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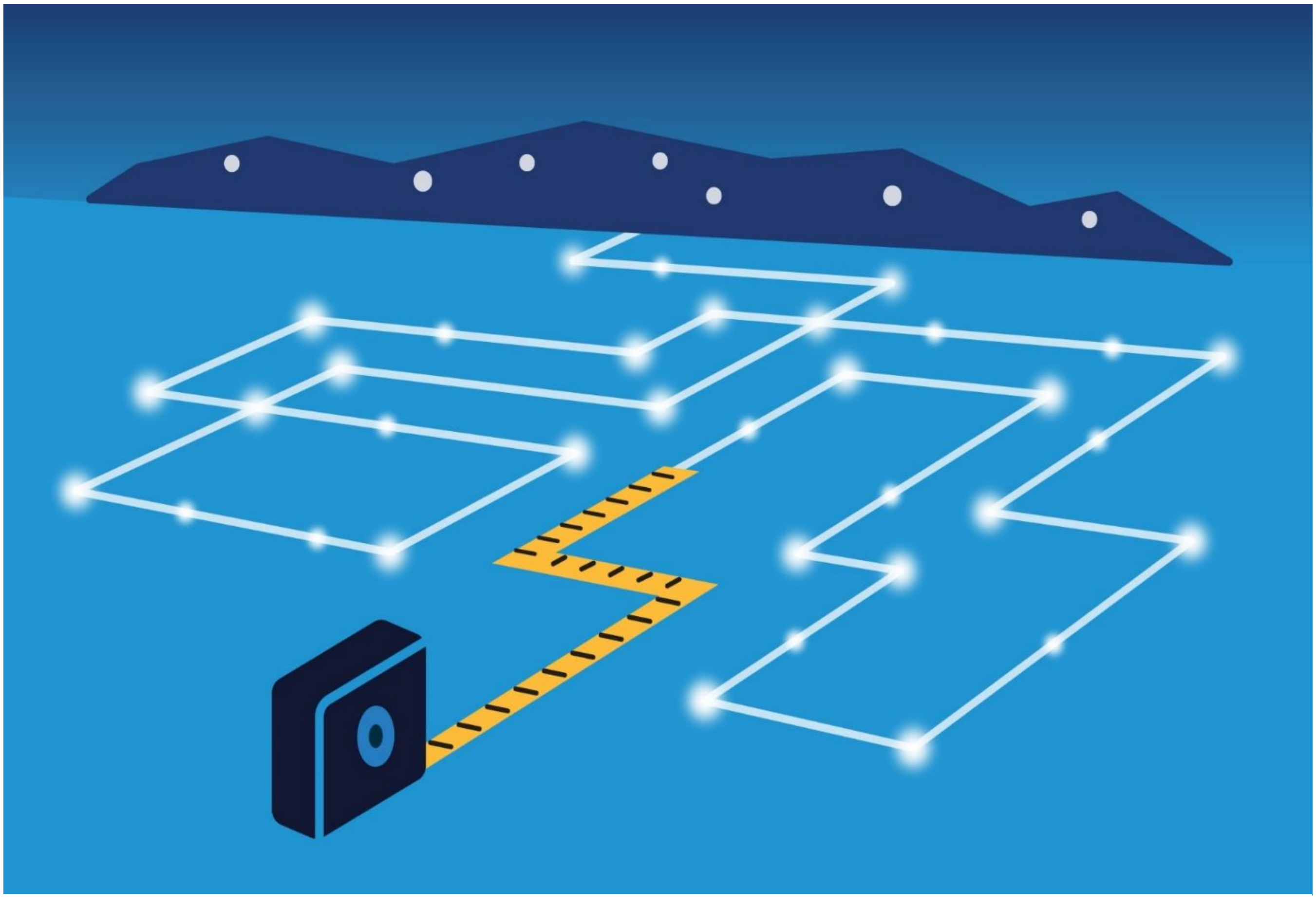

Impact and Process Evaluation of the 2015 (PY8) Ameren Illinois Company Home Efficiency Standard Program

Final

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CADMUS

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1. Executive Summary

This report presents the results of the Program Year 8 (PY8) Ameren Illinois Company (AIC) Home Efficiency Standard Program (HE Standard Program) evaluation. The HE Standard Program is a home energy diagnostic and retrofit program that offers residential customers a home audit, an audit report and recommendations for retrofits, directly installed measures, and incentives for building shell retrofits. In particular, program participants may receive energy-efficient lighting, faucet aerators and shower heads, programmable thermostats, insulation, and air sealing.

While implementation staff do some marketing for the program, trade ally marketing efforts are the main source of customer recruitment. AIC customers can participate in the program in multiple ways, from completing an audit only, a retrofit only, or an audit plus retrofit. CLEAResult implements the HE Standard Program with oversight from Leidos, which manages implementation of AIC's energy efficiency portfolio.

The expected savings from this program was 2,489 MWh, 1.65 MW, and 407,607 therms, which represents 1% of the overall PY8 portfolio electric savings and 7% of therm savings (including both residential and commercial). CLEAResult also estimated that they would perform 2,000 audits, with 1,400 homes receiving retrofits.

For PY8, the evaluation team conducted a process and impact evaluation of the HE Standard Program. However, AIC has decided to discontinue the HE Standard Program after PY8 due to an estimated prospective Total Resource Cost (TRC) less than 1.0. Thus, the evaluation team conducted only a few process-related evaluation tasks to confirm that the program was implemented as planned and to collect feedback on challenges encountered.

