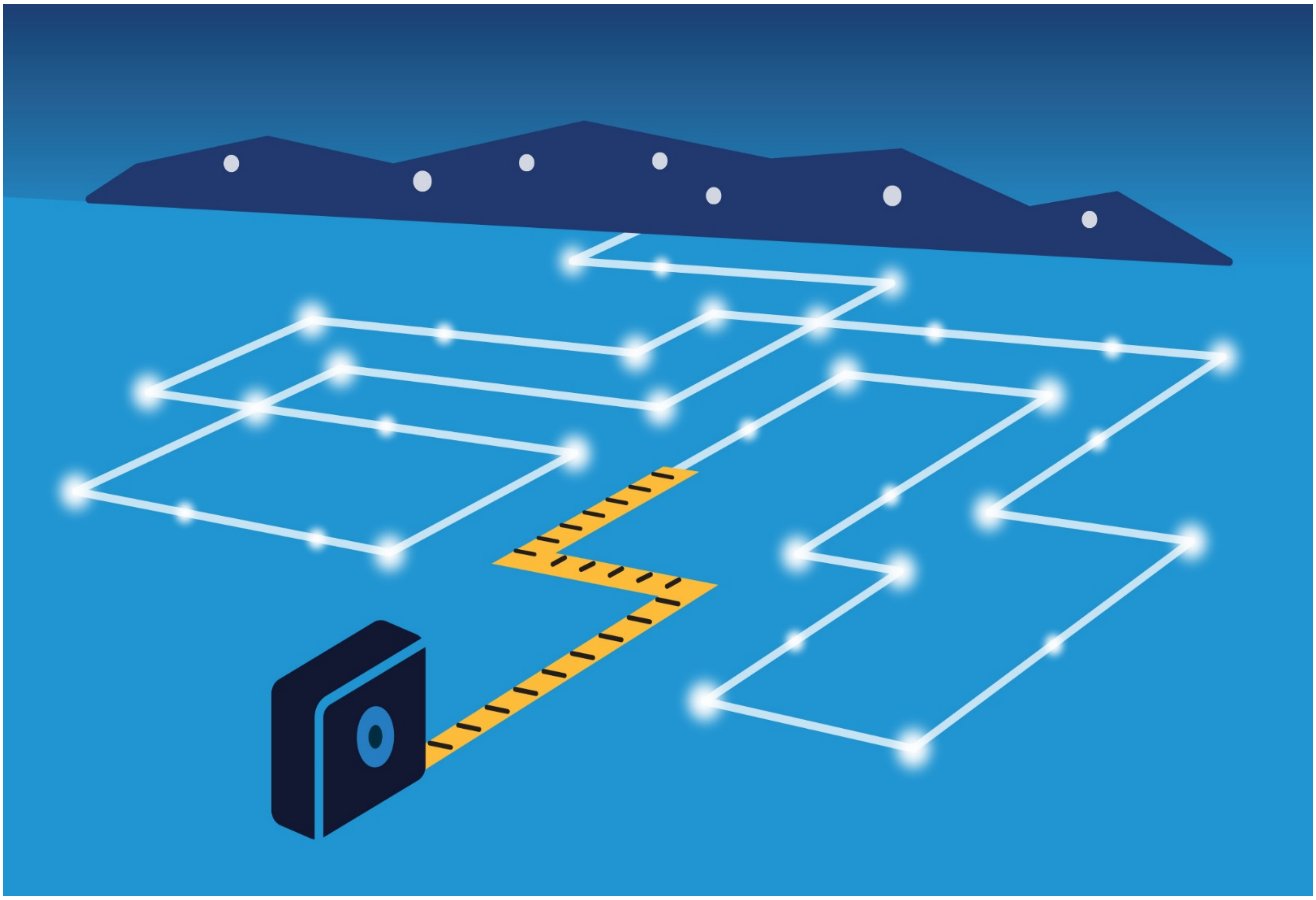
Opinion Dynamics

Boston | Headquarters

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

1000 Winter St
Waltham, MA 02451



Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Warm Neighbors Cool Friends (Moderate Income) Program

Final

December 17, 2014

CADMUS

NAVIGANT

MichaelsEnergy

Contributors

Vincent Greco
Project Manager, Opinion Dynamics

Opinion Dynamics

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1. Executive Summary

This report presents results from the evaluation of Ameren Illinois Company's (AIC) ActOnEnergy Moderate Income or Warm Neighbors Cool Friends (WNCF) program for PY6 (June 2013–May 2014). The program began as a pilot in PY3 and is in its third year of implementation.

Implemented by Conservation Services Group (CSG) and funded in part by the Energy Assistance Foundation (EAF) [1], the WNCF program is a home diagnostic and whole-house retrofit program that focuses on serving AIC gas and/or electric customers who do not qualify for low-income weatherization assistance, but who cannot afford to pay market prices for energy efficiency retrofit improvements to their homes. The target market is existing single-family homes heated by a fuel source (electricity or natural gas) provided by AIC and owned by customers with a household income between 200% and 300% of federal poverty level guidelines for household size.

In PY6, we conducted an impact evaluation and a limited process evaluation. To support the process evaluation, we reviewed program materials and program-tracking data and conducted interviews with implementation and program staff. To estimate gross impacts for PY6, the evaluation team conducted an engineering analysis to verify measure installations and to review program savings assumptions. Further, per the evaluation plan, we applied a net-to-gross ratio (NTGR) of 1.0 to evaluated gross savings to obtain PY6 WNCF net savings.

The expected savings from this program are less than 1.0% of the overall PY6 portfolio of electric savings and 1.4% of the overall portfolio of therm savings.[2]

Impact Results

The primary objective of this evaluation was to estimate the energy savings impacts from installing WNCF measures. For the engineering analysis, we applied the Statewide Illinois Technical Reference Manual V2.0[3] (Statewide IL TRM V2.0) savings algorithms using program-tracking database inputs and applied a NTGR of 1.0 to determine PY6 net savings. Table 1 provides the net impacts for the WNCF program.

In PY6, the WNCF program achieved net realization rates above 100% for both kW and therm savings; however, the net realization rate for kWh savings was lower (95%). This variance in net realization rates can be attributed to differences in input values for ex ante and ex post savings algorithms for air sealing and insulation measures. Specifically, we report differences in values for cooling degree day (CDD), heating degree day (HDD), full load cooling hours, and baseline efficiencies for heating and cooling. Additionally, our ex post calculations use a different set of assumptions to estimate savings for rim joist insulation. We provide a detailed explanation of these differences in the gross impacts section of this report.

[1] A nonprofit organization funded through donations by AIC employees and customers.

[2] Note that the percentage of expected savings is calculated based on the AIC Filing dated January 20, 2011.

[3] State of Illinois: Energy Efficiency Technical Reference Manual v.2.0. Effective June 1, 2013.

Table 1. PY6 WNCF Program Net Impacts

	Ex Ante Gross	RR	Ex Post Gross	NTGR	Ex Post Net
Energy Savings (MWh)					
Total MWh	652	95%	617	1.00	617
Demand Savings (MW)					
Total MW	0.49	109%	0.53	1.00	0.53
Gas Savings (Therms)					
Total Therms	162,026	107%	173,380	1.00	173,380

Process Results

Overall, program staff implemented the WNCF program according to its design with minor changes and few challenges. The program reached 317 customers in PY6, which far surpassed its goal of 182. Although marketing efforts have not dramatically changed, program staff attribute the growth in program participation to increased word-of-mouth and contractor referrals. This has also helped drive a significant pipeline of work in the northern part of the state.

WNCF has added to its marketing efforts by creating a Warm Neighbors program page on the ActOnEnergy.com website (http://www.actonenergy.com/for-my-home/warm-neighbors-cool-friends). This new page is linked to AIC's Home Performance with ENERGY STAR® (HPwES) page and allows users to download an application to participate in the WNCF program. Additionally, PY6 saw the development of WNCF instructional videos planned for use in PY7 to educate homeowners during both the pre- and post-project period. AIC proactively chose to create these videos in response to customer questions relating to the audit reports and the project installation process.

There were also some modifications to the implementation of the WNCF program. Specifically, PY6 saw a greater emphasis on more comprehensive retrofits by program allies. Starting in PY5, the WNCF program issued gold and silver ENERGY STAR certificates of completion for homeowners who completed major improvements and met certain eligibility requirements during their upgrade. In PY6, the WNCF program saw an increase in the number of both silver and gold certificates issued to homeowners. In addition, the evaluation team used program-tracking databases to calculate the average ex ante savings per program participant and found a sizeable increase in average savings from PY5 to PY6. This provides further evidence of a shift toward more comprehensive retrofits.

