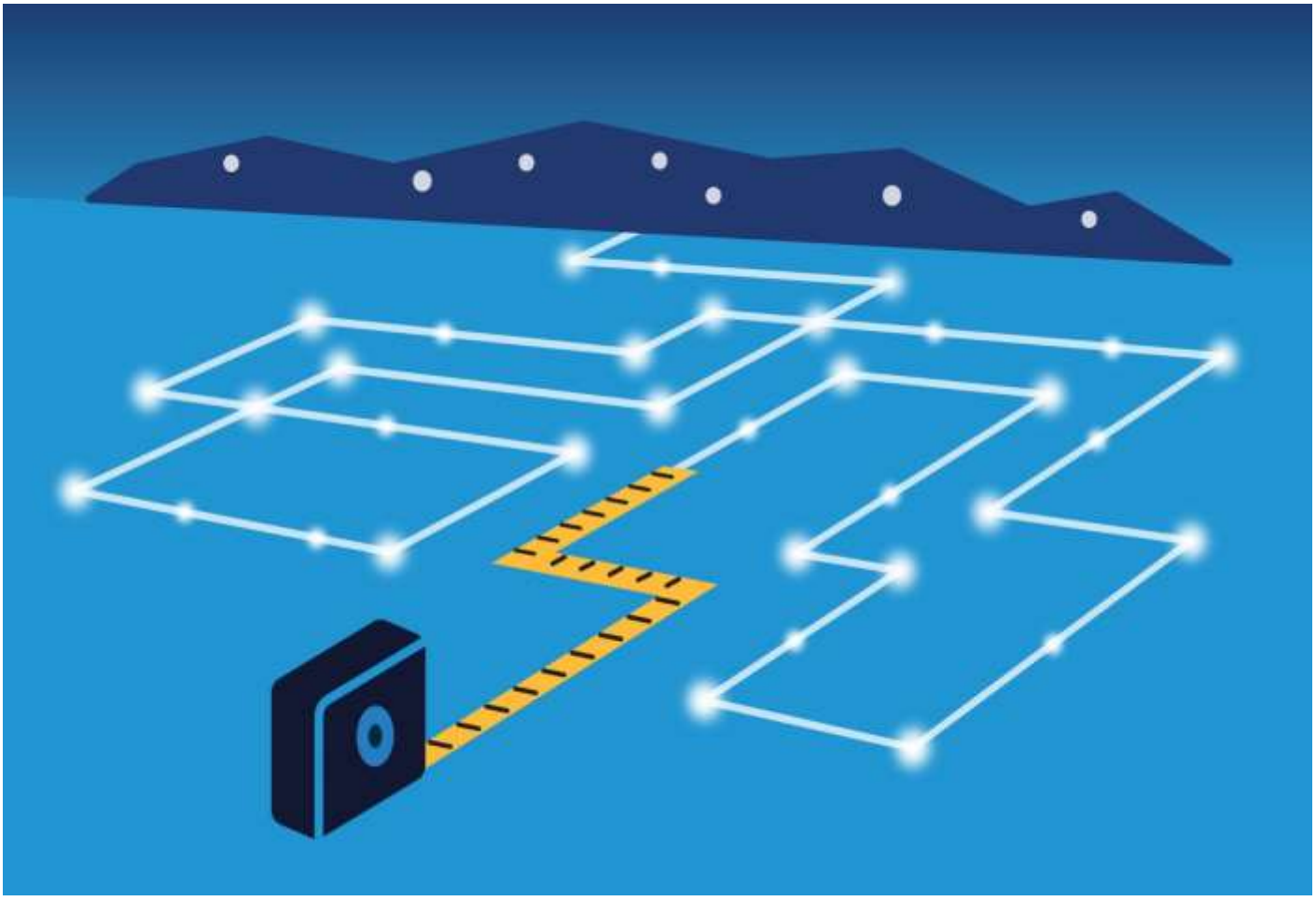
Opinion Dynamics

Boston | Headquarters

617 492 1400 tel
617 497 7944 fax
800 966 1254 toll free

1000 Winter St
Waltham, MA 02451



Impact and Process Evaluation of the 2014 (PY7) Ameren Illinois Company Home Efficiency Standard Program

Final

February 16, 2016

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NAVIGANT

MichaelsEnergy

Opinion Dynamics

Contributors

Jeevika Galhotra
Project Manager, Opinion Dynamics

Seth Wayland
Director, Opinion Dynamics

Mallorie Gattie-Garza
Senior Energy Engineer, Opinion Dynamics

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1. Executive Summary

This report presents the results of the evaluation of the Program Year 7 (PY7) Ameren Illinois Company (AIC) Home Efficiency Standard Program (Standard Program). The Standard Program is a home energy diagnostic and retrofit program that offers customers a home audit, direct install measures, and incentives for additional energy efficiency opportunities. Previously the program had included the Electric Space Heating Pilot (ESHP), but in PY7, this pilot moved to the IPA All Electric Home Program. CLEAResult (formerly Conservation Services Group) implements the Standard Program, reporting to Leidos who manages all of AIC's commercial and residential programs.

The expected savings from this program is 2.5% of the overall PY7 portfolio of electric savings and 17.9% of therm savings (including both residential and commercial).[1] Per the Program Implementation Plan, CLEAResult estimated they would perform 2,100 audits, with 1,500 homes receiving retrofits.

For PY7, the evaluation team conducted a process and impact evaluation of the Standard Program. We also developed a predictive model to help determine the relative influence of various customer- and community-level demographic factors on predicting the likelihood of customer conversions from audits to retrofits.

Program Impacts

The Standard Program reached 2,601 participants in PY7, providing net savings of 3,075 MWh, 1.6 MW and 429,412 therms. While the program performed well in PY7, PY6 performance exceeded PY7 electric savings. The PY6 program achieved net savings of 3,882 MWh, 1.9 MW and 411,594 therms. Table 1 summarizes the impacts for the Standard Program in PY7.

Table 1. PY7 Standard Program Net Impacts

	Ex Ante Gross	Realization Rate	Ex Post Gross	NTGR [a]	Ex Post Net
Energy Savings (kWh)					
Total MWh	3,445,655	99%	3,418,642	0.90	3,075,424
Demand Savings (kW)					
Total MW	1,733	105%	1,816	0.88	1,605
Therm Savings					
Total Therms	494,797	106%	524,885	0.82	429,412

[a] The NTGR are estimated at a measure level but are shown in aggregate for the program here.

The Standard Program achieved gross PY7 realization rates of 99% kWh, 105% for kW and 106% for therms. This variance in net realization rates can be attributed to differences in input values for *ex ante* (calculated by the implementation team) and *ex post* (calculated by the evaluation team) savings algorithms for air sealing, lighting, and insulation measures. Specifically, the evaluation team based values for cooling degree days (CDDs), heating degree days (HDDs), and full load cooling hours on the location of each participating home while the program tracking system applied values for Springfield to all homes, regardless of location. *Ex Ante* and *ex post* savings estimates also differ with respect to baseline assumptions for heating and cooling

[1] Note that the percentage of expected savings here and through the plan is calculated based on Ameren Illinois Order 13-0498, dated January 28, 2014.

equipment and rim joist insulation. We provide a detailed explanation of all differences in the impact section of this report.

Process Results

The program underwent several changes in PY7 including Leidos joining the implementation team on the management side, with CLEAResult remaining the customer-facing implementer. The program also made several design changes to help facilitate participation. The program added a new channel for program participation: allowing trade allies to sell program work directly to customers. The program also re-introduced On-Bill Financing (OBF) as a program offering.

Surveys revealed that the trade allies are generally satisfied with the program overall and believe that the program has had a positive impact on their business (notably, allowing them to provide a program with high customer demand, developing/building their relationship with AIC, and improving customer satisfaction). The program has good recognition among trade allies and they feel very knowledgeable of program components – in part, due to the training they have received from CLEAResult. Allowing trade allies to market the program directly seems to have been a positive change. Trade allies report that direct mailers, word of mouth, pre-existing relationships, and using one's own marketing was most effective in directly promoting the program. Trade allies also reported that the Standard Program has directly impacted their business practices as a whole: adding/training more skilled employees (BPI certification) to their organization and devoting more business resources to the work that the Standard Program brings to their companies.

Although interviews with program staff revealed that very few (if any) trade allies took advantage of OBF (likely due to the delayed start), more than half of the trade allies surveyed reported completing jobs that used OBF and that OBF helps them sell work to customers. Trade allies, however, did encounter some challenges with the program. They report that the program paperwork and general administration are tedious and require streamlining and that payment for services takes too long. These challenges lead some trade allies to complete qualifying jobs outside of the program. Furthermore, the primary reason for trade allies discontinuing their participation in the Standard Program was that it was too time consuming (the same concern expressed by current program participants). Despite changes made in the program to expand incentive offerings and include OBF, these trade allies report that they are highly unlikely to participate in the program in the future due to the administrative burden.

Predictive Analysis

The predictive model shows that the most important variables predicting customer conversion from an audit to measure installation are (1) living in areas where neighbors had previously participated in the Standard Program, (2) higher number of adults in the household, (3) geographic location, and (4) higher number of years of residence at their current address. In addition, the lower proportion of mobile homes, and the higher proportion of people with a graduate or professional degree were also important. The model shows that there may be a reinforcing effect: customers in areas where other customers have received audits and measure installations through the program are actually more likely to convert from audit to measure installation.

Key Findings and Recommendations

Based on the process and impact evaluation findings, the following are some recommendations for the Standard Program:

- **Streamline program paperwork and administration.** The trade ally survey revealed that filling out paperwork is not only time-consuming but also has prevented some contractors from running all of their

qualified projects through the program (if the customer needs a quick project turnaround, for example). Reducing this administrative burden on trade allies would help make the program more attractive, and increase satisfaction with the program.

  - Part of this streamlining should include looking for opportunities to reduce the amount of time it takes to pay trade allies. The trade ally survey revealed that extended lead-times on payments can discourage and limit program participation.

- **Leverage Trade Allies for program marketing**. Historically, the Standard Program has seen growth in both PY5 and PY6 without making any major changes to marketing tactics or program implementation. Based on trade ally feedback, direct mailers and program material handouts are the most relevant marketing tactics. As such, it would be beneficial to work with trade allies to establish additional marketing materials.

- **Update program tracking database to include a flag for projects using OBF.** Given that OBF is likely to be a key program component to facilitate participation, it would be useful to track usage of OBF within the tracking database. This could allow future evaluation efforts to better understand the impact and extent to which OBF affects the Standard Program. This is especially true given the discrepancy between program staff observations and trade allies' self-reported frequency of use of OBF.

- **The predictive model indicates that among customers who have had an audit, those with the highest propensity to install measures tend to be in areas where others have had audits and measures installed, have more adults in the household, have lived in their homes longer, and have professional and graduate degrees.** Another key predictor variable pertains to whether customers live in areas with fewer mobile homes. The model shows that there may be a reinforcing effect: customers in areas where other customers have received audits and measure installations through the program are actually more likely to convert from audit to measure installation.

  - As such, the program may get higher conversion rates by targeting specific areas where others have had audits and measures installed.

  - In addition, the program may want to target customers who have lived in their homes for longer, have more adults in the household, and have more people with graduate or professional degrees.

- **Update program tracking savings assumptions to reflect the *ex post* values used in this evaluation.** Per our *ex post* savings calculations, the evaluation team identified several discrepancies in savings assumptions between the *ex ante* and *ex post* savings calculations. To increase the accuracy of tracked savings and the realization rates, we recommend that the Standard Program adopt the *ex post* assumptions and savings calculations used by the evaluation team.

- **Update *ex ante* savings algorithms for rim joist and crawlspace insulation**. Through discussions with the implementer, we learned that supply vents are installed in below grade spaces, thus turning this space into a semi-conditioned area. However, e*x ante* and *ex post* calculations currently apply CDDs and HDDs for unconditioned space. We recommend modifying the algorithm to use unconditioned basement CDDs and HDDs for pre-existing conditions, and using conditioned basement CDDs and HDDs for post conditions.

2. Evaluation Approach

The PY7 evaluation of the Standard Program involved both process and impact assessments. To support the process evaluation, we reviewed program materials and program-tracking data, interviewed implementation and AIC staff, and completed surveys with participating and non-participating trade allies. We also developed a predictive model, to help determine the relative influence of various project-specific and customer- and community-level demographic factors on predicting the likelihood of customer conversions from audits to retrofits. Our impact analysis effort included an engineering analysis, which estimated program and measure category gross electric and gas savings. Further, per the evaluation plan, we applied net-to-gross ratio (NTGR) values as established through the PY4 evaluation to evaluated gross savings to obtain PY7 net savings.

2.1 Research Objectives

The evaluation team sought to answer the following research questions as part of the PY7 Standard Program evaluation:

2.1.1 Process Questions

- Were program allies satisfied with the program implementation?
- What challenges did program allies face as part of their participation in the program?
- What factors would help improve program ally satisfaction?
- Are there opportunities for program improvement?

In addition, the evaluation team also conducted a forward-looking analysis to help the program understand and predict which customers are most likely to convert from an audit to a retrofit, by developing a predictive model. The predictive model addresses the following primary questions:

- Which of AIC's Standard Program participants are more likely to act on Standard Program audit recommendations? Which program participants are least likely to do so?
- What are the factors that motivate customers to initiate and complete retrofit projects?
- What are the demographic characteristics of customers who complete a retrofit project?

2.1.2 Impact Questions

- What are the estimated program gross energy and demand savings?
- What are the estimated program net energy and demand savings?
- Did the program meet its energy and demand goals?

2.2 Evaluation Tasks

Table 2 summarizes the PY7 evaluation activities conducted for the Standard Program.

Table 2. Summary of PY7 Evaluation Methods

Task	PY7 Process	PY7 Impact	Forward Looking	Details
Program Materials Review	✓			Reviewed program materials—including program design, implementation plans, marketing and outreach efforts, and program databases—to assess program implementation and provide recommendations for improvement, where applicable.
Interviews with Program Staff and Implementers	✓			Interviewed AIC and CLEAResult staff to understand the program's design, implementation, and evaluation priorities.
Trade Ally Survey	✓		✓	Interviewed 19 participating trade allies and 4 non-participating trade allies to inform program processes and satisfaction.
Engineering Review		✓		Conducted an engineering analysis for all PY7 participants to estimate gross and net impacts.
Predictive Analysis			✓	Develop a predictive model to analyze participation data from PY3 to PY7 to help identify the demographic characteristics that best predict conversions from audits to retrofits.

The following activities informed the PY7 process evaluation of the Standard Program.

2.2.1 Review of Program Materials and Data

The evaluation team reviewed program materials, including implementation plans, marketing and outreach activities, training materials, and the program-tracking database.

2.2.2 Program Staff Interviews

We conducted in-depth interviews with one member of the AIC program staff and two members of the CLEAResult implementation team. The purpose of these interviews was to gain insight into whether or not the program was implemented according to plan/design and to determine if there had been any changes in the program's design and implementation from PY6. The team also inquired about data tracking and customer outreach related to the program.

2.2.3 Trade Ally Interviews

During previous program cycles, program staff noted trade ally dissatisfaction with the program, which resulted in reduced involvement with the program. The PY6 analysis showed a decrease in the number of trade ally-driven projects, which could have accounted for some of the drop-off in program participation. As a result, the PY6 evaluation report recommended conducting trade ally surveys to better gauge contractors' satisfaction with the program and understand the challenges they face. As such, in PY7 we conducted trade ally interviews to understand the challenges and opportunities presented to trade allies. Specific survey topics included: overall satisfaction with the program, experience with On-Bill Financing (OBF), program training, and marketing.

We conducted surveys with both participating (in PY7) and non-participating (in PY5 and/or PY6, but not PY7) trade allies. The survey approached non-participants and participants by using two different question batteries, tailored to reflect their disparate participation. For example, participating trade allies were asked about their experience with OBF (a recent addition to the program), program training, marketing, and

satisfaction. Non-participating trade allies were asked why they ceased to participate. However, both batteries inquired about possible program improvements.

Sample Design

The evaluation team attempted to contact all participating trade allies in the PY7 program cycle (i.e., census approach) and thus no sampling was required. We used a mixed modes approach in order to capture as many trade allies as possible, first reaching out through an online survey and then following up, as needed, with phone surveys.

Survey Disposition and Response Rate

We sent emails and/or called all 49 participating trade allies to obtain 19 completed interviews. Table 3 presents the final survey dispositions.

Table 3. Survey Dispositions

Disposition	Total
Completed Interviews (I)	**19**
Partials (P)	**1**
Eligible Non-Interviews	**21**
Refusals (R)	5
Mid-Interview terminate/Break off (R)	4
Respondent never available (NC)	12
Not Eligible (E)	**0**
Unknown Eligibility Non-Interview (U)	**8**
Total Participants in Sample	**49**

Table 4 provides the response and cooperation rates. Appendix C provides information on the methodology used to calculate response and cooperation rates.

Table 4. Survey Response and Cooperation Rates

AAPOR Rate	Percent
Response Rate #3	39%
Cooperation Rate #3	66%

Notably, in PY5 and/or PY6, we also reached out to all 28 non-participating trade allies to obtain four completed interviews.