Program Impacts

The program fell short of its participation goals, reaching 1,777 customers in PY8. This represents 1,087 audits and 873 home retrofit projects, which is 54% and 62% of the program's audit and retrofit goals, respectively. Due to lower-than-expected participation, the program also did not meet its savings goals.

Overall, the program provided net savings of 1,174 MWh, 0.37 MW, and 181,178 therms. The program achieved gross realization rates of 91% for MWh savings, 99% for MW savings, and 97% for therms savings. Table 1 summarizes the impacts for the HE Standard Program in PY8.

Table 1. PY8 HE Standard Program Net Impacts

	Ex Ante Gross	Realization Rate	Ex Post Gross	NTGR[a]	Ex Post Net
Energy Savings (MWh)					
Total MWh	1,691	0.91	1,540	0.76	1,174
Demand Savings (MW)					
Total MW	0.51	0.99	0.51	0.74	0.37
Therm Savings					
Total Therms	248,735	0.97	241,534	0.75	181,178

[a] The NTGRs are estimated at a measure level, but are shown in aggregate for the program above. We weighted the measure level NTGR scores by their total savings to calculate the program NTGRs.

Key Findings

Given the limited process evaluation conducted for the final year of this program, key process findings focus exclusively on changes made to the program's implementation in PY8. In particular, program staff made changes to overcome barriers related to project paperwork, as well as to improve the quality of measure installations and data tracking. For example, CLEAResult streamlined the program's application process by reducing redundancies in paperwork. The implementer also began using the Amplify database system, which staff believe will improve the accuracy of their data tracking. Finally, quality control issues in PY8 prompted CLEAResult to formalize a quality assurance and quality control (QA/QC) process, which included developing standardized inspection rates[1] and disciplinary protocols for trade allies.

Despite the discontinuation of the HE Standard Program due to an estimated prospective TRC of less and one, program staff note that the improvements to the QA/QC process have benefited other programs, such as the Multifamily and Home Efficiency Income Qualified (HEIQ)[2] programs, by ensuring that each trade ally goes through the same standardized inspection. It is also important to note that the quality control issues identified in PY8 led to the suspension of one of the largest trade allies and, thus, adversely affected customer participation. This lower level of participation and the shifting of funds from the HE Standard Program to the HEIQ Program are defining aspects of PY8 program delivery.

[1] For each trade ally, the first five projects and 10% thereafter are inspected.

[2] This program is referred to as the Moderate Income Program in the Plan 3 filing, but marketed as the Home Efficiency Income Qualified Program.

2. Evaluation Approach

The Program Year 8 (PY8) evaluation of Ameren Illinois Company's (AIC) Home Efficiency Standard Program (HE Standard Program) involved both process and impact assessments. To support the process evaluation, we reviewed program materials and program-tracking data and interviewed implementation and AIC program staff. To evaluate gross impacts, the evaluation team reviewed the PY8 program-tracking data and applied the Illinois Statewide Technical Reference Manual for Energy Efficiency Version 4 (IL-TRM V4.0).[3] To assess net impacts, the evaluation team applied the Illinois Stakeholder Advisory Group (SAG)-approved net-to-gross ratio (NTGR) to ex post gross impacts.

2.1 Research Objectives

The objective of the PY8 HE Standard Program evaluation was to assess the program's performance in PY8 and specifically to estimate the gross and net electric and gas savings achieved by the program. In particular, the PY8 process and impact evaluation sought to answer the following research questions:

- 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?
- 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
    - How many homes received audits? How many homes received building shell retrofit measures? Has participation met expectations? If not, why?
    - What were the barriers to installation of incentivized shell measures after receiving an audit?

2.2 Evaluation Tasks

Table 2 summarizes the PY8 evaluation activities conducted for the HE Standard Program. Following the table, we describe each activity in detail.

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

Table 2. PY8 HE Standard Program Evaluation Activities

Task	PY8 Process	PY8 Impact	Forward Looking	Details
Review of Program Materials and Data	✓			Reviewed program materials to assess program implementation and participation.
Interviews with Program Staff and Implementers	✓			Interviewed AIC, CLEAResult, and Leidos staff to understand the program's design, implementation processes, and marketing. We also confirmed evaluation priorities.
Gross Impact Analysis		✓		Conducted an engineering analysis for all PY8 participants to estimate gross impacts.
Net Impact Analysis		✓		Applied the SAG-approved NTGR to ex post gross savings by measure to estimate net impacts.

2.2.1 Review of Program Materials and Data

To understand program implementation and marketing efforts, the evaluation team reviewed the PY8 implementation plan, the marketing and outreach plan, marketing collateral, and trade ally training materials. To assess participation, we reviewed the program-tracking database.

2.2.2 Interviews with Program Staff and Implementers

We conducted in-depth interviews with one AIC program staff person, two members of the CLEAResult implementation team, and one Leidos marketing staff person. The purpose of these interviews was to gain insight into whether or not the program was implemented according to plan and to determine if there had been any changes in the program from PY7. The team also inquired about data tracking and customer outreach related to the program.

2.2.3 Impact Analysis

Gross Impact Analysis

To determine the gross impacts associated with the HE Standard Program, we applied the savings algorithms and variable assumptions from the IL-TRM V4.0 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.

Net Impact Analysis

The evaluation team calculated PY8 ex post net impacts by applying SAG-approved NTGRs to ex post gross savings by measure. Table 3 summarizes the measure-level NTGRs used to calculate PY8 HE Standard Program net savings.