Program staff did not note any major implementation challenges for the PY6 program year. Since its inception, the WNCF program has operated as a small program with a limited budget. This is reflected in the marketing and outreach activities for the program, which focus primarily on word-of-mouth referrals and direct mail. However, this implementation strategy did not appear to hinder the growth of the program in any way. For the second consecutive year, the WNCF program far surpassed its participation and energy savings goals.

Recommendations

Starting in PY7, the WNCF program is set to undergo several changes, one of which may be to lower the threshold for inclusion in the program. However, as this report goes to press, the specifics of those changes have not been determined. As such, the relevance of the recommendations provided by the evaluation team will vary, depending on the nature of the changes to the program in the coming year. With this in mind, our recommendations are as follows.

- As participant numbers increase and as the program becomes a larger contributor to the portfolio, **consider conducting a second year of billing analysis as a follow-on to the PY5 billing analysis**. The PY5 evaluation found sizeable differences in the realization rates between the billing analysis and engineering analysis. A second year of billing analysis will provide additional observations and a wider range of participants from which to refine impact findings.
- **Continue with the existing marketing and implementation strategy.** The WNCF program saw significant growth in both PY5 and PY6 without making any major changes to marketing tactics or program implementation. As a result, AIC should continue with their current marketing and implementation tactics. However, if WNCF's share of portfolio savings significantly increases and/or there is a sizeable increase in program goals, the marketing and implementation strategy may warrant reconsideration.
- **Update program tracking savings assumptions to reflect the ex post values used in this evaluation.** Our engineering analysis identified several discrepancies in input values between ex ante and ex post savings calculations. To increase the accuracy of tracked savings, we recommend that WNCF adopt the ex post assumptions and savings calculations used by the evaluation team.

2. Introduction

This report presents results from the evaluation of the Ameren Illinois Company (AIC) ActOnEnergy Residential Warm Neighbors Cool Friends (WNCF) program for PY6 (June 2013–May 2014). The program began as a pilot in PY3 and is in its third year of implementation. To support the evaluation we reviewed program materials and program-tracking data and conducted interviews with implementation and AIC staff. To estimate impacts, the evaluation team conducted an engineering analysis.

2.1 Program Description

The WNCF program is a home diagnostic and whole-house retrofit program that serves AIC residential customers who do not qualify for low-income weatherization assistance, but who cannot afford energy efficiency retrofit improvements to their homes. The target market is existing single-family homes heated by a fuel source (electricity or natural gas) provided by AIC and owned by customers with a household income between 200% and 300% of the federal poverty level guidelines for household size.

There are two main firms involved in implementing this program. Conservation Services Group (CSG) performs no-cost energy audits for targeted customers. The Energy Assistance Foundation (EAF) refers customers to CSG and contributes funding to help defray costs not covered by the program. The program requires customers to pay a small portion of the overall project cost (the greater of $500 or 10% of the total project cost, in addition to any amount not covered by program incentives). After determination of what the customer should pay based on program incentives, the EAF grants additional funds up to $3,000 to cover the remainder of the project cost.

The EAF is also involved in participant outreach and intake, differentiating the WNCF program from other home performance offerings: Customers who are interested in participating in the program submit their application to the foundation, which screens customers for eligibility. If a customer is eligible, the EAF shares this information with CSG to schedule an appointment.

Audits include the installation of low-cost instant savings measures (ISMs), including CFLs and/or water conservation measures, a comprehensive energy evaluation utilizing a blower door, and a thermal scan of the house using an infrared camera. Homeowners then receive a custom report with a work order outlining recommended energy efficiency improvements that they are encouraged to install by contracting with CSG. CSG then subcontracts the work to selected HPwES and HVAC program allies who have been previously screened and are under contract with CSG to perform work for the WNCF program. Retrofit measures installed after the audit include insulation, air sealing, and heating and cooling equipment replacement.

2.2 Research Objectives

The primary objective of the PY6 WNCF program evaluation is to provide estimates of gross and net electric and gas savings associated with the program. The evaluation team also explored a limited number of process-related research questions.

The impact evaluation answers the following research question:

1. What are the gross and net energy savings impacts from the program?

For the process evaluation, we addressed questions related to program design and implementation, including:

1. Is the program implemented according to design?
2. What implementation challenges have occurred in PY6 and how have they been overcome?
3. Have there been any changes to program design and implementation from PY5? If so, what and why?

3. Evaluation Methods

Table 2 presents the activities that we conducted for the PY6 evaluation.

Table 2. Summary of WNCF Evaluation Activities for PY6

Activity	PY6 Impact	PY6 Process	Forward Looking	Details
Program Material Review		✓		Reviewed program materials—including program design, implementation plans, marketing and outreach efforts, market actor training materials, and program databases—to assess program implementation and provide recommendations for improvement, where applicable.
Interviews with Program Staff and Implementers		✓		Interviewed the AIC program manager and CSG program manager in PY6 to understand the program's design, implementation, and evaluation priorities.
Engineering Analysis	✓			Conducted an engineering analysis of all program measures installed by WNCF PY6 participants.

3.1 Data Collection

The following activities informed the PY6 process evaluation of the WNCF program.

3.1.1 Review of Program Materials and Data

The evaluation team conducted a review of program materials, including implementation plans, marketing and outreach activities, training materials, and the program-tracking database.

3.1.2 Program Staff Interviews

We conducted in-depth interviews with key program staff including one member of the AIC program staff and one member of the CSG implementation team. The purpose of these interviews was to gain insight on whether the program was implemented according to its design and to determine whether there had been any changes in the program's design and implementation from PY5. The interviews also touched on whether any implementation challenges occurred in PY6. The team also inquired about data tracking and customer outreach related to the program.

3.2 Analytical Methods

3.2.1 Gross Impacts

To determine gross impacts associated with the WNCF program, we conducted a review of the program-tracking database and verified the correct application of the Statewide IL TRM V2.0. We estimated gross impact savings for the WNCF participants by applying savings algorithms from the Statewide IL TRM V2.0 to the information in the program-tracking database. The algorithms used to calculate all evaluated program savings, along with all input variables, can be found in Appendix A.

3.2.2 Net Impacts

We applied a NTGR of 1.0 to gross savings to obtain PY6 WNCF program net savings. In PY3, the evaluation team discussed and reached agreement on the calculation of net savings with the ICC and AIC staff given our understanding of program design and targeted customers. We applied a NTGR of 1.0 because the program is targeted to participants with household incomes between 200% 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.

3.3 Sources and Mitigation of Error

Table 3 provides a summary of possible sources of error associated with data collection conducted for the WNCF program.

Table 3. Possible Sources of Error

Research Task	Survey Error		Non-Survey Error
	Sampling Error	Non-Sampling Survey Error	
Gross Savings Calculations	N/A	N/A	Data processing error
Net Savings Calculations	N/A	N/A	Data processing error

The evaluation team took a number of steps to mitigate against potential sources of error throughout the planning and implementation of the PY6 evaluation. We discuss these efforts in detail below.

Survey Errors

There were no survey errors (sampling errors or non-sampling survey errors) because (1) we did not use a participant survey and (2) we performed a census of all program participants for our engineering analysis.

Non-Survey Errors

There might have been two types of non-survey errors.

- **Gross Impact Calculations***:* We applied the TRM calculations to the participant data in the tracking database to calculate gross impacts. To minimize data processing error, the evaluation team had all calculations reviewed by a separate team member to verify the accuracy of our impact calculations.
- **Net Impact Calculations***:* We applied a NTGR of 1.0 to gross savings to obtain PY6 WNCF program net savings. Therefore, although possible, we do not anticipate any error in these calculations.

4. Evaluation Findings

4.1 Program Description and Participation

4.1.1 Program Description

The WNCF program is a home diagnostic and whole-house retrofit program that serves AIC residential customers who do not qualify for low-income weatherization assistance, but who cannot afford energy efficiency retrofit improvements to their homes. The target market is existing homes heated by a fuel source (electricity or natural gas) provided by AIC and owned by customers with a household income between 200% and 300% of the federal poverty level guidelines for household size.

The WNCF program consists of no-cost energy audits for target customers and includes installation of several measures at the time of the audit. These measures include CFLs, faucet aerators, and low-flow showerheads. Upon completion of the audit, homeowners receive a customer report with a work order of recommended energy efficiency improvements that they are encouraged to make by contracting with CSG. The program requires customers pay only a small portion of the overall improvement cost.

