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Impact and Process Evaluation of the 2015 (PY8) Ameren Illinois Company Home Efficiency Income Qualified Program

Final

February 21, 2017

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1. Executive Summary

This report presents the results of the evaluation of the Program Year 8 (PY8) Ameren Illinois Company (AIC) Home Efficiency Income Qualified Program (Income Qualified Program). The program, a home energy diagnostic and whole-house retrofit program, began as a pilot in PY3 and is in its fifth year of implementation. The target market for the Income Qualified Program is AIC customers with homes heated by a fuel source (electricity or natural gas) provided by AIC and with a household income between 0% and 300% of federal poverty guidelines for household size. CLEAResult implements the Income Qualified Program, reporting to Leidos, who manages all of AIC's commercial and residential programs. Participants can join the program in one of two ways: by applying for a home audit through the program or by applying to the program through a trade ally.

The expected savings from this program is 2% of the overall PY8 portfolio of electric savings and 10% of PY8 portfolio therm savings (including both residential and commercial).[1] Per the Program Implementation Plan, CLEAResult estimated it would serve 945 homes and complete 1,180 retrofits in PY8.

For PY8, the evaluation team conducted a process and impact evaluation of the Income Qualified Program, which included research with participating and nonparticipating customers, trade allies, and program staff.

Program Impacts

With an increased implementation budgets of $7,351,499 for electric and $1,257,420 for gas[2] , the Income Qualified Program reached 1,019 participants in PY8, nearly tripling participation rates from previous years. The program provided net savings of 3,047 MWh, 1.29 MW, and 568,483 therms. PY8 performance exceeded PY7, where the program achieved net savings of 873 MWh, 0.52 MW, and 210,250 therms. The Income Qualified Program achieved gross PY8 realization rates of 98% for MWh, 97% for MW, and 99% for therms. The variance in net realization rates is due to differences in input values for ex ante (calculated by the implementation team) and ex post (calculated by the evaluation team) savings algorithms. Table 1 summarizes the net impacts for the Income Qualified program.

Table 1. PY8 Income Qualified Program Net Impacts

	Ex Ante Gross	Realization Rate	Ex Post Gross	Net-to-Gross Ratio (NTGR)	Ex Post Net
Energy Savings (MWh)					
Total MWh	3,098	0.98	3,047	1.00	3,047
Demand Savings (MW)					
Total MW	1.33	0.97	1.29	1.00	1.29
Therm Savings					
Total Therms	571,594	0.99	568,483	1.00	568,483

Key Findings and Recommendations

We identify the following areas for program improvement:

[1] Note that the percentage of expected savings here and throughout the plan is calculated based on AIC Plan 3 Compliance Filing from Docket 13-0498, dated January 28, 2014.

[2] Source: Ameren Illinois Program Year Eight Implementation Plan Sec. 8-103/8-104, December 4, 2015.

- **Key Finding #1:** Through the trade ally interviews, we learned 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). Extended lead times on payments could discourage and limit program participation.
  - **Recommendation:** Reducing the administrative burden on trade allies would help make the program more attractive and increase satisfaction with the program. As such, we suggest looking for additional ways that this process can be streamlined. Part of this streamlining should include looking for opportunities to reduce the amount of time it takes to pay trade allies.
- **Key Finding #2:** In their interviews, trade allies revealed that many customers' homes had major energy inefficiencies (e.g., windows or doors that did not close properly). This finding is underscored by the survey data from program participants where "windows" emerged as one of the most popular responses to the question about what measures were of interest to them.
  - **Recommendation:** We recommend that AIC consider partnering with other organizations in its territory that could provide support to customers with measures that are not covered by the program.
- **Key Finding #3:** By mapping program participation over the last four years, the evaluation team identified areas within AIC's territory with a high density of low-income homeowners, but historically scant program delivery.
  - **Recommendation**: We recommend that AIC staff begin incorporating the interactive mapping tool that we have provided into future program planning. By carefully examining areas of relatively low participation, the AIC team can begin to determine the best approach to increase participation in those areas.
- **Key Finding #4:** AIC customers reported that they are willing to provide a $25 to <$100 co-payment for an audit. However, trade allies were dubious about customers' willingness and ability to provide a co-payment.
  - **Recommendation:** We recommend that if AIC introduces a co-pay, that it is less than $100. Further, AIC may want to customize the co-pay amount on a sliding scale from $25 to <$100 so that households of less means receive the assistance that they need.
- **Key Finding #5:** Per our ex post savings calculations, the evaluation team identified several discrepancies in savings assumptions between the ex ante and ex post savings calculations.
  - **Recommendation:** To increase the accuracy of tracked savings (and improve realization rates), we recommend that the Income Qualified Program adopt the ex post assumptions and savings calculations used by the evaluation team.
- **Key Finding #6:** The evaluation team found a few discrepancies in ex ante calculations where per-measure savings were used in place of the total ex ante savings or different variable assumptions were used instead of what was planned.
  - **Recommendation**: We recommend reviewing the syntax language to verify that all algorithms and variable assumptions are referenced correctly.
- **Key Finding #7:** The evaluation team identified some instances where data across the program-tracking database did not agree. For example, measure labels that indicate heating fuel types do not

always match the heating fuel type provided in the database, heating and cooling HVAC equipment are not always aligned, pre- and post-installation R-values for insulation measures are sometimes reversed, and data were provided that did not accurately reflect characteristics of the installed measures (such as actual pre- and post-insulation R-values in the PY8 program-tracking database).

- Recommendation: We recommend reviewing the program-tracking databases prior to submitting to the evaluation team to minimize these types of discrepancies.

2. Evaluation Approach

The Project Year 8 (PY8) evaluation of the Ameren Illinois Company (AIC) Home Efficiency Income Qualified Program (Income Qualified 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 conducted surveys with participating trade allies and program participants. To evaluate gross impacts, the evaluation team conducted engineering analysis. Further, per the evaluation plan, we applied a net-to-gross ratio (NTGR) of 1.0 to evaluated gross savings to obtain PY8 net savings.

2.1 Research Objectives

The evaluation team sought to answer the following research questions as part of the PY8 Income Qualified evaluation.

2.1.1 Impact Questions

- What were the estimated gross energy and demand impacts from this program?
- What were the estimated net energy and demand impacts from this program?
- Did the program meet its energy and demand goals? If not, why?

2.1.2 Process Questions

- Program Design and Implementation Effectiveness
  - Was the program implemented according to design?
  - What were the program marketing and outreach efforts?
  - What implementation challenges occurred in PY8 and how were they overcome?
- Program Participation
  - Which geographic areas have seen the most participation in the program to date? Are there areas that the program should consider targeting more heavily in the future?
  - How many homes received audits? How many homes received shell measures? Has participation met expectations? If not, why?
  - What were the barriers to installation of incentivized shell measures after receiving an audit?
- Participant Experience and Satisfaction
  - Were customers satisfied with aspects of the program processes in which they have been involved?
  - Were customers satisfied with the participation process and program measures?

   - Are there any particular program measures offered that were important drivers for customers in their decision to participate in the program?
- Opportunities for Program Improvement
   - Did program changes/enhancements from PY7 to PY8 achieve their intended outcomes? What areas for improvement exist from PY8 to PY9? What additional measures could the program offer to generate additional program savings? Which of these measures provide a relatively greater savings opportunity? Which are of greatest interest to participants?
   - Are income-qualified customers able to provide a co-pay for the home audit? If so, what amount are they able to pay?

2.2 Evaluation Tasks

Table 2 summarizes the PY8 evaluation activities conducted for the Income Qualified Program, each of which is described in detail below.

Table 2. Summary of PY8 Income Qualified Program Evaluation Activities

Task	PY8 Process	PY8 Impact	Forward Looking	Details
Review of Program Materials and Data	✓			Reviewed program materials, including program design, implementation plans, and marketing and outreach efforts, to assess effectiveness of program implementation and to provide recommendations for improvement, where applicable.
Program Staff Interviews	✓			Interviewed AIC, CLEAResult, and Leidos staff to understand the program's design, implementation, and evaluation priorities.
Program Database Mapping	✓		✓	Examined program delivery across the last 5 years alongside census data to identify areas of heavy program delivery and areas that have a high percentage of income-qualified customers but relatively low program participation.
Participant Survey	✓	✓	✓	Conducted survey with 100 program participants to learn about their experience and satisfaction with the program and their willingness to pay for in-home audits and to verify measure installation to calculate in-service rates (ISRs).
General Population Survey	✓		✓	Conducted survey with 639 income-qualified customers to assess their willingness to pay for an in-home audit and to learn about what measures are of greatest interest to them.
Trade Ally Interviews	✓		✓	Interviewed 23 participating trade allies to inform program processes and ways to improve customer participation and satisfaction.
Impact Analysis		✓		Conducted an engineering analysis for all PY8 participants to estimate gross and net impacts.

2.2.1 Review of Program Materials and Data

The evaluation team reviewed program materials, including implementation plans, application forms, marketing and outreach activities, training materials, and the program-tracking database. The goal of this review was to document how the program evolved in PY8 and to use that information to inform our evaluation approach.

2.2.2 Program Staff Interviews

The evaluation team conducted in-depth interviews with one member of the AIC program staff, two members of the CLEAResult implementation team, and one member of the Leidos staff. The purpose of these interviews was to gain insight into whether or not the program was implemented according to plan; to determine if there had been any changes in the program's design, implementation, or tracking from PY7; and to understand how the program was marketed.

2.2.3 Program Database Mapping

To identify historical patterns of participation in the Income Qualified Program, the evaluation team aggregated program-tracking data from PY4 through PY8 and linked it to census data. From these data, we produced a heat map showing areas where program participation was most concentrated, as well as areas where AIC may want to consider focusing future marketing and outreach efforts (i.e., those areas with a high percentage of eligible customers and historically low participation rates).

2.2.4 Participant Survey

The evaluation team conducted a telephone survey with PY8 program participants to gauge participants' satisfaction with the program, the energy-efficient measures installed in their homes, measure incentives, and financing options. The evaluation team also collected data to be used for a willingness-to-pay analysis and for measure-level verification and calculation of ISRs.

Sample Design

We reached 495 participants (out of a population of 953) to complete surveys with 100 respondents, as shown in Table 3. To increase the reliability of measure-level findings, we drew a simple random sample of participants for each of the primary measures installed through the program. For participants who received three or more measure types, we randomly selected up to two measures to ask about in the survey. We did not verify installation of air sealing or insulation, as these measures have historically high coincidence rates. We also did not verify the installation of boilers, as only 15 participants in the entire population received this measure.

Table 3. Participant Survey Sample Frame

Population (N)	Sample Frame (N)	Total Respondents (n)
953	495	100

Survey Disposition and Response Rate

Table 4 provides survey dispositions for the participant survey.

Table 4. Participant Survey Disposition

Category Key	Disposition	Total
I	Complete Interview	100
N	Eligible Incomplete Interview	10

Category Key	Disposition	Total
X1	Survey-Ineligible Household	0
U1	Household with Undetermined Eligibility	234
X2	Not a Household	37
U2	Undetermined if Household	114
e1	Estimated Proportion of Cases of Unknown Survey Eligibility That Are Eligible	100%
e2	Estimated Proportion of Cases of Unknown Household/Business Eligibility That Are Eligible	90%
	Total Participants in Sample	495

Table 5 presents the response rate (RR) for the participant survey, which was calculated using the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR), as described in Appendix C.

Table 5. Participant Survey Response Rate

AAPOR Rate	Percent
RR3	22.37%
Cooperation Rate (CR)	65.79%

2.2.5 General Population Survey

In addition to the participant survey, the evaluation team conducted a general population web survey of income-qualified, nonparticipating AIC customers. The goal of this survey was to assess the extent to which income-qualified customers who had not participated in the Income Qualified Program would be willing to pay for a home audit and to hear what measures would be of most interest to them through a program such as this one.

Sample Design

The sample for this survey effort came from the list of those targeted by AIC's Behavioral Modification Program, which included income-qualified customers. We completed surveys with 639 income-qualified customers; Table 6 provides survey dispositions for the general population survey.

Table 6. General Population Survey Disposition

Category Key	Disposition	Total
I	Complete Interview	693
N	Eligible Incomplete Interview	313
X1	Survey-Ineligible Household	4
U1	Household with Undetermined Eligibility	8,462
X2	Not a Household	1,394
U2	Undetermined if Household	0
e1	Estimated Proportion of Cases of Unknown Survey Eligibility That Are Eligible	100%
e2	Estimated Proportion of Cases of Unknown Household/Business Eligibility That Are Eligible	87%
	Total Participants in Sample	10,812

Table 7 presents the RR for the general population survey, which was calculated using the standards and formulas set forth by the AAPOR, as described in Appendix C.

Table 7. General Population Survey Response Rate

AAPOR Rate	Percent
RR3	6.81%
CR	60.92%

2.2.6 Trade Ally Interviews

During previous program cycles, program staff noted trade ally dissatisfaction with the program. Specifically, trade allies felt burdened by the amount of paperwork and the payment time from AIC upon project completion. To see how these challenges were addressed, and to discuss any new challenges that may have arisen, we conducted interviews with participating PY8 trade allies. Specific survey topics included their experiences with the application process, On-Bill Financing (OBF), and program measures.

Trade Ally In-Depth Interviews Design

Using a census approach, the evaluation team attempted to contact all 71 participating trade allies in the PY8 program cycle with the goal of achieving 30 completes consisting of 15 returning trade allies and 15 new trade allies. As shown in Table 8, the evaluation team completed 23 trade ally interviews, 9 of which were with allies that had previously participated in the program.

Table 8. Trade Ally Interview Disposition

Category Key	Disposition	Returning Allies	New Allies	Total Allies
I	Complete Interview	9	14	23
N	Eligible Incomplete Interview	0	0	0
X1	Survey-Ineligible Business	2	0	2
U1	Business with Undetermined Eligibility	21	25	46
X2	Not a Business	0	0	0
U2	Undetermined if Business	0	0	0
e1	Estimated Proportion of Cases of Unknown Survey Eligibility That Are Eligible	82%	100%	92%
e2	Estimated Proportion of Cases of Unknown Household/Business Eligibility That Are Eligible	100%	100%	100%
	Total Participants in Sample	32	39	71

Table 9 presents the RR for the trade ally interviews, which was calculated using the standards and formulas set forth by the AAPOR, as described in Appendix C.