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

Table 3. NTGRs by Measure Category

Measure Category	NTGR	
	Electric	Gas
CFLs	0.82	--
Faucet Aerator	0.92	0.94
Shower Head	0.86	0.91
Air Sealing	0.71	0.72
Insulation	0.78	0.78
Thermostat	0.87	0.87

2.3 Sources and Mitigation of Error

Table 4 provides a summary of possible sources of error associated with the evaluation of the HE Standard Program. We discuss each item in detail below.

Table 4. Potential Sources of Error

Research Task	Survey Error		Non-Survey Error
	Sampling	Non-Sampling	
Gross Impact Analysis	N/A	N/A	Analytical error
Net Impact Analysis	N/A	N/A	Analytical error

Analytical Error

It is possible that analytical error could exist within the impact analysis tasks. For instance, there could be errors in the input and analysis of data or the characterization of results. As with any evaluation, we took precautions to limit the possibility of this sort of error:

- **Gross Impact Calculations*:*** We applied the IL-TRM calculations to the participant data in the program-tracking database to calculate gross impacts. To minimize analytical errors, a separate team member reviewed all impact calculations to verify their accuracy.
- **Net Impact Calculations*:*** We applied the PY6 measure-level NTGRs to gross savings to obtain PY8 program net savings.

3. Detailed Evaluation Findings

The following sections present detailed findings from the PY8 evaluation of the HE Standard Program. The process analysis leverages data from two different data collection methods: a review of program materials and in-depth interviews with program and implementation staff. To calculate ex post gross and net program savings, we used information in the program-tracking databases, algorithms and variable assumptions from the IL-TRM V4.0 and the V4.0 Errata Measures memo, and the SAG-approved NTGRs.

3.1 Program Design and Implementation

3.1.1 Program Design Changes

The HE Standard Program underwent a few changes in PY8, including the streamlining of application forms for trade allies, the migration of program-data tracking to the Leidos' Amplify system, and the creation of a standardized quality assurance/quality control (QA/QC) process. Most importantly, AIC decided that it would no longer offer the HE Standard Program after PY8. We provide additional information on these program changes below.

- **Streamlined Application:** In PY8, the program streamlined its application process by eliminating redundancies and reducing the number of pages that trade allies needed to fill out to participate in the program. This change came in response to PY7 evaluation findings suggesting that trade allies were dissatisfied with the amount of paperwork that they needed to complete. Further, the PY7 evaluation found that the amount of paperwork needed to participate prevented some trade allies from completing all of their qualified projects through the program, particularly when projects had short turnaround times.
- **Data Migration to Amplify:** The program began inputting and tracking data in Amplify, the Leidos database, that they have used for many years on the commercial side of the portfolio. Implementation and program staff believe that Amplify will improve the accuracy of data tracking and their ability to apply deemed savings values at the measure level.
- **QA/QC Standardization:** During PY8, implementation staff discovered several quality issues with installations conducted by one of their largest trade allies. Specifically, staff mentioned safety hazards, such as insulation placed on heat sources and vermiculite debris found underneath installed insulation. In response, CLEAResult established a minimum inspection rate[5] for all trade allies. Further, they established standard disciplinary protocols for trade allies that do not meet program QA/QC requirements.

In addition to refining aspects of the program's implementation, AIC decided to discontinue the program after PY8 due to estimates that the program was not going to be cost effective going forward (the program had an anticipated prospective TRC score of less than 1.0).

3.1.2 Program Marketing Efforts

Overall, the program's marketing and outreach activities remained consistent between PY7 and PY8. According to Leidos staff, who are responsible for program marketing, key activities included direct mail, digital

[5] For each trade ally, the first five projects and 10% thereafter are inspected.

media, and print advertisements. The direct mail effort included business cards with tear-off forms that customers can send back to sign up for an audit. Further, Leidos staff mentioned that trade allies often market the program themselves.

3.2 Program Participation and Measure Installation

Participation

In PY8, the HE Standard Program reached 1,777 participants. As shown in Table 5, around half of those participants received an audit, which included the direct installation of program measures. About half of participants (49%) completed additional building shell retrofits, most of whom did this without receiving an audit or direct install measures.

Table 5. Overview of Participation and Services Received in PY8

Participant Type	Number of Participants	% of Participants
Audit and Retrofit	183	10%
Audit Only	904	51%
Retrofit Only	690	39%
Total	**1,777***	**100%**

* We removed 378 accounts during the data cleaning process; 372 accounts were flagged as having received an audit but did not receive any direct install measures, which suggests that an audit was scheduled but did not take place. The remaining six accounts were flagged as having received an incentive, which suggests that they did some retrofits, but there were no measures and savings for the six accounts.

After the audit, participants received a report with an energy usage analysis, energy savings tips, and recommendations for home retrofits. However, only a small portion of PY8 audit recipients (17%) went on to do a retrofit (referred to as a “conversion”). We calculated the PY8 conversion rate from audit to retrofit by dividing the number of participants who received a retrofit following an audit (audit and retrofit) by the total number of participants who received an audit at all (whether or not they received a retrofit). However, participants who receive an audit in one year and receive the associated retrofit in the following years complicate this calculation. To account for these participants, every evaluation year we update conversion rates across previous program years using cumulative results. Table 6 compares the updated conversion rates from PY4 through PY8. We can see that the conversion rates increased from PY4 to PY5, remained the same from PY5 to PY7, and then dropped significantly from PY7 to PY8.