In PY6, the program reached 317 participants, surpassing its goal of 182 retrofit projects.

4.1.2 Program Participation

Participation in the program is limited by the amount of grant funds available. In PY6, the participation experience varied somewhat across the 317 participants based on the services received. As shown in Table 4, the evaluation team grouped participants based on whether they received only an audit, only a retrofit, or both an audit and a retrofit. A little more than half of the participants (51%) received an on-site audit, after which they received ISMs and had retrofit measures installed through a participating contractor. Notably, one-quarter of participants received only retrofit services. According to program staff, these customers either (1) received a Home Energy Performance audit and a referral to WNCF based on income eligibility or (2) did not initially qualify for a WNCF audit and subsequently remediated a disqualifying feature (e.g., made repairs to roof, removed vermiculite, or replaced knob and tube wiring).

Table 4. Overview of PY6 Participation by Services Received

Participant Type	Number of Participants	% of Participants[a]
Audit and Retrofit	161	51
Retrofit Only	78	25
Audit Only (received only ISMs)	78	25
Total	**317**	**100**

[a] Percentages do not total 100% due to rounding.

We calculated a conversion rate by dividing the number of participants who received a retrofit following an audit by the total number of participants who received an audit (whether or not they received a retrofit). Table 5 shows that the conversion rate decreased slightly between PY5 and PY6; however, this type of fluctuation occurs commonly and may stem partially from a shift toward more comprehensive retrofits (see Section 4.2.1).

Table 5. PY5 and PY6 Conversion Rates

Participant Type	PY5 Participants	PY6 Participants
Audit and Retrofit	138	161
Audit Only	48	78
Total Audits	**186**	**238**
Conversion Rate (Audit and Retrofits / Total Audits)	**74%**	**68%**

4.2 Process Evaluation

The process evaluation effort explored the following research objectives: (1) the degree to which program implementation was consistent with program design; (2) whether there were any implementation challenges in PY6 and, if so, how were they overcome; and (3) whether there were changes to program design and implementation compared to PY5 and, if so, what were those changes and why were they made.

4.2.1 Program Design Changes and Challenges

Overall, the WNCF program implementation operated according to design. The program made no significant design changes in PY6.

The program exceeded its PY6 participation goal. Similar to PY5, program staff reported that the most effective marketing channel continues to be word-of-mouth and contractor referrals. PY6 marketing and outreach efforts continue to include letters to WNCF audit customers who are eligible for the program (i.e., they meet the income profile); referrals from AIC program ally contractors; outreach to organizations that serve participants (e.g., churches, senior centers, community programs); and word of mouth from program participants to friends, family, and colleagues. PY6 did see the development of a new marketing channel via a program page linked to the ActOnEnergy website. This new program page provides customers the ability to download an application to participate in the program.

Additionally, in PY6, program staff worked to develop a series of instructional audio and video materials planned for use by program allies over the course of retrofit projects beginning in PY7. Prior to the start of the project, these instructional materials will educate homeowners about program measures and will guide homeowners through the retrofit process. After the completion of the project, homeowners will receive a second set of audio and video materials to help promote future energy-saving actions. Program staff reviewed and approved these educational materials toward the end of PY6.

With respect to design changes, the program did make some slight modifications to its measure list. These changes include the addition of specialty CFL candelabra, globe, and reflector bulbs. (See Table 6 for the full list of measures in PY6.)

Although there were no major program design changes in PY6, program staff did note a shift toward more comprehensive retrofits by energy advisors and program allies. As an example, PY6 saw an increase in the number of participants that received silver and gold ENERGY STAR certificates. As mentioned earlier, homeowners receive ENERGY STAR certificates when they make significant energy efficiency improvements during their home upgrade. The eligibility requirements to receive such certificates include such criteria as 15% modeled total energy savings (compared to the initial home assessment), a 30%

reduction below the baseline building infiltration rate, the installation of ENERGY STAR-qualified heating and cooling equipment, and the installation of insulation above defined R-values.[4]

Table 6 shows both the number and percentage of homes with ENERGY STAR certificates for PY5 and PY6. Although the number of homes receiving these certificates still represents a small subset of program participants, it is worth pointing out that we see an increase in both the number and percentage of ENERGY STAR certificates in PY6.

Table 6. Number of Homes with ENERGY STAR Certificates by Program Year

ENERGY STAR Certificates	PY5	PY6
Silver	13	23
Gold	16	23
Total	**29**	**46**
% of Program Participants	**11**	**15**

Additionally, the evaluation team used the program-tracking database to examine the average ex ante energy savings per participant for PY5 and PY6. Specifically, the evaluation team summed all ex ante energy savings in the program database and divided it by the total number of program participants. To adjust for potential differences in the savings algorithms across program years, the evaluation team applied the PY5 savings algorithms to both the PY5 and PY6 data. From this analysis, we found a 7% increase in the average (per participant) ex ante electric savings and a 13% increase in the average ex ante gas savings. Moreover, we found that the key driver for these increases was from the installation of more expensive measures, such as central AC, heat pumps, furnaces, and boilers. In total, these findings help support the insights from our program staff interviews, which highlighted a shift in PY6 toward more comprehensive retrofits.

Program staff did not mention any major challenges faced in PY6. Similar to PY4 and PY5, the WNCF program disqualified about 20% of applicants because their homes include such items as knob and tube wiring, vermiculite, and holes in the roof. Such disqualifications often occur in the St. Louis Metro East area. Project coordinators who interact with these customers during the audit and test-in provide references to contractors who can remediate disqualifying features. It is often difficult for customers with modest incomes to remediate the problems before they can be accepted into the program.

With the exception of disqualified homes, program staff did not raise any other major implementation issues. The program is still able to find opportunities to market using word-of-mouth referrals and direct mail. These approaches continue to yield success, as the program had no problem reaching its end-of-year participation and energy savings goals.

Measures Installed

Program participants had a variety of measures installed through the program. Table 7 provides an overview of households that received measures and the total number of measures received based on program-tracking data.

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[4] Note that homeowners do not need to satisfy all criteria listed.

Table 7. Overview of PY6 WNCF Participation by Measure Category

Measure Category	Measure	Unique Households[a]	# of Measures	Unit
Lighting	CFL – Low (13–15 Watt)	131	825	Bulb
	CFL – Medium (18–20 Watt)	25	138	Bulb
	CFL – High (23-25 Watt)	30	161	Bulb
	Specialty CFL – 9W Candelabra	56	382	Bulb
	Specialty CFL – 14W Globe	36	210	Bulb
	Specialty CFL – 15W Reflector	22	126	Bulb
Domestic Hot Water (DHW)	Faucet Aerators	164	222	Aerator
	Showerheads	159	170	Showerhead
HVAC	Air Source Heat Pump Replacement	6	7	Heat pump
	Central AC Replacement	86	86	CAC
Boiler/Furnace	Furnace > 95 AFUE	209	211	Furnace
	Gas Boiler > 90 AFUE	10	10	Boiler
Envelope	Air Sealing	217	378,720	CFM
	Attic Insulation	196	219,775	Sqft
	Wall Insulation	107	91,378	Sqft
	Rim Joist Insulation	142	16,836	Linear Feet
	Crawl Space Insulation	79	18,209	Sqft
	Basement Wall Insulation	5	768	Linear Feet
Thermostat	Programmable Thermostat	168	168	Thermostat
Motor	ECM – Brushless Motor	16	16	Motor

[a] Note that the sum of the number of unique households in Table 7 is greater than the number of participating households (N=317) because any given household could install more than one measure.

4.3 Impact Assessment

4.3.1 Gross Impacts

The evaluation team conducted an engineering analysis to derive PY6 WNCF gross impacts. Table 8 summarizes these results.

Table 8. PY6 WNCF Program Gross Impacts

	Ex Ante Gross[a]			Ex Post Gross		
Number of Participants	kWh	kW	Therms	kWh	kW	Therms
317	652,231	487	162,026	617,197	529	173,380
Gross Realization Rate[b]				95%	109%	107%

[a] Source of ex ante savings: PY6 program-tracking database.
[b] The gross realization rate is calculated as the PY6 gross ex post savings divided by the PY6 ex ante gross savings.

Detailed Results

Below we provide gross impact results by measure. We calculated ex post gross savings using inputs and algorithms from the Statewide IL TRM V2.0. CSG provided the evaluation team with documentation of the inputs and algorithms used to calculate ex ante savings. The gross realization rate was 95% for electric savings, 109% for demand savings, and 107% for gas savings.