2.2.4 Impact Analysis

Gross Impact Analysis Approach

To determine the gross impacts associated with the Standard Program, we applied savings algorithms from the Statewide Illinois Technical Reference Manual V3.0[2] (IL TRM V3.0) to the information in the program-

[2] Illinois Statewide Technical Reference Manual for Energy Efficiency V3.0. Effective June 1, 2014.

tracking database. We outline the algorithms used to calculate all evaluated program savings in Appendix A, along with all input variables.

Net Impact Analysis Approach

To estimate net savings, we applied the PY4 program cycle measure-specific NTGRs, per the team's recommendations to the Stakeholder Advisory Group (SAG), to the gross savings to obtain PY7 Standard Program net savings. Table 5 contains the NTGRs used for this study.

Table 5. NTGRs by Measure Category

Measure Category	Electric			Gas		
	Free-Ridership	Spillover	NTGR	Free-Ridership	Spillover	NTGR
CFLs	0.12	0.09	0.97	--	--	--
Faucet Aerator	0.23		0.86	0.28	0.025	0.75
Shower Head	0.04		1.05	0.21		0.82
Air Sealing	0.21		0.88	0.20		0.83
Insulation	0.21		0.88	0.23		0.80
Thermostat	0	0	1.00	0.13		0.90
Water Heater Temperature Adjustment	0	0	1.00	0	0	1.00

2.2.5 Predictive Modeling

The Standard Program has historically seen relatively low customer conversion rates with most customers choosing only to receive an audit. For PY7, the evaluation team developed a predictive model to analyze program participation data from PY3 to PY7. This model helps identify the customer and demographic characteristics that best predict conversions from audits to retrofits. These results may help AIC to understand barriers to program participation and to more effectively target customers and maximize per project savings.

Classification Algorithm

The predictive model uses a Random Forests classifier. Random Forests is a machine learning technique based on the recursive partitioning algorithm, which is analogous to the classification and regression trees (CART) algorithm. The recursive partitioning algorithm relies on repeated partitioning of the data (in the form of decision trees) to estimate the conditional distribution of a response variable given a set of predictors. In a binary classification problem, recursive partitioning continually splits the data (using the predictor variables) within new partitions until there are no further splits that decrease the misclassification rate sufficiently. Once the algorithm can no longer partition the data (i.e., it reaches the optimal splits), model estimation is complete. We used the randomForest[3] package for R statistical software[4] for this work.

The Random Forests classifier generalizes the idea of a single classification tree into a collection of trees (i.e., forests). Specifically, the algorithm draws a series of bootstrapped samples (i.e., sampling with replacement) from the observations, and grows a classification tree for each bootstrapped sub-sample. The algorithm then

[3] A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18--22.
[4] R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

aggregates results from all of the classification trees to produce a single set of model estimates. Random Forests provides several important advantages compared to other prediction algorithms. By using bootstrapped sampling and incorporating information from multiple trees, the Random Forests classifier produces more stable model estimates that are far less susceptible to model overfitting. Overfitting is a condition where a statistical model describes random error and not the underlying relationship within the data. This is often due to the inclusion of too many parameters within the model.

Additional details about the model can be found in Appendix D and Appendix E.

2.3 Sources and Mitigation of Error

Table 6 provides a summary of possible sources of error associated with the data collection conducted for the Standard Program. We discuss each item in detail below.

Table 6. Potential Sources of Error

Research Task	Survey Error		Non-Survey Error
	Sampling	Non-Sampling	
Trade Ally Interviews	None, census attempt	▪ Measurement error ▪ Non-response and self-selection bias ▪ Data processing error	N/A
Predictive Analysis	N/A	N/A	Analytical error
Gross Savings Calculations	N/A	N/A	Analytical error
Net Savings Calculations	N/A	N/A	Analytical error

The evaluation team took a number of steps to mitigate potential sources of error throughout the planning and implementation of the PY7 evaluation.

Survey Error

- **Sampling Error**

Given that the trade ally surveys were conducted at the census level, there are no sampling errors.

- **Non-Sampling Error**

  - **Measurement Error**: We addressed the validity and reliability of quantitative data through multiple strategies. First, we relied on the experience of the evaluation team to create questions that, at face value, appear to measure the idea or construct that they are intended to measure. We reviewed the questions to ensure that we did not ask double-barreled questions (i.e., questions that ask about two subjects, but with only one response) or loaded questions (i.e., questions that are slanted one way or the other). We also checked the overall logical flow of the questions so as not to confuse respondents, which would decrease reliability.

    Key members of the evaluation team, as well as AIC staff, reviewed all survey instruments. To determine whether the questions were clear and unambiguous, we pre-tested each survey instrument, reviewed the pre-test survey data, and monitored the telephone interviews as they were being conducted. We also used the pre-tests to determine that the length of the survey was reasonable.

- **Non-Response Bias**: Since the response rate for the trade ally survey was approximately 39%, there is the potential for non-response bias. However, we attempted to mitigate possible bias by using a mixed modes survey approach which contacted customers five times. The emailed invitation to the online survey contacted contractors first, and an email reminder followed. For our third effort, we reached out to contractors by calling all those who had not yet completed the internet survey (this critical step allowed us to update email address information). We followed up with another round of email invitations/reminders. Finally, we fielded a phone survey, calling each potential respondent at least once, or until we received a firm refusal, and by calling at different times of day, as appropriate.[5]

- **Data Processing Error**: The team addressed processing error through interviewer training and through quality checks of completed survey data. Opinion Dynamics interviewers went through rigorous training before interviews began. Interviewers received a general overview of the research goals and the intent of each survey instrument. Through survey monitoring, members of the evaluation team also provided guidance on proper coding of survey responses.

Non-Survey Error

Three types of non-survey errors were possible.

- **Gross Impact Calculations*:*** We applied the TRM calculations to the participant data in the tracking database to calculate gross impacts. To minimize analytical errors, all impact calculations were reviewed by a separate team member to verify their accuracy.

- **Net Impact Calculations*:*** We applied the PY4 measure-level NTGR to gross savings to obtain PY7 Standard Program net savings. Therefore, although possible, we do not anticipate any error in these calculations.

- **Predictive Models*:*** We used the Random Forests method to build the predictive model, this approach is a common and effective method for building predictive models and yields information on the relative importance of variables. While building the model, we followed best practices in model selection, using nested cross-validation to reduce the potential for overfitting.

[5] The evaluation team also checked available program data to see if there were any differences on observable variables. Unfortunately, due to data limitations, there were not many variables available to assess non-response error.

3. Detailed Evaluation Findings

3.1 Program Design and Implementation

The process analysis leverages data from three different data collection methods: a review of program materials, in-depth interviews with program and implementation staff, and surveys with participating and non-participating trade allies.

3.1.1 Program Design Changes

In PY7, the Standard Program underwent many changes, with one of them being Leidos assuming the role of program prime implementer. Through PY6, Leidos was the prime implementer for AIC's commercial and industrial programs; in PY7, they became the prime implementer for both residential and commercial programs. As such, although CLEAResult is still implementing the Standard Program, instead of reporting directly to AIC they now report to Leidos.

In their role as the prime, Leidos took steps to ensure that marketing materials and messages were uniform across the residential program portfolio. They also worked to improve data tracking and reporting for the program. To accomplish these goals, the following changes were made:

- Program names were changed to standardize marketing. The Home Performance with ENERGY STAR Program became the Home Efficiency Standard Program and is now under the Home Efficiency Programs umbrella along with the Home Efficiency Income Qualified Program (previously the Warm Neighbors Cool Friends Program).
- Starting in PY7, customers can access the program through three channels: receiving an audit from an Energy Advisor, contacting a program ally to make shell measure improvements such as insulation, or receiving solicitation to make improvements from a program ally.
    - In previous years, customers had two channels for program participation: (1) request an in-home audit from AIC, or (2) contact an AIC approved trade ally for installing qualifying retrofits. In PY7, the program added a new channel where trade allies gained the ability to sell the program directly to qualifying clients rather than waiting for AIC to provide them with customer leads. Trade allies underwent training in the middle of the program cycle to learn how to sell the program.
    - The trade ally surveys revealed that about half of the trade allies (8 of 19 trade allies interviewed) directly marketed the Standard Program to their customers in PY7.
- In PY7, Leidos reviewed all marketing materials to assure consistent messaging across AIC's portfolio of programs. As such, the Standard Program marketing efforts, while similar to those in PY6, also included sales training (i.e., how to market and sell the program), bill inserts, direct mail (regarding energy audits), marketing events (home shows, realtor group events, etc.), and Pandora and television advertisements
- In PY6, AIC discontinued the OBF component due to insufficient funds. Program staff expressed concern that dropping OBF hurt program participation and reduced trade allies' ability to market the program. Given this, the PY6 evaluation report recommended re-introducing OBF for the Standard Program. While OBF was re-introduced to the Standard Program in PY7, there was a delay in the implementation and OBF was implemented in March/April as opposed to its planned date in mid-January.

- Although this program change had the capacity to increase program uptake, our interview with CLEAResult revealed that almost none of the Standard Program projects actually employed OBF. This could have been due to the late start of the program and/or due to the lack of awareness of OBF as a program offering (our interviews revealed that trade allies tend to associate OBF with the Home Efficiency Income Qualified program).
- Our trade ally interviews showed a different picture where almost all trade allies were aware of OBF (17 of 19 trade allies interviewed), and 12 of 19 trade allies reported having used OBF. Thus, there seems to be some confusion among the trade allies in regards to the OBF component of the program. Notably, the trade allies could be thinking about their experience with OBF in the PY8 program cycle rather than PY7.

3.2 Program Participation and Measure Installation

Participation

In PY7, the Standard Program reached 2,601 participants. The participation experience varied somewhat across the 2,601 participants based on the services received. As shown in Table 7, the evaluation team grouped participants based on whether they received only an audit, only a retrofit, or both an audit and a retrofit.

Table 7. Overview of Participation by Household and Services Received in PY7

Participant Type	Number of Participants	% of Participants
Audit and Retrofit	331	13%
Audit Only	1,123	43%
Retrofit Only	1,147	44%
Total	**2,601**	**100%**

We also calculated a conversion rate by dividing the number of participants who received a retrofit following an audit (audit and retrofit) by the total number of participants who received an audit at all (whether or not they received a retrofit). However, participants who receive an audit in one year and receive the associated retrofit in the following year (or two) complicate this calculation. Thus, to take these participants into account, the conversion rate was calculated using cumulative results. For example, 2,130 participant received an audit in PY4, and then 231 received a retrofit in PY5, 37 received a retrofit in PY6, and 16 received a retrofit in PY7. As such, conversion rates for each program year can change from year to year (see Table 8). Comparing the conversion rates between PY4 through PY7, we can see that the conversion rate is increasing over time from PY4 to PY6, but drops again in PY7. Notably, these counts do not include Program-Ally driven leads/contacts that ultimately chose not to participate as these are not tracked and reported.

Table 8. PY4-PY7 Conversion Rates

Approach	Participant Type	PY4 Participants	PY5 Participants	PY6 Participants	PY7 Participants
CLEAResult-Driven	(a) Audit & Retrofit	648	718	551	331
	(b) Audit Only	2,134	1,905	1,421	1,123
Program Ally-Driven	(c) Retrofit Only	1,419	1,529	1,005	1,147
Total Participants = a + b + c		4,201	4,152	2,977	2,601
Total Audits = a + b		2,782	2,623	1,972	1,454
Conversion Rate = a/(a +b)		**23%**	**27%**	**28%**	**23%**

Measures Installed

The program offers a variety of measures to participants. Table 9 summarizes the number of households and the quantity of installed measures based on the team's review of the program-tracking database.

Table 9. Overview of PY7 Standard Program Participation by Measure Category

Measure Category	Measure	Unique Households [a]	Unit	Measure Quantity	Database Verification Rate
Lighting	CFL - Low 13 TO 15 Watt	764	Bulb	6,309	1.00
	CFL - Medium 18 to 20 Watt	195	Bulb	915	1.00
	CFL - High 23 to 25 Watt	167	Bulb	570	1.00
	Specialty CFL - 9W candelabra	449	Bulb	2,910	1.00
	Specialty CFL - 14W globe	704	Bulb	5,140	1.00
	Specialty CFL - 15W reflector	424	Bulb	2,466	1.00
Domestic Hot Water (DHW)	Faucet Aerators	605	Aerator	1,426	1.00
	Showerheads	633	Showerhead	971	1.00
	Water Heater Temperature Adjustment	31	Water Heater	31	1.00
HVAC (Controls)	Programmable Thermostat	26	Thermostat	57	1.00
Envelope	Air Sealing	1,403	CFM	4,644,414	1.00
	Attic Insulation	1,178	SqFt	2,738,668	1.00
	Wall Insulation	577	SqFt	783,959	1.00
	Rim Joist Insulation	1,022	Linear Feet	247,237	1.00
	Crawlspace Insulation	601	SqFt	121,193	1.00

[a] A unique household represents one particular (unique) household regardless of the number and types of measures installed. As such, the sum of the number of unique households is greater than the number of participating households (N=2,601) because any given household could install more than one measure.

3.3 Trade Ally Interview Results

The evaluation team conducted interviews with both participating and non-participating trade allies. In addition to overall satisfactions levels, the evaluation team asked trade allies for suggestions to help improve the program overall as well as specific program components such as training, technical assistance, and marketing. This section provides the results from the interviews[6]. The data collection instrument can be found in Appendix B.

[6] Notably, these findings summarize what the Evaluation Team learned from the 19 trade allies interviewed. The findings are not generalized to all trade allies.

3.3.1 PY7 Participating Trade Allies

The evaluation team conducted interviews with 19 participating trade allies. Of these 19 trade allies, six also participated in the Home Efficiency Income Qualified program.

Trade Ally Firmographics

All the trade allies classified themselves as air sealing/insulation contractors, while a majority also classified themselves as energy audit contractors (see Table 10). On average, the 19 trade allies have nine employees (minimum of 2 and maximum of 25) conducting about 185 jobs per year (minimum 10 and maximum of 500).

Table 10. Business Category (Multiple Response)

	Number of Respondents (n=19)
Contractor - Air Sealing/Insulation	19
Contractor - Energy Audits	12
Contractor - HVAC	7
Contractor - Other	7
Energy Consultant	4
Roofing Contractor	1

Satisfaction with the Program

In general, trade allies are very familiar with the program (average score of 9.2 out of 10) and, overall, are satisfied with the program (average score of 7.7 out of 10). The majority of trade allies (13 of 19) noted that the program had a positive impact on their business and they would recommend the program to other trade allies (14 of 19).

When asked about specific program components, the trade allies rated the program high on interactions with CLEAResult and assistance with completing required paperwork but were significantly less satisfied with the payment time and the On-Bill Financing component (see Table 11).

Table 11. Satisfaction with the Program

On a scale of 0-10, how satisfied were you with the following.....(n=19)	Score of 0-3	Score of 4-7	Score of 8-10	Don't Know / Refused	Average Score
The Standard Program overall	6%	44%	50%	0%	7.7
Program Components					
Interactions with the implementer	0%	28%	72%	0%	8.4
Assistance in completing required paperwork	6%	44%	50%	0%	7.6
On-Bill Financing	33%	33%	33%	0%	5.7
Incentive payment time upon project completion	39%	44%	11%	6%	4.4

Note: totals may not equal 100% due to rounding.

Overall, trade allies are very knowledgeable of all program components. They are most knowledgeable on the program's benefits to program participants and the application process but relatively less knowledgeable about the best strategies to market the program to customers (see Table 12).

Table 12. Knowledgeable about Program Components

On a scale of 0-10, how knowledgeable are you with the following.....(n=19)	Score of 0-3	Score of 4-7	Score of 8-10	Don't Know / Refused	Average Score
Benefits to program participants	0%	5%	95%	0%	9.1
The application process	0%	16%	84%	0%	8.9
Where to find help or information about the program	5%	5%	89%	0%	8.7
On-Bill Financing	0%	42%	58%	0%	7.6
Best strategies to market the program to customers	11%	32%	53%	5%	7.4

Note: totals may not equal 100% due to rounding.

Given their overall satisfaction with and knowledge of the program, trade allies noted that the program has numerous benefits, including providing a program with high customer demand and corresponding satisfaction. They also indicate that the program has allowed them to develop/build a relationship with AIC (see Table 13). Notably, only a few trade allies consider marketing as a program benefit.

Table 13. Identified Program Benefits (Multiple Response)

Benefits	Number of Respondents (n=19)
Providing a program with high customer demand	14
Developing/building a relationship with AIC	14
Improving customer satisfaction	14
Receiving training through the program	13
Receiving technical assistance through the program	13
Increasing jobs/revenue	12
Expanding customer base	12
Providing On-Bill Financing to customers	12
Increasing sales of energy efficient equipment	9
Marketing through the program	8

While the trade allies are generally satisfied with the program and view it to have multiple benefits, most (13 of 19) experienced a number of challenges with the program. The most frequently encountered challenge was the tedious paperwork and administration and challenges marketing the program (see Table 14). Five noted that they did not encounter any challenges.