Table 9. Trade Ally Interview Response Rates

AAPOR Rate	Returning	New	Percent
RR3	34.4%	35.9%	35.2%

2.2.7 Impact Analysis

To determine the gross impacts associated with the Income Qualified Program, we applied savings algorithms and variable assumptions from the Illinois Technical Reference Manual (IL-TRM) V4.0[3] and the V4.0 Errata Measures memo[4] using information provided in the program-tracking database. We outline the algorithms used to calculate all evaluated gross program savings in Appendix A, along with all input variables.

We applied a NTGR of 1.0 to gross savings to obtain PY8 Income Qualified Program net savings. In PY3, the evaluation team discussed and reached agreement on the calculation of net savings with AIC staff given our understanding of program design and targeted customers. We applied a NTGR of 1.0 because the program targets participants with household incomes between 0% and 300% of the federal poverty level guidelines for household size. These participants are unlikely to have installed many of the measures offered through the program without assistance. As a result, ex post gross impacts and ex post net impacts are identical.

2.3 Sources and Mitigation of Error

Table 10 provides a summary of possible sources of error associated with the data collection conducted for the Income Qualified Program. We discuss each item in detail below.

Table 10. Potential Sources of Error

Research Task	Survey Error		Non-Survey Error
	Sampling	Non-Sampling	
Trade Ally Interviews	None, census attempt	▪ Measurement error ▪ Nonresponse and self-selection bias ▪ Data processing error	N/A
Participant Survey	▪ Sampling error	▪ Measurement error ▪ Nonresponse and self-selection bias ▪ Data processing error	N/A
General Population Survey	▪ Sampling error	▪ Measurement error ▪ Nonresponse and self-selection bias ▪ Data processing error	N/A
Mapping Analysis	N/A	N/A	N/A
Gross Savings Calculations	N/A	N/A	Analysis error
Net Savings Calculations	N/A	N/A	Analysis error

The evaluation team took a number of steps to mitigate potential sources of error throughout the planning and implementation of the PY8 evaluation.

Survey Error

Sampling Error

For both surveys, there is the potential for sampling error, which is a reflection of the extent to which the sample is representative of the population from which it was pulled.

[3] Illinois Statewide Technical Reference Manual for Energy Efficiency V4.0. Effective June 2015.

[4] V4.0 Errata Measures Effective 06/01/2015 documenting 13 errata changes to version 4.0 of the IL-TRM that the Technical Advisory Committee (TAC) recommends be made, effective June 2015.

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 pretested each survey instrument, reviewed the pretest survey data, and monitored the telephone interviews as they were being conducted. We also used the pretests to determine that the length of the survey was reasonable.

- **Nonresponse and Self-Selection Bias**: Since the RR for the trade ally survey was approximately 32%, there is the potential for nonresponse bias. We attempted to mitigate possible bias by calling each potential respondent at least four times, or until we received a firm refusal, and by calling at different times of day, as appropriate. For the participant and general population survey, we had RRs of 22% and 7%, respectively. We attempted to mitigate bias on the participant survey by calling households multiple times, if needed, and by calling at different times of day. For the general population survey, the evaluation team for the Behavior Modification Program conducted an analysis comparing respondent characteristics with population characteristics and found only minimal differences (3% points or less) in demographic characteristics, suggesting that nonresponse bias was not a major source of error in those data. Unfortunately, the evaluation team does not have sufficient program-tracking data to conduct a similar assessment of nonresponse bias for the participant survey.

- **Data Processing Error**: The team addressed data 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

- **Analysis Errors**
  - **Gross and Net Impact Calculations*:*** We applied IL-TRM V4.0 algorithms to the participant data in the program-tracking database to calculate gross impacts. To minimize analytical errors, all impact calculations were reviewed by a separate team member to verify their accuracy.

3. Detailed Evaluation Findings

The following sections present detailed findings from the PY8 evaluation of the Income Qualified Program.

3.1 Program Design and Implementation

3.1.1 Program Design Changes

In general, the Income Qualified Program was implemented according to plan; however, there were numerous changes to the program in PY8 compared to PY7. Program changes include increases to program goals, budget, and incentives; streamlining of application forms; migration of program-tracking data to Leidos's Amplify platform; addition of an OBF; standardization of the quality assurance/quality control (QA/QC) process; development of a price comparison tool; and cross-promotion of the program through AIC's Behavior Modification Program. We provide additional detail on each of these changes below:

- **Program Goals, Budget, and Incentives:** The program goals and budget were increased in the middle of PY8 as participation increased, while the incentives for HVAC measures were decreased due to higher-than-expected demand for and incentive spend rate on HVAC measures.
- **Streamlined Application:** In PY8, the program streamlined its application process by eliminating redundancies and reducing the amount of pages that trade allies needed to fill out to participate in the program. This change came in response to PY7 evaluation findings from the trade ally survey, which revealed that filling out paperwork was not only time-consuming, but also prevented some contractors from running all of their qualified projects through the program (if the customer needs a quick project turnaround, for example).
- **Data Migration to Amplify:** The program began inputting and tracking data in Amplify, the Leidos database, which has been used for many years within the commercial and industrial portfolio. Implementation and program staff report that Amplify will improve the accuracy of data tracking and their ability to apply deemed savings values at the measure level.
- **Addition of an OBF Flag in Program-Tracking Data:** As recommended during the PY7 program evaluation, an OBF flag was included in the PY8 program-tracking database, which helped the evaluation team identify which projects, and corresponding participants and trade allies, used OBF.
- **QA/QC Standardization:** During PY8, implementation staff discovered several quality issues that affected the Home Efficiency Standard Program. Specifically, program staff mentioned safety hazards, such as insulation placed on heat sources, and vermiculite debris found underneath installed insulation. In response, through a joint effort with CLEAResult, Leidos' QA/QC Manager established a minimum inspection rate for projects, which required that the first five projects of each trade ally, as well as 10% of complete projects overall. Further, it established standard disciplinary protocols for trade allies that do not meet program QA/QC requirements. This QA/QC process has been implemented across several programs, including the Income Qualified Program.
- **Price Comparison Tool:** In the last quarter of PY8, CLEAResult developed a price comparison tool designed to help with the assessment of work scopes proposed by trade allies. The tool is used to establish program pricing and customer co-pays, as well as to identify financing opportunities. The tool compares proposed project cost, savings, and incentives to average program costs and savings by measure and assesses the overall quality of the proposed project against established parameters of

the Income Qualified Program. The price comparison tool is also capable of comparing the relative cost-effectiveness between or among proposed projects.

- **Cross-Promotion through the Behavioral Modification Program:** Toward the end of PY8, in spring 2016, cross-promotion of the Income Qualified Program began through Home Energy Reports (HERs) provided through the Behavioral Modification Program. Program implementation staff worked with Opower, the implementer of the Behavioral Modification Program, to develop marketing materials in print and digital formats. The marketing materials outlined the major benefits of the Income Qualified Program, including incentive information and general tips for saving energy. There was also a custom campaign page accessible by clicks or trackable links on the HERs, which attracted between 500 and 600 visitors per report.

Overall, these changes were implemented to streamline and improve program implementation, which contributes to the program's success. However, due to the implementation timing, the full impact of these changes may be more apparent in succeeding program years.

3.1.2 Program Marketing Efforts

Apart from the cross-promotion of the Income Qualified Program through the Behavioral Modification Program, the Income Qualified Program marketing efforts remained consistent between PY7 and PY8. These efforts included direct mail, such as bill inserts and targeted program recruitment letters sent to customers who may qualify for program. The program was also marketed through trade shows, service events, and customer service calls. However, trade allies conducted most of the outreach activities through co-branded materials. These combined marketing and outreach activities are done in an effort to increase program participation, which we discuss in the following section.

3.2 Program Participation

As noted above, the budget for the Income Qualified Program increased substantially from PY7 to PY8. As such, a key area of interest to this evaluation was the extent to which additional budget contributed to program growth, as well as how program participation has changed over time. In this section, we review current participation data alongside historical program delivery data to provide insight into how the program has grown and where there are areas for increased program delivery.

Program Participation Levels

In PY8, the Income Qualified Program served 1,019 participants or 86% of the 1,180 goal for PY8. Of these participants, nearly two-thirds (61%) received both an audit and a retrofit, while 39% received only a retrofit and 1% received only an audit.

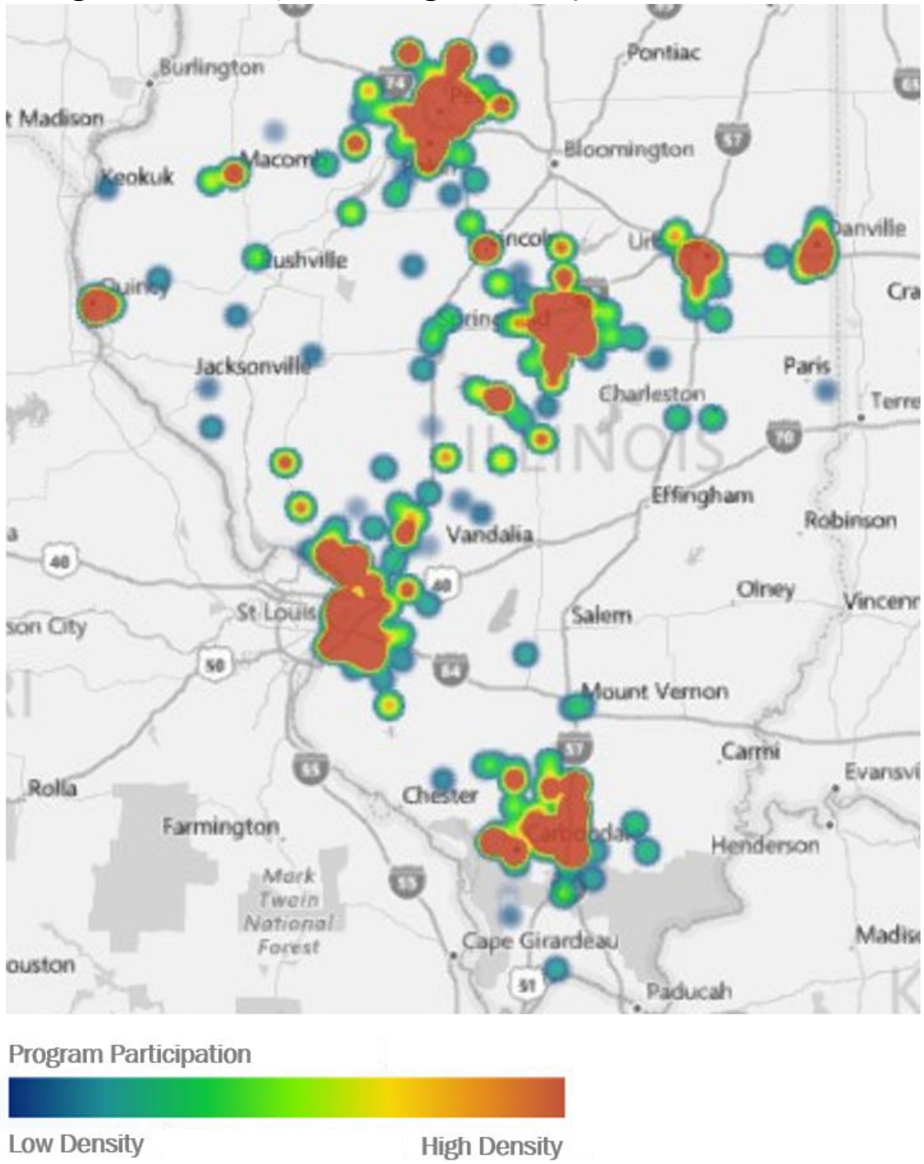
In addition to looking at participation overall, the evaluation team assessed the level of conversion from program audit to completed project (i.e., the percentage of customers who received an audit who went on to install equipment). The evaluation team calculated the PY8 conversion rate by dividing 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 received an audit in one year and received the associated retrofit in the following year complicate this calculation. To account for these participants, every evaluation year we update conversion rates across previous program years using cumulative results. Table 11 compares the updated conversion rates from PY4 through PY8 and shows that these rates increased from 80% in PY4 to 99% in PY8.

Table 11. PY4–PY8 Income Qualified Program Conversion Rates

Participant Type	PY4 Participants	PY5 Participants	PY6 Participants	PY7 Participants	PY8 Participants
(a) Audit and Retrofit	198	195	244	225	619
(b) Audit Only	48	27	19	12	7
(c) Retrofit Only	15	78	53	115	393
Total Participants = a + b + c	261	300	316	352	1,019
Total Audits = a + b	246	222	263	237	626
Conversion Rate = a/(a +b)	80%	88%	93%	95%	99%

In addition to examining trends in conversion rates, we sought to illustrate the geographic areas in which the Income Qualified Program has been most active over the last five years. To do this, we aggregated program-tracking data from PY4 through PY8 and created a heat map of program participation. As shown in Figure 1, areas of heavy program participation are denoted by red and areas of relatively light program participation are blue. From this map, a few key areas emerged as high program participation regions: Peoria, Springfield, Carbondale, and a large area just east of St. Louis. There are other, smaller "hot spots" shown in Figure 1; however, the majority of program delivery has taken place in these four regions.