Table 9. WNCF Impacts by Measure

Measure	Ex Ante Gross Impacts			Ex Post Gross Impacts			Gross Realization Rate[a]		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
Air Sealing	329,958	318.22	43,791	293,175	330.18	47,573	89%	104%	109%
Central Air Conditioner	88,220	92.36	-	93,379	96.40	-	106%	104%	NA
Attic Insulation	45,317	20.81	16,212	33,091	31.29	17,056	73%	150%	105%
Wall Insulation	36,976	25.98	16,277	30,459	33.99	19,628	82%	131%	121%
CFL - Low (13–15 Watt)	34,988	3.96	-	36,601	3.88	-	105%	98%	NA
Heat Pump	31,007	5.28	-	47,474	8.00	-	153%	152%	NA
Specialty CFL - 9W Candelabra	15,127	1.57	-	16,153	1.55	-	107%	99%	NA
Crawl Space Insulation	13,409	7.00	8,891	6,294	7.06	9,493	47%	101%	107%
Specialty CFL - 14W Globe	11,523	1.20	-	12,303	1.21	-	107%	101%	NA
ECM - Brushless Motor	11,360	4.83	-	11,712	5.92	-	103%	122%	NA
CFL - High (23–25 Watt)	7,118	0.81	-	7,609	0.81	-	107%	100%	NA
Rim Joist Insulation	6,664	3.15	2,930	8,296	6.80	5,286	125%	216%	180%
Programmable Thermostats - Gas Htg	6,013	-	6,625	5,929	-	6,514	99%	NA	98%
Specialty CFL - 15W Reflector	5,684	0.64	-	6,070	0.64	-	107%	100%	NA
CFL - Medium (18–20 Watt)	4,108	0.47	-	4,525	0.48	-	110%	102%	NA
Showerhead - Electric	2,207	0.14	-	2,207	0.14	-	100%	100%	NA
Programmable Thermostats - Electric Htg	1,321	-	-	1,019	-	-	77%	NA	NA
Faucet Aerator - Electric	676	0.33	-	675	0.33	-	100%	99%	NA
Basement Wall Insulation	556	0.27	399	225	0.22	534	41%	84%	134%

Measure	Ex Ante Gross Impacts			Ex Post Gross Impacts			Gross Realization Rate[a]		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
Gas Furnace	-	-	59,983	-	-	60,248	NA	NA	100%
Gas Boiler	-	-	3,965	-	-	4,095	NA	NA	103%
Showerhead - Gas	-	-	2,565	-	-	2,565	NA	NA	100%
Faucet Aerator - Gas	-	-	387	-	-	388	NA	NA	100%
Total	**652,231**	**487.00**	**162,026**	**617,197**	**528.89**	**173,380**	**95%**	**109%**	**107%**

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

Differences in ex post and ex ante gross savings stem from differences in input values for the savings algorithms for each measure. Through our discussions with CSG, we identified the sources of these differences. Table 10 summarizes these findings.

Table 10. Reasons for Realization Rates per Measure

Measure	kWh RR	kW RR	Therms RR	CDD, HDD, FLH	Pre & Post R-Value	Framing Factor	Waste Heat Factors	Other (Specified)
Air Source Heat Pump	153%	152%	NA	X				- Baseline Equipment Type
Rim Joist Insulation	125%	216%	180%	X	X	X		- Misapplied ex ante per-unit value for homes with CAC - Height of installed rim joist insulation
Lighting (CFLs)	105%–110%	98%–102%	NA				X	
Central Air Conditioners	106%	104%	NA	X				
ECM - Brushless Motor	103%	122%	NA					- Cooling Present
Air Sealing	89%	104%	109%	X				- Misapplied ex ante per-unit value for homes with CAC - Latent Multiplier - Nheat
Wall Insulation	82%	131%	121%	X	X			- Misapplied ex ante per-unit

Measure	kWh RR	kW RR	Therms RR	CDD, HDD, FLH	Pre & Post R-Value	Framing Factor	Waste Heat Factors	Other (Specified)
								value for homes with CAC
Programmable Thermostat	77% (E) 99% (G)	NA	98%					- Climate Zone
Attic Insulation	73%	150%	105%	X	X	X		- Misapplied ex ante per-unit value for homes with CAC
Crawl Space Insulation	47%	101%	107%	X	X			- Misapplied ex ante per-unit value for homes with CAC
Basement Wall Insulation	41%	84%	134%	X	X			- Misapplied ex ante per-unit value for homes with CAC
Faucet Aerator	100%	99%	100%					
Showerheads	100%	100%	100%					
Gas Boiler	NA	NA	103%					
Gas Furnace	NA	NA	100%					

The inputs for air sealing and insulation measures have the largest impact on program level realization rates. Because air sealing measures account for 51% of the kWh program savings, and insulation measures account for 16% of the kWh program savings, any differences within these measures affect the program savings significantly. We describe the differences in the ex ante and ex post savings calculations for these two measures as well as CFLs in detail below. Note that while certain inputs may increase savings, others decrease savings. The combination of all inputs brings about the overall realization rate for a specific measure.

- **CDD, HDD, and Full Load Hours (FLH):** CSG applied the CDD, HDD, and FLH input values for Springfield to all projects regardless of location to estimate ex ante savings, while the evaluation team used input values appropriate for the location of each participating home. Using location-appropriate values for these inputs as directed by the TRM yields ex post per-unit savings estimates for shell measures that are on average 24% lower than the ex ante due to the change in HDDs (i.e., fewer HDDs) and 3% higher due to the change in CDDs. The per-unit savings for the installation of air source heat pumps increased by an average of 5% and for the installation of central air conditioners decreased by an average of 14% due to changes in FLH.

- **Pre and Post R-Value:** CSG applied the same pre-existing and post-retrofit R-values for all participants to estimate ex ante savings despite the availability of actual pre-existing and post-retrofit R-values in the database. The evaluation team, however, used the actual pre and post R-values from the database to calculate ex post savings per participant. As a result, the per-unit savings for shell measures increased by an average of 9%.

- **Framing Factor (Attic Insulation)**: The savings algorithm for attic insulation in the Statewide TRM Version 2 stipulates that the framing factor for attic insulation be divided by two. Ex ante calculations did not divide the framing factor by two, except in cases where savings are claimed for electric cooling only, and as such underestimate savings. The per-unit savings for attic insulation increased by 8% when dividing the framing factor by two.

- **Framing Factor (Rim Joist Insulation):** Ex ante calculations for rim joist insulation underestimate savings by including a framing factor of 0.15, which assumes that insulation installed is in either the studs or cavity. Per the Statewide TRM Version 2, a framing factor of zero should be used for spray foam insulation and 0.15 for cavity insulation. Ex post calculations applied a framing factor of zero for participants who installed spray foam rim joist insulation (84%), and also for those where the type of rim joist insulation is unknown (12%). A framing factor of 0.15 was applied for those who installed rigid rim joist insulation (4%). As a result, the per-unit savings increased by 10% when applying framing factors based on the type of installed rim joist insulation (spray foam vs. cavity).

- **Height of Rim Joist Insulation:** The tracking database includes only the linear feet of installed rim joist insulation and does not indicate the rim joist height. CSG applied a rim joist height value of 11.2" to calculate ex ante savings while the evaluation team used a value of 12" to calculate ex post savings. The database shows that 84% of participants who installed rim joist insulation used spray foam insulation, which is often irregular and uneven in depth between joists. We believe it is best to slightly overestimate the rim joist height to account for the imprecise installation of spray foam insulation. The per-unit savings increased by 7% when assuming a rim joist height of 12".

- **Waste Heat Factors***:* Consistent with past evaluations and per agreements between ICC staff and AIC regarding the treatment of waste heat factors, we did not include waste heat factors for lighting in the calculation of ex post savings, but we will include calculations with waste heat factors for the cost-effectiveness analysis.[5] The discrepancy in realization rate is due to the inclusion of waste heat factors for electric heating in the ex ante savings, which is an average 6.35% kWh penalty. The average kWh realization rate for ex post savings for lighting measures is 107%. Had we applied the electric waste heat factors, the ex post values would have been reduced and the realization rate would have been close to 100%.

- **Latent Multiplier for Air Sealing:** The latent multiplier accounts for latent cooling demand for air sealing measures and is dependent on project location. The ex ante savings calculations applied the latent multiplier for Springfield to all projects regardless of their project location. The ex post calculations applied the latent multiplier for each project's actual location. As a result, the per-unit savings for air sealing measures decreased by an average of 2%.