Table 14. Challenges to Participation (Multiple Response)

Challenges	Number of Respondents (n=19)
Paperwork/administration was tedious/too time-consuming	11
Challenges marketing the program/ Marketing support was not adequate	6
Delays in payment	5
Many customers did not qualify for the program	4
Lack of communication from AIC/Implementer	3
Training provided was not adequate/technical problems	2
Other	4

Given these challenges, the evaluation team asked about suggestions to help improve the program. Notably, eight of the 19 trade allies could not offer suggestions. However, those that provided suggestions to improve the program focused on a more streamlined administrative process, increasing marketing to make customers more aware of the program, increasing the scope of the incentives to increase participation, and improvements in providing estimates to homeowners during an audit. Some verbatim responses are shown below:

1. Streamline the paperwork and administration process

- *"[streamline the paperwork process, it] is a very time consuming process, almost enough to not take the time to participate in the program..."*
- *"Smoother transition into and out of program years."*

2. Increase marketing

- *"they could advertise it better with the public..."*
- *"...more on the advertising side. Letting people be more aware..."*

3. Increase scope of incentives or increase existing incentives to help increase customer participation.

- *"Increase incentives to compensate for unincentivised required upgrades."*
- *"Help pay for the required improvements such as the vapor barrier, fans and mechanical ventilation"*

4. Improve estimates provided to homeowners after the audit

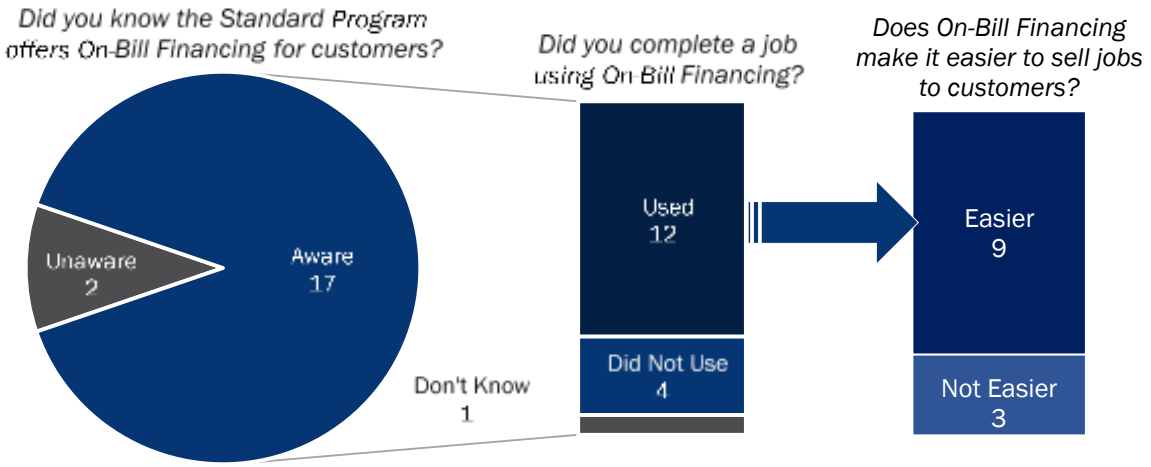
- *"Quit quoting expected project costs - such as the incentives will cover 50-80% of the project cost"*
- *"Include other required work costs, such as bath fan and vapor barrier installation, in the 'estimated cost' they provide the home owner after the audit."*
- *"Ameren's audits present HUGE problems for us. First, the "estimated cost" they provide the home owner doesn't ever include required, but not incentivized work such as bath fan installation, vapor barrier installation, (which can be expensive)."*
- *"Include other required work costs, such as bath fan and vapor barrier installation, in the 'estimated cost' they provide the home owner after the audit."*
- *"Require Ameren auditors to perform a blower door test with each home audit. Include other required work costs, such as bath fan and vapor barrier installation, in the "estimated cost" they provide the home owner after the audit."*

On-Bill Financing

In PY7, the Standard Program reintroduced OBF as a program offering. Program and implementer staff reported that trade allies did not take advantage of OBF in PY7; they assumed that this low adoption might have been the result of a late start to the program offering or program confusion (i.e., trade allies might associate OBF with the Income Qualified Program).

However, our survey effort with trade allies suggested the opposite. The majority of trade allies (17 of 19) were aware of the Standard Program's OBF offering and most of these trade allies (12 of 17) reported that they completed a job that used OBF (see Figure 1). The feedback for OBF from those who used it to complete a job revealed that most trade allies (9 of 12) believe that OBF makes it easier to sell jobs to customers - specifically saying that this type of financing not only mitigates the cost burden for customers but also is convenient.

Figure 1. On-Bill Financing Awareness and Usage (n=19)



1. On-Bill Financing helps mitigate customers' cost burden

- *"It makes it more affordable and they see the return investment versus energy savings and the cost of doing the work."*

2. On-Bill Financing is a convenient option for customers

- *"the customers can qualify easier, and it is on their bill and they…like only paying one thing."*

We also looked at the trade allies who only participated in the Standard Program to see whether their answers differed from those who participated in both the Standard and Income Qualified Program. As noted previously, six trade allies participated in both programs and, therefore, we looked at the responses for the remaining 13 trade allies. This analysis did not change the results; the majority of trade allies (11 of 13) were aware of the Standard Program's OBF offering and more than half of these trade allies (7 of 11) stated they completed a job using OBF.

The 12 trade allies who used OBF noted that the OBF application form was neither particularly easy nor difficult to fill out (ranking the form a 5.3, on average, on a 0 to 10 scale where 0 is "very difficult" and 10 is "very easy"). Challenges with the form varied, with no one particular challenge standing above the rest (see Table 15).

Table 15. On-Bill Financing Application Challenges (Multiple Response)

Challenges with OBF Application	Number of Respondents (n=12)
Takes too much time	4
Instructions are not clear	3
Too many details required	3
Difficult to contact AIC if I have questions	1
Other	3
No challenges	2

A few trade allies (4 of 17) who knew about OBF but did not complete a job with it said that their customers either did not qualify for OBF or did not want/need OBF. Additionally, some trade allies felt that some of the

requirements/measure qualifications prevented customers from participating. For example, one trade ally noted, "*On-Bill Financing has been very challenging. The Standard Program customers are unable to finance furnaces, only the ECM motor. If a customer is looking to finance they want to finance the whole project not just a portion of it.*"

Given the information collected through the staff interviews and the trade ally interviews, there seems to be a disconnect between what the program staff is observing (no trade allies took advantage of OBF) versus what the trade allies say they are doing (12 of 19 have completed a job using OBF). Notably, this could have been due to trade allies thinking about PY8 projects rather than PY7, however, the evaluation team could not verify this discrepancy because the tracking database does not have an OBF flag.

Marketing

In previous years, customers had two channels for program participation: (1) request an in-home audit from AIC, or (2) search a list of AIC trade allies capable of installing qualifying retrofits through AIC programs. In PY7, the program added a new channel for program participation: trade allies were allowed to directly sell the program to qualifying clients. Given this, the trade ally survey revealed that about half of the trade allies (10 of 19) directly marketed the Standard Program to their customers. These trade allies used a variety of tactics to directly market the program: direct mailers (including program brochures), hand out applications/program materials at bids or jobs, door-to-door canvassing, radio/newspaper advertisements, advertising on own website and with previous clients, and using trade shows or local community events. Trade allies, who do not directly market the Standard Program (9 of 19), reported that they do not typically rely on marketing for business development.

Trade allies indicated that word-of-mouth and their own company website are the most effective marketing tactics to increase customer participation (see Table 16). Thus, marketing the program directly is not overly onerous as most trade allies already include it as a part of their existing marketing tactics.

Table 16. Effective Marketing Tactics (Multiple Response)

Marketing Tactics	Number of Respondents (n=19)
Word of mouth	6
My company website	5
AIC website/leads	4
Company brochures and printed information	3
TV or radio advertising	2
Cold-calling	1
Cross-selling	1

In line with these findings, all trade allies reported that customers found them through the trade ally's company marketing, leveraging their past customer-contractor relationship(s), with the AIC's website and referrals from other contractors also playing key roles (see Table 17).

Table 17. How Program Customers Find the Trade Allies (Multiple Response)

	Number of Respondents (n=19)
The company's own marketing	14
Past relationship with customer/existing customer	13

	Number of Respondents (n=19)
AIC provided customer leads	8
Referral from another contractor	8
AIC website	7
Other	3

Training and Technical Support

Overall, trade allies were satisfied with the training provided through the program (average score of 7.8 out of 10). They most often received training on BPI certification opportunities and the program's application process (see Table 18) and were most likely to receive it through industry or other group meetings (see Table 19).

Table 18. Training Received through the Program (Multiple Response)

Training	Number of Respondents (n=19)
BPI certification opportunities	11
On the application process	8
Best practices for On-Bill Financing sales	6
More professional certification opportunities in general	6
On marketing materials available	6
Sales training for On-Bill Financing	6
To help develop marketing materials	5
On eligible equipment	4
Other	4

Table 19. Mode of Receiving Training (Multiple Response)

Training Mode	Number of Respondents (n=19)
Industry or other group meetings	12
One on one meeting	6
Workshop	6
Brochures and other handouts	5
Through the Trade Ally Coordinators	5
Website	4
Other	3

Only one trade ally suggested that the training offered through the program could be improved by offering more trade specific training (or tailor the training based on contractor type).

Similarly, trade allies were satisfied with the technical assistance provided through the program (average score of 8.9 out of 10). They most often received technical assistance for answering questions on eligible/qualified measures and support filling out forms (see Table 20).

Table 20. Technical Assistance Received through the Program (Multiple Response)

Technical Assistance	Number of Respondents (n=19)
Answered questions on eligible/qualified measures	11
Support filling out forms	10
Answered questions on application process	9
Sales leads	8
Accompany on sales calls	3
I did not receive any support	2
Other: Specify	2

Jobs outside the Program

The evaluation team also asked trade allies about eligible jobs performed outside of the program (i.e., eligible jobs for which they did not seek an incentive). Of the total 19 trade allies interviewed, seven performed these types of projects. On average, this happened for about 19% of their jobs (as low as 5% and as high as 50%).

Trade allies reported that time-consuming paperwork and administration is the chief driver for completion of projects outside of the program (4 of 7). Trade allies also indicated that the program can be costly due to program requirements that lacked incentives or "*the amount of incentive to be received was much less than the cost of post-testing and paperwork*".

Table 21. Reasons for Eligible Jobs Not through the Standard Program (Multiple Response)

	Number of Respondents (n=7)
Paperwork/administration was tedious/too time-consuming	4
Easier to sell the jobs without the program	3
Delay in payment	2
Other	1

Finally, looking at the effect of the program on trade allies' business practices (both inside and outside of the program), the survey revealed that seven of the 19 trade allies have made changes to their company as a direct result of their participation in the Standard Program. These changes include adding/training more skilled employees (BPI certification) and devoting more business resources to Standard Program (and Income Qualified Program) related work. Specific verbatim comments are presented below:

Adding skilled employees

- *"I have more BPI certified employees"*

Business Growth and Resource Development to HEPs

- *"We are now participating in the Income Qualified Program also. We will be looking to add to our staff due to an increase of jobs with both programs"*
- *"We no longer in the remodel/restoration business. Energy efficiency is driving our business; there is so much demand for good air sealing and insulation…"*

3.3.2 Non-Participating Trade Allies

The evaluation team attempted to talk with trade allies who had participated in the Standard Program in previous program cycles (PY5 or PY6) but not in the current PY7 cycle. Overall, we attempted to contact 28

trade allies, and seven trade allies were willing to complete the interview. Of these seven, we removed three respondents due to their circumstances: one no longer operates in Ameren's service territory, one performs primarily new construction work, and the third claimed to be an active program participant.

The remaining four non-participating trade allies noted several reasons for no longer participating in the program. Three indicated that the program was too time-consuming, one said the program failed to expand their customer base, and another noted that the program did not increase their company's jobs or revenue. The burden of administration referenced here is similar to the primary challenge faced by currently participating trade allies. A majority of the non-participating trade allies classified themselves as air sealing/insulation contractors (see Table 22). On average, the four non-participating trade allies have eight employees (minimum of 1 and maximum of 20) and complete about 270 jobs per year (minimum 2 and maximum of 800).

Table 22. Business Category (Multiple Response)

(n=4)	Number of Respondents
Contractor - Air Sealing/Insulation	3
Contractor - Energy Audits	2
Energy Consultant	1
Contractor - Other	1

We did find, however, that these non-participating trade allies did see some potential benefits to participating in the program. In general, they noted the potential increase in jobs/company revenue as the primary benefit of participation (see Table 23), even if they did not all experience it.

Table 23. Potential Benefits to Participating in the Standard Program (Multiple Response)

(n=4)	Number of Respondents
Increasing jobs/revenue	3
Providing a program with high customer demand	1
Developing/building a relationship with AIC	1
Increasing sales of energy efficient equipment	1
Receiving training through the program	1

The evaluation team also asked these trade allies whether they were aware of the changes that have occurred within the program (such as, including incentives for programmable thermostats and crawl spaces and On-Bill Financing). Half of the four trade allies were aware of these changes. However, when asked to indicate their likelihood of participation on a 0 -10 scale given these program changes, with "0" being not at all likely and "10" being extremely likely, the average response score was a 2.3.

We also inquired about possible improvements that would motivate them to once again participate. Some of the changes specified (which are in-line with some of the challenges faced and/or improvements suggested by the participating trade allies) include:

1. A More Streamlined Application Process
   - *"Ease of use. Less red tape"*
2. Accurate Quotes from Auditors Regarding the Scope of Work for the Retrofit Projects
   - *"…upfront honest 'scope' of the program from inception"*
   - *"I recommend 3rd party testing. It will eliminate numbers being fudged to improve incentives"*

3.3 Predictive Model

The Standard Program has historically seen relatively low customer conversion rates with most customers choosing only to receive an audit. For PY7, the evaluation team developed a predictive model to analyze program participation data from PY3 to PY7. This model helps identify the customer and demographic characteristics that best predict conversions from audits to retrofits.

The predictive model shows that the most important variables predicting customer conversion from an audit to measure installation are (1) living in areas where neighbors had previously participated in the Standard Program, (2) higher number of adults in the household, (3) geographic location, and (4) higher number of years of residence at their current address. In addition, we also found certain variables from the American Community Survey to be of importance: lower proportion of mobile homes and a higher proportion of people with a graduate or professional degree. The model shows that there may be a reinforcing effect: customers in areas where other customers have received audits and measure installations through the program are actually more likely to convert from audit to measure installation.

3.3.1 Predictor Variables

We used a variety of data sources to develop potential predictor variables, including Standards Program tracking data from PY4 thorough PY7, billing data from Standards Program participants for PY4 through PY6, American Community Survey data, and demographic, housing and psychographic data purchased from Experian.

Through our data collection, we created three classes of predictor variables that we used during the development of our predictive model. We list these sets of predictors below:

- **Household characteristics** – from the program tracking and Experian data, characteristics such as heating fuel, the proportion of nearby participant households who have installed measures, income, household size, homeowner status, and other variables.
- **Billing and usage** – household specific average consumption of electricity and gas on a yearly and seasonal basis.
- **Neighborhood demographics and characteristics** – demographic variables such as education levels and neighborhood characteristics such as proportion of apartments at the census block group level, from the American Community Survey.

Additional details on input variables are in Appendix E.

3.3.2 Model Results

We divide our results into three key categories: (1) customer propensity scoring, (2) variable importance, and (3) overall predictive accuracy.

Customer Propensity Scoring

The evaluation team used the Random Forests classification algorithm to produce propensity scores for Standards Program participants. Propensity scores estimate how likely it is that a customer will convert from

an audit to installing measures within the next year[7]. These results provide an important source of information for program marketing and outreach and allow for the enhanced targeting of customers most likely to convert. Using propensity scores to target customers can lead to more effective marketing strategies and may increase program participation rates and cost effectiveness.

One caveat with propensity scores is that they use only historical participation. Whether or not a customer has participated in the past is dependent on many factors, many of which are difficult or impossible to directly measure, such as the local economy, previous marketing approaches, quality of the utility-customer relationship, and energy and cost savings potential. Most of these factors can and do change over time, while the model remains the same. Future discussions with the program administration team on how the model was or was not useful will also help with refinements to the model.

Customers Most or Least Likely to Convert to Measure Installation

Using our model, we calculated propensity scores for all customers in our dataset of Standards Program audit participants. We then separated customers into propensity score quintiles to examine customers who are most and least likely to participate. Table 24 shows some of the measures that most differentiate the groups most likely and least likely to convert from an audit to measure installation[8].

Table 24. Mean Values for Top 20% and Bottom 20%[9]

Propensity	Conversion Rate	Nearby Audits or Measures	Years at Current Residence	Census Block Group : % with Graduate Degree
Top 20%	73%	14%	17	14%
Bottom 20%	0.1%	7%	14	12%

The customers who have the highest propensity scores tend to be in areas where others have participated in the program, and customers who are in census block groups (CBGs) with graduate or professional degrees are more likely to convert. Seventy-three percent of customers in the top quintile of propensity scores converted within a year compared to less than one percent of customers in the bottom quintile. While the linkages between these variables and conversion are not perfectly clear, these results suggest that customers with several of these factors are much more likely to convert.

Electricity and gas usage were not among the important variables, possibly meaning that a participant's level of usage is not important in their decision to move from the audit to installing measures, though it may be an important part of the decision to get an audit in the first place. The energy data used in the model comes from billing data, which contain the average daily kWh and therm usage on a monthly frequency. We calculated some additional variables such as the standard deviation of usage, but these measures of monthly variation were also not important in the propensity score model.