Table 6. PY4–PY8 Conversion Rates

Participant Type	PY4 Participants	PY5 Participants	PY6 Participants	PY7 Participants	PY8 Participants
(a) Audit and Retrofit	657	725	561	402	183
(b) Audit Only	2,125	1,898	1,411	1,054	904
(c) Retrofit Only	1,419	1,529	1,005	1,145	690
Total Participants = a + b + c	4,201	4,152	2,977	2,601	1,777
Total Audits = a + b	2,782	2,623	1,972	1,456	1,087
Conversion Rate = a/(a + b)	24%	28%	28%	28%	17%

According to program implementation staff, trade allies performed audits for customers, but were less interested in doing additional building shell retrofits through the program when it was easier to sell the higher incentives for HVAC measures offered through the HEIQ Program.

3.3 Impact Assessment

The evaluation team applied savings algorithms from the IL-TRM V4.0 using program-tracking database inputs and applied in-service rates (ISRs) from IL-TRM V4.0 to estimate program gross savings. To assess net impacts, the evaluation team applied the Illinois SAG-approved NTGR to ex post gross impacts.

3.3.1 Measure Verification

The program offers a variety of measures to participants, including direct install measures and building shell measures. To determine the verified measure quantities, the evaluation team applied ISRs provided in the IL-TRM V4.0 to ex ante measure quantities. Table 7 summarizes the quantity of installed measures based on the team's review of the program-tracking database.

Table 7. PY8 HE Standard Program Measure Quantities and Verification Rates

Measure Category	Measure	Unit	Ex Ante Measure Quantity [a]	In-Service Rate [b]	Verified Measure Quantity [a * b]
Lighting	CFL - Low (13W–15W)	Bulb	4,442	97%	4,304
	CFL - Medium (18W–20W)	Bulb	458	97%	444
	CFL - High (23W–25W)	Bulb	205	97%	199
	Specialty CFL - 9W Candelabra	Bulb	2,113	97%	2,047
	Specialty CFL - 14W Globe	Bulb	3,970	97%	3,847
	Specialty CFL - 15W Reflector	Bulb	2,194	97%	2,126
Domestic Hot Water (DHW)	Faucet Aerator	Aerator	599	95%	569
	Shower Head	Shower Head	463	98%	454
HVAC (Controls)	Programmable Thermostat	Thermostat	155	100%	155
Envelope	Air Sealing	Cu. Ft./Min. (CFM)	2,187,630	100%	2,187,630
	Attic Insulation	Sq. Ft.	1,536,634	100%	1,536,634
	Wall Insulation	Sq. Ft.	311,214	100%	311,214
	Rim Joist Insulation	Linear Feet	135,997	100%	135,997
	Crawl Space Insulation	Sq. Ft.	68,514	100%	68,514
Total			4,254,588	100%	4,254,134

3.3.2 Ex Post Gross Impact Results

The total ex post gross impacts for the PY8 HE Standard Program are 1,540 MWh, 0.51 MW, and 241,534 therm savings. As shown in Table 8, there is close alignment between the ex ante and ex post gross impacts with gross realization rates of 91% for electric savings, 99% for demand savings, and 97% for therm savings.

Table 8. PY8 HE Standard Program Gross Impacts

Program	Number of Participants	Ex Ante Gross[a]			Ex Post Gross		
		MWh	MW	Therms	MWh	MW	Therms
Standard Program	1,777[b]	1,691	0.51	248,735	1,540	0.51	241,534
Gross Realization Rate[c]					91%	99%	97%

[a] Source of ex ante savings: PY8 program-tracking database.
[b] The total verified count of project IDs is 1,885. This is larger than the total number of participants because some participants completed multiple projects.
[c] Gross Realization Rate = ex post gross value/ex ante gross value.

Table 9 summarizes the ex post gross electric impacts results by measure.

Table 9. HE Standard Program Electric Impacts by Measure

Measure	Verified Measure Quantity	Units	Ex Ante Gross Impacts		Ex Post Gross Impacts		Gross Realization Rate[a]	
			MWh	MW	MWh	MW	MWh	MW
Air Sealing	2,187,630	CFM	776	0.340	680	0.340	88%	100%
Attic Insulation	1,536,634	SqFt	279	0.087	198	0.069	71%	80%
Specialty CFL - 14W Globe	3,847	Bulb	112	0.015	120	0.015	107%	100%
Crawl Space Insulation	68,514	SqFt	110	0.002	114	0.019	104%	929%
CFL - Low (13W–15W)	4,304	Bulb	104	0.011	109	0.011	105%	100%
Specialty CFL - 15W Reflector	2,126	Bulb	91	0.011	97	0.011	107%	100%
Specialty CFL - 9W Candelabra	2,047	Bulb	75	0.009	80	0.009	106%	100%
Wall Insulation	311,214	SqFt	56	0.023	56	0.023	100%	100%
Rim Joist Insulation	135,997	Linear Feet	37	0.010	26	0.006	70%	61%
Shower Head	454	Shower Head	20	0.002	20	0.002	100%	100%
Programmable Thermostat	155	Thermostat	8	–	14	–	180%	N/A
CFL - Medium (18W–20W)	444	Bulb	10	0.001	12	0.001	124%	100%
CFL - High (23W–25W	199	Bulb	8	0.001	8	0.001	104%	100%
Faucet Aerator	569	Aerator	7	0.003	7	0.003	100%	100%
Total	4,254,134		1,691	0.512	1,540	0.507	91%	99%

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

Table 10 summarizes the ex post gross therm impacts results by measure.