- **Nheat for Air Sealing:** The Nheat conversion factor (converting CFM50 to CFMnat) is based on the climate zone, building height, and level of wind exposure. The ex ante savings calculations applied a Nheat of 16.7 (assuming 1.5 stories) to all homes. The database does not include the number of stories per participant, and therefore ex post calculations used the average Nheat of 15.75 since we did not know how many stories single home had. Because this ex post input value is lower than the ex ante value, the per-unit savings for air sealing measures increased by an average of 4%.

[5] Appendix B provides the program savings with these factors included.

- **Misapplied Ex Ante Per Unit Value:** For customers with cooling only (93% of participants with shell measures), the per-unit ex ante values found in the database for attic insulation, rim joist insulation, wall insulation, crawlspace insulation, basement wall insulation, and air sealing are inconsistent with the per unit values included in a secondary source received from CSG. The ex ante per-unit values in the database apply the sum of the per-unit value for cooling and runtime savings due to reduced heating loads (for those with gas heating) to all participants with cooling only. However, the database includes separate measure labels for participants with runtime savings. In other words, ex ante per-unit values for runtime savings are applied twice for these participants since runtime savings are accounted for in the cooling only measures and then once again in the runtime savings measures. As a result, ex ante savings are double counted for these participants. In addition, not all participants with cooling only have gas heating, but the ex ante per-unit value assumes that this is the case. Once we make these adjustments, the per-unit ex post savings for customers with cooling decreased by an average of 45%. While 93% of participants who installed shell measures saw an average decrease in per-unit ex post savings of 45%, overall program savings were not significantly affected because the savings for those affected by the double-counting issue were relatively small. We recommend that the cooling-only and runtime savings be assigned separately to avoid double counting runtime energy savings.

- **Climate Zone:** Programmable thermostat savings within the Statewide IL TRM V2.0 are calculated using a deemed percentage of savings of assumed electric consumption based on climate zone. For the two customers with programmable thermostats and electric heating, the implementation team appears to have applied the incorrect climate zone assumptions. Both participants were located within Climate Zone 4 (electric consumption value of 8,217 kWh/year per IL TRM) yet appear to have had Climate Zone 3 electric consumption values (10,652 kWh/year) applied. If ex ante values applied Climate Zone 4 consumption values, the kWh realization rate would increase from 77% to 100%.

- **Baseline Equipment Type:** Two participants installed air source heat pumps that replaced central air conditioners, but their heating fuel was unknown. We assumed electric heating was in place at the time of the installation, as the implementer indicated that gas furnaces would not be replaced with air source heat pumps due to fuel switching. However, the ex ante per-unit savings (981 kWh) applied to these two participants was calculated for the replacement of an existing heat pump. Had the ex ante per-unit value for the replacement of electric resistance heating (12,321 kWh) been applied, the realization rate for this measure would have been 88%.

- **Cooling Present for ECM Measures:** Savings for ECM motors is a deemed value within the Statewide IL TRM V2.0, which varies based on the presence of cooling. The ex ante savings calculations applied deemed IL TRM values for "cooling unknown," whereas ex post applied deemed IL TRM values for "cooling present." The deemed savings value for homes with "cooling present" is 10% greater than the deemed value for homes with "cooling unknown." The evaluation team applied IL TRM values for "cooling present" due to the fact that the measure labels for shell measures indicated whether cooling was present or not.

4.3.2 Net Impacts

As mentioned earlier, the evaluation team applied a NTGR ratio of 1.0 to the evaluated gross savings. In PY3, the evaluation team discussed and reached agreement with ICC staff and AIC on this value given the program design and targeted customers. In particular, the group agreed that this value was reasonable given that the program targets participants with household incomes between 200% 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. Table 11 below displays the overall net impacts for WNCF in PY6.

Table 11. PY6 WNCF Program Net Impacts

Number of Participants	Ex Ante Net[a]			Ex Post Net		
	kWh	kW	Therms	kWh	kW	Therms
317	652,231	487	162,026	617,197	529	173,380
Net Realization Rate[b]				95%	109%	107%

[a] Source of ex ante savings: PY6 program-tracking database.
[b] The net realization rate is calculated as the PY6 net ex post savings divided by the PY6 ex ante net savings.

4.4 Conclusion and Recommendations

In PY6, the WNCF program saw sizeable growth in the number of program participants and total energy savings. As part of our limited process evaluation, we found only small changes to program design and implementation as compared to PY5. These changes include the addition of WNCF program webpage and the approval to use in-home instructional videos to help educate homeowners on the project installation process and energy management. Our in-depth interviews with program staff highlighted a shift towards more comprehensive project installations. Through our review of program materials and program tracking databases, we found more Energy Star certificates awarded in PY6 (as compared to PY5) along with higher per participant average ex ante savings.

Turning to the results from our impact analysis, we report net realization rates above 100% for both kW and therms savings, however the net realization rate for kWh savings was lower at 95%. Based on our analysis of the program database and our discussions with CSG, the evaluation team identified differences in input values between the ex ante and ex post savings calculations for air sealing and insulation as the main factors driving the differences in net realization rates.

As for recommendations, given the success of WNCF in achieving (and surpassing) both their participation and energy savings goals for the year, we do not have much to say in the way of modifications to the program design or implementation. As such, our recommendations are forward-looking and based on whether the WNCF program continues to grow in proportion to the rest of the AIC portfolio. With this in mind, our recommendations are as follows:

- As participant numbers increase and as the program becomes a larger contributor to the portfolio, consider conducting a second year of billing analysis as a follow on to the PY5 billing analysis. In PY5 the evaluation team reported a large discrepancy between the results from the engineering and billing analysis, with WNCF achieving a little over one third of anticipated ex-ante electric and gas net savings per the billing analysis. A second year of billing analysis will provide additional observations and a wider range of participants from which to refine impact findings.

- Continue to implement existing marketing and implementation strategy. The WNCF program has seen significant growth in both PY5 and PY6 without making any major changes to marketing tactics or program implementation. As a result, AIC should continue with their current marketing and implementation tactics. However, if WNCF's share of portfolio savings significantly increases

and/or there is a sizeable increase in program goals, the WNCF program may want to consider a broader marketing strategy.

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

A. Appendix: Engineering Analysis Algorithms

In PY6, the impact evaluation efforts estimated gross impact savings for the WNCF participants by applying savings algorithms from the Statewide IL TRM V2.0[6] to the information in the program-tracking database. We present the algorithms used to calculate all evaluated program savings below, along with all input variables.

Lighting Algorithms

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

Equation 1. Interior Standard and Specialty CFL Algorithms

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

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

Where:

WattsBase = Wattage of existing equipment

Table 12 Baseline Wattages for Lighting Measures

Measure	EISA Adjusted[1]	Baseline Wattage
CFL - Low 13 to 15 Watt	No	60
CFL - Medium 18 to 20 Watt	Yes	53
CFL - High 23 to 25 Watt	Yes	72
Specialty CFL – 9W Candelabra	No	40
Specialty CFL – 14W Globe	No	60
Specialty CFL – 15W Reflector	No	65

The EISA schedule requires baseline adjustments to measures with incandescent baseline wattages of 100W (as of June 2012) and 75W (as of June 2013). Lighting measures with incandescent baseline wattages of 60W and 40W are scheduled for EISA adjustments beginning June 2014. This will impact the PY7 lighting estimates.

WattsEE = Wattage of installed equipment

ISR = In-service rate or the percentage of units rebated that get installed = 97%[7]

HOURS = Annual operating hours

[6] State of Illinois: Energy Efficiency Technical Reference Manual V2.0. Effective June 1, 2013.

[7] ISR calculated for the WNCF program in PY4 was used for PY6 participants.

Table 13. Annual Hours of Use for Lighting Measures

Measure	Hours
Standard CFL (Spiral)	938
Specialty CFL (Globe)	1,240
Specialty CFL (Candelabra)	1,328
Specialty CFL (Interior Reflector)	938

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

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

CF = Summer Peak Coincidence Factor

Table 14. Coincidence Factors for Lighting Measures

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

Lighting Measures Heating Penalty

The evaluation team determined heating penalties for electric and gas heated homes using the algorithms below. Based on the agreement between the ICC and AIC, we do not include heating penalties in the ex post energy savings but will include this in data for the PY6 cost-effectiveness analysis.