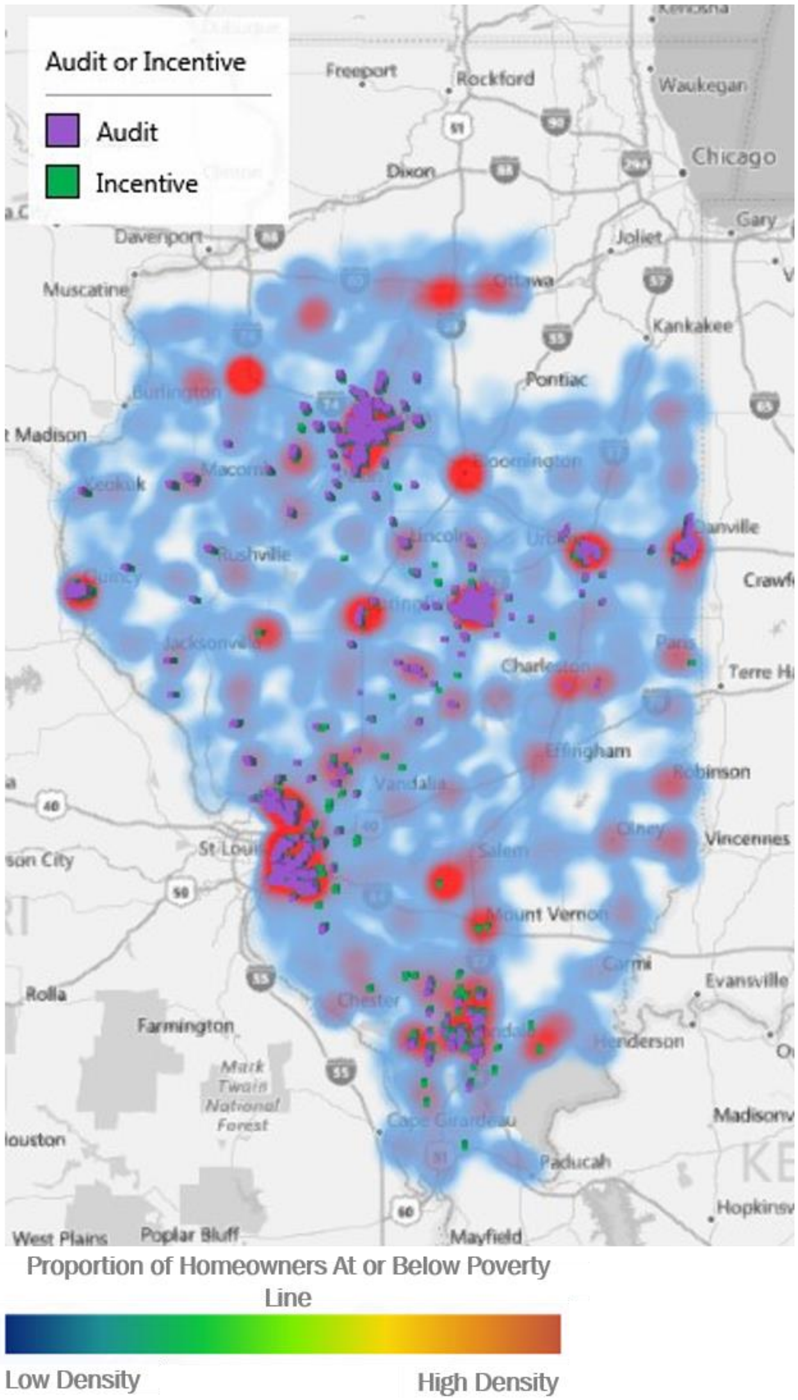
Figure 1. Income Qualified Program Participation from PY4 to PY8



In addition to mapping program participation, we linked program-tracking data with Census geo-location data.[5] In doing so, we were able to identify regions within AIC's territory that have a high percentage of low-income customers, and thus may benefit from the Income Qualified Program. Figure 2 shows program delivery (as indicated by purple and green dots) overlain with a census data heat map indicating areas where there are high densities of low-income homeowners (where red denotes a high density of these customers and blue denotes a low density). Areas such Bloomington, Burlington, and Ottawa appear to have a high density of customers in need, but currently are not areas of heavy program delivery.

[5] 2014 American Community Survey 5-year Estimates

Figure 2. Income Qualified Program Delivery with Census Data Overlay



We have included this program-tracking and census database as a deliverable to AIC, along with a memo describing the Microsoft Office components needed to use the interactive mapping function in Excel. Through this tool, AIC staff can examine program delivery as a function of a variety of demographic characteristics, across the entire AIC territory.

3.3 Participant Experience

Program Awareness Channels

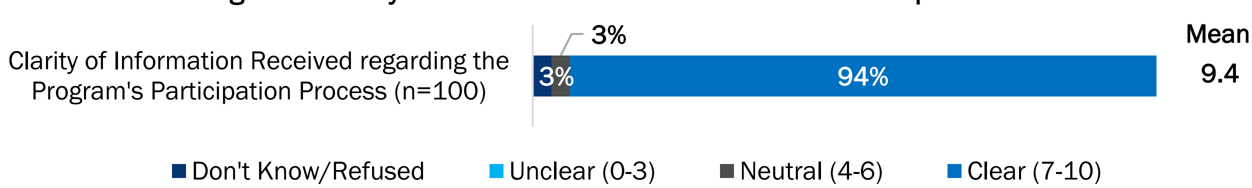
The most common way participants learned about the Income Qualified Program was through word of mouth from a friend, relative, or colleague (39%), followed by receiving a letter in the mail (21%) and through a contractor or trade ally (14%). Notably, these findings are consistent with the marketing activities of both Leidos and trade allies. As previously mentioned, one of the main marketing activities for the program was direct mail. Similarly, trade allies indicated that they market the program mainly through direct mail and door to door during service calls. In addition, trade allies reported that word ofmouth between or among customers has helped with program awareness (Section 3.3).

Table 12. Program Information Sources (Multiple Response)

Where did you first hear about the Home Efficiency Program?	Percent of Respondents (n=100)
Friend, relative or colleague	39%
Letter in the mail	21%
Contractor/ Trade ally	14%
Door flyer/hanger	4%
Other AIC source	4%
Advertisement	3%
AIC website	2%
Bill insert	2%
Postcard	1%
Public event	1%
Social media	1%
Trade Show	1%
Other	2%
Don't Know	6%

Regardless of how they learned about the program, 94% of participants indicated that the information they received about how to participate in the program was clear, with a mean score of 9.4, on a scale from 1 to 10.

Figure 3. Clarity of Information Received about the Participation Process



With regard to communication about future energy efficiency programs, most participants indicated that direct mail, email, or phone calls from AIC are the best ways to contact them.

Table 13. Preferred Source of Program Information

What are the best ways for Ameren Illinois to inform you about the energy efficiency programs it offers residential customers?	Percent of Respondents (n=100)
Letter in mail	54%
Email from AIC	16%
Phone call from an representative	12%
Bill insert	9%
Postcard	6%
AIC website	3%
Social media	3%
Advertising	2%
Door flyer/hanger	2%
Billboard	1%
Contractor/trade ally	1%
Door flyer/hanger	1%
News	1%
Word of mouth	1%
Don't know	8%

Participation through Audit vs. Retrofit

Despite the fact that customers are not required to conduct an energy audit to participate in the program, 77% of customers received an energy audit. Each participant who received an audit installed at least two energy efficiency measures, which suggests that participants are receptive to the information that they receive during audits.

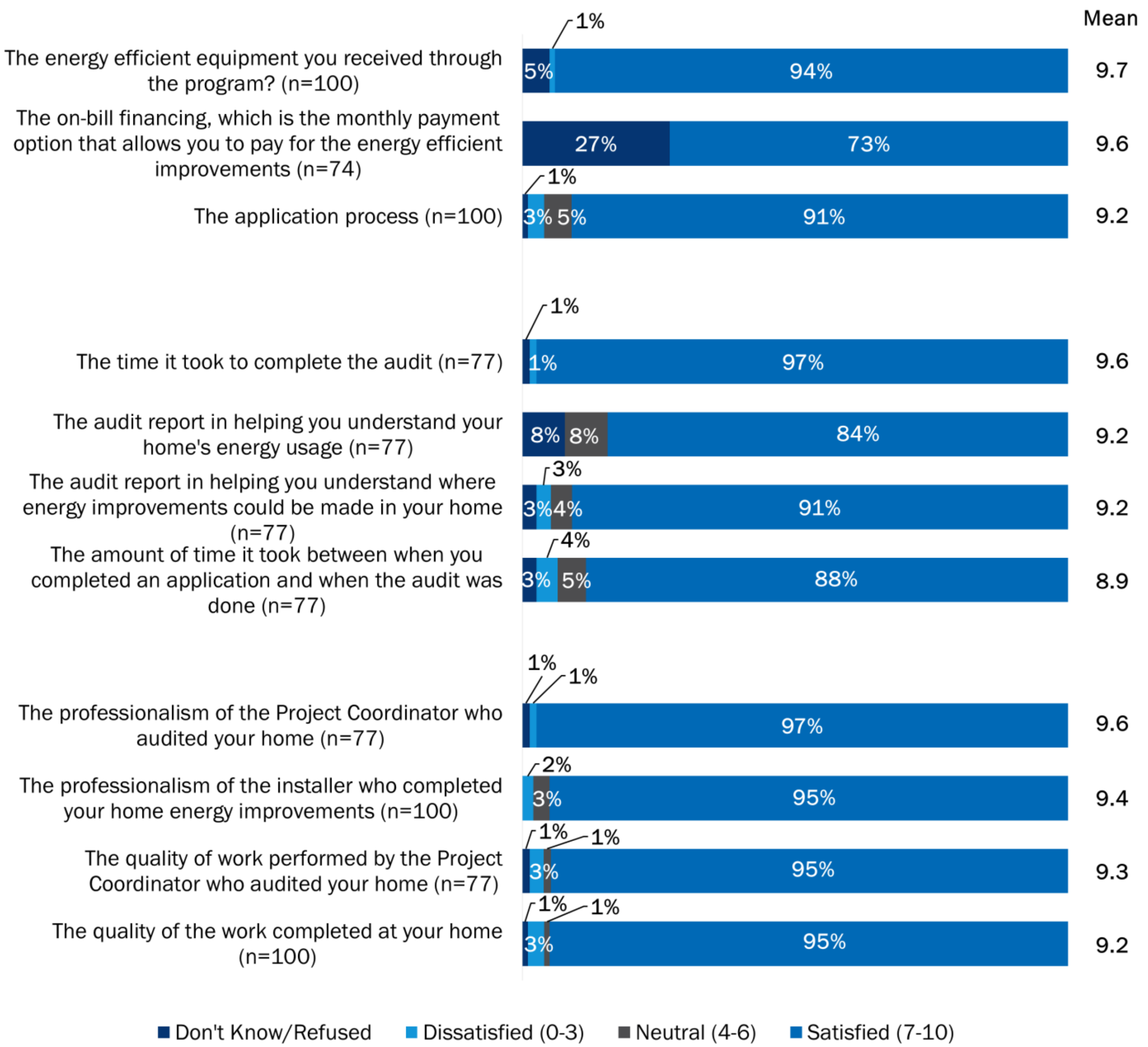
As mentioned earlier, some trade allies indicated that they were able to convince participants to do certain retrofits by educating them about their benefits, particularly when it came to less popular retrofits, such as insulation, crawl space, and air sealing. The energy audit seems to be an effective tool for communicating with customers about the different energy efficiency measures incentivized by the program, particularly those that are not as popular as HVAC equipment.

These are in line with the 99% conversion rate from an audit to a retrofit shown in Table 11 and suggests that the audit is highly effective in communicating with the participants about the program and encouraging participation.

Satisfaction with the Program

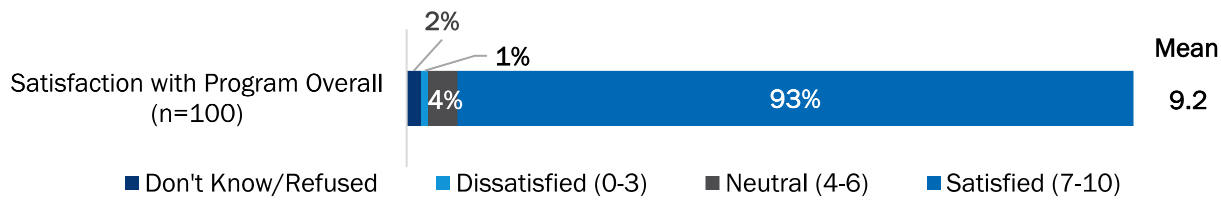
Most participants indicated that they were extremely satisfied with the various components of the program, as shown in Figure 4. A large majority of participants (94%) reported that they were satisfied with the measures that they received through the program, with a mean score of 9.7 on a scale from 1 to 10. Participants also indicated satisfaction with the energy audit, including the time it took to complete the energy audit (97%), as well as the content of the audit report in terms of its ability to help participants understand their energy usage (84%) and in terms of helping participants understand where energy improvements can be made in their homes (91%). A majority of participants were also pleased with the professionalism of the project coordinator who performed the audit (97%), as well as the quality of work performed by the project coordinator (95%). Participants also indicated satisfaction with the trade allies' work quality (95%).

Figure 4. Satisfaction with Program Components



Consistent with participants' satisfaction with the different program components, 93% of participants indicated that they were satisfied with the program overall, with a mean score of 9.2 on a scale from 1 to 10. The few instances of reported dissatisfaction (1%) were due to installation quality issues, a perceived increase in energy bills, and dissatisfaction with the energy-efficient equipment that they received through the program.

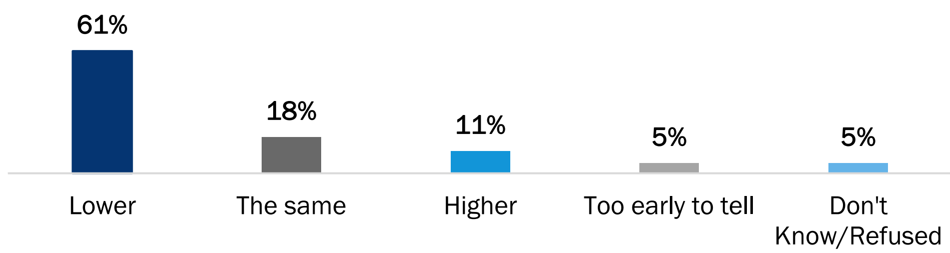
Figure 5. Overall Program Satisfaction



Perceived Program Benefits

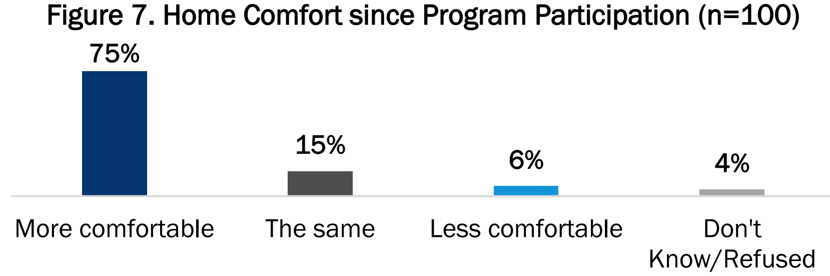
In addition to the participants' positive reception of the program, since participating, a majority of participants reported positive changes in their utility bill, their home comfort, and their homes' air quality. Almost two-thirds (61%) of participants reported that their utility bill decreased since their participation in the program, while 18% found no change and 11% noticed increases in their utility bills.

Figure 6. Change in Utility Bill since Program Participation (n=100)



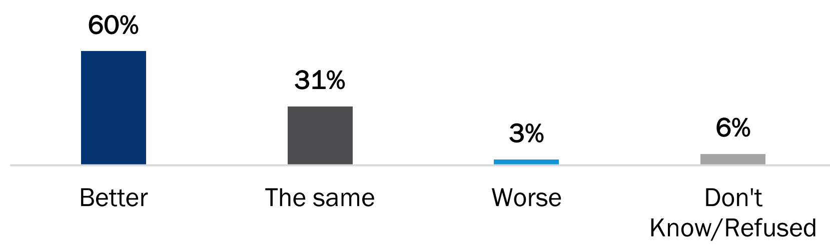
In addition to the changes in their utility bills, 75% of participants indicated that their home feels more comfortable after participating in the program.