Table 10. HE Standard Program Therm Impacts by Measure

Measure	Verified Measure Quantity	Units	Ex Ante Gross Impacts	Ex Post Gross Impacts	Gross Realization Rate[a]
			Therms	Therms	Therms
Air Sealing	2,187,630	CFM	136,683	136,703	100%
Attic Insulation	1,536,634	Sq. Ft.	58,047	46,668	80%
Specialty CFL - 14W Globe	3,847	Bulb	−2,701	–	N/A
Crawl Space Insulation	68,514	Sq. Ft.	33,864	27,417	81%
CFL - Low (13W–15W)	4,304	Bulb	−2,446	–	N/A

Measure	Verified Measure Quantity	Units	Ex Ante Gross Impacts	Ex Post Gross Impacts	Gross Realization Rate[a]
			Therms	Therms	Therms
Specialty CFL - 15W Reflector	2,126	Bulb	−2,186	–	N/A
Specialty CFL - 9W Candelabra	2,047	Bulb	−1,804	–	N/A
Wall Insulation	311,214	Sq. Ft.	15,097	15,096	100%
Rim Joist Insulation	135,997	Linear Feet	6,867	7,766	113%
CFL - Medium (18W–20W)	444	Bulb	−277	–	N/A
CFL - High (23W–25W)	199	Bulb	−184	–	N/A
Faucet Aerator	569	Aerator	1,480	1,480	100%
Programmable Thermostat	155	Thermostat	2,032	2,142	105%
Shower Head	454	Shower Head	4,262	4,261	100%
Total	**4,254,134**		**248,735**	**241,534**	**97%**

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 air sealing, lighting, and insulation measures have the largest impact on program-level realization rates. Because air sealing measures account for 46%, insulation measures account for 29%, and lighting measures account for 26% of the total program energy savings, any differences within these measures affect the program savings significantly. Table 11 summarizes the source of differences between ex ante and ex post gross savings.

Table 11. Reasons for Realization Rates per Measure

Measure	Gross Realization Rate			Source of Discrepancy		
	MWh RR	MW RR	Therms RR	Preexisting and Post-Retrofit R-Value	Waste Heat Factors	Other Discrepancies
Air Sealing	88%	100%	100%			• Ex ante savings not aligned with the "Electric CAC" savings algorithm.
Attic Insulation	71%	80%	80%	✓		• Ex ante savings not aligned with the "Electric Resistance & CAC" and "Gas Heat Runtime" savings algorithms
Specialty CFL	107%	100%	N/A		✓	
Standard CFL	106%	100%	N/A		✓	
Crawl Space Insulation	104%	929%	81%	✓		• Demand savings off by an order of magnitude
Rim Joist Insulation	70%	61%	113%	✓		• Rim joist height assumptions • Incorrect adjustment factor • Ex ante savings not aligned with the "Heat Pump" savings algorithms

Measure	Gross Realization Rate			Source of Discrepancy		
	MWh RR	MW RR	Therms RR	Preexisting and Post-Retrofit R-Value	Waste Heat Factors	Other Discrepancies
Programmable Thermostat	180%	N/A	105%			• Incorrect electric heating consumption • Some projects excluded from savings calculations due to missing climate zone data
Faucet Aerator	100%	100%	100%			
Wall Insulation	100%	100%	100%			
Shower Head	100%	100%	100%			

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 Issues:**
  - **Ex ante Savings Not Aligned with "Electric CAC" Savings Algorithm:** All variable inputs for air sealing measures are consistent across ex ante and ex post assumptions. The implementer confirmed that the ex ante savings from Amplify do not align with ex ante algorithm for cooling energy savings. This discrepancy may have been due to incorrect programming of the cooling savings algorithm into Amplify. It is also possible that the algorithm was fixed in Amplify, but never refreshed in the final database. Due to this discrepancy, the ex ante savings are 25% greater than that of the ex post air sealing savings for those with "Electric CAC". This reduces the overall air sealing realization rate by 12%. Since air sealing accounts for 46% of the program's reported energy savings, this discrepancy has the greatest impact on the overall program realization rate.
- **Attic Insulation Issues:**
  - **Preexisting and Post-Retrofit 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 are unreliable due to inconsistent data collection. For example, sometimes the contractors provide the values and sometimes they leave the field left 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 use the assumed R-values indicated in the measure label (see Appendix A for more detail). As a result, ex ante overestimates savings by 11%.
  - **Ex ante Savings Not Aligned with "Electric Resistance and CAC" and "Gas Heat Runtime" Savings Algorithms:** All variable inputs for attic insulation measures are consistent across ex ante and ex post assumptions (with the exception of the pre-existing and post-retrofit R-values as described above). The ex ante savings from Amplify do not align with ex ante algorithms for "Electric Resistance and CAC" and "Gas Heat Runtime" measures (for reasons similar to those described under Air Sealing Issues). As a result, the ex ante savings are 13% greater than that of the ex post attic insulation savings.

- **Specialty and Standard CFL Issues:**
  - **Waste Heat Factors:** Ex ante energy savings included the waste heat factor heating penalty for all standard and specialty CFLs, which results 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 1.0 for standard and specialty CFLs.