Equation 2. Heating Penalty Algorithms

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

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

Where:

WattsBase = Wattage of existing equipment

Table 15. Baseline Wattages for Lighting Measures

Measure	EISA Adjusted[1]	Baseline Wattage
CFL - Low 13 to 15 Watt	No	60
CFL - Medium 18 to 20 Watt	Yes	53
CFL - High 23 to 25 Watt	Yes	72
Specialty CFL – 9W Candelabra	No	40
Specialty CFL – 14W Globe	No	60
Specialty CFL – 15W Reflector	No	65

[1] The EISA schedule requires baseline adjustments to measures with incandescent baseline wattages of 100W

(as of June 2012) and 75W (as of June 2013). Lighting measures with incandescent baseline wattages of 60W and 40W are scheduled for EISA adjustments beginning June 2014. This will impact the PY7 lighting estimates.

WattsEE = Wattage of installed equipment

ISR = In-service rate or the percentage of units rebated that get installed = 97%[8]

HOURS = Annual operating hours

Table 16. Annual Hours of Use for Lighting Measures

Measure	Hours
Standard CFL (Spiral)	938
Specialty CFL (Globe)	1,240
Specialty CFL (Candelabra)	1,328
Specialty CFL (Interior Reflector)	938

HF = Heating Factor = 0.49

ηHeat = Efficiency of Heating equipment (Assumed COP 2.0 for heat pumps, 1.0 COP for electric resistance heating, and AFUE 0.7 for gas heating)

Heating penalties vary based on the type of heating equipment within each home. Table 17 summarizes the heating penalties for the six lighting measures offered through the program by heating equipment type.

Table 17. Heating Penalty

Lighting Measure	Heating Equipment	ΔkWh	ΔkW	Δtherms
CFL - Low 13 TO 15 Watt	Heat Pump (htg only)	-10.25	n/a	n/a
CFL - Medium 18 to 20 Watt	Heat Pump (htg only)	-7.58	n/a	n/a
CFL - High 23 to 25 Watt	Heat Pump (htg only)	-10.92	n/a	n/a
CFL - Low 13 TO 15 Watt	Electric Resistance	-20.51	n/a	n/a
CFL - Medium 18 to 20 Watt	Electric Resistance	-15.16	n/a	n/a
CFL - High 23 to 25 Watt	Electric Resistance	-21.85	n/a	n/a
CFL - Low 13 TO 15 Watt	Gas Heating	n/a	n/a	-1.00
CFL - Medium 18 to 20 Watt	Gas Heating	n/a	n/a	-0.74
CFL - High 23 to 25 Watt	Gas Heating	n/a	n/a	-1.06
Specialty CFL - 9W candelabra	Heat Pump (htg only)	-9.77	n/a	n/a
Specialty CFL - 14W globe	Heat Pump (htg only)	-13.54	n/a	n/a
Specialty CFL - 15W reflector	Heat Pump (htg only)	-11.13	n/a	n/a
Specialty CFL - 9W candelabra	Electric Resistance	-19.55	n/a	n/a
Specialty CFL - 14W globe	Electric Resistance	-27.08	n/a	n/a
Specialty CFL - 15W reflector	Electric Resistance	-22.27	n/a	n/a
Specialty CFL - 9W candelabra	Gas Heating	n/a	n/a	-0.95

[8] ISR calculated for the WNCF program in PY4 was used for PY6 participants.

Lighting Measure	Heating Equipment	ΔkWh	ΔkW	Δtherms
Specialty CFL - 14W globe	Gas Heating	n/a	n/a	-1.32
Specialty CFL - 15W reflector	Gas Heating	n/a	n/a	-1.08

Water Heating Measure Algorithms

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

Equation 3. Showerhead 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. Faucet Aerator Algorithms

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

Demand Savings: *ΔkW = ΔkWh/ Hours * CF*

Therm Savings: *ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_gas * ISR*

Where:

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

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

GPM_base = Flow rate of the baseline showerhead/faucet aerator

GPM_low = As-used flow rate of the low-flow showerhead/faucet aerator

Table 18. GPM for Water Heating Measures

Measure	GPM_base	GPM_low
Faucet aerator	1.20	0.94
Showerhead	2.67	1.75

L_base = Average baseline length faucet use per capita for all faucets in minutes

Table 19. L_base for Water Heating Measures

Measure	Minutes
Faucet aerator	9.85
Showerhead	8.20

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

Household = Average number of people in household = 2.56

SPCD = Showers Per Capita Per Day = 0.75

SPH = Showerheads Per Household = 1.79

DF = Drain Factor = 0.795 (unknown location)

FPH = Faucets Per Household = 3.83 (unknown location)

EPG_electric = Energy per gallon of hot water supplied by electric

EPG_gas = Energy per gallon of hot water supplied by gas

Table 20. EPG for Water Heating Measures

Measure	EPG_electric	EPG_gas
Faucet Aerator	0.0894	0.0040
Showerhead	0.1270	0.0054

ISR = In-Service Rate[9]

Table 21. ISR for Water Heating Measures

Measure	ISR
Faucet Aerator	95%
Showerhead	98%

Hours = Annual electric DHW recovery hours

Table 22. Hours for Water Heating Measures

Measure	Hours
Faucet Aerator[a]	45
Showerhead[b]	431

(a) Hours of use for single family with unknown location
(b) Hours of use for single family direct install

CF = Coincidence Factor for electric load reduction

[9] ISR calculated for the WNCF program in PY4 was used for PY6 participants.

Table 23. CF for Water Heating Measures

Measure	CF
Faucet Aerator	0.0220
Showerhead	0.0278

Air Sealing Algorithms

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

Equation 5. Air Sealing Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*ΔkWh_cooling = [(((CFM50_existing - CFM50_new)/N_cool) * 60 * 24 * CDD * DUA * 0.018) / (1000 * ηCool)] * LM*

ΔkWh_heating (electric heat) = *(((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 3,412)*

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

Gas Savings (gas heat): *ΔTherms = (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 100,000)*

*ΔkWh_heating (gas heat furnace fan run time reduction) = ΔTherms * 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[10]

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

Table 24. 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

[10] Assumed Zone 2 Normal Exposure.

ηCool = Seasonal Energy Efficiency Ratio (SEER) of cooling system (used age of existing equipment pre 2006)

Table 25. ηCool for Air Sealing Measures

Measure	ηCool (Pre 2006)	ηCool (Post 2006)
Central Air Conditioner	10	13
ASHP	10	13

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

Table 26. Latent Multiplier by Climate Zone

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

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions = 15.75[11]

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

Table 27. Heating Degree Days by Climate Zone

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

ηHeat = Efficiency of heating system (based on heating equipment type per participant) (used age of existing equipment pre 2006)

Table 28. ηHeat for Air Sealing Measures

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

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

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

Table 29. FLH cooling by Climate Zone

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

CF = Coincidence Factor = 0.915

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

Attic and Wall Insulation Algorithms

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

Equation 6. Attic Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*ΔkWh_cooling = (((1/R_old - 1/R_new) * A_attic * (1-Framing_factor/2)) * 24 * CDD * DUA) / (1,000 * ηCool)*

*ΔkWh_heating (electric heat) = (((1/R_old - 1/R_new) * A_attic* (1-Framing_factor/2))) * 24 * HDD) / (ηHeat * 3,412)*

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

Gas Savings (gas heat): *ΔTherms = (((1/R_old - 1/R_new) * A_attic * (1-Framing_factor/2)) * 24 * HDD) / (ηHeat * 100,067 Btu/therm)*

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

Equation 7. Wall Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*ΔkWh_cooling = (((1/R_old - 1/R_new) * A_wall * (1-Framing_factor)) * 24 * CDD * DUA) / (1,000 * ηCool)*

*ΔkWh_heating (electric heat) = (((1/R_old - 1/R_new) * A_wall* (1-Framing_factor))) * 24 * HDD) / (ηHeat * 3,412)*

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

Gas Savings (gas heat): *ΔTherms = (((1/R_old - 1/R_new) * A_wall * (1-Framing_factor)) * 24 * HDD) / (ηHeat * 100,067 Btu/therm)*

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

Where:

R_new = Total attic or wall assembly R-value after the installation of additional insulation (see Equation 8 for assembly R-value algorithms)

R_old = R-value of existing attic or wall assembly and any existing insulation with a minimum of R-5 (see Equation 8 for assembly R-value algorithms)

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

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

Framing_factor = Adjustment to account for area of framing = 0.15 (Framing Factor included in the assembly R-value algorithms; see Equation 8)

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

Table 30. Cooling Degree Days by Climate Zone

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

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio of cooling system (actual if available, 10 SEER if unknown) (used age of existing equipment pre 2006)

Table 31. ηCool for Attic and Wall Insulation Measures

Measure	ηCool (Pre 2006)	ηCool (Post 2006)
Central Air Conditioner	10	13
ASHP	10	13

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

Table 32. Heating Degree Days by Climate Zone

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

ηHeat = Efficiency of heating system (applied based on heating equipment type per participant) (used age of existing equipment pre 2006)

Table 33. Assumed ηHeat by Heat Type

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

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

Table 34. FLH_cooling by Climate Zone

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

CF = Coincidence Factor = 0.915

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

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

- We determined the assembly wall value using the ASHRAE Isothermal Planes method (page 27.3, ASHRAE Fundamentals, 2013).
- This method includes the IL TRM framing factor within the calculations as shown below.
- Equation 8 was not applied to calculate assembly R-values for pre-existing attic or wall insulation for those with R-values less than 5. These cases were assigned an assembly R-value of 5 for both attic and wall insulation.