Figure 7. Home Comfort since Program Participation (n=100)



Similarly, nearly two-thirds (60%) indicated that the air quality in their homes improved after participating in the program, while almost a third (31%) did not notice a change.

Figure 8. Air Quality since Program Participation (n=100)



These findings suggest that the Income Qualified Program is making progress toward achieving the program's objective of helping low-to-moderate income homeowners improve the comfort and efficiency of their homes and advocating energy efficiency within the AIC service territory.

We also asked participants about what they see as the main benefits of the program. More than a third of participants (36%) cited measure upgrades as one of the main benefits of the program, while almost one-fourth (22%) cited improved home comfort, followed by saving on their energy bills (16%) and the affordability of retrofits through OBF (11%).

Table 14. Main Benefits of Program Participation (Multiple Response)

Main Benefits to Participation	Percent of Respondents (n=100)
Measure upgrades	36%
Home comfort	22%
Save on energy bill	16%
Affordability due to OBF	11%
Cost savings	11%
Increased value of home	6%
Energy efficiency	2%
Good for environment	2%
Health and safety improvement	2%
Other	4%
Don't know	8%
None	3%

Suggestions for Program Improvement

Overall, almost half of the participants (46%) did not believe any changes were necessary to improve the program. Among those who offered suggestions, feedback included increased advertising or promotion efforts (8%) so that the program can reach more customers; streamlining the application process for customers to shorten wait times for approval of applications (6%); and following up or checking in on participants after retrofits are completed in case of feedback, questions, or interest in other retrofits (5%).

Table 15. Suggestions for Program Improvement

Suggestions for Program Improvement	Percent of Respondents (n=100)
Increase advertising or promotion to customers	8%

Suggestions for Program Improvement	Percent of Respondents (n=100)
Faster/smoother application process	6%
Follow up with participants after retrofit	5%
Faster completion of projects	4%
Improve quality of measure installation	4%
Better communication between customers, AIC, and trade allies	3%
Make program more budget-friendly/free	3%
Continue with program	2%
Option to OBF pay off sooner	2%
Provide detailed information regarding retrofits	2%
Provide information regarding program qualifications	2%
Other	13%
Don't know	8%
No suggestions	46%

3.4 Trade Ally Experience

The evaluation team conducted interviews with 23 participating trade allies to understand their level of satisfaction with the program and to gain their perspective on opportunities for improvement. As noted earlier, of the 23 trade allies, 9 had participated in the Income Qualified Program the previous year, while 14 were new to the program.

Trade Ally Firmographics

Most of the trade allies classified themselves as HVAC contractors. Two contractors indicated that they are also energy audit contractors (see Table 16). The 23 trade allies conducted an average of 52 jobs through the program in PY8 (a minimum of 1 and maximum of 321).

Table 16. Business Category (Multiple Response)

Business Category	Number of Respondents (n=23)
Contractor – HVAC	18
Contractor – Home Performance	6
Contractor – Insulation	3
Energy Consultant	2
Contractor - Other	1

Application Process a Main Barrier to Participation

One of the changes in PY8 was the streamlining of the application forms for the trade allies. Nearly half of returning trade allies reported that the application process was better in PY8 compared to previous program years, while a few new trade allies reported that the application process went smoothly. As one trade ally reported:

> "In 2015, everybody was pretty responsive, quick to get everything back to me, quick to pay and quick to approve everything."

Despite improvements, however, some trade allies cited issues with the application process in PY8, including delays in getting approvals for jobs, redundancies and multiple changes to application forms, and delays in receiving payment for jobs (Table 17).

Table 17. Issues with Application Process (Multiple Response)

Issues with Application Process	Number of Respondents (n=23)
No issues (process was smooth, better)	7
Approval process took too long	7
Issues with paperwork	6
Delays in payment	3
Issues with program/program staff changes	3
Lack of communication	2

As one trade ally reported:

> "It is taking very long to get a contract. It was like a month to get a contract. So I feel like that needs to improve greatly because we rely on that for cash flow. We are paying our guys. We are buying materials. That money is all spent and we are not paid for the job from Ameren or CLEAResult for eight weeks and then the AFC we were thinking that is more like four weeks. Well now it is like eight weeks too."

To streamline the application process, the trade allies had a few pointed recommendations. First, they suggested creating a single application form for them to fill out rather than having multiple forms, many of which have redundancies. Second, the trade allies would like to see improved communication about program changes to avoid confusion regarding program guidelines and the application process. Finally, the trade allies believe that shortening turnaround times for approving projects and providing partial payments for retrofits upfront in case payments are delayed would improve their experience with the program.

On-Bill Financing Key to Participation

All 23 trade allies reported having knowledge of the program's OBF component. The majority of trade allies (21 of 23) completed a job that used OBF, and all 21 of these trade allies noted that OBF helps sell jobs to customers. A few have noted that customers would not have participated in the program had it not been for the availability of OBF. One trade ally noted:

> "It helps a lot in the respect that because we're talking about a certain income level, people just don't have the out of pocket – they don't have the disposable cash to write a check for $1,500 or $2,000. So, it makes the whole project doable for them. With the financing… the thing that makes all the difference in the world. They can finance that so then the end result is their bill drops in half or say it drops 30% because they are high efficiency with insulation and air sealing they didn't have before, so now they're just going to tack a little bit back on over a period of three, five, or ten years to pay that back. So, it's really a win-win situation for the homeowner."

Notably, these 21 trade allies also reported that while applications for projects that include OBF take longer to be approved, the application forms for OBF have been very easy to fill out, in contrast to the program application forms.

Measures Influential to Participation

In addition to OBF and the incentives offered by the program, specific measures incentivized by the program also influenced participation. Nine trade allies indicated that participants were excited about getting new HVAC measures, such as furnaces and air conditioners, followed by insulation, as shown in Table 18.

Table 18. Measures Influential to Participation (Multiple Response)

Measures	Number of Respondents (n=23)
HVAC	9
Insulation	3
Any new and efficient measure	2
Boiler	1
Don't know	1
Other (Non Measure)	9

Since HVAC was cited as the most influential measure in terms of attracting participants into the program, it is also likely that any future changes to either HVAC measures or incentives would also affect customer participation.

In contrast, there are some measures offered by the program that trade allies have a hard time convincing participants to install, such as basement insulation or insulation in general, air sealing, and crawl space insulation. Trade allies reported that participants require some education regarding the benefits of such measures prior to having them installed.

Application Process Affects Completion of Jobs in 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 23 trade allies interviewed, 11 indicated that they did some jobs outside of the program and cited such reasons as the time it takes to complete the projects and having to fill out too much paperwork for small projects, as shown in Table 19.

Table 19. Reasons for Doing Jobs Outside Program

Reasons for Doing Jobs Outside of Program	Number of Respondents (n=11)
Time it takes to complete project	3
Too much paperwork for small job	2
Customer declined to participate in program	2
Could not afford measure	1
Work not covered by program	1
Neglected to send application by mistake	1
Did job through Standard Program instead	1

3.5 Future Program Offerings

To ensure that the program continues to meet the needs of AIC's customers, we asked trade allies, Income Qualified Program participants, and Income Qualified Program nonparticipants about the energy-related upgrades of particular interest to them. The Income Qualified Program participants were asked in an open-ended question to list measures of interest. They cited energy-efficient windows (19%), refrigerators (11%), additional insulation (9%), and hot water heaters (9%) as the key energy upgrades that they were interested in. Nonparticipating customers who met the program's income qualification criteria were provided a list of measures and asked to indicate which were of the most interest to them. The most popular responses were air sealing (16%), energy-efficient light bulbs (14%), hot water heaters (13%), and insulation (13%), as shown in Table 20.

Similarly, trade allies noted that, while the Income Qualified Program incentivizes a number of measures, there are some measures not incentivized by the program that would benefit participants and help make their homes more energy-efficient. These measures include ductwork, air quality solutions or ventilation, hot water heaters/tanks, electrical work, and measures that do not meet the program requirements, such as older boilers and thermostats. Of these suggested measures, we believe that ductwork is among the most promising, as it has high potential for savings and could feasibly be incorporated into the program.

Table 20. Percentage of Respondents Interested in Each Measure

Measures	Income Qualified Program Participants (n=73)	Income Qualified Program Nonparticipants (n=639)
Windows	19%	–
Refrigerators	11%	–
Insulation	9%	13%
Hot water heaters	9%	13%
Electrical/power outlets	8%	–
Roof	8%	–
Light bulbs	6%	14%
Doors	6%	–
Ventilation (i.e., fan, vents)	6%	–
Washer/dryer	6%	–
Other	6%	–
Central air conditioner	4%	11%
Stove	4%	–
Furnaces	2%	11%
Air sealing	2%	16%
WiFi-enabled thermostats	2%	10%
Heat pump	2%	–
Light fixtures	2%	–
Appliances - general	2%	–
LED bulbs	2%	–
Shower heads	–	7%
Faucet aerators	–	4%
Wall or window air conditioner	–	3%
Boilers	–	2%
Programmable thermostats	–	9%

Measures	Income Qualified Program Participants (n=73)	Income Qualified Program Nonparticipants (n=639)
Hot water tank/pipe insulation	–	8%
Duct insulation and sealing	–	11%
Ductless mini-split heat pumps	–	4%
None	9%	–

In addition to asking about energy efficiency measures that are of primary interest to participants and income qualified nonparticipants, we also explored whether introducing a co-payment for the home audit would deter participation and what amount these customers would be willing to pay for the audit. We gathered data from three sources to examine this issue: survey data from Income Qualified Program participants, survey data from income-qualified nonparticipants, and interview data from participating trade allies. For the participant and nonparticipant surveys, data were analyzed using the Van Westendorp Price Sensitivity Meter[6], which is an inquiry method that allows us to identify price ranges that consider customer financial constraints alongside the perceived value of a good or service. Specifically, customers were asked four questions about the value of the in-home audit:

- At what price would you consider the audit to be …
  - So expensive that you would not consider having one done? (Too expensive)
  - So low that you would feel the quality of the audit couldn't be very good? (Too cheap)
- At what price would you consider the audit to be…
  - Starting to get expensive, so that it is not out of the question, but you would have to give some thought to having one done? (Getting expensive)
  - A bargain—a great investment for the money? (Bargain)

Based on visual inspection of the data, our results suggest that for income-qualified nonparticipants, between \$25 and <\$50 is the ideal range for the cost of the in-home audit (i.e., where the co-pay is inexpensive enough that participants consider it a bargain, but it is not prohibitively expensive) (see Figure 9). In contrast, Income Qualified Program participants place a slightly higher value on the audit, with \$50 to <\$100 emerging as the range within which customers would be willing to pay for their in-home audit (see Figure 10). This increased value on the part of participants serves to underscore the findings previously reported regarding the benefits of the energy audits; it is clear that receiving an audit and knowing what one entails increases its perceived value.

[6] Source: "Van Westendorp pricing (the Price Sensitivity Meter)", 5 Circles Research (2016), accessed October 2016, http://www.5circles.com/van-westendorp-pricing-the-price-sensitivity-meter/.

Figure 9. Income-Qualified Nonparticipant Willingness-to-Pay for an Audit

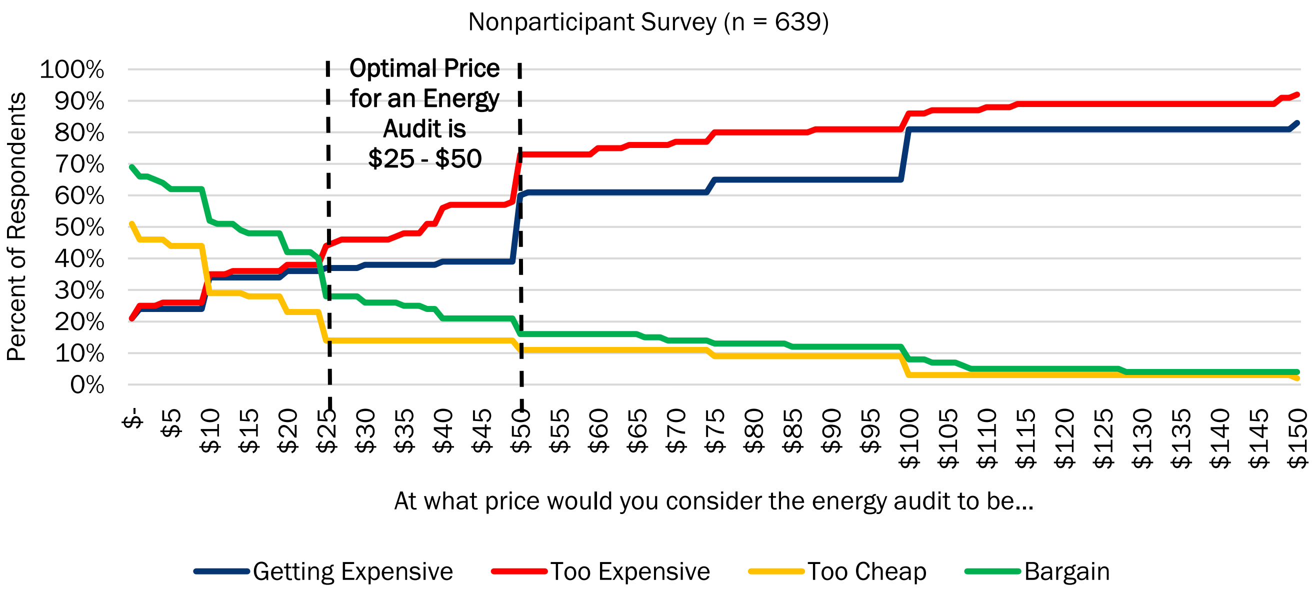
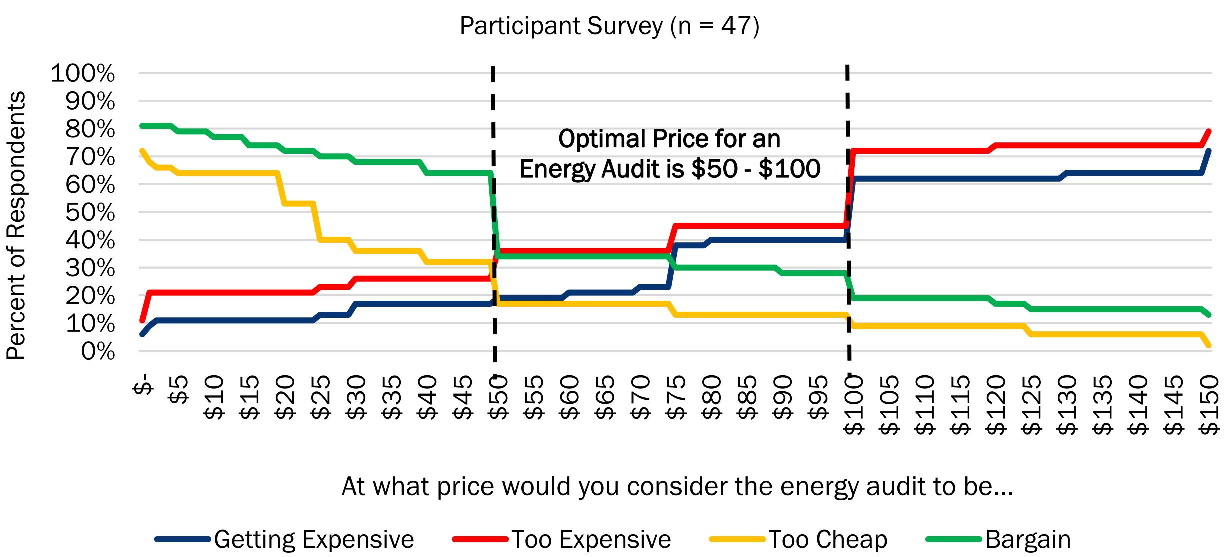


Figure 10. Income-Qualified Program Participant Willingness-to-Pay for an Audit



While qualitative in nature, the audit-conducting trade allies with whom we spoke largely felt that customers would be unable to pay a co-pay for an audit. Those that thought introducing a co-pay was feasible said it should be no more than $100, which aligns with the results from the customer surveys.