- **Crawl Space Insulation Issues:**
  - **Preexisting and Post-Retrofit R-Value:** Ex ante calculations applied the incorrect preexisting below grade R-value (3' below grade R-value R-6.41 versus 2' below grade R-value R-5.41), resulting in ex ante savings 4% smaller than ex post savings.
  - **Demand Savings off by an Order of Magnitude:** Ex ante savings are underestimated by an order of magnitude. The implementer was well aware of the issue; however, a correction was not made prior to receiving the final dataset used for evaluation.

- **Rim Joist Insulation Issues:**
  - **Preexisting R-Value:** The IL-TRM does not provide algorithms and variable assumptions specific to rim joist insulation. Ex post savings assume a preexisting R-value of R-3.18 (based on the sum of R-values for a 1.5" joist, wallboard, and indoor and outdoor air film, taken from ASHRAE Fundamentals, 2013 Section 27.3). Ex ante assumes a preexisting R-value of R-3. As a result, ex ante estimates overstate savings by 5% for energy and 11% for therms.
  - **Post-Retrofit R-Value:** Ex ante calculations overestimated rim joist insulation energy savings by 3% and therm savings by 6% by misinterpreting the application of the post R-value in the savings algorithm. The algorithm specifies that the denominator is equal to the sum of pre R-value and the added R-value of insulation (ultimately resulting in the total post R-value). Ex post calculations applied a pre R-value of R-3.18 and an added R-value of R-11 (resulting in total post R-value of R-14.18). Ex ante applied a pre R-value of R-3 and an added R-value of R-14 (resulting in a total post R-value of R-17). Discussions with the implementer confirmed that the total post R-value should be R-14, which verified that the ex ante R-post of R-17 was applied in error.
  - **Rim Joist Height:** Ex ante calculations overestimated rim joist insulation energy savings by 7% and therm savings by 11% by assuming a rim joist height of 0.933 feet, which assumes 2x12 framing. Ex post savings includes a rim joist height assumption of 0.85 feet, which is the average of 2x10 and 2x12 framing. The implementer confirmed that there is 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 apply the adjustment factor from the IL-TRM V4.0 for above grade walls (0.63). However, this adjustment factor is incorrect since 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 understate savings for rim joist insulation by 13%.
  - **Ex ante Savings not Aligned with "Heat Pump" Savings Algorithms:** All variable inputs for rim joist insulation measures are consistent across ex ante and ex post assumptions (with the exception of

the those described above). The ex ante savings from Amplify do not align with ex ante algorithms for "Heat Pump" (for reasons similar to those described under Air Sealing Issues). As a result, the ex ante savings are 132% greater than that of the ex post rim joist savings. This reduces the overall rim joist realization rate by 32%. Since rim joist accounts for 2% of the program's reported energy savings, this discrepancy does not have a significant impact on the overall program realization rate.

- **Programmable Thermostat Issues:**
  - **Electric Heating Consumption:** Ex ante calculations underestimated savings for programmable thermostats by applying electric heating consumption for heat pumps to all homes with electric resistance heat. Because of this error, ex ante estimates underestimate savings by about 22%. While this may seem high, energy savings for programmable thermostats account for less than 1% of the program's total reported energy savings and therefore play a small role in the overall program realization rate.
  - **Missing Climate Zone Data:** Ex ante savings excluded seven cases where the program-tracking database did not provide the participant's zip code or city, which is required to assign the appropriate heating degree days (HDD) from the IL-TRM V4.0. The programming syntax used to calculate ex ante savings excludes cases from its calculations when address data are missing. In our ex post analysis, we included these cases by assigning the correct HDD based on the actual project location (provided to us by the implementer in a separate database). As a result, ex ante underestimates savings by 57%.

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 hardcoded values as opposed to showing the algorithm syntax. As a result, we suspect there may be mistakes within the savings algorithms inputted for the program, but we cannot verify that visually. In particular, we believe this occurred for air sealing (”Electric CAC” measures), attic insulation ("Electric Resistance and CAC" and "Gas Heat Runtime" measures**),** rim joist insulation ("Heat Pump" measures), and demand savings for crawl space insulation, as there are no discrepancies between ex ante and ex post variable assumptions, and no other reason savings would differ.

3.3.3 Ex Post Net Impacts Results

To determine the overall net savings associated with the HE Standard Program, the team applied the SAG-approved NTGRs to ex post gross savings. As a result, the program achieved a net realization rate of 91% for electric energy, 99% for demand, and 97% for therms (see Table 12).

Table 12. PY8 HE Standard Program Net Impacts

Program Component	Ex Ante Net[a]			Ex Post Net		
	MWh	MW	Therms	MWh	MW	Therms
Standard Program	1,284	0.38	185,676	1,174	0.37	181,178
Net Realization Rate[b]				91%	99%	97%

[a] Source of ex ante savings: PY8 program-tracking database.
[b] Net Realization Rate = ex post net value/ex ante net value .

4. Conclusions and Recommendations

AIC has decided to discontinue the HE Standard Program after PY8 due to an estimated prospective TRC less than 1.0. Program and implementation staff also mentioned declining interest from trade allies and low customer participation as reasons that the program fell short of its participation goals in PY8, achieving one-half to two-thirds of its audit and retrofit goals (54% and 62%, respectively). The program also achieved less savings than expected.

While AIC has discontinued the HE Standard Program, staff made several QA/QC process improvements in PY8, including establishing standardized inspection rates and disciplinary protocols for trade allies. These changes have benefited other programs that leverage trade allies, such as the Multifamily and HEIQ programs.