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

Equation 8. Attic and Wall Assembly R-value Algorithms

$$\text{Attic Assembly R-value} = ((1/\text{R-value}_{database}) * \%\text{ of Assembly} + 1/\text{R-value}_{Joist} * \text{Framing\_Factor}/2) + (\text{R-value}_{indoor\ air\ film} + \text{R-value}_{plywood} + \text{R-value}_{gypsum} + \text{R-value}_{indoor\ air\ film})$$

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

Where:

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

Framing_factor = Adjustment to account for area of framing = 0.15

Figure 1. Engineering Factors Used within Attic Insulation Calculations

No Insulation				With Insulation			
N	Element	R	R	N	Element	R	R
1	indoor air film, still air		0.68	1	indoor air film, still air		0.68
2	air[a]	0.86	0.92	2	mineral fiber batt insulation	19	16.22
3	Joist (nominal 5.5") - southern pine	5.78		3	Joist (nominal 5.5") - southern pine	5.8	
4	plywood, 5/8", douglas fir		0.85	4	plywood, 5/8", douglas fir		0.85
5	gypsum wallboard, 0.5 inch		0.45	5	gypsum wallboard, 0.5 inch		0.45
6	indoor air film, still air		0.68	6	indoor air film, still air		0.68
	R value		3.6		R value		18.9
	U value		0.28		U value		0.05
	% of assembly	0.925	0.075		% of assembly	0.925	0.075
	U of assembly	0.28			U of assembly	0.05	
	R of assembly	3.58			R of assembly	18.88	

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

Figure 2. Engineering Factors Used within Wall Insulation Calculations

No Insulation				With Insulation			
N	Element	R	R	N	Element	R	R
1	Outdoor Air film, 15 mph wind		0.17	1	Outdoor Air film, 15 mph wind		0.17
2	clay tile, 1 cell deep, 4", no insulation		1.11	2	clay tile, 1 cell deep, 4", no insulation		1.11
3	rigid foam insulating sheathing		4	3	rigid foam insulating sheathing		4
4	air[a]	1.25	1.40	4	mineral fiber batt insulation	13	10.04
5	Wood stud (nominal 2 x 4)	4.38		5	Wood stud (nominal 2 x 4)	4.38	
6	gypsum wallboard, 0.5 inch		0.45	6	gypsum wallboard, 0.5 inch		0.45
7	indoor air film, still air		0.68	7	indoor air film, still air		0.68
	R value		7.8		R value		16.5
	% of assembly	0.85	0.15		% of assembly	0.85	0.15
	R of assembly	7.81			R of assembly	16.45	

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

Rim Joist Insulation and Basement Wall Insulation Algorithms

The evaluation team calculated the ex post basement wall insulation and rim joist insulation savings using the algorithms below. The TRM does not have algorithms specifically for rim joist; therefore the basement sidewall insulation algorithms were used.

Equation 9. Rim Joist Insulation Algorithms

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

*ΔkWh_cooling = (((1/R_old_AG – (1/(R_new + R_old_AG))) * L_rimjoist * H_rimjoist * (1-Framing_factor)) * 24 * CDD * DUA) / (1,000 * ηCool)*

*ΔkWh_heating (electric heat) = (((1/R_old_AG – (1/(R_new + R_old_AG))) * L_rimjoist * H_rimjoist * (1-Framing_factor)) * 24 * HDD) / (3412 * ηHeat)*

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

Gas Savings (gas heat): *∆Therms = (((1/R_old_AG – (1/(R_new + R_old_AG))) * L_rimjoist * H_rimjoist * (1-Framing_factor)) * 24 * HDD) / (100,067 * ηHeat)*

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

Equation 10. Basement Sidewall Insulation Algorithms

Energy Savings: *ΔkWh = ΔkWh_cooling + ΔkWh_heating*

*ΔkWh_cooling = (((1/R_old_AG – (1/(R_new + R_old_AG))) * L_basement_wall total * H_basement_wall_AG * (1-Framing_factor)) * 24 * CDD * DUA) / (1,000 * ηCool)*

*ΔkWh_heating (electric heat) = [(((1/R_old_AG – (1/(R_new + R_old_AG))) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) +((1/R_old_BG – (1/R_new + R_old_BG))) * L_basement_wall_total * (H_basement_wall_total – H_basement_wall_AG) * (1-Framing_Factor))) * 24 * HDD] / (3,412 * ηHeat)*

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

Gas Savings (gas heat): *∆Therms = [(((1/R_old_AG – (1/(R_new + R_old_AG))) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) +((1/R_old_BG – (1/R_new + R_old_BG))) * L_basement_wall_total * (H_basement_wall_total – H_basement_wall_AG) * (1-Framing_Factor))) * 24 * HDD] / (100,067 * ηHeat)*

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

Where:

R_old_AG = R-value of existing foundation wall assembly above grade = R-2.25

R_old_BG = R-value of existing foundation wall assembly below grade (including thermal resistance of Earth) = 10.71 (for 6’ below grade basement wall)

R_new = R-value of added insulation (spray foam, rigid foam, cavity)

L_rimjoist = Total linear feet of installed insulation (ft)

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

H_rimjoist = Height of floor joist in which insulation is installed = 1.0 ft

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 = 0.0 for spray foam and 0.15 for studs and cavity insulation)

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

Table 35. 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 = Seasonal Energy Efficiency Ratio of cooling system (actual if available, 10 SEER if unknown) (used age of existing equipment pre 2006)

Table 36. ηCool for Rim Joist Insulation Measures

Measure	ηCool (Pre 2006)	ηCool (Post 2006)
Central Air Conditioner	10	13
ASHP	10	13

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

Table 37. Heating Degree Days by Climate Zone for Unconditioned Basement

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

ηHeat = Efficiency of heating system (applied per participant based on heating equipment type) (used age of existing equipment pre 2006)

Table 38. Assumed ηHeat by Heat Type

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

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

Table 39. FLH_cooling by Climate Zone

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

CF = Coincidence Factor = 0.915

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

Crawlspace Insulation Algorithms

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

Equation 11. Crawlspace Insulation Algorithms

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

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

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

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

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

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

Where:

R_old_AG = Above grade existing R-value of crawlspace insulation (assume ¾” plywood subfloor and carpet with pad) = 2.25

R_old_BG = Below grade existing R-value of crawlspace insulation (assume 2’ below grade) = 6.66

R_added = R-value of additional insulation (spray foam, rigid foam, cavity)

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

H_AG = Height of crawlspace wall above grade = 1 foot

H_BG = Height of crawlspace wall below grade = 2 feet

Framing_factor = Adjustment to account for area of framing = 0.15

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

Table 40. Cooling Degree Days by Climate Zone for Unconditioned (Vented) Crawlspace

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

DUA = Discretionary Use Adjustment = 0.75

ηCool = Seasonal Energy Efficiency Ratio of cooling system (actual if available, 10 SEER if unknown) (used age of existing equipment pre 2006)

Table 41. ηCool for Crawl Space Insulation Measures

Measure	ηCool (Pre 2006)	ηCool (Post 2006)
Central Air Conditioner	10	13
ASHP	10	13

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

Table 42. Heating Degree Days by Climate Zone for Unconditioned (Vented) Crawlspace

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

ηHeat = Efficiency of heating system (applied per participant based on heating equipment type) (used age of existing equipment pre 2006)

Table 43. Assumed ηHeat by Heat Type

Measure	ηHeat (pre 2006)	ηHeat (post 2006)

	COP	AFUE	COP	AFUE
Gas Furnace	n/a	0.7	n/a	0.7
Electric Resistance	1.00	n/a	1.00	n/a
Air Source Heat Pump (ASHP)	1.70	n/a	1.92	n/a

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

Table 44. FLH_cooling by Climate Zone

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

CF = Coincidence Factor = 0.915

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

Programmable Thermostat Algorithms

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

Equation 12. 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)

Table 45. Electric Heating Consumption by Climate Zone

Climate Zone	kWh	
	Electric	Heat Pump

	Resistance	
1 (Rockford)	26,038	13,019
2 (Chicago)	24,875	12,438
3 (Springfield)	21,304	10,652
4 (Belleville)	16,434	8,217
5 (Marion)	16,726	8,363

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

Table 46. Gas Heating Consumption by Climate Zone

Climate Zone	Therms
1 (Rockford)	889
2 (Chicago)	849
3 (Springfield)	727
4 (Belleville)	561
5 (Marion)	571

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

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

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

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

Gas Boiler

The evaluation team calculated the ex post gas boiler savings using the algorithms below.