3.6 Impact Assessment

The evaluation team applied savings algorithms from the IL-TRM V4.0 using program-tracking database inputs and applied ISRs from the PY8 participant survey to estimate program gross savings. The evaluation team applied a NTGR of 1.0 to determine PY8 net savings.

3.6.1 Measure Verification

The program offers a variety of measures to participants, including lighting, aerators and shower heads, HVAC measures, and building shell measures. To determine the verified measure quantities, the evaluation team applied ISRs developed based on the PY8 participant survey to ex ante measure quantities. Table 21 summarizes the quantity of installed measures based on the team's review of the program-tracking database and compares the ex ante and ex post ISRs.

Table 21. PY8 Income Qualified Program Measure Quantities and In-Service Rates

Measure Category	Measure	Unit	Ex Ante ISR [a]	Ex Ante Measure Quantity [b]	Ex Post ISR[a] [c]	Verified Measure Quantity [b*c]
Lighting	Standard CFL (Spiral) – Low (13W–15W)	Bulb	97%	2,315	99%	2,297
	Standard CFL (Spiral) – Medium (18W–20W)	Bulb	97%	812	99%	806
	Standard CFL (Spiral) – High (23W–25W)	Bulb	97%	696	99%	691
	Specialty CFL – 9W Candelabra	Bulb	97%	1,327	99%	1,317
	Specialty CFL – 14W Globe	Bulb	97%	1,086	99%	1,078
	Specialty CFL – 15W Reflector	Bulb	97%	351	99%	348
Domestic Hot Water	Faucet Aerator	Aerator	95%	566	92%	522
	Shower Head	Shower Head	98%	413	77%	318
HVAC Equipment	Central Air Conditioner	Central Air Conditioner	100%	823	97%	795
	Air Source Heat Pump (ASHP)	Pump	100%	102	100%	102
	Furnace	Furnace	100%	816	96%	786
	Boiler	Boiler	100%	17	100%	17
Motor	Electronically Commutated (EC) Motor	Motor	100%	685	94%	643
HVAC (Controls)	Programmable Thermostat	Thermostat	100%	1,675	97%	1,621
Envelope	Air Sealing	CFM	100%	2,935,081	100%	2,935,081
	Attic Insulation	Square feet	100%	1,821,650	100%	1,821,650
	Wall Insulation	Square feet	100%	644,326	100%	644,326
	Rim Joist Insulation	Linear feet	100%	194,449	100%	194,449
	Basement Wall Insulation	Linear feet	100%	40,790	100%	40,790
	Crawl Space Insulation	Square feet	100%	106,023	100%	106,023
Total			N/A	**5,754,003**	**100%**	**5,753,660**

[a] ISRs come from PY8 participant survey results with the exception of boilers, air sealing, and insulation measures.

As shown in Table 21, the overall ex ante and verified measure quantities differ insignificantly and yield an overall ex post ISR of 100%. Even though there are notable differences between ex ante and ex post ISRs on a per-measure level, the difference to the overall measure quantity is negligible.

3.6.2 Ex Post Gross Impact Results

The total ex post gross impacts for the PY8 Income Qualified Program are 3,047 MWh, 1.29 MW, and 568,483 therm savings. As shown in Table 22, there is close alignment between the ex ante and ex post gross impact with gross realization rates of 98% for electric savings, 97% for demand savings, and 99% for therm savings.

Table 22. PY8 Income Qualified Program Gross Impacts

Program Component	Number of Participants	Ex Ante Gross[a]			Ex Post Gross		
		MWh	MW	Therms	MWh	MW	Therms
Income Qualified Program	1,019	3,098	1.33	571,594	3,047	1.29	568,483
Gross Realization Rate[b]					98%	97%	99%

[a] Source of ex ante savings: PY8 program-tracking database.
[b] The gross realization rate is calculated as the PY8 ex post gross savings divided by the PY8 ex ante gross savings.

Table 23 summarizes the ex post gross electric impact results by measure. There was a fairly wide range of gross realization rates, from 62% to 108%.

Table 23. Income Qualified Program Electric Impacts by Measure

Measure	Verified Measure Quantity	Unit	Ex Ante Gross Impacts		Ex Post Gross Impacts		Gross Realization Rate[a]	
			MWh	MW	MWh	MW	MWh	MW
Air Sealing	2,935,081	CFM	934	0.472	797	0.495	85%	105%
Central Air Conditioner	795	Air Conditioner	586	0.412	558	0.376	95%	91%
ASHP	102	Pump	494	0.071	513	0.077	104%	108%
EC Motor	643	Motor	321	0.142	457	0.133	142%	94%
Attic Insulation	1,821,650	Square Feet	220	0.102	174	0.083	79%	81%
Crawl Space Insulation	106,023	Square Feet	120	0.029	122	0.030	102%	102%
Programmable Thermostat	846	Thermostat	86	–	83	–	97%	N/A
Wall Insulation	644,326	Square Feet	70	0.049	70	0.050	101%	103%
Standard CFL (Spiral) – Low (13W–15W)	2,297	Bulb	55	0.006	58	0.006	104%	102%
Specialty CFL – 9W Candelabra	1,317	Bulb	49	0.005	51	0.005	105%	102%
Specialty CFL – 14W Globe	1,078	Bulb	32	0.004	34	0.004	106%	102%
Standard CFL (Spiral) – High (23W–25W)	691	Bulb	27	0.003	28	0.003	104%	102%
Rim Joist Insulation	194,449	Linear Feet	31	0.015	25	0.009	82%	62%
Standard CFL (Spiral) – Medium (18W–20W)	806	Bulb	20	0.002	22	0.002	111%	102%
Basement Wall Insulation	40,790	Linear Feet	20	0.010	22	0.010	111%	103%
Specialty CFL – 15W Reflector	348	Bulb	14	0.002	16	0.002	111%	102%
Shower Head – Electric	40	Shower Head	13	0.001	11	0.001	78%	78%

Measure	Verified Measure Quantity	Unit	Ex Ante Gross Impacts		Ex Post Gross Impacts		Gross Realization Rate[a]	
			MWh	MW	MWh	MW	MWh	MW
Faucet Aerator – Electric	60	Aerator	4	0.002	4	0.002	97%	97%
Total	**5,751,341**		**3,098**	**1.330**	**3,047**	**1.290**	**98%**	**97%**

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

Table 24 summarizes the ex post gross therm impact results by measure, which also show a wide range of gross realization rates.

Table 24. Income Qualified Program Therm Impacts by Measure

Measure	Verified Measure Quantity	Unit	Ex Ante Gross Impacts	Ex Post Gross Impacts	Gross Realization Rate[a]
			Therms	Therms	Therms
Furnace	786	Furnace	192,529	185,755	96%
Air Sealing	2,935,081	CFM	174,258	174,611	100%
Attic Insulation	1,821,650	Square Feet	65,251	51,672	79%
Crawl Space Insulation	106,023	Square Feet	48,102	44,456	92%
Programmable Thermostat	775	Thermostat	40,159	38,943	97%
Wall Insulation	644,326	Square Feet	30,797	30,935	100%
Basement Wall Insulation	40,790	Linear Feet	22,189	18,191	82%
Rim Joist Insulation	194,449	Linear Feet	8,947	10,104	113%
Boiler	17	Boiler	2,473	9,255	374%
Shower Head – Gas	278	Shower Head	3,986	3,128	78%
Faucet Aerator – Gas	462	Aerator	1,474	1,433	97%
Total	**5,744,637**		**590,164**	**568,483**	**99%**

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. In particular, differences in the inputs for cooling equipment, gas furnaces, and air sealing have the largest impact on program-level realization rates. Cooling equipment and air sealing account for approximately 35% and 30%, respectively, of the total ex ante electric savings. Gas furnaces and air sealing account for 33% and 30%, respectively, of the total ex ante therm savings. Therefore, any differences within these measures affect the program savings significantly. Table 25 summarizes the source of difference between ex ante and ex post gross savings.

Table 25. Reasons for Realization Rates per Measure

Measure	Gross Realization Rate			Source of Discrepancy				
	MWh	MW	Therms	Pre- and Post-Installation R-Value	Waste Heat Factors	HVAC Efficiency	ISRs	Other Discrepancies
Air Sealing	85%	105%	100%			✓		• Incorrect algorithm for cooling energy savings

Measure	Gross Realization Rate			Source of Discrepancy				
	MWh	MW	Therms	Pre- and Post-Installation R-Value	Waste Heat Factors	HVAC Efficiency	ISRs	Other Discrepancies
Central Air Conditioner	95%	91%	N/A				✓	
ASHP	104%	108%	N/A			✓		
EC Motor	142%	94%	N/A				✓	• Excluded cooling season savings
Attic Insulation	79%	81%	79%	✓				• Missing demand savings for those with cooling and electric resistance heating
Crawl Space Insulation	102%	102%	92%					
Programmable Thermostat	97%	N/A	97%				✓	
Wall Insulation	101%	103%	100%					
Standard CFLs	106%	102%	N/A		✓			
Specialty CFLs	106%	102%	N/A		✓			
Rim Joist Insulation	82%	62%	113%					• Rim joist height assumptions • Incorrect adjustment factor
Basement Wall Insulation	111%	103%	82%	✓		✓		• Total basement wall height • Miscalculated savings for those with electric resistance heating
Shower Head	78%	78%	78%				✓	
Faucet Aerator	97%	97%	97%				✓	
Furnace	N/A	N/A	96%				✓	
Boiler	N/A	N/A	374%			✓		

Through our discussions with the implementer, we identified the sources of the differences between ex ante and ex post savings. 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. We describe the differences in the ex ante and ex post savings calculations in detail below.

- **Air Sealing Discrepancies:**
  - **Incorrect Algorithm for Cooling Energy Savings:** All variable inputs for air sealing measures were consistent across ex ante and ex post assumptions (with the exception of heating efficiencies, which we detail below). The implementer confirmed that the algorithm in the program-tracking database was input incorrectly, and therefore it miscalculated energy savings for those with cooling only. Because of this error, ex ante overestimated savings by 18% for those with cooling only. This reduced the overall air sealing realization rate by 12%. Since air sealing accounts for 30% of the program's reported energy savings, this discrepancy had a significant impact on the overall program realization rate.
  - **HVAC Efficiency:** Ex ante savings calculations applied heating efficiencies for those with heat pumps of either 1.70 coefficient of performance (COP) or 0.00 COP, bringing the overall average to 1.46 COP. The source from which the ex ante heating efficiency was referenced is unknown. Ex post savings used the heating equipment age provided within the program-tracking database to assign the appropriate heating efficiency (varies by equipment age) as stated in the IL-TRM V4.0 The average ex post heating efficiency (2.40 COP) is 64% greater than the average ex ante heating efficiency (1.46 COP). As a result, ex ante savings overestimated energy savings by 3%.
- **ASHP Discrepancies:**
  - **HVAC Efficiency:**
    - **Heating Efficiency:** Ex ante and ex post savings calculations applied the actual heating efficiencies as provided in the program-tracking database. However, there were two cases in the database where the heating efficiency was zero. For these cases, ex post applied the average heating efficiency (Heating System Performance Factor [HSPF] 8.7) from those with known heating efficiencies (n=100). Ex ante savings used the heating efficiency of zero, thus excluding heating savings for these two cases. As a result, ex ante underestimated energy savings by 4%.
    - **Cooling Efficiency:** Ex ante savings mistakenly applied the baseline cooling efficiency for the replacement of ASHPs (8.55 Energy Efficiency Ratio [EER]) to measures that replaced central air conditioners (8.15 EER). As a result, ex ante underestimated demand savings by 8%.
- **EC Motor Discrepancies:**
  - **Excluded Cooling Season Savings**: Ex ante calculations underestimated energy savings by 51% by excluding blower motor savings during the cooling season. The exclusion of cooling savings was not intentional, as ex ante not only defines the cooling savings deemed value to be included in their algorithms but also provides demand savings.
- **Attic Insulation Discrepancies:**
  - **Pre- and Post-Installation R-Value:** Ex ante estimates applied the preexisting and post-retrofit R-values for all participants based on the values provided in the program-tracking database. Typically, ex post savings apply the same method, but the implementer informed us that these values were unreliable due to inconsistent data collection. For example, sometimes the contractors provide the values and sometimes they leave the field blank and other staff populate it later. Due to these concerns, the implementer advised the evaluation team not to use this

information for ex post calculations and instead to use the assumed R-values indicated in the measure label (see Appendix A for more detail). As a result, ex ante overestimated savings by 12%.

  - **Missing Demand Savings:** Ex ante savings excluded demand savings for those with central air conditioning and electric resistance heating. Since ex ante calculations include demand savings for participants with heat pumps and central air conditioners with gas heating, the evaluation team feels the exclusion of these savings was not intentional. As a result, ex ante understated demand savings by 2%.