In addition, we also identified customers in the top ten percent of propensity scores who had not converted from audit to measure installation. These customers probably experienced a significant barrier to full

[7] The Evaluation Team used a cut-off of 0.5 for the likelihood of installing to be considered as an installation

[8] The Evaluation Team used nested coefficient of variation (CV) to select the model parameters. These results could be used to calculate uncertainty estimates around estimated conversion rates based on the variation in results of the CV.

[9] Notably, while there are additional important variables, this table includes the variables with the highest differences between the lowest and highest quintiles (such as number of adults in the household). In addition, the variables not included in the table are those that are effective as interactions with the important variables rather than stand-alone variables (such as geographic location).

participation, as they are otherwise similar to customers who did convert. We suggest that valuable information about these barriers could be identified though further research with these high propensity non-converting customers.

Variable Importance

In addition to estimating propensity scores, we also used our predictive model to calculate the relative importance of each of our predictor variables. These results help us to understand what variables are most important for determining whether a customer will convert. To determine variable importance, we calculated the marginal effect of each predictor on the overall misclassification rate[10]. If including the variable in our model significantly reduced misclassification error, then that variable is important.

Based on our analysis, the important variables from highest to lowest importance in our model are whether neighbors had previously participated in the Standard Program, number of adults in the household, geographic location, and number of years of residence at their current address. In addition, certain variables from the American Community Survey are also important, most notably the proportion of mobile homes (fewer) and the proportion of people with a graduate or professional degree (higher).

Overall Predictive Accuracy

To assess the performance of our predictive model, we examine how well our model predicts "out-of-sample" data. Specifically, we randomly subset our customer data to produce a "training" and "test" dataset. We used only the training data to develop our predictive model and set aside the test data to evaluate predictive accuracy. This is a key step often missing in the design of predictive models. By separating the data used for model building and prediction, we significantly reduce the possibility of model over-fitting[11] , thus producing a more robust predictive model that provides stable and accurate results irrespective of the particular data used for analysis.

The key metric to assess model performance is the accuracy rate on the test dataset, which details the percentage of cases where the model correctly predicts whether the customer will install measures within a year of their audit. The accuracy rate for our model is 78% on the test data, and 97% on the training data. Changing the model to increase the training accuracy further caused a reduction in the test accuracy, showing that we have a model that will most accurately predict the participation for customers who were not in the training data.

We display in more detail the predictive performance of our model in Table 25, which tabulates the observed outcomes (i.e., whether a customer is actually a program participant or not) against our model predicted outcomes. This table shows how the model classifies customers as participants and non-participants in the test dataset compared to what we actually observe.

[10] Misclassification rate is the rate at which the model incorrectly assigns customers who did not convert into the conversion group or customers who did convert into the non-conversion group.

[11] Over-fitting refers to building a model that so completely reflects the data that it captures the noise of the data. Over-fitting results in low bias but high variance models that provide excellent model fit and accuracy for the training data set, but which perform very poorly when applied to other data. There is a trade-off between training accuracy and test (or out-of-sample) accuracy that can only be reported if a test dataset is withheld before the model is built.

Table 25. Test Data Classification Matrix

	Participant	Non-Participant
Model Predicted	10.6%	89.4%
Actual Observed data	18.1%	81.9%

In terms of misclassification, we see that our model under-predicts participants and slightly over-predicts non-participants. However, in total, these results demonstrate good predictive validity for our model. By assessing performance on out-of-sample data, we show that our model can handle new data and provide accurate predictions for customers not currently in our dataset.

Future Research

While the predictive model results help explain which variables are related to conversion from audit to measure installation, the model does not show causality (i.e., these variables, while related to conversion, may not cause the conversion). The investigation of the causes of conversion requires future analysis, typically in combination with some experimental design.

As noted above, the model helps identify customers who fell into the top ten percent of propensity scores but did not convert from Standard Program audit to measure installation. These customers, though they are very similar to customers who installed measures, chose not to do so because of one or more barriers. Valuable future research would reveal the barriers these customers experienced and suggest solutions for reducing or removing those barriers. We recommend conducting future research to explore the barriers for these customers.

3.4 Impact Assessment

The evaluation team applied savings algorithms from the IL TRM V3.0 using program-tracking database inputs and applied in-service rates from the PY6 participant survey results to estimate program gross savings. The evaluation team applied measure-specific NTGRs developed during the PY4 evaluation to determine PY7 net savings.

3.4.1 In-Service Rates

The evaluation team used results from the PY6 participant survey to adjust in-service rates for direct install and shell measures.[12] Programmable thermostats were introduced in PY7 and therefore the evaluation team assumed an installation rate of 100%. Table 26 provides the survey-derived verification rates for each measure category.

Table 26. PY6 In-Service Rates by Measure Category (Applied in PY7 Evaluation)

Measure	In-Service Rate	Resource
CFLs	0.96	PY6 Participant Survey
Faucet Aerators	0.96	
Showerheads	0.96	
Insulation	0.99	

[12] Sampled participants were asked to confirm program-tracking measure quantities and, if necessary, provide the corrected quantity. The participants were also asked to confirm whether program measures were still installed in their homes.

Measure	In-Service Rate	Resource
Air Sealing	1.0	
Water Heater Temperature Adjustment	1.0	
Programmable Thermostats	1.0	New Measure in PY7 (assumed 1.0)

3.4.2 Ex Post Gross Impact Results

Overall, total *ex post* gross savings impacts for the PY7 Standard Program are 3,419 MWh, 1.8 MW, and 524,885 therm savings. The gross realization rates are 99% for electric savings, 105% for demand savings, and 106% for therm savings. We calculated *ex post* savings using inputs and algorithms from the IL TRM V3.0 and applying the in-service rates. The implementer provided the evaluation team with documentation of the inputs and algorithms used to calculate *ex ante* savings. Table 27 summarizes these results.

Table 27. PY7 Standard Program Gross Impacts

Program Component	Number of Participants	Ex Ante Gross [a]			Ex Post Gross		
		kWh	kW	Therms	kWh	kW	Therms
Standard Program	2,601	3,445,655	1,733	494,797	3,418,642	1,816	524,885
Gross Realization Rate [b]					**99%**	**105%**	**106%**

[a] Source of *ex ante* savings: PY7 program-tracking database.
[b] The gross realization rate is calculated as the PY7 gross *ex post* savings divided by the PY7 *ex ante* gross savings.

Table 28 summarizes the gross impact results by measure.

Table 28. PY7 Program Gross Impacts by Measure

Measure	Ex Ante Gross Impacts			Ex Post Gross Impacts			Gross Realization Rate[a]		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
Air Sealing	2,020,776	1,424.5	301,196	2,031,391	1,476.1	310,819	1.01	1.04	1.03
Specialty CFL - 14W globe	288,405	29.5	-	203,789	29.2	-	0.71	0.99	N/A
Attic Insulation	245,418	108.5	78,130	244,448	114.1	73,467	1.00	1.05	0.94
Crawlspace Insulation	233,006	36.8	48,999	217,508	37.9	52,611	0.93	1.03	1.07
CFL – 13 to 15 Watt	174,633	19.4	-	180,660	19.2	-	1.03	0.99	N/A
Specialty CFL - 9W candelabra	117,855	11.8	-	121,907	11.7	-	1.03	0.99	N/A
Specialty CFL - 15W reflector	113,781	12.6	-	117,691	12.5	-	1.03	0.99	N/A
Wall Insulation	111,025	61.6	40,233	145,828	84.5	53,717	1.31	1.37	1.34
Rim Joist Insulation	36,751	13.9	12,377	49,745	16.1	19,930	1.35	1.16	1.61
Showerhead – Electric	34,814	3.2	-	34,056	3.1	-	0.98	0.98	N/A
CFL – 18 to 20 Watt	27,862	3.1	-	28,821	3.1	-	1.03	0.99	N/A
CFL – 23 to 25 Watt	25,775	2.9	-	26,659	2.8	-	1.03	0.99	N/A
Faucet Aerator – Electric	13,177	5.6	-	13,319	5.6	-	1.01	1.01	N/A
Programmable Thermostat - Electric	2,376	-	-	2,818	-	-	1.19	n/a	N/A
Showerhead – Gas	-	-	9,229	-	-	9,041	n/a	n/a	0.98

Measure	Ex Ante Gross Impacts			Ex Post Gross Impacts			Gross Realization Rate[a]		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
Faucet Aerator – Gas	-	-	3,628	-	-	3,670	n/a	n/a	1.01
Programmable Thermostat - Gas	-	-	807	-	-	1,431	n/a	n/a	1.77
Water Heater Temperature Adjustment	-	-	198	-	-	198	n/a	n/a	1.00
Total	**3,445,655**	**1,733.3**	**494,797**	**3,418,642**	**1,815.9**	**524,885**	**0.99**	**1.05**	**1.06**

Note: Numbers may not total due to rounding.
[a] Gross Realization Rate = *ex post* gross value / *ex ante* gross value.

Differences in *ex post* and *ex ante* gross savings stem from differences in input values for the savings algorithms for each measure. Through our discussions with the implementer, we identified the sources of these differences. Table 29 summarizes these findings.

Table 29. Reasons for Realization Rates per Measure

Measure	kWh RR	kW RR	Therms RR	CDD, HDD, FLH	Pre & Post R-Value	Waste Heat Factors	HVAC Efficiency	Other (Specified)
Air Sealing	1.01	1.04	1.03	X			X	- Latent multiplier
Specialty CFLs	0.85	0.99	N/A			X		- Hours of Use - Installation rate
Standard CFLs	1.03	0.99	N/A			X		- Installation rate
Attic Insulation	1.00	1.05	0.94	X	X		X	
Wall Insulation	1.31	1.37	1.34	X	X		X	
Rim Joist Insulation	1.35	1.16	1.61	X	X		X	- Framing factor
Crawl Space Insulation	0.93	1.03	1.07	X	X		X	
Showerhead	0.98	0.98	0.98					- Installation rate
Faucet Aerator	1.01	1.01	1.01					- Installation rate
Programmable Thermostat	1.19	N/A	1.77					Reasons are unknown
Water Heater Temperature Adjustment	N/A	N/A	1.00					

The inputs for air sealing, lighting and insulation measures have the largest impact on program level realization rates. Because air sealing measures account for 59%, lighting measures account for 22%, and insulation measures account for 18% of the total kWh program savings, any differences within these measures affect the program savings significantly. We describe the differences in the *ex ante* and *ex post* savings calculations in detail below. Note that, while certain inputs may increase savings, others decrease savings. The combination of all inputs brings about the overall realization rate for a specific measure.

- **Air Sealing Issues:**
  - **Cooling Degree Days (CDDs), Heating Degree Days (HDDs), Full Load Hours (FLH):** *Ex ante* savings applies the CDD, HDD, and FLH input values for Springfield to all projects regardless of location to estimate *ex ante* savings, while the evaluation team used input values appropriate for the location of each participating home. Table 30 summarizes the *ex post* savings increase or decrease from the *ex ante* values due to locational differences.

Table 30. Change in Ex Post per unit Savings due to Differences in CDD, HDD, and FLH

Measure	% Difference in Ex Post kWh/per Unit	
	CDD	HDD
Air Sealing	3% Decrease	1% Decrease
Attic Insulation	0.2% Increase	3% Decrease
Wall Insulation	3% Decrease	1% Decrease
Rim Joist Insulation	3% Decrease	3% Decrease
Crawlspace Insulation	0.4% Increase	14% Decrease

- **Latent Multiplier for Air Sealing:** The latent multiplier accounts for latent cooling demand for air sealing measures and is dependent on project location. The *ex ante* savings calculations applied the latent multiplier for Springfield to all projects regardless of their project location. The *ex post* calculations applied the latent multiplier for each project's actual location. As a result, the *ex post* per-unit savings for air sealing measures decreased by an average of 3%.

- **HVAC Efficiency:** *Ex ante* air sealing savings uses weighted averages for cooling (10.9 SEER) and heating (1.77 COP) efficiencies. In past program years, the program database provided the actual existing efficiencies for HVAC equipment. However, the PY7 database did not include this information. As a result, *ex post* savings applied the efficiencies from the IL TRM (with equipment age pre 2006) of 10 SEER for cooling and 1.7 COP for heat pumps. Table 31 summarizes the *ex post* increases over *ex ante* values due to the difference in HVAC efficiencies.

Table 31. Change in Ex Post Per Unit Savings Due to Differences in HVAC Efficiencies

Measure	% Difference in Ex Post kWh/per Unit
Air Sealing	7% Increase
Attic Insulation	5% Increase
Wall Insulation	6% Increase
Rim Joist Insulation	4% Increase
Crawlspace Insulation	2% Increase

- **Standard and Specialty CFL Issues:**

  - **Waste Heat Factors:** The *ex ante* energy savings included the waste heat factor heating penalty for all standard and specialty CFLs, which results in less *ex ante* savings. However, consistent with past evaluations, and per agreements between ICC staff and AIC regarding the treatment of waste heat factors, we did not include waste heat factor heating penalties for lighting in the calculation of *ex post* savings. Therefore, *ex post* savings were higher.

  - **Hours of Use (Specialty CFLs):** *Ex ante* savings applied hours of use (1,240 hrs/yr) for specialty globe CFLs based on the hours of use provided in an older version of the IL TRM V3.0.[13] *Ex post* savings applied the hours of use (847 hrs/yr) from a more recent publication of the same version of the IL TRM V3.0. As a result, *ex ante* per-unit savings for specialty globe CFLs overestimate

[13] The *ex ante* hours of use (1,240 hours per year) for specialty globe CFLs is from the IL TRM dated January 3, 2014. *Ex post* hours of use (847 hours per year) is from the IL TRM dated February 24, 2014.

savings by 29%. Specialty globe CFLs account for 8.4% of the program's total reported energy savings and therefore affect the overall program realization rate.

- **Installation Rates:** *Ex ante* savings for standard and specialty CFLs applied the installation rates from the IL TRM V3.0. *Ex post* savings used the installation rates derived from the PY6 participation survey results. Table 32 summarizes the *ex post* savings increase or decrease from the *ex ante* values due to the differences in installation rates.

Table 32. Installation Rates and Ex Post per unit Savings Differences

Measure	Ex Ante Installation Rate	Ex Post Installation Rate	% Difference in Ex Post kWh/per Unit
Standard CFLs	0.97	0.96	1% Decrease
Specialty CFLs	0.97	0.96	1% Decrease
Aerators	0.95	0.96	1% Increase
Showerheads	0.98	0.96	2% Decrease

- **Attic, Wall, Rim Joist, and Crawl Space Insulation Issues:**
  - **CDD, HDD, FLH:** See Table 30 above for specifics
  - **HVAC Efficiency:** See Table 31 above for specifics
  - **Pre and Post R-Value:** *Ex ante* applied the same pre-existing and post-retrofit R-values for all participants to estimate *ex ante* savings despite the availability of actual pre-existing and post-retrofit R-values in the database. The evaluation team, however, used the actual pre and post R-values from the database to calculate *ex post* savings per participant.

    Table 33 summarizes the ex post increases and decrease over ex ante values due to the differences in pre and post R-values.

Table 33. Change in Ex Post per unit Savings due to Differences in R-values

Measure	% Difference in Ex Post kWh/per Unit	
	Pre R-value	Post R-value
Attic Insulation	9% Increase	15% Decrease
Wall Insulation	0%	1% Decrease
Rim Joist Insulation	7% Decrease	1% Decrease
Crawlspace Insulation	0% (Above Grade) 4% Increase (Below Grade)	1% Decrease

  - **Framing Factor (Rim Joist Insulation):** *Ex ante* calculations underestimate rim joist insulation savings by including a framing factor of 0.25, which assumes that insulation installed is in either the studs or cavity. *Ex post* savings apply a framing factor of 0.05, because rim joist insulation is typically installed above any frame. The implementer agreed a framing factor of 0.05 is more appropriate.[14] As a result, the per unit *ex post* savings for rim joist insulation is increased by 21%.

[14] The reason for this is that the framing factor for rim joists should average the framing factor for joists that run from the front of the home to the back, and joists that run from the left side of the home to the right side of the home. Framing for joists that run parallel to the front of the home to the back is 1.75" for every 16, resulting in a framing factor of 0.10. However, joists that run perpendicular to

While this increase may seem high, rim joist insulation accounts for 1% of the program's total reported energy savings and therefore play a small role in the overall program realization rate.

- **Low-flow Showerhead and Faucet Aerator Issues:**
  - **Installation Rates:** See Table 32 above for specifics.
- **Programmable Thermostat Issues:**
  - We are unable to track down the reasons for this measures' realization rate. However, at 0.08% of the overall *ex post* electric savings, the measure realization rate over 1.0 made little difference in the program savings.

3.4.3 Ex Post Net Impacts Results

PY7 *ex post* net savings were calculated by applying measure-specific NTGRs to *ex post* gross savings (see Table 34). The implementer provided the evaluation team with documentation of the inputs and algorithms used to calculate *ex ante* savings.

Table 34. PY7 Standard Program Net Impacts

Program Component	# of Participants	Ex Ante Net			Ex Post Net		
		kWh	kW	Therms	kWh	kW	Therms
Standard Program	2,601	3,105,369	1,533	402,561	3,075,424	1,605	429,412
Net Realization Rate					99%	105%	107%

In Table 35, we provide the net impact results by measure.