Given that the program will not continue, we do not provide any recommendations at this time.

Appendix A. Engineering Analysis Algorithms

In PY8, the impact evaluation efforts estimated gross impact savings for the HE Standard 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 CFL 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 13. Baseline Wattages for Lighting Measures

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

[a] The Energy Independence and Security Act of 2007 (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 14. CFL Wattages for Lighting Measures

Measure	CFL Wattage	Resource
CFL - Low (13W–15W)	13	Actual installed CFL wattage
CFL - Medium (18W–20W)	20	
CFL - 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 = 96.9%

Hours = Annual operating hours

Table 15. 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

Table 16. 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. Heating Penalty Algorithms

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

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

Where:

WattsBase = Wattage of existing equipment (see Table 13)

WattsEE = Wattage of installed CFLs (see Table 14)

ISR = In-service rate or the percentage of units rebated that get installed = 96.9%

Hours = Annual operating hours (see Table 15)

HF = Heating Factor = 0.49

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

Table 17. ηHeat for Lighting 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 18 summarizes the heating penalties for the six lighting measures offered through the program by heating equipment type.

Table 18. Per-Measure Heating Fuel Penalties for CFL Lighting

Heating Equipment	Measure	ΔkWh	Δtherms
Heat Pump (Heating Only)	CFL - Low (13W–15W)	−5.00	n/a
	CFL - Medium (18W–20W)	−5.50	n/a
	CFL - High (23W–25W)	−8.16	n/a
	Specialty CFL - 9W Candelabra	−7.75	n/a
	Specialty CFL - 14W Globe	−6.18	n/a
	Specialty CFL - 15W Reflector	−9.04	n/a
Electric Resistance	CFL - Low (13W–15W)	−11.30	n/a
	CFL - Medium (18W–20W)	−12.43	n/a
	CFL - High (23W–25W)	−18.45	n/a
	Specialty CFL - 9W Candelabra	−17.52	n/a
	Specialty CFL - 14W Globe	−13.96	n/a
	Specialty CFL - 15W Reflector	−20.44	n/a
Gas Heating	CFL - Low (13W–15W)	n/a	−0.55
	CFL - Medium (18W–20W)	n/a	−0.61
	CFL - High (23W–25W)	n/a	−0.90
	Specialty CFL - 9W Candelabra	n/a	−0.85
	Specialty CFL - 14W Globe	n/a	−0.68
	Specialty CFL - 15W Reflector	n/a	−1.00

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: *ΔTherms = %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 in gallons per minute (GPM) (see Table 19)

GPM_low = As-used flow rate of the low-flow shower head or faucet aerator (see Table 19)

Table 19. GPM for Water Heating 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 20)

L_low = Length (in minutes) per low-flow shower head or low-flow faucet (see Table 20)

Table 20. L_base for Water Heating 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 (EPG) of hot water supplied by electric water heater (see Table 21)

EPG_gas = Energy per gallon of hot water supplied by gas water heater (see Table 21)

Table 21. EPG for Water Heating 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 22. ISR for Water Heating Measures

Measure	ISR
Faucet Aerator	95%
Shower Head	98%

Hours = Annual recovery hours for shower head or faucet use

Table 23. Hours for Water Heating Measures

Measure	Hours
Faucet Aerator[a]	52
Shower Head	302

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

CF = Summer peak coincidence factor

Table 24. Coincidence Factors for Water Heating 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 25. 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 26. 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 = 56%[6]

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

A.5 Air Sealing Algorithms

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

Equation 6. Air Sealing Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

[6] Programmable thermostats were not directly installed, yet they were applied for separately through the program, and therefore the evaluation team applied an ISR of 56% from the IL-TRM V4.0. This is also consistent with ex ante savings assumptions.

$$\Delta kWh\_cooling = [(((CFM50\_existing - CFM50\_new)/N\_cool) * 60 * 24 * CDD * DUA * 0.018)/(1{,}000 * \eta Cool)] * LM$$

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

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

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

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

Where:

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

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

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions = 18.5[7]

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

Table 27. Cooling Degree Days by Climate Zone

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

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (applied per participant based on existing equipment age provided in database)

Table 28. ηCool for Air Sealing Measures

Cooling Equipment Age	SEER
Before 2006	10
2006–2014	13
Central Air Conditioning (AC) After 1/1/2015	13
Heap Pump After 1/1/2015	14

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

Table 29. Latent Multiplier by Climate Zone

Climate Zone	Latent Multiplier

[7] Assumed climate zone 2 (CZ2) Normal Exposure.

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[8]

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

Table 30. 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 31. ηHeat for Air Sealing Measures

Existing Heating Equipment	Equipment Age	COP
Heat Pump	Before 2006	1.70
	2006–2014	1.92
	2015 and beyond	2.40
Electric Resistance	N/A	1.00
Gas Furnace	N/A	0.70

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

Table 32. 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

CF = Summer peak coincidence factor (varies by cooling equipment type)

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

Table 33. Coincidence Factors for Air Sealing Measures

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.6 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 7. Attic Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

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

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

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

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

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

Equation 8. Wall Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

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

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

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

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

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

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).[9] For attic insulation, we

[9] The program-tracking database included the preexisting and post-retrofit R-values per participant. However, these data were collected by means of 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), and R-values not typical of installation application (those

added R-0.68 (indoor air film) and R-0.15 (¾" plaster) to account for total assembly R-value.[10] The total assembly preexisting R-value for wall insulation is R-5 (per IL-TRM V4.0).