- **Specialty and Standard CFL Discrepancies:**

  - **Waste Heat Factors:** Ex ante energy savings included the waste heat factor heating penalty for all standard and specialty CFLs, which resulted in less ex ante savings (approximately 6%) compared to ex post. Consistent with past evaluations, the evaluation team did not include waste heat factor heating penalties for lighting in the calculation of ex post savings. Removing the heating penalty from ex ante savings would have resulted in realization rates of 100% for standard and specialty CFLs.

- **Rim Joist Insulation Discrepancies:**

  - **Rim Joist Height:** Ex ante calculations overestimated rim joist insulation savings by 7% by assuming a rim joist height of 0.933 feet, which assumes 2x12 framing. Ex post savings included a rim joist height assumption of 0.85 feet, which is the average of 2x10 and 2x12 framing. The implementer confirmed that there was an equal mix of 2x10 and 2x12 framing in homes where rim joist insulation was installed. Therefore, using an average rim joist height for 2x10 and 2x12 framing is more accurate.

  - **Adjustment Factor:** Ex ante savings applied the adjustment factor from the IL-TRM V4.0 for above-grade walls (0.63). However, this adjustment factor was incorrect because rim joint insulation is below grade. Ex post estimates applied the adjustment factor for (below-grade) basement walls (0.88) from the IL-TRM V.4.0. As a result, ex ante estimates understated savings for rim joist insulation by 13%.

- **Basement Wall Insulation Discrepancies:**

  - **Basement Wall Height:** Ex ante savings assumed a basement wall height of 4 feet (3 feet below grade). This is because code requires insulation in the top 4 feet of the basement wall. However, in past discussions the implementer confirmed that they install basement wall insulation for the entire wall. Ex post savings assumed a basement wall height of 7 feet (6 feet below grade), which is a more representative value per previous discussions with the implementer. The basement wall height and the amount of basement wall below grade affected the below-grade R-value. Ex ante assumed a below-grade R-value of R-6.4 (3 feet below grade) and ex post used the below-grade R-value of R-9.5 (6 feet below grade). As a result, ex ante underestimated savings by 2%.

  - **HVAC Efficiency:** Ex ante savings calculations incorrectly assigned a gas heating efficiency (70% Annual Fuel Utilization Efficiency [AFUE]) for one participant with a heat pump, bringing the overall average for heat pump efficiency to 1.98 COP. Ex post savings used the heating equipment age provided within the program-tracking database to assign the appropriate heating efficiency (varies by equipment age) as stated in the IL-TRM V4.0 The average ex post heating efficiency (2.40 COP) is 21% greater than the average ex ante heating efficiency (1.98 COP). As a result, ex ante savings overestimated energy savings by 2%.

- **Miscalculated Savings for Electric Resistance Heating:** Ex ante savings miscalculated savings for 50% (2 of 4) of the participants with electric resistance heating. The total ex ante savings for these two participants were assigned the deemed per-measure savings instead of the total savings for installed basement wall insulation (in linear feet). As a result, ex ante underestimated savings by 9%.

- **Boiler Discrepancies:**
  - **HVAC Efficiency:** Ex ante savings applied the time of sale (TOS) baseline efficiency (82% AFUE) to all boilers that were specified as early replacement (ER) cases. Ex post savings used the baseline efficiency specified in the IL-TRM V4.0 for ER boilers (61.6% AFUE). As a result of this error, ex ante underestimated savings by 274%.

In addition to the discrepancies summarized above, it is important to note some of the challenges the evaluation team encountered in using the first year of residential data from Amplify. As noted, the evaluation team typically compares all variable assumptions across all program measures to identify those that drive the differences between ex ante and ex post estimates. However, the ex ante savings for PY8 (calculated using Amplify) provide the assumptions as hard-coded values as opposed to showing the algorithm syntax. As a result, we suspect that there may be mistakes within the savings algorithms inputted into the program, but we cannot verify that visually. In particular, we believe this occurred for air sealing (cooling-only measures) and rim joist insulation, as there are no discrepancies between ex ante and ex post variable assumptions and no other reason savings would differ.

3.6.3 Ex Post Net Impact Results

The evaluation team applied a NTGR of 1.0 to the evaluated gross savings. In PY3, the evaluation team discussed and reached agreement with AIC staff that a NTGR of 1.0 is reasonable given that the program targets participants with household incomes between 0% and 300% of the federal poverty level guidelines for household size. As such, program participants are unlikely to have installed many of the measures offered through the program without assistance. Ex post gross impacts and ex post net impacts are, therefore, identical (see Table 26).

Table 26. PY8 Income Qualified Program Net Impacts

Program Component	Number of Participants	Ex Ante Net[a]			Ex Post Net		
		MWh	MW	Therms	MWh	MW	Therms
Income Qualified Program	1,019	3,098	1.33	571,594	3,047	1.29	568,483
				Net Realization Rate[b]	98%	97%	99%

[a] Source of ex ante savings: PY8 program-tracking database.
[b] The net realization rate is calculated as the PY8 ex post net savings divided by the PY8 ex ante net savings.

4. Conclusions and Recommendations

We identify the following areas for program improvement:

- **Key Finding #1.** Through the trade ally interviews, we learned 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). Extended lead times on payments could discourage and limit program participation.
  - **Recommendation:** Reducing the administrative burden on trade allies would help make the program more attractive and increase satisfaction with the program. As such, we suggest looking for additional ways that this process can be streamlined. Part of this streamlining should include looking for opportunities to reduce the amount of time it takes to pay trade allies.
- **Key Finding #2.** In their interviews, trade allies revealed that many customers' homes had major energy inefficiencies (e.g., windows or doors that did not close properly). This finding is underscored by the survey data from program participants where "windows" emerged as one of the most popular responses to the question about what measures were of interest to them.
  - **Recommendation:** We recommend that AIC consider partnering with other organizations in its territory that could provide support to customers with measures that are not covered by the program.
- **Key Finding #3**. By mapping program participation over the last four years, the evaluation team identified areas within AIC's territory with a high density of low-income homeowners, but historically scant program delivery.
  - **Recommendation**: We recommend that AIC staff begin incorporating the interactive mapping tool that we have provided into future program planning. By carefully examining areas of relatively low participation, the AIC team can begin to determine the best approach to increase participation in those areas.
- **Key Finding #4**. AIC customers reported that they are willing to provide a $25 to <$100 co-payment for an audit. However, trade allies were dubious about customers' willingness and ability to provide a co-payment.
  - **Recommendation:** We recommend that if AIC introduces a co-pay, that it is less than $100. Further, AIC may want to customize the co-pay amount on a sliding scale from $25 to <$100 so that households of less means receive the assistance that they need.
- **Key Finding #5.** Per our ex post savings calculations, the evaluation team identified several discrepancies in savings assumptions between the ex ante and ex post savings calculations.
  - **Recommendation:** To increase the accuracy of tracked savings (and improve realization rates), we recommend that the Income Qualified Program adopt the ex post assumptions and savings calculations used by the evaluation team.
- **Key Finding #6.** The evaluation team found a few discrepancies within ex ante calculations where per-measure savings were used in place of the total ex ante savings or different variable assumptions were used instead of what was planned.

  - **Recommendation**: We recommend reviewing the syntax language to verify that all algorithms and variable assumptions are referenced correctly.

- **Key Finding #7.** The evaluation team identified some instances where data across the program-tracking database did not agree. For example, measure labels indicate heating fuel types do not always match the heating fuel type provided in the database, heating and cooling HVAC equipment are not always aligned, pre- and post-installation R-values for insulation measures are sometimes reversed, and data were provided that did not accurately reflect characteristics of the installed measures (such as actual pre- and post-insulation R-values in the PY8 program-tracking database).

  - **Recommendation**: We recommend reviewing the program-tracking databases prior to submitting to the evaluation team to minimize these types of discrepancies.

Appendix A. Engineering Analysis Algorithms

In PY8, the impact evaluation efforts estimated gross impact savings for the Income Qualified Program by applying savings algorithms from the IL-TRM V4.0 using the information provided in the program-tracking database.

We present the algorithms and input variables used to calculate all evaluation program savings below.

A.1 Lighting Measures Algorithms

The evaluation team determined ex post lighting savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 1. Standard and Specialty CFL Algorithms

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

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

Where:

WattsBase = Wattage of existing equipment

Table 27. Baseline Wattages for Lighting Measures

Measure	EISA Adjusted[a]	Baseline Wattage	Resource
Standard CFL (Spiral) – Low (13W–15W)	Yes	43	IL-TRM V4.0
Standard CFL (Spiral) – Medium (18W–20W)	Yes	53	IL-TRM V4.0
Standard CFL (Spiral) – High (23W–25W)	Yes	72	IL-TRM V4.0
Specialty CFL – 9W Candelabra	No	40	IL-TRM V4.0
Specialty CFL – 14W Globe	No	60	IL-TRM V4.0
Specialty CFL – 15W Reflector	No	65	IL-TRM V4.0

[a] The 2007 Energy Independence and Security Act (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 CFL

Table 28. CFL Wattages for Lighting Measures

Measure	CFL Wattage	Resource
Standard CFL (Spiral) – Low (13W–15W)	13	Actual installed CFL wattage
Standard CFL (Spiral) – Medium (18W–20W)	20	
Standard CFL (Spiral) – High (23W–25W)	23	
Specialty CFL – 9W Candelabra	9	
Specialty CFL – 14W Globe	14	
Specialty CFL – 15W Reflector	15	

ISR = In-service rate of installed CFLs = 99.2% (PY8 participant survey results)

HOURS = Annual operating hours

Table 29. Annual Hours of Use for Lighting Measures

Measure	Hours
Standard CFL (Spiral)	793
Specialty CFL (Globe)	639
Specialty CFL (Candelabra)	1,190
Specialty CFL (Reflector)	861

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 (CF)

Table 30. Coincidence Factors for Lighting Measures

Measure	CF
Standard CFL (Spiral)	0.074
Specialty CFL (Globe)	0.075
Specialty CFL (Candelabra)	0.121
Specialty CFL (Reflector)	0.091

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 Illinois Commerce Commission (ICC) and AIC, we do not include heating penalties in the ex post energy savings, but will include this in the data for the PY8 cost-effectiveness analysis.

Equation 2. Lighting Measures Heating Penalty Algorithms

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

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

Where:

WattsBase = Wattage of existing equipment (see Table 27)

WattsEE = Wattage of installed CFLs (see Table 28)

ISR = In-service rate of the percentage of units rebated that get installed = 99.2% (PY8 participant survey results)

HOURS = Annual operating hours (see Table 29)

HF = Heating Factor = 0.49

ISR = In-service rate of installed CFLs = 99.2% (PY8 participant survey results)

ηHeat = Efficiency of heating equipment (we used the COP for heat pumps for those manufactured between 2006 and 2014)

Table 31. ηHeat for Lighting Measures Heating Penalties

Measure	ηHeat	Units
Heat Pump (Before 2006)	2.00	COP
Heat Pump (2006–2014)	2.26	COP
Heat Pump (2015 and beyond)	2.40	COP
Electric Resistance	1.00	COP
Gas Heating	0.70	AFUE

Table 32 summarizes the heating penalties for the six lighting measures offered through the program by heating equipment type.

Table 32. Per-Measure Heating Fuel Penalties for CFL Lighting

Heating Equipment	Measure	ΔkWh	Δtherms
Heat Pump (Heating only)	CFL – Low (13W–15W)	−5.12	N/A
	CFL – Medium (18W–20W)	−5.63	N/A
	CFL – High (23W–25W)	−8.36	N/A
	Specialty CFL – 9W Candelabra	−7.94	N/A
	Specialty CFL – 14W Globe	−6.32	N/A
	Specialty CFL – 15W Reflector	−9.26	N/A
Electric Resistance	CFL – Low (13W–15W)	−11.57	N/A
	CFL – Medium (18W–20W)	−12.72	N/A
	CFL – High (23W–25W)	−18.89	N/A
	Specialty CFL – 9W Candelabra	−17.94	N/A
	Specialty CFL – 14W Globe	−14.29	N/A
	Specialty CFL – 15W Reflector	−20.93	N/A
Gas Heating	CFL – Low (13W15W)	N/A	−0.56
	CFL – Medium (18W–20W)	N/A	−0.62
	CFL – High (23W–25W)	N/A	−0.92
	Specialty CFL – 9W Candelabra	N/A	−0.87
	Specialty CFL – 14W Globe	N/A	−0.70
	Specialty CFL – 15W Reflector	N/A	−1.02

A.3 Water Heating Conservation Measure Algorithms

The evaluation team determined ex post water heating conservation measure savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 3. Low-Flow Shower Head Algorithms

Energy Savings: *ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR*

Demand Savings: *ΔkW = ΔkWh / 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 shower head or faucet aerator (see Table 33)

GPM_low = As-used flow rate of the low-flow shower head or faucet aerator (see Table 33)

Table 33. Gallons per Minute (GPM) for Water Heating Conservation Measures

Measure	GPM_base	GPM_low
Faucet Aerator	1.39	0.94
Shower Head	2.67	1.75

L_base = Length (in minutes) per baseline shower head or baseline faucet (see Table 34)

L_low = Length (in minutes) per low-flow shower head or low-flow faucet (see Table 34)

Table 34. L_base for Water Heating Conservation Measures

Measure	Minutes
Faucet Aerator	9.0
Shower Head	7.8

Household = Average number of people per household = 2.56

SPCD = Showers per capita per day = 0.60

SPH = Shower heads per household for single-family homes = 1.79

DF = Drain factor = 79.5% (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 water heater (see Table 35)

EPG_gas = Energy per gallon of hot water supplied by gas water heater (see Table 35)

Table 35. EPG for Water Heating Conservation Measures

Measure	EPG_electric	EPG_gas
Faucet Aerator	0.09190	0.00394
Shower Head	0.11700	0.00501

ISR = In-service rate of installed low-flow shower heads or low-flow aerators

Table 36. ISR for Water Heating Conservation Measures

Measure	ISR
Faucet Aerator	92.3%
Shower Head	76.9%

Source: PY8 Participant Survey.