Table 35. PY7 Standard Program Net Impacts by Measure

Measure	*Ex Ante* Net Impacts			*Ex Post* Net Impacts			Net Realization Rate[a]		
	kWh	kW	Therm	kWh	kW	Therm	kWh	kW	Therm
Air Sealing	1,778,283	1,253.6	248,518	1,787,624	1,298.9	257,980	1.01	1.04	1.04
Specialty CFL - 14W globe	279,753	28.6	-	197,676	28.3	-	0.71	0.99	n/a
Attic Insulation	215,968	95.5	62,113	215,114	100.4	58,773	1.00	1.05	0.95
Crawlspace Insulation	205,046	32.4	38,954	191,407	33.4	42,089	0.93	1.03	1.08
CFL – 13 to 15 Watt	169,394	18.8	-	175,240	18.6	-	1.03	0.99	n/a
Specialty CFL - 9W candelabra	114,319	11.5	-	118,250	11.4	-	1.03	0.99	n/a
Specialty CFL - 15W reflector	110,368	12.2	-	114,160	12.1	-	1.03	0.99	n/a
Wall Insulation	97,702	54.2	31,985	128,329	74.3	42,974	1.31	1.37	1.34
Showerhead – Electric	36,554	3.4	-	35,759	3.3	-	0.98	0.98	n/a
Rim Joist Insulation	32,341	12.2	9,839	43,776	14.1	15,944	1.35	1.16	1.62
CFL – 18 to 20 Watt	27,026	3.0	-	27,957	3.0	-	1.03	0.99	n/a
CFL – 23 to 25 Watt	25,002	2.8	-	25,860	2.7	-	1.03	0.99	n/a
Faucet Aerator – Electric	11,332	4.8	-	11,454	4.9	-	1.01	1.01	n/a

the front of the home to the back are continuous (uninterrupted) and have a framing factor of 0. Therefore, the average framing factor is 0.05.

Measure	*Ex Ante* Net Impacts			*Ex Post* Net Impacts			Net Realization Rate[a]		
	kWh	kW	Therm	kWh	kW	Therm	kWh	kW	Therm
Programmable Thermostat - Electric	2,280	-	-	2,818	-	-	1.24	n/a	n/a
Showerhead – Gas	-	-	7,522	-	-	7,414	n/a	n/a	0.99
Faucet Aerator – Gas	-	-	2,703	-	-	2,752	n/a	n/a	1.02
Programmable Thermostat - Gas	-	-	722	-	-	1,288	n/a	n/a	1.78
Water Heater Temperature Adjustment	-	-	203	-	-	198	n/a	n/a	0.98
Total	**3,105,369**	**1,532.9**	**402,561**	**3,075,424**	**1,605.5**	**429,412**	**0.99**	**1.05**	**1.07**

Note: Numbers may not total due to rounding.

[a] Net Realization Rate = *ex post* net value / *ex ante* net value.

The *ex ante* NTGRs were not provided by the implementer and were empirically determined for purposes of comparing *ex ante* to *ex post* values using data from the program tracking database. The application of NTGRs for *ex ante* net savings were determined by comparing the total net *ex ante* savings and the total gross *ex ante* savings for each measure. *Ex post* net savings differ from *ex ante* net savings for programmable thermostats, air sealing, and water heater temperature adjustment measures for the following reasons.

- **Programmable Thermostats:** The *ex ante* net kWh and kW for programmable thermostats with electric heating used a NTGR of 0.96 instead of 1.00.
- **Air Sealing:** The *ex ante* net therms for air sealing used a NTGR of 0.86 instead of 0.83.
- **Water Heater Temperature Adjustment:** The *ex ante* net therms for water heater temperature adjustment used a NTGR of 1.03 instead of 1.00.

4. Conclusions and Recommendations

The results from our impact analysis show net realization rates of 99% for kWh, 105% for kW and 107% for therm savings. Based on our analysis of the program database and our discussions with the implementer, the evaluation team identified differences in input values between the *ex ante* and *ex post* savings calculations for air sealing, lighting, and insulation as the main factors driving the differences in net realization rates.

As part of our process evaluation, we found that the program underwent many changes to help improve the efficiency, data management, and marketing for the Standard Program. The main change being Leidos assuming the role of program prime implementer, with CLEAResult remaining the customer-facing implementer but reporting to Leidos instead of AIC directly.

Some of the changes made in PY7 were primarily to help facilitate participation. These changes include introducing a new channel for customer participation (allowing trade allies to sell program work directly to customers, and providing training to the trade allies to market the program), and re-introducing the OBF program offering.

Interviews with program trade allies revealed that they are generally satisfied with the program and believe that it has had a positive impact on their business (notably, increases in revenue and customer satisfaction). Allowing trade allies to market the program directly seems to have been a positive change; trade allies report that direct mailers, word of mouth, pre-existing relationships, and their own marketing are most effective in directly promoting the program. However, trade allies did encounter some challenges with the program. They report that the program paperwork and general administration are tedious and require streamlining and that payment for services takes too long. These challenges lead some trade allies to complete qualifying jobs outside of the program. This challenge was also identified as the primary reason that non-participating trade allies' no longer participate in the program.

Our predictive model results show the important variables relating to conversion from audit to retrofit, and identify a group of customers valuable for future research. Using a propensity scoring model, we found that the most important variables predicting customer conversion from an audit to measure installation are whether neighbors had previously participated in the Standard Program, higher number of adults in the household, geographic location, and higher number of years of residence at their current address. In addition, variables from the American Community Survey, most notably lower proportion of mobile homes, and higher proportion of people with a graduate or professional degree, were also important.

The customers that we identified for future research are the customers who fell into the top ten percent of propensity scores but did not convert from Standard Program audit to measure installation. These customers, though they are very similar to customers who installed measures, chose not to do so because of one or more barriers. Further research could reveal the barriers these customers experienced and suggest solutions for reducing or removing them.

Based on these findings, the following are some recommendations:

- **Streamline program paperwork and administration.** The trade ally survey revealed that filling out paperwork is not only time-consuming but also has prevented some contractors from running all of their qualified projects through the program (if the customer needs a quick project turnaround, for example). Reducing this administrative burden on trade allies would help make the program more attractive, and increase satisfaction with the program.

  - Part of this streamlining should include looking for opportunities to reduce the amount of time it takes to pay trade allies. The trade ally survey revealed that extended lead-times on payments can discourage and limit program participation.

- **Leverage Trade Allies for program marketing**. Historically, the Standard Program has seen growth in both PY5 and PY6 without making any major changes to marketing tactics or program implementation. Based on trade ally feedback, direct mailers and program material handouts are the most relevant marketing tactics. As such, it would be beneficial to work with trade allies to establish additional marketing materials.

- **Update program tracking database to include a flag for projects using OBF.** Given that OBF is likely to be a key program component to facilitate participation, it would be useful to track usage of OBF within the tracking database. This could allow future evaluation efforts to better understand the impact and extent to which OBF affects the Standard Program. This is especially true given the discrepancy between program staff observations and trade allies' self-reported frequency of use of OBF.

- **The predictive model indicates that among customers who have had an audit, those with the highest propensity to install measures tend to be in areas where others have had audits and measures installed, have more adults in the household, have lived in their homes longer, and have professional and graduate degrees.** Another key predictor variable pertains to whether customers live in areas with fewer mobile homes. The model shows that there may be a reinforcing effect: customers in areas where other customers have received audits and measure installations through the program are actually more likely to convert from audit to measure installation.
  - As such, the program may get higher conversion rates by targeting specific areas where others have had audits and installed measures.
  - In addition, the program may want to target customers who have lived in their homes for longer, have more adults in the household, and have more people with graduate or professional degrees.

- **Update program tracking savings assumptions to reflect the *ex post* values used in this evaluation.** Per our *ex post* savings calculations, the evaluation team identified several discrepancies in savings assumptions between the *ex ante* and *ex post* savings calculations. To increase the accuracy of tracked savings, we recommend that the Standard Program adopt the *ex post* assumptions and savings calculations used by the evaluation team.

- **Update *ex ante* savings algorithms for rim joist and crawlspace insulation**. Through discussions with the implementer, we learned that supply vents are installed in below grade spaces, thus turning this space into a semi-conditioned area. However, *ex ante* and *ex post* calculations currently apply CDDs and HDDs for unconditioned space. We recommend modifying the algorithm to use unconditioned basement CDDs and HDDs for pre-existing conditions, and using conditioned basement CDDs and HDDs for post conditions.

Appendix A. Engineering Analysis Algorithms

In PY7, the impact evaluation efforts estimated gross impact savings for the Standard Program by applying savings algorithms from the Illinois Statewide Technical Reference Manual (TRM) V3.0 (2014)[15] to the information in the program-tracking database.

We present the algorithms used to calculate all evaluation program savings below, along with all input variables.

A.1 Compact Fluorescent Lighting (CFLs) Algorithms

The evaluation team determined ex post lighting savings using the algorithms below.

Equation 1. Standard and Specialty CFL Algorithms

Energy Savings: $\Delta kWh = ((WattsBase - WattsEE) / 1{,}000) * ISR * HOURS * WHF_e$

Demand Savings: $\Delta kW = ((WattsBase - WattsEE) / 1{,}000) * ISR * WHFd * CF$

Where:

WattsBase = Wattage of existing equipment

Table 36 Baseline Wattages for Lighting Measures

Measure	EISA Adjusted[a]	Baseline Wattage	Resource
CFL - Low 13 to 15 Watt	Yes	43	IL TRM V3.0
CFL - Medium 18 to 20 Watt	Yes	53	IL TRM V3.0
CFL - High 23 to 25 Watt	Yes	72	IL TRM V3.0
Specialty CFL – 9W Candelabra	No	40	IL TRM V3.0
Specialty CFL – 14W Globe	No	60	IL TRM V3.0
Specialty CFL – 15W Reflector	No	65	IL TRM V3.0

[a] The EISA schedule requires baseline adjustments to measures with incandescent baseline wattages of 100W (as of June 2012), 75W (as of June 2013), and 60W (as of June 2014).

WattsEE = Wattage of installed equipment (actual wattage used)

ISR = In-service rate or the percentage of units rebated that get installed = 96%[16]

Hours = Annual operating hours (See Table 37)

[15] Illinois Statewide Technical Reference Manual for Energy Efficiency V3.0. Effective June 1, 2014.
[16] Installation rate from PY6 participant survey results.

Table 37. Annual Hours of Use for Lighting Measures

Measure	Hours
Standard CFL (Spiral)	938
Specialty CFL (Globe)	847
Specialty CFL (Candelabra)	1,328
Specialty CFL (Interior Reflector)	938

WHF_e = Waste heat factor for energy (accounts for cooling savings from efficient lighting) = 1.06

WHF_d = Waste heat factor for demand (accounts for cooling savings from efficient lighting) = 1.11

CF = Summer Peak Coincidence Factor

Table 38. Coincidence Factors for Lighting Measures

Measure	CF
Standard CFL (Spiral)	0.095
Specialty CFL (Globe)	0.116
Specialty CFL (Candelabra)	0.122
Specialty CFL (Interior Reflector)	0.095

A.2 Lighting Measures Heating Penalty

The evaluation team determined heating penalties for different heating fuel types using the algorithms below. Based on the agreement between the ICC and AIC, we do not include heating penalties in the ex post energy savings, but will include this in the data for the PY7 cost-effectiveness analysis.

Equation 2. Heating Penalty Algorithms

Electric Heating Penalty: $\Delta kWh = -(((WattsBase - WattsEE) / 1{,}000) * ISR * HOURS * HF) / \eta Heat$

Gas Heating Penalty: $\Delta therms = -(((WattsBase - WattsEE) / 1{,}000) * ISR * Hours * HF * 0.03412) / \eta Heat$

Where:

WattsBase = Wattage of existing equipment (See Table 36)

WattsEE = Wattage of installed equipment

ISR = In-service rate or the percentage of units rebated that get installed = 96%

Hours = Annual operating hours (See Table 37)

HF = Heating Factor = 0.49

ηHeat = Efficiency of Heating equipment (we used the COP for heat pumps for those manufactured before 2006)

Table 39. ηHeat for Lighting Heating Penalties

Measure	ηHeat	Units
Heat Pump (Before 2006)	2.0	COP
Heat Pump (After 2006)	2.26	COP
Electric Resistance	1.0	COP
Gas Heating	0.7	AFUE

Table 40 summarizes the heating penalties for the six lighting measures offered through the program by heating equipment type.

Table 40. Heating Fuel Penalties for CFL Lighting

Heating Equipment	Measure	ΔkWh	Δtherms
Heat Pump (Heating only)	CFL - Low 13 TO 15 Watt	-6.62	n/a
	CFL - Medium 18 to 20 Watt	-7.28	n/a
	CFL - High 23 to 25 Watt	-10.81	n/a
	Specialty CFL - 9W candelabra	-9.68	n/a
	Specialty CFL - 14W globe	-9.16	n/a
	Specialty CFL - 15W reflector	-11.03	n/a
Electric Resistance	CFL - Low 13 TO 15 Watt	-13.24	n/a
	CFL - Medium 18 to 20 Watt	-14.56	n/a
	CFL - High 23 to 25 Watt	-21.62	n/a
	Specialty CFL - 9W candelabra	-19.37	n/a
	Specialty CFL - 14W globe	-18.33	n/a
	Specialty CFL - 15W reflector	-22.06	n/a
Gas Heating	CFL - Low 13 TO 15 Watt	n/a	-0.65
	CFL - Medium 18 to 20 Watt	n/a	-0.71
	CFL - High 23 to 25 Watt	n/a	-1.05
	Specialty CFL - 9W candelabra	n/a	-0.94
	Specialty CFL - 14W globe	n/a	-0.89
	Specialty CFL - 15W reflector	n/a	-1.08

A.3 Water Heating Conservation Measure Algorithms

The evaluation team determined ex post water heating conservation measure savings using the algorithms below.

Equation 3. Low-flow Showerhead Algorithms

Energy Savings: $\Delta kWh = \%ElectricDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * SPCD * 365.25 / SPH) * EPG\_electric * ISR$

Demand Savings: $\Delta kW = \Delta kWh / Hours * CF$

Therm Savings: $\Delta Therms = \%FossilDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * SPCD * 365.25 / SPH) * EPG\_gas * ISR$

Equation 4. Low-flow Faucet Aerator Algorithms

Energy Savings: $\Delta kWh = \%ElectricDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * 365.25 * DF / FPH) * EPG\_electric * ISR$

Demand Savings: $\Delta kW = \Delta kWh / Hours * CF$

Therm Savings: $\Delta Therms = \%FossilDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * 365.25 * DF / FPH) * EPG\_gas * ISR$

Where:

%ElectricDHW = 100% if electric water heater, 0% if gas water heater

%GasDHW = 100% if gas water heater, 0% if electric water heater

GPM_base = Flow rate of the baseline showerhead or faucet aerator (See Table 41)

GPM_low = As-used flow rate of the low-flow showerhead or faucet aerator (See Table 41)

Table 41. GPM for Water Heating Measures

Measure	GPM_base	GPM_low
Faucet aerator	1.39	0.94
Showerhead	2.67	1.75

L_base = Average baseline length faucet use per capita for all faucets in minutes (see Table 42)

Table 42. L_base for Water Heating Measures

Measure	Minutes
Faucet aerator	9.0
Showerhead	7.8

L_low = Average retrofit length faucet use per capita for all faucets in minutes (same as L_base)

Household = Average number of people in household = 2.56

SPCD = Showers per capita per day = 0.60

SPH = Showerheads per household for single family homes = 1.79

DF = Drain factor = 0.795 (unknown location)

FPH = Faucets per household for single family homes = 3.83 (unknown location)

EPG_electric = Energy per gallon of hot water supplied by electric (See Table 43)

EPG_gas = Energy per gallon of hot water supplied by gas (See Table 43)

Table 43. EPG for Water Heating Measures

Measure	EPG_electric	EPG_gas
Faucet Aerator	0.09190	0.00394
Showerhead	0.11700	0.00501

ISR = In-Service Rate[17]

Table 44. ISR for Water Heating Measures

Measure	ISR
Faucet Aerator	96%
Showerhead	96%

Hours = Annual electric DHW recovery hours

Table 45. Hours for Water Heating Measures

Measure	Hours
Faucet Aerator[a]	52
Showerhead	302

[a] Hours of use for single family with unknown location

CF = Coincidence Factor for electric load reduction

Table 46. CF for Water Heating Measures

Measure	CF
Faucet Aerator	0.0220
Showerhead	0.0278

A.4 Water Heater Temperature Setback Algorithms

The evaluation team calculated the ex post water heater temperature setback savings using the algorithms below.

Equation 5. Water Heater Temperature Setback Algorithms (Electric Water Heater)

Energy Savings: $\Delta kWh = 86.4\ kWh * (Tpre - Tpost) / 15$

Demand Savings: $\Delta kW = \Delta kWh / Hours * CF$

Equation 6. Water Heater Temperature Setback Algorithms (Gas Water Heater)

Energy Savings: $\Delta kWh = -34.2\ kWh * (Tpre - Tpost) / 15$

Therm Savings: $\Delta therms = 6.4\ therms * (Tpre - Tpost) / 15$

Where:

Tpre = Temperature setpoint of water heater prior to temperature adjustment = 135°F

[17] Installation rate from PY6 participant survey results.