Table 34. Preexisting R-Value for Attic and Wall Insulation

Measure	Preexisting 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-retrofit R-values per participant were unreliable).[9] For attic insulation we added R-0.68 (indoor air film) and R-0.15 (¾" plaster) to account for total assembly R-value.[10] The total assembly R-value for wall insulation is R-16 (which includes R-5 [uninsulated wall] and added R-11).

Table 35. Post-Retrofit R-Value for Attic and Wall Insulation

Measure	Post-Retrofit 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 (sq. ft.)

A_attic = Total area of insulated attic (sq. ft.)

Framing_factor = Adjustment to account for area of framing

Table 36. 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%

that exceed normal R-values). The implementer advised that we not use this information for PY8. However, data collection for PY9 will represent accurate preexisting and post-retrofit R-values that vary by participant and reflect the actual installed R-values for attic and wall insulation.

[10] 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.

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

Table 37. 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 38. ηCool for Attic and Wall Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
2006–2014	13
Central AC after 1/1/2015	13
Heap Pump after 1/1/2015	14

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

Table 39. 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 40. ηHeat for Attic and Wall Insulation Measures

Existing Heating Equipment	Equipment Age	COP
Heat Pump	Before 2006	1.70
	2006–2014	1.92
	2015 and beyond	2.40
Electric Resistance	N/A	1.00
Gas Furnace	N/A	0.70

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

Table 41. FLH_cooling by Climate Zone

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

CF = Summer peak coincidence factor (varies by cooling equipment type)

Table 42. Coincidence Factors for Attic and Wall Insulation Measures

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

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

A.7 Rim Joist Insulation Algorithms

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

Equation 9. Rim Joist Insulation Algorithms

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

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

$$\Delta kWh\_heating\ (electric\ heat) = ((((1/R\_old\_AG_{RimJoist} - (1/(R\_added + R\_old\_AG_{RimJoist}))) * L\_rimjoist * H\_rimjoist * (1 - Framing\_factor)) * 24 * HDD)/(3{,}412 * \eta Heat) * ADJ)$$

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

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

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

Where:

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

Table 43. Rim Joist above Grade R-Value

Variable	R-Value
$R\text{-value}_{Joist}$ (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_added = R-value of additional insulation (per implementer) = R-11

L_rimjoist = Total linear feet of installed insulation (ft.)

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

Framing_factor = Adjustment to account for area of framing = 0.25

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 44. 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 45. ηCool for Rim Joist Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
2006–2014	13
Central AC after 1/1/2015	13
Heap Pump after 1/1/2015	14

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

Table 46. 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 47. ηHeat for Rim Joist Insulation Measures

Existing Heating Equipment	Equipment Age	COP
Heat Pump	Before 2006	1.70
	2006–2014	1.92
	2015 and beyond	2.40
Electric Resistance	N/A	1.00
Gas Furnace	N/A	0.70

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

Table 48. FLH_cooling by Climate Zone

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

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

Table 49. Rim Joist Insulation Coincidence Factors

Cooling Equipment	CF
Central Air Conditioner	0.68
Heat Pump	0.72

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

A.8 Crawl Space Insulation Algorithms

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

Equation 10. Crawl Space Insulation Algorithms

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

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

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

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

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

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

Where:

R_old_AG = Above-grade existing R-value of 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 (sq. ft.) (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 (spray foam)

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

Table 50. 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 51. ηCool for Crawl Space Insulation Measures

Cooling Equipment Age	SEER
Before 2006	10
2006–2014	13
Central AC after 1/1/2015	13
Heap Pump after 1/1/2015	14

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

Table 52. 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 53. ηHeat for Crawl Space Insulation Measures

Existing Heating Equipment	Equipment Age	COP
Heat Pump	Before 2006	1.70
	2006–2014	1.92
	2015 and beyond	2.40
Electric Resistance	N/A	1.00
Gas Furnace	N/A	0.70

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

Table 54. FLH_cooling by Climate Zone

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

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

Table 55. 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. Cost-Effectiveness Inputs

Table 56 presents total gross impacts for AIC cost-effectiveness calculations. These values differ from those included in the main report due to the inclusion of heating penalties for lighting measures. This approach was taken based on discussions with AIC and past agreements between AIC and ICC staff that heating penalties would not be included in savings calculations for goal attainment. Overall, total gross savings reduced by 1.3% for kWh and 3.5% for therms after the application of waste heat factors.

Table 56. PY8 HE Standard Program Gross Impacts (Including Heating Penalties)

	kWh	kW	Therms
Gross Savings	1,539,682	507	241,534
Lighting Heating Penalty	−19,458	0	−8,398
Total Gross Savings with Heating Penalty	**1,520,224**	**507**	**233,136**

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 13,382 lamps based on heating fuel type and installed lamp type. The heating fuel type is known for 96% (12,843 lamps) of the installed lighting measures. For the remaining 539 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 62% of PY7 lamps installed in homes with electric heating were installed in homes with electric resistance heating, and the remaining 38% were installed in homes with heat pumps. Table 57 summarizes the percentage of installed lamps for each heating fuel type.

Table 57. PY8 HE Standard Program Known Heating Fuel Type for Lighting Measures

Heating Fuel	Heating Equipment	% of Installed Lamps
Electric	Electric Resistance	7.60%
Electric	Heat Pump	4.58%
Gas	Furnace/Boiler	87.8%

The total heating penalty for lighting measures is 19,458 kWh and 8,398 therms.

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