Hours = Annual recovery hours for shower head or faucet use

Table 37. Hours for Water Heating Conservation Measures

Measure	Hours
Faucet Aerator[a]	52
Shower Head	302

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

CF = Summer Peak CF

Table 38. Coincidence Factors for Water Heating Conservation Measures

Measure	CF
Faucet Aerator	0.0220
Shower Head	0.0278

A.4 Programmable Thermostat Algorithms

The evaluation team calculated ex post programmable thermostat savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 5. Programmable Thermostat Algorithms

*ΔkWh_heating (electric heat) = %ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR*

Gas Savings (gas heat): *ΔTherms = %FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR*

*ΔkWh_heating (gas heat furnace fan run time reduction) = ΔTherms ** 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 and electric heating type [i.e., electric resistance, heat pump])

Table 39. 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 40. Gas Heating Consumption by Climate Zone

Climate Zone	Therms
1 (Rockford)	1,052
2 (Chicago)	1,005
3 (Springfield)	861
4 (Belleville)	664
5 (Marion)	676

Heating_Reduction = Reduction in heating energy consumption due to installing a 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 = 96.8% (PY8 participant survey results)

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

A.5 Gas Boiler

The evaluation team determined ex post gas boiler savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 6. Gas Boiler Algorithms

$$\text{(Time of Sale) Gas Savings: } \Delta Therms = Gas\_Boiler\_Load * ((1 / AFUE_{base}) - (1 / AFUE_{eff})) * ISR$$

$$\text{(Early Replacement) Gas Savings: } \Delta Therms = Gas\_Boiler\_Load * ((1 / AFUE_{exist}) - (1 / AFUE_{eff})) * ISR$$

Where:

Gas_Boiler_Load = Estimated annual household load for gas boiler for single-family homes (applied per participant based on project location)

Table 41. Gas Boiler Load by Climate Zone

Climate Zone	Gas_Boiler Load (Therms)
1 (Rockford)	1,275
2 (Chicago)	1,218
3 (Springfield)	1,043
4 (Belleville)	805
5 (Marion)	819

$AFUE_{base}$ = Baseline boiler efficiency for TOS installations in units of AFUE = 82% AFUE[7]

$AFUE_{exist}$ = Baseline boiler efficiency for ER installations in units of AFUE = 61.6% AFUE

$AFUE_{eff}$ = Efficiency of newly installed boiler in units of AFUE = 92.5%

ISR = In-service rate of installed boilers = 100.0%

A.6 Gas Furnace Algorithms

The evaluation team determined ex post gas furnace savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 7. Gas Furnace Algorithms

$$\text{(Time of Sale) Gas Savings: } \Delta Therms = Gas\_Furnace\_Htg\_Load * ((1 / AFUE_{base}) - (1 / AFUE_{eff})) * ISR$$

$$\text{(Early Replacement) Gas Savings: } \Delta Therms = Gas\_Furnace\_Htg\_Load * ((1 / AFUE_{exist}) - (1 / AFUE_{eff})) * ISR$$

Where:

Gas_Furnace_Htg_Load = Estimated annual household heating load for gas furnace for single-family homes (applied per participant based on project location)

Table 42. Gas Furnace Load by Climate Zone

Climate Zone	Gas_Furnace_Htg_Load (Therms)
1 (Rockford)	873
2 (Chicago)	834
3 (Springfield)	714
4 (Belleville)	551
5 (Marion)	561

$AFUE_{base}$ = Baseline furnace efficiency for TOS installations in units of AFUE = 80% AFUE

$AFUE_{exist}$ = Baseline furnace efficiency for ER installations in units of AFUE = 64.4% AFUE

$AFUE_{eff}$ = Efficiency of newly installed furnace in units of AFUE = 95% AFUE

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[7] Illinois TRM V4.0 specifies a baseline boiler efficiency of 82% AFUE for program years beyond 2013.

ISR = In-service rate of installed furnaces = 96.3% (PY8 participant survey results)

A.7 Air Source Heat Pump Algorithms

The evaluation team determined ex post ASHP savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 8. Air Source Heat Pump Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*(Time of Sale) ΔkWh_cooling = ((FLH_cooling * Capacity_Cooling * ((1 / $SEER_{base}$) – (1 / $SEER_{eff}$))) / 1,000 * ISR*

*(Early Replacement) ΔkWh_cooling = ((FLH_cooling * Capacity_Cooling * ((1 / $SEER_{exist}$) – (1 / $SEER_{eff}$))) / 1,000 * ISR*

*(Time of Sale) ΔkWh_heating (electric heat) = ((FLH_heating * Capacity_heating * ((1 / $HSPF_{base}$) – (1 / $HSPF_{eff}$))) / 1,000 * ISR*

*(Early Replacement) ΔkWh_heating (electric heat) = ((FLH_heating * Capacity_heating * ((1 / $HSPF_{exist}$) – (1 / $HSPF_{eff}$))) / 1,000 * ISR*

*(Time of Sale) Demand Savings: ΔkW = (Capacity_cooling * ((1 / EER_{base}) – (1 / EER_{eff})) / 1,000)*CF * ISR*

*(Early Replacement) Demand Savings: ΔkW = (Capacity_cooling * ((1 / EER_{exist}) – (1 / EER_{eff})) / 1,000)*CF * ISR*

Where:

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 43. Full Load Cooling Hours by Climate Zone

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

Capacity_Cooling = Cooling capacity of ASHP in units of Btuh (actual from database)

$SEER_{base}$ = Baseline ASHP cooling efficiency for TOS installations in units of Seasonal Energy Efficiency Ratio (SEER) (varies by replaced equipment type)

Table 44. Time of Sale Cooling Efficiency ($SEER_{base}$)

Replaced Equipment	$SEER_{base}$
ASHP	14
Central Air Conditioner	13

$SEER_{exist}$ = Baseline ASHP cooling efficiency for ER installations in units of SEER

Table 45. Early Replacement Cooling Efficiency ($SEER_{exist}$)

Replaced Equipment	$SEER_{exist}$
ASHP	9.12
Central Air Conditioner	8.60

$SEER_{eff}$ = Cooling efficiency of newly installed ASHP in units of SEER (actual from database)

FLH_heating = Full Load Heating Hours (applied per participant based on project location)

Table 46. Full Load Heating Hours by Climate Zone

Climate Zone	FLH_heating
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288

Capacity_Heating = Heating capacity of ASHP in units of Btuh (actual from database)

$HSPF_{base}$ = Baseline ASHP heating efficiency for TOS installations in units of HSPF (varies by replaced equipment type)

Table 47. Time of Sale Heating Efficiency ($HSPF_{base}$)

Replaced Equipment	$HSPF_{base}$
ASHP	8.20
Electric Resistance	3.41

$HSPF_{exist}$ = Baseline ASHP heating efficiency for ER installations in units of HSPF

Table 48. Early Replacement Heating Efficiency ($HSPF_{exist}$)

Replaced Equipment	$HSPF_{exist}$
ASHP	5.44
Electric Resistance	3.41

$HSPF_{eff}$ = Heating efficiency of newly installed ASHP in units of HSPF (actual from database)

EER_{base} = Baseline ASHP cooling efficiency for TOS installations in units of EER

Table 49. Time of Sale Cooling Efficiency (EER_{base})

Replaced Equipment	EER_{base}
ASHP	11.76
Central Air Conditioner	11.18

EER_{exist} = Baseline ASHP cooling efficiency for ER installations in units of EER

Table 50. Early Replacement Cooling Efficiency (EER_{exist})

Replaced Equipment	EER_{exist}
ASHP	8.55

Replaced Equipment	EER_{exist}
Central Air Conditioner	8.15

EER_{eff} = Cooling efficiency of newly installed ASHP in units of EER (actual from database)

ISR = In-service rate of installed ASHPs = 100.0% (PY8 participant survey results)

CF = Summer Peak CF = 0.72

A.8 Central Air Conditioner Algorithms

The evaluation team determined ex post central air conditioner savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 9. Central Air Conditioner Algorithms

*(Time of Sale) ΔkWh_cooling = ((FLH_cooling * Capacity_Cooling * ((1 / $SEER_{base}$) − (1 / $SEER_{eff}$))) / 1,000 * ISR*

*(Early Replacement) ΔkWh_cooling = ((FLH_cooling * Capacity_Cooling * ((1 / $SEER_{exist}$) − (1 / $SEER_{eff}$))) / 1,000 * ISR*

*(Time of Sale) Demand Savings: ΔkW = (Capacity_cooling * ((1 / EER_{base}) − (1 / EER_{eff})) / 1,000) * CF * ISR*

*(Early Replacement) Demand Savings: ΔkW = (Capacity_cooling * ((1 / EER_{exist}) − (1 / EER_{eff})) / 1,000) * CF * ISR*

Where:

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 51. Full Load Cooling Hours by Climate Zone

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

Capacity_Cooling = Cooling capacity of air conditoiner in units of Btuh (actual from database when availabe, if unknown we applied 33,600 BTUh per IL-TRM V4.0)

$SEER_{base}$ = Baseline central air conditioner cooling efficiency for TOS installations in units of SEER (varies by replaced equipment type) = 13 SEER

$SEER_{exist}$ = Baseline central air conditioner cooling efficiency for ER installations in units of SEER = 10 SEER

$SEER_{eff}$ = Cooling efficiency of newly installed central air conditioner in units of SEER (actual from database)

EER_{base} = Baseline central air conditioner cooling efficiency for TOS installations in units of EER = 11.18 EER

EER_{exist} = Baseline central air conditioner cooling efficiency for ER installations in units of EER = 9.20 EER

EER_{eff} = Cooling efficiency of newly installed central air conditioner in units of EER (actual from database)

ISR = In-service rate of installed central air conditioners = 96.6% (PY8 participant survey results)

CF = Summer Peak CF = 0.68

A.9 EC Motor Algorithms

The evaluation team determine ex post EC motor savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 10. EC Motor Algorithms

$$\Delta kWh = \Delta kWh\_cooling + \Delta kWh\_heating + \Delta kWh\_shoulder * ISR$$

$$\Delta kWh\_cooling \text{ (unkown if have CAC)} = 241 \text{ kWh (deemed value)}$$

$$\Delta kWh\_heating = 418 \text{ kWh (deemed value)}$$

$$\Delta kWh\_shoulder = 51 \text{ kWh (deemed value)}$$

$$\Delta kW = \Delta kWh\_cooling / FLH\_cooling * CF$$

$$\Delta therms = - \Delta kWh\_heating * 0.03412 * ISR$$

Where:

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 52. Full Load Cooling Hours by Climate Zone

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

ISR = In-service rate of installed EC Motors = 93.9% (PY8 participant survey results)

CF = Summer Peak CF = 0.68

A.10 Air Sealing Algorithms

The evaluation determined ex post air sealing savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 11. Air Sealing Algorithms

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

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

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

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

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

$\Delta kWh\_heating$ (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[8]

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

Table 53. 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 = SEER of cooling system (applied per participant based on existing equipment age provided in database)

Table 54. ηCool for Air Sealing Measures

Cooling Equipment Age	SEER	Source
Before 2006	10.00	IL-TRM V4.0
2006–2014	13.00	
Central Air Conditioner after 1/1/2015	13.00	
Heap Pump after 1/1/2015	14.00	
Unknown Central Air Conditioner Age[a]	11.09	Average SEER for those with known central air conditioner equipment age (n=742)
Unknown Heat Pump Age[a]	11.63	Average SEER for those with known heat pump equipment age (n=27)

[8] Assumed CZ2 Normal Exposure.

[a] The program-tracking database does not include cooling equipment age for 14% (n=119) of participants with central air conditioners and 4% (n=1) of participants with heat pumps.

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

Table 55. Latent Multiplier by Climate Zone

Climate Zone	Latent Multiplier
1 (Rockford)	3.3
2 (Chicago)	3.2
3 (Springfield)	3.7
4 (Belleville)	3.6
5 (Marion)	3.7

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions = 15.75[9]

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

Table 56. 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 space heating equipment (applied per participant based on existing equipment age provided in database)

Table 57. ηHeat for Air Sealing Measures

Existing Heating Equipment	Equipment Age	COP	Source
Heat Pump	Before 2006	1.70	IL-TRM V4.0
	2006–2014	1.92	
	2015 and beyond	2.40	
	Unknown[a]	2.40	Average COP for those with known heat pump equipment age (n=27)
Electric Resistance	N/A	1.00	IL-TRM V4.0
Gas Furnace	N/A	0.70	IL-TRM V4.0

[a] The program-tracking database does not include heating equipment age for 4% (n=1) of participants with heat pumps.

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 58. Full Load Cooling Hours by Climate Zone

Climate Zone	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570

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

Climate Zone	FLH_cooling
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903

ISR = In-service rate of air sealing = 100.0%

CF = Summer Peak CF (varies by cooling equipment type)

Table 59. 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.11 Attic and Wall Insulation Algorithms

The evaluation team determined ex post attic and wall insulation savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 12. 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 13. Wall Insulation Algorithms

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

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

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

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

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

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

Where:

R_old = Total attic or wall assembly R-value prior to installing insulation (assumed R-11 per implementer; actual R-values per participant were unreliable).[10] For attic insulation, we added R-0.68 (indoor air film) and R-0.15 (3/4" plaster) to account for total assembly R-value.[11] The total assembly pre R-value for wall insulation is R-5 (per IL-TRM V4.0).

Table 60. Pre-Assembly R-value for Attic and Wall Insulation

Measure	Pre-Installation R-value
Attic Insulation (R-11 to R-49) - uninsulated	5.00[a]
Attic Insulation (R-11 to R-49)	11.83
Attic Insulation (R-19 to R-49)	19.83
Wall Insulation	5.00

[a] From IL-TRM V4.0 for uninsulated assemblies.

R_new = Total attic or wall assembly R-value after the installation of additional insulation (assumed R-49 per implementer; actual post R-values per participant were unreliable).[12] For attic insulation we added R-0.68 (indoor air film) and R-0.15 (3/4" plaster) to account for total assembly R-value.[13] The total assembly R-value for wall insulation is R-16 (which includes R-5 (uninsulated wall) and added R-11).

Table 61. Post-Assembly R-value for Attic and Wall Insulation

Measure	Post-Installation R-value
Attic Insulation (R-11 to R-49)	49.83
Attic Insulation (R-19 to R-49)	49.83
Wall Insulation	16.00

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

[10] The program-tracking database included the pre- and post-installation R-values per participant. However, these data were collected with inconsistent methods, such as contractors that include actual and accurate values, blank values later populated by personnel with R-values identical to the measure name (not actual value), R-values not typical of installation application (those that exceed normal R-values), etc. The implementer advised us not to use this information for PY8. However, data collection for PY9 will represent accurate pre- and post-installation R-values that vary by participant and reflect the actual installed R-values for attic and wall insulation.