Tpost = Temperature setpoint of water heater after temperature adjustement = 120°F

Hours = Annual hours of Use in which water heater is operating or idle = 8,766 hours

CF = Coincidence Factor = 1.0

For homes with gas water heaters, a negative electricity savings is achieved due to an increase in supplemental heating for homes with dishwashers. The negative impact was included in the program's ex post savings. The reason for this is that the electric penalty is embedded within the deemed kWh savings for those with electric water heaters, and since it was applied to paritcipants with electric water heaters, it needs to be included for those with gas water heaters.

A.5 Programmable Thermostat Algorithms

The evaluation team calculated the ex post programmable thermostat savings using the algorithms below.

Equation 7. Programmable Thermostat Algorithms

$$\Delta kWh\_heating\ (electric\ heat) = \%ElectricHeat * Elec\_Heating\_Consumption * Heating\_Reduction * HF * Eff\_ISR$$

$$\text{Gas Savings (gas heat): } \Delta Therms = \%FossilHeat * Gas\_Heating\_Consumption * Heating\_Reduction * HF * Eff\_ISR$$

$$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$$

Where:

%ElectricHeat = 100% if electric space heating fuel, 0% if gas space heating fuel

%FossilHeat = 100% if gas space heating fuel, 0% if electric space heating fuel

Elec_Heating_Consumption = Estimated annual household heating consumption for electrically heated homes (applied per participant based on project location)

Table 47. Electric Heating Consumption by Climate Zone

Climate Zone	kWh	
	Electric Resistance	Heat Pump
1 (Rockford)	21,741	12,789
2 (Chicago)	20,771	12,218
3 (Springfield)	17,789	10,464
4 (Belleville)	13,722	8,072
5 (Marion)	13,966	8,215

Gas_Heating_Consumption = Estimated annual household heating consumption for gas heated homes (applied per participant based on project location)

Table 48. Gas Heating Consumption by Climate Zone

Climate Zone	Therms
1 (Rockford)	1,052

Climate Zone	Therms
2 (Chicago)	1,005
3 (Springfield)	861
4 (Belleville)	664
5 (Marion)	676

Heating_Reduction = Reduction in heating energy consumption due to installing programmable thermostat = 6.2%

HF = Household factor to adjust heating consumption for single family homes = 100%

Eff_ISR = Percentage of thermostats installed and effectively programmed = 100% (Direct Install)

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

A.6 Air Sealing Algorithms

The evaluation determined ex post air sealing savings using the algorithms below.

Equation 8. Air Sealing Algorithms

Energy Savings: $\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

$\Delta kWh\_cooling = [((CFM50\_existing - CFM50\_new)/N\_cool) * 60 * 24 * CDD * DUA * 0.018) / (1000 * \eta Cool)] * LM$

$\Delta kWh\_heating\ (electric\ heat) = (((CFM50\_existing - CFM50\_new)/N\_heat) * 60 * 24 * HDD * 0.018) / (\eta Heat * 3{,}412)$

Demand Savings: $\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Gas Savings (gas heat): $\Delta Therms = (((CFM50\_existing - CFM50\_new)/N\_heat) * 60 * 24 * HDD * 0.018) / (\eta Heat * 100{,}000)$

$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$

Where:

CFM_existing = Infiltration at 50 Pascals as measured by blower door before air sealing

CFM_new = Infiltration at 50 Pascals as measured by blower door after air sealing

N_Cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions = 18.5[18]

CDD = Cooling Degree Days (applied per participant based on location)

[18] Assumed CZ2 Normal Exposure.

Table 49. Cooling Degree Days by Climate Zone

Climate Zone	CDD 65
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (actual cooling efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 50. ηCool for Air Sealing Measures

Cooling Equipment Age	SEER
Before 2006	10
After 2006	13

LM = Latent Multiplier to account for latent cooling demand (applied per participant based on project location)

Table 51. Latent Multiplier by Climate Zone

Climate Zone	Latent Multiplier
1 (Rockford)	8.5
2 (Chicago)	6.2
3 (Springfield)	6.6
4 (Belleville)	5.8
5 (Marion)	6.6

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions = 15.75[19]

HDD = Heating Degree Days (applied per participant based on project location)

Table 52. Heating Degree Days by Climate Zone

Climate Zone	HDD 65
1 (Rockford)	6,569
2 (Chicago)	6,339
3 (Springfield)	5,497
4 (Belleville)	4,379
5 (Marion)	4,476

ηHeat = Efficiency of heating system (based on heating equipment type per participant) (actual heating efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

[19] Applied average of 1, 1.5, 2 and 3 story homes for homes with normal exposure in CZ2.

Table 53. ηHeat for Air Sealing Measures

Existing Heating Equipment	ηHeat (pre 2006)		ηHeat (post 2006)	
	COP	AFUE	COP	AFUE
Gas Furnace	n/a	0.7	n/a	0.7
Electric Resistance	1.00	n/a	1.00	n/a
Air Source Heat Pump (ASHP)	1.70	n/a	1.92	n/a

FLH_cooling = Full Load Hours of air conditioning (applied per participant based on project location)

Table 54. FLH cooling by Climate Zone

Climate Zone	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903

CF = Coincidence Factor (varies by cooling equipment type)

Table 55. Air Sealing Coincidence Factors

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

A.7 Attic and Wall Insulation Algorithms

The evaluation team determined ex post attic and wall insulation savings using the algorithms below.

Equation 9. Attic Insulation Algorithms

Energy Savings: $\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

$$\Delta kWh\_cooling = ((((1/R\_old - 1/R\_new) * A\_attic * (1-Framing\_factor_{attic})) * 24 * CDD * DUA) / (1{,}000 * \eta Cool)) * ISR$$

$$\Delta kWh\_heating\ (electric\ heat) = ((((1/R\_old - 1/R\_new) * A\_attic * (1-Framing\_factor_{attic}) * ADJ_{attic}) * 24 * HDD) / (\eta Heat * 3{,}412)) * ISR$$

Demand Savings: $\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Gas Savings (gas heat): $\Delta Therms = ((((1/R\_old - 1/R\_new) * A\_attic * (1-Framing\_factor_{attic}) * ADJ_{attic}) * 24 * HDD) / (\eta Heat * 100{,}067\ Btu/therm)) * ISR$

$$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$$

Equation 10. Wall Insulation Algorithms

Energy Savings: $\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

$$\Delta kWh\_cooling = ((((1/R\_old - 1/R\_new) * A\_wall * (1\text{-}Framing\_factor_{wall})) * 24 * CDD * DUA) / (1{,}000 * \eta Cool)) * ISR$$

$$\Delta kWh\_heating\ (electric\ heat) = ((((1/R\_old - 1/R\_new) * A\_wall * (1\text{-}Framing\_factor_{wall}) * ADJ_{wall}) * 24 * HDD) / (\eta Heat * 3{,}412)) * ISR$$

Demand Savings: $\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Gas Savings (gas heat): $\Delta Therms = ((((1/R\_old - 1/R\_new) * A\_wall * (1\text{-}Framing\_factor_{wall}) * ADJ_{wall}) * 24 * HDD) / (\eta Heat * 100{,}067\ Btu/therm)) * ISR$

$$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$$

Where:

R_new = Total attic or wall assembly R-value after the installation of additional insulation (see Equation 11 for assembly R-value algorithms)

R_old = R-value of existing attic or wall assembly and any existing insulation with a minimum of R-5 (see Equation 11 for assembly R-value algorithms)

A_wall = Total area of insulated wall (ft^2)

A_attic = Total area of insulated attic (ft^2)

Framing_factor = Adjustment to account for area of framing (Framing Factor included in the assembly R-value algorithms; see Table 56)

Table 56. Framing Factors for Attic and Wall Areas

Measure	Framing Factor
Attic Insulation	0.07
Wall Insulation	0.25

ADJ_{attic} = Adjustment for attic insulation to account for prescriptive engineering algorithms over claiming savings = 74%

ADJ_{wall} = Adjustment for wall insulation to account for prescriptive engineering algorithms over claiming savings = 63%

CDD = Cooling Degree Days (applied per participant based on project location)

Table 57. Cooling Degree Days by Climate Zone

Climate Zone	CDD
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (actual cooling efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 58. ηCool for Attic and Wall Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
After 2006	13

HDD = Heating Degree Days (applied per participant based on project location)

Table 59. Heating Degree Days by Climate Zone

Climate Zone	HDD
1 (Rockford)	5,352
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438

ηHeat = Efficiency of heating system (based on heating equipment type per participant) (actual heating efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 60. ηHeat for Attic and Wall Insulation Measures

Existing Heating Equipment	ηHeat (pre 2006)		ηHeat (post 2006)	
	COP	AFUE	COP	AFUE
Gas Furnace	n/a	0.7	n/a	0.7
Electric Resistance	1.00	n/a	1.00	n/a
Air Source Heat Pump (ASHP)	1.70	n/a	1.92	n/a

FLH_cooling = Full Load Hours of air conditioning (applied per participant based on project location)

Table 61. FLH_cooling by Climate Zone

Climate Zone	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903

CF = Coincidence Factor

Table 62. Attic and Wall Insulation Coincidence Factors

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

ISR = In-Service Rate for attic and wall insulation = 99%[20]

Because the R-values in these algorithms are stated to be assembly R-values, our engineering calculations deviated somewhat from the TRM as follows:

- We determined the assembly R-value using the ASHRAE Isothermal Planes method (page 27.3, ASHRAE Fundamentals, 2013).
- This method includes the IL TRM framing factor within the calculations as shown below.
- Equation 11 was not applied to calculate assembly R-values for pre-existing attic or wall insulation for those with R-values less than 5. These cases were assigned an assembly R-value of 5 for both attic and wall insulation.

The following algorithms used to calculate the assembly R-values for attic insulation and wall insulation include:

Equation 11. Attic and Wall Assembly R-value Algorithms

$$\textit{Attic Assembly R-value} = ((1/\textit{R-value}_{database}) * (1-\textit{Framing\_Factor}_{attic}) + 1/\textit{R-value}_{WoodStud2x6} * \textit{Framing\_Factor}_{attic}) + (\textit{R-value}_{indoor\ air\ film} + \textit{R-value}_{plywood} + \textit{R-value}_{gypsum} + \textit{R-value}_{indoor\ air\ film})$$

$$\textit{Wall Assembly R-value} = ((1/\textit{R-value}_{database}) * (1-\textit{Framing\_Factor}_{wall}) + 1/\textit{R-value}_{WoodStud2x4} * \textit{Framing\_Factor}_{wall}) + (\textit{R-value}_{outdoor\ air\ film} + \textit{R-value}_{rigidfoam} + \textit{R-value}_{claytile} + \textit{R-value}_{gypsum} + \textit{R-value}_{indoor\ air\ film})$$

Where:

$R\text{-value}_{database}$ = Pre or post insulation R-value found in the database (for R-values that are greater than 5)

$Framing\_factor_{attic}$ = Adjustment to account for area of framing = 0.07

$Framing\_factor_{wall}$ = Adjustment to account for area of framing = 0.25

[20] Installation rate from PY6 participant survey results.

Figure 2. Engineering Factors Used within Attic Insulation Calculations

No Insulation				With Insulation			
N	Element	R	R	N	Element	R	R
1	indoor air film, still air		0.68	1	indoor air film, still air		0.68
2	air[a]	0.86	0.92	2	mineral fiber batt insulation	19	16.45
3	Joist (nominal 5.5") - southern pine	5.78		3	Joist (nominal 5.5") - southern pine	5.78	
4	plywood, 5/8", douglas fir		0.85	4	plywood, 5/8", douglas fir		0.85
5	gypsum wallboard, 0.5 inch		0.45	5	gypsum wallboard, 0.5 inch		0.45
6	indoor air film, still air		0.68	6	indoor air film, still air		0.68
	R value		3.6		R value		19.1
	U value		0.28		U value		0.05
	% of assembly	0.925	0.07		% of assembly	0.925	0.07
	U of assembly	0.28			U of assembly	0.05	
	R of assembly	3.58			R of assembly	19.11	

[a]horizontal position, up heat flow, 50 degree mean with 30 degree difference, emissivity of 0.82 for building materials, 5.5" air space

Figure 3. Engineering Factors Used within Wall Insulation Calculations

No Insulation				With Insulation			
N	Element	R	R	N	Element	R	R
1	Outdoor Air film, 15 mph wind		0.17	1	Outdoor Air film, 15 mph wind		0.17
2	clay tile, 1 cell deep, 4", no insulation		1.11	2	clay tile, 1 cell deep, 4", no insulation		1.11
3	rigid foam insulating sheathing		4	3	rigid foam insulating sheathing		4
4	air[a]	1.25	1.52	4	mineral fiber batt insulation	13	8.71
5	Wood stud (nominal 2 x 4)	4.38		5	Wood stud (nominal 2 x 4)	4.38	
6	gypsum wallboard, 0.5 inch		0.45	6	gypsum wallboard, 0.5 inch		0.45
7	indoor air film, still air		0.68	7	indoor air film, still air		0.68
	R value		7.9		R value		15.1
	% of assembly	0.75	0.25		% of assembly	0.75	0.25
	R of assembly	7.94			R of assembly	15.13	

[a]vertical position, horizontal heat flow, 50 degree mean with 30 degree difference, emissivity of 0.82 for building materials

After speaking with the implementer and learning more about typical attic and wall assemblies in the Illinois territory for homes built in pre 1970s, we feel it is appropriate to update these values as part of the PY8 evaluation.

A.8 Rim Joist Insulation Algorithms

The evaluation team calculated the ex post rim joist insulation savings using the algorithms below. The TRM does not have algorithms specifically for rim joist; therefore, we applied the basement sidewall insulation algorithms to determine rim joist savings.

Equation 12. Rim Joist Insulation Algorithms

Energy Savings: $\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

$$\Delta kWh\_cooling = ((((1/R\_old\_AG_{RimJoist} - (1/(R\_new + R\_old\_AG_{RimJoist}))) * L\_rimjoist * H\_rimjoist * (1-Framing\_factor)) * 24 * CDD * DUA) / (1{,}000 * \eta Cool)) * ISR$$

$$\Delta kWh\_heating\ (electric\ heat) = ((((1/ R\_old\_AG_{RimJoist} - (1/(R\_new + R\_old\_AG_{RimJoist}))) * L\_rimjoist * H\_rimjoist * (1-Framing\_factor)) * 24 * HDD) / (3412 * \eta Heat) * ADJ) * ISR$$

Demand Savings: $\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Gas Savings (gas heat): $\Delta Therms = ((((1/ R\_old\_AG_{RimJoist} - (1/(R\_new + R\_old\_AG_{RimJoist}))) * L\_rimjoist * H\_rimjoist * (1-Framing\_factor)) * 24 * HDD) / (100{,}067 * \eta Heat) * ADJ) * ISR$

$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$

$R\_old\_AG_{RimJoist} = R\text{-}value_{Joist} + R\text{-}value_{outdoor\ air\ film} + R\text{-}value_{wallboard} + R\text{-}value_{indoor\ air\ film}$

Where:

R_old_AG$_{RimJoist}$ = R-value of existing foundation wall assembly above grade = R-3.18 (using algorithm above and R-values in Table 63).

Table 63. Rim Joist Above-Grade R-value

Variable	R-value[a]
R-value$_{Joist}$ (1.5")	1.88
R-value$_{outdoor\ air\ film}$	0.17
R-value$_{wallboard}$	0.45
R-value$_{indoor\ air\ film}$	0.68
Total R-value	**3.18**

R_new = R-value of added insulation (spray foam, rigid foam, cavity); Used actual R-value from database

L_rimjoist = Total linear feet of installed insulation (ft)

H_rimjoist = Height of floor joist in which insulation is installed = 0.85 ft (average of 2x10 and 2x12 framing)

Framing_factor = Adjustment to account for area of framing (varies by measure)

Table 64. Framing Factor for Rim Joist Insulation

Measure	Framing Factor
Rim Joist	0.05[a]

[a] Average framing factor for joists from front to back (1.75" for every 16" = FF 0.10) and joists from side to side (continuous FF = 0)

ADJ = Adjustment to account for prescriptive engineering algorithms over claiming savings (used non low income since this program targets moderate income participants)

Table 65. Adjustment for Rim Joist Insulation

Market	ADJ
Low Income	70%
Non Low Income	88%

CDD = Cooling Degree Days (assumed unconditioned basement) (applied per participant based on project location)

Table 66. Cooling Degree Days by Climate Zone

Climate Zone	CDD 65

	Unconditioned Basement
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (actual cooling efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 67. ηCool for Rim Joist Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
After 2006	13

HDD = Heating Degree Days (assumed unconditioned basement) (applied per participant based on project location)

Table 68. Heating Degree Days by Climate Zone for Unconditioned Basement

Climate Zone	HDD
1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796

ηHeat = Efficiency of heating system (based on heating equipment type per participant) (actual heating efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 69. ηHeat for Rim Joist Insulation Measures

Existing Heating Equipment	ηHeat (pre 2006)		ηHeat (post 2006)	
	COP	AFUE	COP	AFUE
Gas Furnace	n/a	0.7	n/a	0.7
Electric Resistance	1.00	n/a	1.00	n/a
Air Source Heat Pump (ASHP)	1.70	n/a	1.92	n/a

FLH_cooling = Full Load Hours of air conditioning (applied per participant based on project location)

Table 70. FLH_cooling by Climate Zone

Climate Zone	FLH_cooling
1 (Rockford)	512

2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903

CF = Coincidence Factor

Table 71. Rim Joist Insulation Coincidence Factors

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

ISR = In-Service Rate for attic and wall insulation = 99%[21]

A.9 Crawlspace Insulation Algorithms

The evaluation team calculated the ex post crawlspace insulation savings using the algorithms below.

Equation 13. Crawlspace Insulation Algorithms

Energy Savings: $\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating$

$$\Delta kWh\_cooling = ((((1/R\_old\_AG - (1/(R\_added + R\_old\_AG))) * LF * H\_AG * (1\text{-}Framing\_factor)) * 24 * CDD * DUA) / (1{,}000 * \eta Cool)) * ISR$$

$$\Delta kWh\_heating\ (electric\ heat) = [(((((1/R\_old\_AG - (1/(R\_added + R\_old\_AG))) * LF * H\_AG * (1\text{-}Framing\_factor)) + ((1/R\_old\_BG - (1/R\_added + R\_old\_BG))) * LF * H\_BG * (1\text{-}Framing\_Factor))) * 24 * HDD] / (3{,}412 * \eta Heat) * ADJ) * ISR$$

Demand Savings: $\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$

Gas Savings (gas heat): $\Delta Therms = [(((((1/R\_old\_AG - (1/(R\_added + R\_old\_AG))) * LF * H\_AG * (1\text{-}Framing\_factor)) + ((1/R\_old\_BG - (1/R\_added + R\_old\_BG))) * LF * H\_BG * (1\text{-}Framing\_Factor))) * 24 * HDD] / (100{,}067 * \eta Heat) * ADJ) * ISR$

$$\Delta kWh\_heating\ (gas\ heat\ furnace\ fan\ run\ time\ reduction) = \Delta Therms * F_e * 29.3$$

Where:

R_old_AG = Above grade existing R-value of crawlspace = 1.0

R_old_BG = Below grade existing R-value of crawlspace insulation (assume 2.0' below grade) = 5.41

R_added = R-value of additional insulation (actual value from database)

[21] Installation rate from PY6 participant survey results.

ADJ = Adjustment to account for prescriptive engineering algorithms over claiming savings (used non low income since this program targets moderate income participants)

Table 72. Adjustment for Crawlspace Insulation

Market	ADJ
Low Income	70%
Non Low Income	88%

LF = Total linear feet of installed insulation (ft^2) (from database)

H_AG = Height of crawlspace wall above grade = 1.0 foot

H_BG = Height of crawlspace wall below grade = 2.0 feet

Framing_factor = Adjustment to account for area of framing = 0.0 (spray foam)

CDD = Cooling Degree Days (assumed unconditioned (vented) crawlspace) (applied per participant based on project location)

Table 73. Cooling Degree Days by Climate Zone for Unconditioned (Vented) Crawlspace

Climate Zone	CDD
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (actual cooling efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 74. ηCool for Crawlspace Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
After 2006	13

HDD = Heating Degree Days (assumed unconditioned (vented) crawlspace) (applied per participant based on project location).

Table 75. Heating Degree Days by Climate Zone for Unconditioned (Vented) Crawlspace

Climate Zone	HDD
1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796

ηHeat = Efficiency of heating system (based on heating equipment type per participant) (actual heating efficiency and age of existing equipment unknown; used age of existing equipment pre 2006)

Table 76. ηHeat for Crawlspace Insulation Measures

Existing Heating Equipment	ηHeat (pre 2006)		ηHeat (post 2006)	
	COP	AFUE	COP	AFUE
Gas Furnace	n/a	0.7	n/a	0.7
Electric Resistance	1.00	n/a	1.00	n/a
Air Source Heat Pump (ASHP)	1.70	n/a	1.92	n/a

FLH_cooling = Full Load Hours of air conditioning (applied per participant based on project location)

Table 77. FLH_cooling by Climate Zone

Climate Zone	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903

CF = Coincidence Factor

Table 78. Crawlspace Insulation Coincidence Factors

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

ISR = In-Service Rate for attic and wall insulation = 99%[22]

[22] Installation rate from PY6 participant survey results.

Appendix B. Data Collection Instrument

PARTICIPANT QUESTION BATTERY

Screening

SC1. Our records indicate that your company participated in…
[IF SP=1, READ IN…
"the Home Efficiency Standard Program, previously the Home Performance with Energy Star program."]
[IF SP=1 & IQ=1, READ IN…
"both the Home Efficiency Standard Program, previously the Home Performance with Energy Star program and the Home Efficiency Income Qualified Program, previously the Moderate Income Program."]
Is that correct?
1. (Yes)
2. (No) [THANK AND TERMINATE]
98. (Don't Know) [SKIP TO SC3]
99. (Refused) [THANK AND TERMINATE]

SC2. Are you knowledgeable about your company's involvement in this program?
1. Yes [SKIP TO SC4]
2. No
98. Don't know [THANK AND TERMINATE]

SC3. Is there someone more knowledgeable in your company to whom we could send this survey? If so, could you please provide us with their Name and email address or phone number.
1. Yes [OPEN END, RECORD DETAILS and then thank and terminate]
2. No [THANK AND TERMINATE]

SC4. How familiar are you with the…?

	Not at all familiar										Very familiar
	0	1	2	3	4	5	6	7	8	9	10
A. Standard Program	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

[IF SP=1 & SC4a=0 OR SP=1 & IQ=1 & SC4a=0 & SC4b=0, THANK AND TERMINATE]

Benefits and Barriers

[ASK QUESTION BATTERY IF SP=1 & SC4a>0]

SP1. How knowledgeable do you feel about each of the following aspects of the Standard Program? [ROTATE]

	Not at all Knowledgeable										Very knowledgeable
	0	1	2	3	4	5	6	7	8	9	10
A. The application process	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B. Benefits to program participants	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
C. Best strategies to market the program to customers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
D. Where to find help or information about the program	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
E. On-Bill Financing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

SP2. Which, if any, of the following benefits has your company experienced through its participation in the Standard Program? Please mark all that apply. [MULTIPLE RESPONSE]

	ROTATE	Yes	No	Don't Know
1	Helped increase jobs/revenue	☐	☐	☐
2	Helped expand customer base	☐	☐	☐
3	Customers had been asking about the program	☐	☐	☐
4	Developing/building a relationship with Ameren Illinois	☐	☐	☐
5	Increased sales of energy efficient equipment	☐	☐	☐
6	Helped improve customer satisfaction	☐	☐	☐
7	Marketing provided through the program	☐	☐	☐
8	Training provided through the program	☐	☐	☐
9	Technical assistance provided through the program	☐	☐	☐
10	On-bill financing provided through the program	☐	☐	☐
00	Other, specify_____	☐	☐	☐

SP3. Did you encounter any challenges while participating in the program?

1. Yes
2. No
98. Don't know

[ASK IF SP3=1]

SP4. What challenges did you face? Please mark all that apply. [MULTIPLE RESPONSE]

1. Lack of customer demand
2. Many customers did not qualify for the program
3. Paperwork/administration was tedious/too time-consuming
4. Difficulty understanding program process
5. Challenges marketing the program
6. Difficulty meeting program requirements
7. Marketing support was not adequate
8. Training provided was not adequate
9. Technical assistance was not adequate
10. Delays in payment
11. Lack of communication from CSG (CLEAResult)
12. Lack of communication from Ameren Illinois
00. Other, specify_____
98. Don't Know

SP5. In your opinion, what could Ameren Illinois change to help improve the Standard program? [OPEN END]
00. Other, specify_____
96. Nothing/No Changes
98. Don't Know

SP6. Would you recommend the Standard Program to another contractor?
1. Yes
2. No

Jobs outside the Program

OP1. In the last year, have you completed a job that would have been eligible for the [IF SP=1 "Standard Program", IF SP=1 & IQ=1 "Standard or Income Qualified programs"], but you chose not to go through the program?
1. Yes
2. No
98. Don't Know

[ASK IF OP1=1]
OP2. With approximately what percentage of jobs did this happen? [NUMERIC OPEN END]
00. Specify, _____
98. Don't Know

[ASK IF OP1=1]
OP3. Why did you choose to complete the jobs outside of the program? Please mark all that apply. [MULTIPLE RESPONSE]
1. Paperwork/administration was tedious/too time-consuming
2. Easier to sell the jobs without the program
3. Customers did not qualify for the program
4. Delay in payment
5. Lack of communication from CSG (CLEAResult)
6. Lack of communication from Ameren Illinois
00. Other, specify___
98. Don't Know

OP4. Are there any changes in your company that have occurred as a direct result of your participation in the [IF SP=1 "Standard Program", IF SP=1 & IQ=1 "Standard or Income Qualified programs"].
1. Yes
2. No
98. Don't know

[ASK IF OP4=1]
OP5. Could you tell us about these changes? [OPEN END]
00. Specify___
98. Don't Know

On-Bill Financing

OBF1. Did you know that the Standard Program offers On-Bill Financing for customers?

1. Yes
2. No

[ASK IF OBF1 = 1]
OBF3. Have you completed a job that used On-Bill Financing?
1. Yes
2. No
98. Don't know

[ASK IF OBF3 = 2]
OBF4. Why haven't you used On-Bill Financing? Please mark all that apply. [MULTIPLE RESPONSE]
1. The application is difficult, too many details required
2. The application takes too long to fill out
3. The application instructions are not clear
4. Customers did not qualify for it
5. Customers did not want it
6. Do not quite understand how On-Bill Financing works
00. Other, specify: _____
98. Don't know

[ASK IF OBF3 = 1]
OBF5. Has On-Bill Financing made it easier to sell jobs to customers?
1. Yes
2. No
98. Don't know

[ASK IF OBF5 = 1]
OBF6. How has it made it easier? [OPEN END]

[ASK IF OBF3=1]
OBF7. How easy or difficult is it to fill out an On-Bill Financing application?

Very Difficult										Very Easy
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

[ASK IF OBF7<7]
OBF8. What challenges, if any, have you experienced with the application? Please mark all that apply. [MULTIPLE RESPONSE]
1. Too many details required
2. Takes too much time
3. Difficult to contact Ameren Illinois if I have questions
4. Instructions are not clear
00. Other, specify: _____
98. Don't know

Training and Support

T1. What training did Ameren Illinois provide to you and/or your company? Trainings can cover topics like On-Bill Financing application process, eligible equipment etc. Please mark all that apply. [MULTIPLE

CHOICE]

1. On the application process
2. On marketing materials available
3. On eligible equipment
4. To help develop marketing materials
5. Sales training for On-Bill Financing
6. Best practices for On-Bill Financing sales
7. BPI certification opportunities
8. More professional certification opportunities in general
9. I opted out of receiving training [SKIP TO T5]
10. I did not receive any training [SKIP TO T5]
00. Other, specify: _____
98. Don't know

[ASK IF ANY T1 (1-00) = "YES"]

T2. How did Ameren Illinois train you and/or your company? Please mark all that apply. [MULTIPLE CHOICE]

1. One on one meeting
2. Industry or other group meetings
3. Workshop
4. Brochures and other handouts
5. Website
6. Through the Trade Ally Coordinators
00. Other, specify: _____
98. Don't know

T3. How would you rate your satisfaction with the overall training you received?

Very Dissatisfied										Very Satisfied
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

[ASK IF T3 <7]

T4. How can they improve their training? [OPEN END]

00. Specify: _____
96. Nothing/no changes
98. Don't know

T5. What technical support did Ameren Illinois provide to you and/or your company? Please mark all that apply. [MULTIPLE CHOICE]

1. Sales leads
2. Support filling out forms
3. Accompany on sales calls
4. Answered questions on eligible/qualified measures
5. Answered questions on application process
6. I opted out of receiving any support [SKIP TO M1]
7. I did not receive any support [SKIP TO M1]
00. Other, specify: _____
98. Don't know

[ASK IF ANY T5 (1-00) = "YES"]
T6. How would you rate your satisfaction with the overall technical support that you received?

Very Dissatisfied										Very Satisfied
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

[ASK IF T6 <7]
T7. How can they improve their technical support? [OPEN END]
- 00. Specify: _____
- 96. Nothing/no changes
- 98. Don't know

Marketing

M1. How do your program customers find out about you? Please mark all that apply. [MULTIPLE CHOICE]
- 1. Ameren Illinois provides me with customer leads
- 2. Ameren Illinois website
- 3. Our company's own marketing
- 4. Referral from another contractor
- 5. Past relationship with customer/existing customer
- 00. Other, specify_____
- 98. Don't know

M2. Do you do any marketing or outreach specifically for the [IF SP=1 "Standard Program", IF SP=1 & IQ=1 "Standard or Income Qualified programs"]?
- 1. Yes
- 2. No
- 98. Don't know

[ASK IF M2=2]
M3. Why not? [OPEN END]

[ASK IF M2=1]
M4. What marketing or outreach do you do? [OPEN END]

M6. Which marketing tactics are most effective in encouraging customer participation? Please mark all that apply. [MULTIPLE RESPONSE]
- 1. Company brochures and printed information
- 2. My company website
- 3. Ameren Illinois website
- 4. Events/workshops
- 5. TV or Radio Advertisements
- 6. Word of mouth
- 7. Direct mail
- 8. Cross-selling
- 9. Cold-calling
- 10. Emailing customers
- 00. Other, specify: _____
- 98. Don't know

M7. Do you think the level of marketing and promotion that Ameren Illinois conducts is appropriate?
1. Yes
2. No
98. Don't know

M8. Is there anything that Ameren Illinois could do to help you be more effective in promoting the program to your customers? [OPEN END]
00. Specify_____
96. None – current materials are enough
98. Don't know

Satisfaction

SA1. How satisfied are you with the following: [ROTATE]

	Very Dissatisfied										Very Satisfied
	0	1	2	3	4	5	6	7	8	9	10
A. Your interactions with CSG (CLEAResult)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
B. Assistance in completing required paperwork	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
C. On-Bill Financing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
D. Payment time from Ameren Illinois upon project completion	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
E. The Standard program overall [ANCHOR LAST]	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

SA2. Did the [IF SP=1 "Standard Program", IF SP=1 & IQ=1 "Standard or Income Qualified programs"] have a positive, negative, or no effect at all on your business since you started participating?
1. Positive
2. No affect at all
3. Negative
98. Don't know

SA6. Do you have any suggestions on ways to improve the [IF SP=1 "Standard Program", IF SP=1 & IQ=1 "Standard or Income Qualified programs"]? [OPEN END]
00. Specify: _____
96. No suggestions
98. Don't Know

Firmographics

We just have some last few questions about the size and type of your company.

F1. Please select the business categories below that describe your company. [MULITPLE RESPONSE]
1. Contractor - Air Sealing
2. Contractor - HVAC
3. Contractor - Energy Audits
4. Contractor – Other
5. Energy Consultant
6. Manufacturer's Rep
7. Equipment Supplier

8. Engineer [ANCHOR AS LAST BEFORE OTHER SPECIFY]
00. Other. specify____ [ANCHOR LAST]

F2. Approximately, how many employees does your company have? [OPEN END]

F3. Approximately, how many jobs does your company complete in a year? [OPEN END]

NON-PARTICIPANT QUESTION BATTERY

NP1. Our records indicate that your company participated in the Home Performance with Energy Star Program in <YEAR>. Is this correct?
1. Yes,
2. No [THANK AND TERMINATE]
98. Don't Know [THANK AND TERMINATE]

NP2. Could you briefly explain the reasons why your company no longer performs services through the program? Please mark all that apply. [MULTIPLE RESPONSE]
1. Company no longer offers program services covered by the program
2. Did not meet eligibility requirements
3. Did not help increase jobs/revenue
4. Did not help expand customer base
5. Lack of customer demand
6. Program was not worth effort/too time-consuming to participate
7. Challenges marketing the program
8. Marketing support was not adequate
9. Training provided was not adequate
10. Technical assistance was not adequate
11. Lack of communication with CSG (CLEAResult)
12. Lack of communication with Ameren Illinois
13. General dissatisfaction with Ameren Illinois
00. Other, Specify ____
95. Company no longer in business [THANK AND TERMINATE]
96. Was never a program participant [THANK AND TERMINATE]
98. Don't know

[ASK IF NP2 = 2]
NP3. You mentioned that you encountered challenges with meeting the eligibility requirements. Could you specify which eligibility requirements were difficult for you to meet? [OPEN END]

[ASK IF NP2=13]
NP4. You mentioned a general dissatisfaction with Ameren Illinois. Could you specify the reasons for this dissatisfaction? [OPEN END]

NP5. What did your company see as the potential benefits to participating in the program? Please mark all that apply. [MULTIPLE RESPONSE]
1. Helped increase jobs/revenue
2. Helped expand customer base
3. Customers had been asking about the program
4. Developing/building a relationship with Ameren Illinois

5. Increased sales of energy efficient equipment
6. Helped improve customer satisfaction
7. Marketing provided through the program
8. Training provided through the program
9. Technical assistance provided through the program
20. On-bill financing provided through the program
00. Other, specify_____
96. No benefits
98. Don't know

NP6. In your opinion, what could be done to change the program so that your company would once again participate in the program(s)? [OPEN END]
00. Please specify: _____
96. Nothing/Will not participate

NP7. Were you aware that there have been changes made to the programs this year, including incentives for programmable thermostats and crawl spaces and On-Bill Financing?
1. Yes
2. No
98. Don't know

NP8. Given these changes, how likely is your company to participate in the program again?