[11] We used the ASHRAE Isothermal Planes method (page 27.3, ASHRAE Fundamentals, 2013) to determine the R-values for indoor air film and ¾" plaster.

[12] The program-tracking database included the pre- and post-installation R-values per participant. However, these data were collected with inconsistent methods, such as contractors that include actual and accurate values, blank values later populated by personnel with R-values identical to the measure name (not actual value), R-values not typical of installation application (those that exceed normal R-values), etc. The implementer advised us not to use this information for PY8. However, data collection for PY9 will represent accurate pre- and post-installation R-values that vary by participant and reflect the actual installed R-values for attic and wall insulation.

[13] We used the ASHRAE Isothermal Planes method (page 27.3, ASHRAE Fundamentals, 2013) to determine the R-values for indoor air film and ¾" plaster.

Table 62. 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 63. 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 = SEER of cooling system (applied per participant based on existing equipment age provided in database)

Table 64. ηCool for Attic and Wall Insulation Measures

Cooling Equipment Age	SEER	Source
Before 2006	10.00	IL-TRM V4.0
2006–2014	13.00	
Central Air Conditioner after 1/1/2015	13.00	
Heap Pump after 1/1/2015	14.00	
Unknown Central Air Conditioner Age (Wall Insulation)[a]	11.18	Average SEER for those with known central air conditioner equipment age (n=285)
Unknown Central Air Conditioner Age (Attic Insulation)[a]	11.16 (R-11 to R-49) 10.91 (R-19 to R-49)	Average SEER for those with known central air conditioner equipment age (R-11 to R-49: n=497) (R-19 to R-49: n=188)
Unknown Heat Pump Age (Attic Insulation)[b]	11.87 (R-11 to R-49)	Average SEER for those with known heat pump equipment age (n=15)

[a] The program-tracking database does not include cooling equipment age for 17% (n=59) of participants who installed wall insulation, 13% (n=76) of participants who installed R-11 to R-49 attic insulation, and 13% (n=29) of participants who installed R-19 to R-49 attic insulation for those with central air conditioners.

[b] The program-tracking database does not include cooling equipment age for 6% (n=1) of participants who installed R-11 to R-49 attic insulation for those with heat pumps. All cooling equipment ages were provided in the tracking database for participants who installed wall insulation and R-19 to R-49 attic insulation for those with heat pumps.

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

Table 65. 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 space heating equipment (applied per participant based on existing equipment age provided in database)

Table 66. ηHeat for Attic and Wall Insulation Measures

Existing Heating Equipment	Equipment Age	COP	Source
Heat Pump	Before 2006	1.70	IL-TRM V4.0
	2006–2014	1.92	
	2015 and beyond	2.40	
	Unknown (Attic Insulation)[a]	2.40 (R-11 to R-49)	Average COP for those with known heat pump equipment age (n=15)
Electric Resistance	N/A	1.00	IL-TRM V4.0
Gas Furnace	N/A	0.70	IL-TRM V4.0

[a] The program-tracking database does not include heating equipment age for 6% (n=1) of participants who installed R-11 to R-49 attic insulation for those with heat pumps.

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 67. Full Load Cooling Hours by Climate Zone

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

ISR = In-service rate of attic and wall insulation = 100.0%

CF = Summer Peak CF (varies by cooling equipment type)

Table 68. 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%

A.12 Rim Joist Insulation and Basement Wall Insulation Algorithms

The evaluation team calculated ex post basement wall insulation and rim joist insulation savings using the algorithms below. The IL-TRM V4.0 does not provide algorithms specifically for rim joist insulation; therefore, we applied the basement sidewall insulation algorithms to determine rim joist insulation savings. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 14. Rim Joist Insulation Algorithms

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

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

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

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

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

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

Equation 15. Basement Sidewall Insulation Algorithms

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

$$\Delta kWh\_cooling = (((1 / R\_old\_AG_{basement} - (1 / (R\_added + R\_old\_AG_{basement}))) * L\_basement\_wall\ total * H\_basement\_wall\_AG * (1 - Framing\_factor)) * 24 * CDD * DUA) / (1{,}000 * \eta Cool) * ISR$$

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

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

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

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

Where:

$R\_old\_AG_{RimJoist}$ = R-value of existing foundation wall assembly above grade

Table 69. Rim Joist Above-Grade R-value

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

Source: ASHRAE Fundamentals, 2013 Section 27.3.

$R\_old\_AG_{basement}$ = R-value of existing foundation wall above grade = R-1.0

R_old_BG = R-value of existing foundation wall below grade (including thermal resistance of Earth) = 9.46 (for 6' below-grade basement wall)

R_added = R-value of additional insulation (per implementer) = R-11

L_rimjoist = Total linear feet of installed insulation (ft)

L_basement_wall_total = Length of basement wall for the insulated perimeter (ft) (actual from database)

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

H_basement_wall_AG = Height of above-grade insulated basement wall (ft) = 1.0 ft

H_basement_wall_total = Total height of basement wall = 7.0 ft

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

Table 70. Framing Factor for Rim Joist and Basement Wall Insulation

Measure	Framing Factor
Rim Joist	0.25
Basement Wall	0.00

ADJ = Adjustment to account for prescriptive engineering algorithms over claiming savings = 0.88

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

Table 71. Cooling Degree Days by Climate Zone for Unconditioned Basement

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 = SEER of cooling system (applied per participant based on existing equipment age provided in database)

Table 72. ηCool for Rim Joist and Basement Wall Insulation Measures

Cooling Equipment Age	SEER	Source
Before 2006	10.00	IL-TRM V4.0
2006–2014	13.00	
Central Air Conditioner after 1/1/2015	13.00	
Heap Pump after 1/1/2015	14.00	
Unknown Central Air Conditioner Age[a]	11.00 (Basement Wall) 11.10 (Rim Joist)	Average SEER for those with known central air conditioner equipment age (basement wall; n=180) (rim joist; n=614)

[a] The program-tracking database does not include cooling equipment age for 14% (n=29) of participants who installed basement wall insulation and 14% (n=102) of participants who installed rim joist insulation for those with central air conditioners.
Note: All cooling equipment ages were provided in the tracking database for participants who installed basement wall and rim joist insulation for those with heat pumps.

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

Table 73. 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 space heating equipment (applied per participant based on existing equipment age provided in database)

Table 74. ηHeat for Rim Joist and Basement Wall Insulation Measures

Existing Heating Equipment	Equipment Age	COP	Source
Heat Pump	Before 2006	1.70	IL-TRM V4.0
	2006–2014	1.92	
	2015 and beyond	2.40	
Electric Resistance	N/A	1.00	IL-TRM V4.0
Gas Furnace	N/A	0.70	IL-TRM V4.0

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 75. Full Load Cooling Hours by Climate Zone

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

ISR = In-service rate of installed basement wall and rim joist insulation = 100.0%

CF = Summer Peak CF (varies by cooling equipment type)

Table 76. Rim Joist and Basement 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%

A.13 Crawl Space Insulation Algorithms

The evaluation team calculated ex post crawl space insulation savings using the algorithms below. All variable assumptions are from the IL-TRM V4.0 unless otherwise referenced.

Equation 16. Crawl Space Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*ΔkWh_cooling = (((1 / R_old_AG – (1 / (R_added + R_old_AG))) * LF * H_AG * (1 – Framing_factor)) * 24 * CDD * DUA) / (1,000 * ηCool) * ISR*

*ΔkWh_heating (electric heat) = [(((1 / R_old_AG – (1 / (R_added + R_old_AG))) * LF * H_AG * (1 – Framing_factor)) + ((1 / R_old_BG – (1 / R_added + R_old_BG))) * LF * H_BG * (1 – Framing_Factor))) * 24 * HDD] / (3,412 * ηHeat) * ADJ) * ISR*

Demand Savings: *ΔkW = (ΔkWh_cooling / FLH_cooling) * CF*

Gas Savings (gas heat): *ΔTherms = [(((1 / R_old_AG – (1 / (R_added + R_old_AG))) * LF * H_AG * (1 – Framing_factor)) + ((1 / R_old_BG – (1 / R_added + R_old_BG))) * LF * H_BG * (1 – Framing_Factor))) * 24 * HDD] / (100,067 * ηHeat) * ADJ) * ISR*

*ΔkWh_heating (gas heat furnace fan run time reduction) = ΔTherms * F_e * 29.3*

Where:

R_old_AG = Above-grade existing R-value of crawl space = 1.0

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

R_added = R-value of additional insulation (per implementer) = R-11

ADJ = Adjustment to account for prescriptive engineering algorithms over claiming savings = 0.88

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

H_AG = Height of crawl space wall above grade = 1.0 foot

H_BG = Height of crawl space 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 (basement) (applied per participant based on project location)

Table 77. Cooling Degree Days by Climate Zone for Unconditioned Basement

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 SEER of cooling system (applied per participant based on existing equipment age provided in database)

Table 78. ηCool for Crawl Space Insulation Measures

Cooling Equipment Age	SEER	Source
Before 2006	10.00	IL-TRM V4.0
2006–2014	13.00	
Central Air Conditioner after 1/1/2015	13.00	
Heap Pump after 1/1/2015	14.00	
Unknown Central Air Conditioner Age[a]	11.13	Average SEER for those with known central air conditioner equipment age (n=378)

[a] The program-tracking database does not include cooling equipment age for 13% (n=54) of participants with central air conditioners.
Note: All cooling equipment ages were provided in the tracking database for participants who installed crawl space insulation for those with heat pumps.

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

Table 79. 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 space heating equipment (applied per participant based on existing equipment age provided in database)

Table 80. ηHeat for Crawl Space Insulation Measures

Existing Heating Equipment	Equipment Age	COP	Source
Heat Pump	Before 2006	1.70	IL-TRM V4.0
	2006–2014	1.92	
	2015 and beyond	2.40	
Electric Resistance	N/A	1.00	IL-TRM V4.0

Existing Heating Equipment	Equipment Age	COP	Source
Gas Furnace	N/A	0.70	IL-TRM V4.0

FLH_cooling = Full Load Cooling Hours (applied per participant based on project location)

Table 81. Full Load Cooling Hours by Climate Zone

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

ISR = In-service rate of crawl space insulation = 100.0%

CF = Summer Peak CF (varies by cooling equipment type)

Table 82. Crawl Space 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%

Appendix B. Data Collection Instrument

Trade Ally In-Depth Interview Guide

Ameren PY8 - HEIQ
Trade Ally In-Depth I

Participant Survey

Ameren PY8 - HEIQ
Participant Survey_F

Appendix C. Survey Response Rate Methodology

The survey RR is the number of completed interviews divided by the total number of potentially eligible respondents. We calculated RR3 using the standards and formulas set forth by the AAPOR.[14] The formulas used to calculate RR3 are presented below. The definitions of the letters used in the formulas are displayed in the Survey Disposition tables (Table 4 and Table 6). The RR for this survey was 38%.

Equation 17. Formula for Response Rate 3

$$RR3 = \frac{I}{\left(I + N + e1(U1 + e2 * U2)\right)}$$

Where:

$$e1 = \frac{(I + N)}{(I + N + X1)}$$

$$e2 = \frac{(I + N + X1 + U1)}{(I + N + X1 + U1 + X2)}$$

[14] *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. Participant Survey Respondent Demographic Profile

The demographic characteristics of the participant survey respondents are present in Table 83.

Table 83. Survey Respondent Demographic Profile

Demographic Category	Percent
Type of Home (n=100)	
Single-Family Detached Home (no common walls)	94%
Single-Family Attached Home (townhouse or duplex)	6%
Home Ownership (n=100)	
Own	98%
Rent/Lease	2%
Size of Household by Occupant (n=100)	
1	29%
2	22%
3	20%
4	11%
5	11%
6	4%
7	2%
8	1%
Size of Home by Square Footage (n=100)	
Less than 1,000	18%
1,000–1,499	39%
1,500–1,999	23%
2,000–2,999	10%
3,000–3,999	2%
4,000–4,999	0%
5,000 or more	0%
Don’t Know/Refused	8%
Educational Attainment (n=100)	
Less than ninth grade	4%
High school graduate (includes GED)	27%
Some college, no degree	23%
Associates degree	17%
Bachelor’s degree	21%
Graduate or professional degree	6%
Don’t Know/Refused	2%
Annual Household Income in 2015 (n=100)	
Less than $15,000	11%
$15,000 to less than $20,000	11%
$20,000 to less than $30,000	27%
$30,000 to less than $40,000	15%
$40,000 to less than $50,000	9%
$50,000 to less than $75,000	12%
$75,000 to less than $100,000	7%
Don’t Know/Refused	8%

Appendix E. Cost-Effectiveness Inputs

Table 84 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 and the reduction in waste heat for EC motors. 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 program savings were reduced by 0.1% for kWh and 3.4% for therms after the application of waste heat factors.

Table 84. PY8 Income Qualified Program Gross Impacts (Including Heating Penalties)

	kWh	kW	Therms
Gross Savings	3,047,023	1,289	568,483
Lighting Heating Penalty	−3,542	0	−4,441
EC Motor Heating Penalty	0	0	−15,170
Total Gross Savings with Heating Penalty	**3,043,481**	**1,289**	**548,872**

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 6,587 lamps based on heating fuel type and installed lamp type. The heating fuel type is known for 96% (6,350 lamps) of the installed lighting measures. For the remaining 237 lamps with unknown space heating fuel types, we applied waste heat factors assuming gas heating as directed per the IL-TRM V4.0. The program-tracking database did not provide the equipment type for those with electric heating; therefore, the evaluation team used data from the PY7 database to estimate the number of lamps installed in homes with heat pumps or electric resistance heating. The evaluation team found that 30% of PY7 lamps installed in homes with electric heating were installed in homes with electric resistance heating, and the remaining 70% were installed in homes with heat pumps. Table 85 summarizes the percentages of installed lamps for each heating fuel type.

Table 85. PY8 Income Qualified Program Known Heating Fuel Type for Lighting Measures

Heating Fuel	Heating Equipment	% of Installed Lamps
Electric	Electric Resistance	1.69%
Electric	Heat Pump	4.02%
Gas	Furnace/Boiler	94.29%

The total heating penalty for lighting measures is 3,542 kWh and 4,441 therms.

EC Motor Heating Penalty

High efficiency EC motors operate at cooler temperatures than traditional furnace blower motors. The amount of heat released decreases due to cooler operating conditions. Heating equipment must make up for this loss of heat during the heating season, resulting in an increase in HVAC heating loads (negative therm savings). We applied the heating penalty to all 685 EC motors incented within the program for a total heating penalty of 15,170 therms.

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