Very Unlikely										Very Likely
0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Firmographics

We just have some last few questions about the size and type of your company.

F1. Please select the business categories below that describe your company. [MULITPLE RESPONSE]
1. Contractor - Air Sealing
2. Contractor - HVAC
3. Contractor - Energy Audits
4. Contractor – Other
5. Energy Consultant
6. Manufacturer's Rep
7. Equipment Supplier
8. Engineer [ANCHOR AS LAST BEFORE OTHER SPECIFY]
00. Other. specify____ [ANCHOR LAST]

F2. Approximately, how many employees does your company have? [OPEN END]

F3. Approximately, how many jobs does your company complete in a year? [OPEN END]

Appendix C. Survey Response Rate Methodology

The survey response rate is the number of completed interviews divided by the total number of potentially eligible respondents in the sample. We calculated the response rate (Response Rate 3 (RR3)) using the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR).[23] The formulas used to calculate RR3 are presented below. The definitions of the letters used in the formulas are displayed in the Survey Disposition table. The response rate for this survey was 39%.

$$RR3 = \frac{I}{(I + R + P + NC) + (E * U)}$$

We also calculated a cooperation rate, which is the number of completed interviews divided by the total number of eligible sample units actually contacted. In essence, the cooperation rate gives the percentage of participants who completed an interview out of all of the participants with whom we actually spoke. The cooperation rate for this survey was 66%. We used AAPOR Cooperation Rate 3 (COOP3), which is calculated as:

$$COOP3 = \frac{I}{(I + P) + R}$$

[23] *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, AAPOR, 2011. http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions2&Template=/CM/ContentDisplay.cfm&ContentID=3156

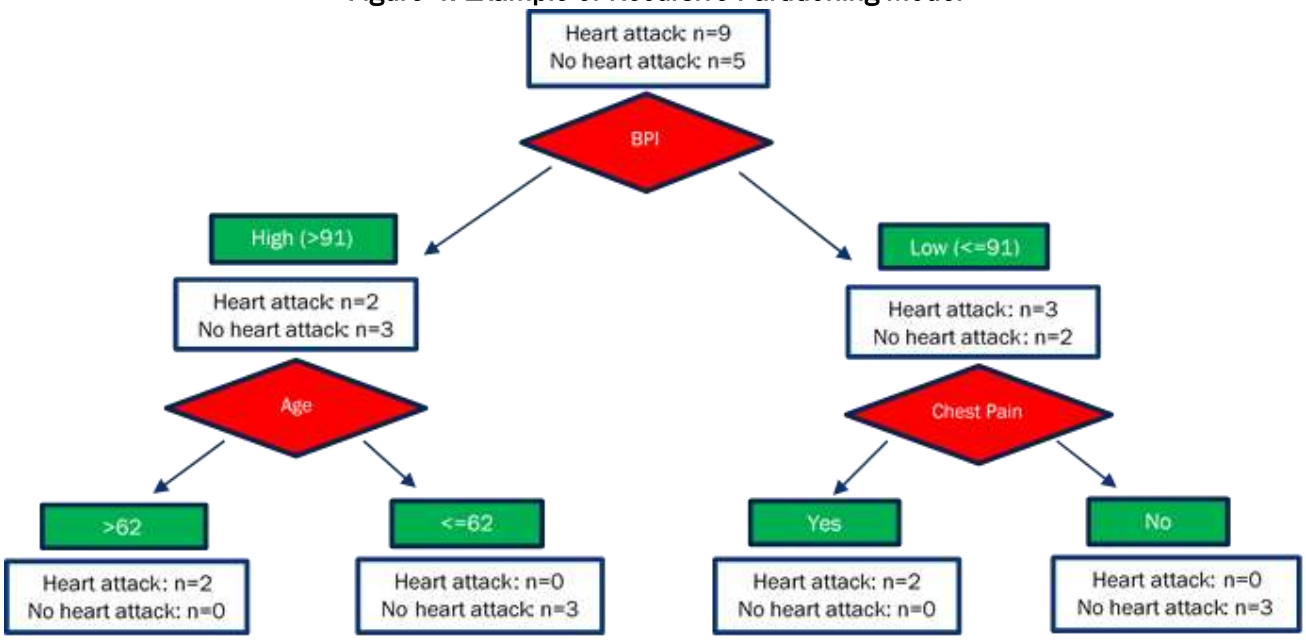
Appendix D. Predictive Model Methodology

Recursive Partitioning for Classification and Prediction

In this section, we provide a more detailed description of our predictive model methodology. We developed our predictive model using a Random Forests classifier. Random Forests is a machine learning technique based on recursive partitioning. A recursive partitioning model relies on repeated partitioning of the data (in the form of decision trees) to estimate the conditional distribution of a response variable given a set of predictors. A classification or decision tree can be interpreted as a flow chart of questions to be asked when classifying data. At each fork in the tree, we ask a question of the data to help in classification. In the example below, we illustrate classification tree for predicting who is at risk for a heart attack based on a set of potential predictors. In this recursive partitioning model, the response variable is a binary outcome (i.e., whether a patient had a heart attack or not) and we include a set of predictor variables including: blood pressure (BPI), age, whether the patient reported chest pain, medical history, EKG, and medical history.

The goal of the recursive partitioning algorithm is to partition the data in a way that minimizes misclassification error of the response variable. In a binary classification problem, recursive partitioning continually splits the data (using each of the predictor variables) within new partitions until there are no further splits that decrease the misclassification rate sufficiently. Once the algorithm can no longer partition the data, model estimation is complete. As part of this modeling process, recursive partitioning identifies the key predictor variables that yield the largest decrease in the misclassification or error rate. As such, recursive partitioning models usually include only a subset of predictor variables. Once model estimation is complete and we have a decision tree, the algorithm classifies all new or "out-of-sample" observations by running each observation through the decision tree. The new data traverses down the decision tree and is bucketed into smaller and smaller (homogenous) sets until the model is able to classify the observation.

Figure 4. Example of Recursive Partitioning Model



Recursive partitioning is an effective classifier when the functional form (including nonlinearities and interactions) are unknown and the number of possibly relevant predictors is large. However, recursive partitioning models have two important limitations: fitted values have high variance and there is a substantial risk for over-fitting. Fitted values derived by recursive partitioning are often unstable since the algorithm is locally optimal and as such it produces different classifications if we make any changes to the data used to fit the model (i.e., the estimator has high variance). That is, the order in which the variables recursive partitioning partitions the data can result in different tree structures and thus different predictions.

Random Forests

The Random Forest classifier addresses these issues by generalizing the idea of a single tree (i.e., recursive partitioning) into a collection of trees (i.e., a forest). The Random Forest algorithm estimates each tree in the forest as described in the section above and it classifies new data by holding a vote over all trees. More specifically, the Random Forest algorithm performs the following steps:

1. Specify the total number of trees to build (N).
2. For N_i, i=1,...,N, draw a bootstrapped sample from the observations, leaving a subset of observations out of the bootstrapped sample ("out-of-bag" sample)
3. Grow decision tree by recursively partitioning data until obtaining the optimal variable split points using the following sub-algorithm:
    a. Randomly select a subset of variables (or predictors) from the total set of variables.
    b. Select the optimal variable/split-point among the subset of variables.
4. Output ensemble of trees.
5. Predict new cases using out-of-bag observations by counting the number of times (over trees) that each case is classified in each category of the outcome of interest. Use majority voting over the set of bootstrapped classification trees to classify cases.

The Random Forest classifier provides several important advantages compared to other prediction algorithms. First, this algorithm includes a measure of accuracy built directly into the algorithm. By predicting new observations using the out-of-bag observations, the Random Forests tests its trees on data that was not involved in their construction. This helps to prevent potential over-fitting and model dependency. Relatedly, by growing trees based on random subsets of variables, the Random Forest classifier reduces dependence between trees thus again reducing the potential for over-fitting. More generally, by incorporating information from multiple trees, the Random Forests classifier produces more stable model estimates and is less susceptible to extreme values.

Appendix E. Predictive Model Data Overview

This section provides a detailed overview of the data used to develop our predictive model.

To build our predictive model, we collected data from multiple sources including program tracking databases, census data, and additional data from Experian. We filtered all collected data to include only customers who had an audit during program years PY4-PY7. Table 79 summarizes our data collection sources.

Table 79. Data Sources

Data Category	Source
Program tracking and participation data	AIC
Monthly Usage Billing data	AIC
Geo-Location data	ArcGIS
Census data	American Community Survey Database
Customer-level data	Experian

Program Tracking and Participation Database Cleaning

We used the program tracking database to determine audit to measure installation conversions for PY4 through PY7. The data from received from AIC. As part of our data collection efforts, we made the following data cleaning decisions:

- Cleaned address and city, parsing out unit numbers
- Determine audit date and date of first measure installation following an audit
- Aggregated dataset to be unique by account and program year.
- Mark customers as having converted if they installed Standard Program measure within 365 days of an audit

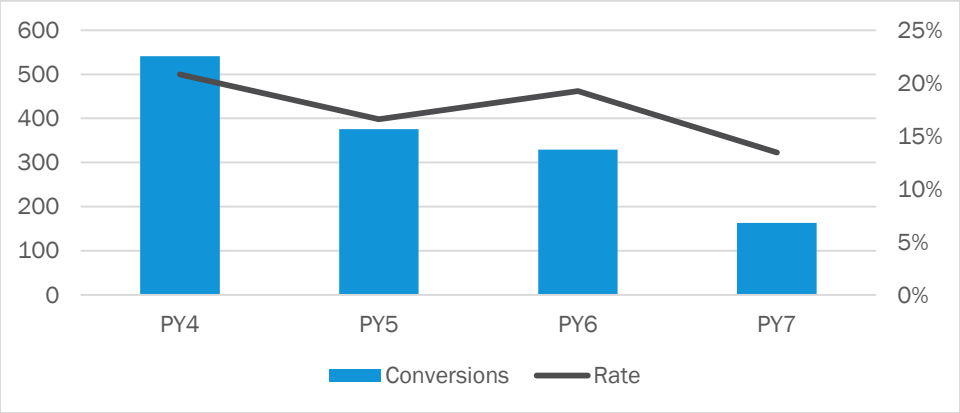
Data Overview

This section provides a brief overview and summary of the data used to develop our predictive model. The data includes 8,281 unique customers from PY4 through PY7 who had an audit through the Standard Program.

The main outcome of interest for our predictive modeling is conversion: whether a customer who had an audit installed any Standard Program measure within 365 days following the audit. Prior to statistical modeling, we carefully analyzed trends in conversions. The overall conversion rate is 18%.[24] The per year conversion rate ranged between 19% and 21% during PY4-PY6. The conversion rate for PY7 was 13%, although it is important to note that a full year has not elapsed since the end of PY7, so the declining rate in PY7 is not representative of a full year's data.

[24] Notably, this conversion rate is on an annual basis and is thus different from the cumulative conversion ate shown in the body of the report.

Figure 5. Number of Conversions and Conversion Rate for PY4-PY7



Monthly Usage Billing Data Cleaning

The evaluation team cleaned the billing data in order to determine average daily kWh and therm usage for each customer. These average daily usages allow us to compare customers without having to align billing periods. The monthly data also allows us to look at monthly usage trends and variance from month to month. The data from received from AIC. We cleaned the billing data following our billing analysis protocols:

- Check consistency of billing period start and end dates
- Drop bills with very short (1 day) or negative billing days unless they are corrections to a previous bill
- Check for record overlaps, and merge bills as necessary
- Month year variable from midpoint of billing period start and end date
- Aggregate to unique account and month year

Census Data

The evaluation team used ArcGIS to geocode customers, and combined customer data with census data from the American Community Survey Database using Census geography codes on a census block group level. The final data fields include:

- Population
- Education
- Poverty
- Family Makeup
- Employment
- Owner vs Renter
- Housing type

We normalized all census data fields by population. All census variables in the predictive model are a percentage of total population or total households. This allows us to compare neighborhood demographics between customers in different census block groups.

Customer-Level Data from Experian

The evaluation team obtained secondary data for demographic, housing, and psychographic characteristics for program participants. We obtained the data through Experian; Experian's CONSUMERVIEW Database is the foundation for their consumer marketing lists, data enhancement, and data licensing services. It includes compiled, self-reported, and modeled data built using over 3,500 original public and proprietary sources, including white pages, census data, public records (both state and local), product registrations and surveys (self-reported), property/realty records such as property deeds, mail order transactions, and other proprietary sources. Table 80 lists the data points obtained from Experian, with their match rates.

Table 80. Secondary Data from Experian

Data Type	Description of Data	Match Rate
Total Number of Customers Sent to Experian		13,694
Total Matches		13,693
Overall Match Rate		100%
Demographic Data		
Household Income	Income is the total estimated income for a living unit and incorporates several highly predictive individual, household, and geographical level variables including Summarized Credit Statistics.	99%
Number of Adults in Household	Number of Adults in Household is calculated from the number of records in a household. An adult is anyone 19 years old or older living in a household.	99%
Gender	Gender information is applied during the convert prior to enhancement. Records coded as gender include both those with prefixes of Mr. & Mrs. and/or first names.	98%
Occupation – Group	Information is compiled from self-reported surveys, derived from state licensing agencies, or calculated through the application of predictive models.	97%
Education	Information is compiled from self-reported surveys, derived based on occupational information, or calculated through the application of predictive models.	97%
Age	Date of Birth is acquired from public and proprietary files. These sources provide, at a minimum, the year of birth. The birth month is provided where available.	92%
Number of Children (18 or Less)	Number of Children in Household information is calculated from the number of records in a household that indicate children whose age is 18 or younger.	23%
Housing Data		
Dwelling Type	Each household is assigned a dwelling type code based on United States Postal Service (USPS) information.	100%
Homeownership	Homeowner information indicates the likelihood of a consumer owning a home, and is received from tax assessor	96%

Data Type	Description of Data	Match Rate
	and deed information. Renter status is derived from self-reported data. Unit numbers are not used to infer rented status because units may be owner condominium/coop.	
Year Home Built	Year built is based on county assessor's records, the year the residence was built, or through the application of a predictive model.	55%
Home Square Footage Ranges	The square footage of any buildings associated with the home determined from Grant/Warranty Deed information recorded or other legal documents filed at the county recorder's office in the county where the property is located.	55%
Length of Residence	Length of Residence (LOR) is the length of time a customer has resided at their current address. A primary source of LOR is public source white page compilation initiating a counter showing the first time a name and number appear in the directory.	100%
Psychographic Data		
Internet/Online Subscriber	Internet online subscriber indicates a household has self-reported being an Internet/online subscriber. BehaviorBank® Household Indicators groups similar self-reported elements into slightly broader categories.	84%
Other Social Causes and Concerns	Activities and Interests/Social Causes and Concerns are derived from direct reported survey data that represents a household's interest in each of the social causes/concerns	26%
Religious Social Causes and Concerns		20%
Health Social Causes and Concerns		21%
Children Social Causes and Concerns		15%
Veterans Social Causes and Concerns		14%
Animal Welfare Social Causes and Concerns		10%
Political-Conservative Social Causes and Concerns		5%
Political-Liberal Social Causes and Concerns		3%
Volunteer Work		1%

Appendix F. Cost-Effectiveness Inputs

Table 81 presents total gross impacts for AIC cost-effectiveness calculations. These values differ from those included in the main report due to the inclusion of heating penalties for lighting measures. This approach was taken based on discussions with AIC and past agreements between AIC and ICC staff that heating penalties would not be included in savings calculations for goal attainment. Overall, total gross savings reduced by 0.7% for kWh and 2.6% for therms after the application of waste heat factors.

Table 81. PY7 Standard Program Gross Impacts (Including Heating Penalties)

	kWh	kW	Therms
Gross Savings	3,418,642	1,816	524,885
Lighting Heating Penalty	- 23,642	0	- 13,893
Total Gross Savings with Heating Penalty	3,395,000	1,816	510,992

Lighting Heating Penalty

The inclusion of waste heat factors for lighting is based on the concept that heating loads are increased to supplement the reduction in heat that was once provided by the existing lamp type. We applied the heating penalty to 18,310 lamps based on heating fuel type and installed lamp type. The heating fuel type is known for 15% (2,789 lamps) of the installed lighting measures. For the remaining 15,521 lamps with unknown space heating fuel types, we applied waste heat factors based on the percentage of installed lighting measures where heating fuel types are known. Therefore, 896 lamps (5.8%) were applied waste heat factors for electric resistance heating, 540 lamps (3.5%) were applied waste heat factors for heat pumps, and 14,085 (90.7%) were applied waste heat factors for gas heating. Table 82 summarizes the percentages for lighting measures with known heating fuel types.

Table 82. PY7 Standard Program Known Heating Fuel Type for Lighting Measures

Heating Fuel	Heating Equipment	% of Htg Fuel Type Known
Electric	Electric Resistance	5.8%
Electric	Heat Pump	3.5%
Gas	Furnace/Boiler	90.7%

The total heating penalty for lighting measures is 23,642 kWh and 13,893 therms.

For more information, please contact:

Hannah Arnold
Managing Director

510 444 5050 tel
510 444 5222 fax
harnold@opiniondynamics.com

1999 Harrison Street, Suite 1420
Oakland, CA 94612