Equation 13. Gas Boiler Algorithms

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

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

Where:

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

Table 47. Gas Boiler Load by Climate Zone

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

$AFUE_{base}$ = Annual Fuel Utilization Efficiency (AFUE) for the baseline boiler for time of sale installation = 82% AFUE[12]

$AFUE_{exist}$ = Annual Fuel Utilization Efficiency (AFUE) of the existing boiler for early replacement installation = Actual if available. If unknown use 61.6% AFUE

$AFUE_{eff}$ = Annual Fuel Utilization Efficiency (AFUE) for the newly installed boiler = Actual if available. If unknown use 95% AFUE

Gas Furnace Algorithms

The evaluation team calculated the ex post gas furnace savings using the algorithms below.

Equation 14. Gas Furnace Algorithms

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

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

Where:

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

Table 48. Gas Furnace Load by Climate Zone

Climate Zone	Therms
1 (Rockford)	843
2 (Chicago)	806
3 (Springfield)	690
4 (Belleville)	532
5 (Marion)	542

$AFUE_{base}$ = Annual Fuel Utilization Efficiency (AFUE) for the baseline furnace for a time of sale installation = 80% AFUE

[12] Illinois TRM v.2.0 specifies a baseline boiler efficiency of 82% AFUE for program year beginning June 2013

$AFUE_{exist}$ = Annual Fuel Utilization Efficiency (AFUE) of the existing furnace for early replacement installation = Actual if available. If unknown use 90% AFUE

$AFUE_{eff}$ = Annual Fuel Utilization Efficiency (AFUE) for the newly installed furnace = Actual if available. If unknown use 95% AFUE

Air Source Heat Pump Algorithms

The evaluation team calculated the ex post savings for the installation of air source heat pumps using the algorithms below.

Equation 15. Air Source Heat Pump Algorithms

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

$$\text{(Time of Sale) } \Delta kWh\_cooling = ((FLH\_cooling * Capacity\_Cooling * ((1/SEER_{base}) - (1/SEER_{eff})))/1{,}000$$

$$\text{(Early Replacement) } \Delta kWh\_cooling = ((FLH\_cooling * Capacity\_Cooling * ((1/SEER_{exist}) - (1/SEER_{eff})))/1{,}000$$

$$\text{(Time of Sale) } \Delta kWh\_heating \text{ (electric heat)} = ((FLH\_heating * Capacity\_heating * ((1/HSPF_{base}) - (1/HSPF_{eff})))/1{,}000$$

$$\text{(Early Replacement) } \Delta kWh\_heating \text{ (electric heat)} = ((FLH\_heating * Capacity\_heating * ((1/HSPF_{exist}) - (1/HSPF_{eff})))/1{,}000$$

$$\text{(Time of Sale) Demand Savings: } \Delta kW = (Capacity\_cooling * ((1/EER_{base}) - (1/EER_{eff}))/1{,}000)*CF$$

$$\text{(Early Replacement) Demand Savings: } \Delta kW = (Capacity\_cooling * ((1/EER_{exist}) - (1/EER_{eff}))/1{,}000)*CF$$

Where:

FLH_cooling = Full load hours for air conditioning (applied per participant based on project location)

Table 49. 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 source heat pump in units of Btuh = actual value from database

$SEER_{base}$ = Seasonal Energy Efficiency Ratio (SEER) of the baseline air source heat pump or air conditioner for a time of sale installation = 13 SEER

$SEER_{exist}$ = Seasonal Energy Efficiency Ratio (SEER) of the existing air source heat pump or existing air conditioner for early replacement installation = Actual if available. If unknown use 9.12 SEER for ASHP or 8.60 SEER for Central A/C

$SEER_{eff}$ = Seasonal Energy Efficiency Ratio (SEER) for the newly installed air source heat pump = Actual value from database

FLH_heating = Full load hours for heating (applied per participant based on project location)

Table 50. 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 air source heat pump in units of Btuh = actual value from database

$HSPF_{base}$ = Heating System Performance Factor (HSPF) for the baseline air source heat pump for time of sale installation = 7.7 HSPF

$HSPF_{exist}$ = Heating System Performance Factor (HSPF) for the baseline air source heat pump or electric resistance heating for early replacement installation = Actual if available. If unknown use 5.44 HSPF for ASHP or 3.41 HSPF for Electric Resistance

$HSPF_{eff}$ = Heating System Performance Factor (HSPF) for the newly installed air source heat pump = Actual value from database

EER_{base} = Energy Efficiency Ratio (EER) for the baseline air source heat pump or air conditioner for time of sale installation = 11.2 EER

EER_{exist} = Energy Efficiency Ratio (EER) for the existing air source heat pump or air conditioner for early replacement installation (actual value from database was used). Calculated using using $EER = -0.02 * SEER^2 + 1.12 * SEER$); If actual SEER unavailable use 8.55 EER for ASHP or 8.15 EER for Central A/C

EER_{eff} = Energy Efficiency Ratio (EER) for the newly installed air source heat pump (actual value from database was used) calculated using using $EER = (-0.02 * SEER^2) + (1.12 * SEER)$)

CF = Coincidence Factor = 0.915

Central Air Conditioner Algorithms

The evaluation team calculated the ex post savings for the installation of central air conditioners using the algorithms below.

Equation 16. Central Air Conditioner Algorithms

$$(Time\ of\ Sale)\ \Delta kWh\_cooling = ((FLH\_cooling * Capacity\_Cooling * ((1/SEER_{base}) - (1/SEER_{eff})))/1{,}000$$

$$(Early\ Replacement)\ \Delta kWh\_cooling = ((FLH\_cooling * Capacity\_Cooling * ((1/SEER_{exist}) - (1/SEER_{eff})))/1{,}000$$

(Time of Sale) Demand Savings: $\Delta kW = (Capacity\_cooling * ((1/EER_{base}) - (1/EER_{eff}))/1{,}000)*CF$

(Early Replacement Demand Savings: $\Delta kW = (Capacity\_cooling * ((1/EER_{exist}) - (1/EER_{eff}))/1{,}000)*CF$

Where:

FLH_cooling = Full load hours for air conditioning (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 value from database

$SEER_{base}$ = Seasonal Energy Efficiency Ratio (SEER) for the baseline air conditioner for a time of sale installation = 13 SEER

$SEER_{exist}$ = Seasonal Energy Efficiency Ratio of the existing air conditioner for early replacement installation = Actual if available. If unknown use 10 SEER

$SEER_{eff}$ = Seasonal Energy Efficiency Ratio (SEER) for the newly installed air conditioner = Actual if available. If unknown use 14.5 SEER

EER_{base} = Energy Efficiency Ratio (SEER) for the baseline air conditioner for a time of sale installation = 11.2 EER

EER_{exist} = Energy Efficiency Ratio of the existing air conditioner for early replacement installation = Actual if available. If unknown use 9.2 EER

EER_{eff} = Energy Efficiency Ratio (SEER) for the newly installed air conditioner = Actual if available. If unknown use 12.0 EER

CF = Coincidence Factor = 0.915

Furnace Blower Motor (ECM Brushless Motor)

The evaluation team calculated the ex post savings for the installation of ECM brushless furnace blower motors using the algorithms below.

Equation 17. ECM Brushless Motor Algorithms

ΔkWh = ΔkWh_cooling + ΔkWh_heating + ΔkWh_shoulder

ΔkWh_cooling (with CAC) = 263 kWh (deemed value)

ΔkWh_cooling (without CAC) = 175 kWh (deemed value)

ΔkWh_cooling (unknown if CAC) = 241 kWh (deemed weight average value)

ΔkWh_heating = 418 kWh (deemed value)

ΔkWh_shoulder = 51 kWh (deemed value)

*ΔkW_shoulder = ΔkWh_cooling / FLH_Clg * CF*

*Δtherms = - ΔkWh_heating * 0.03412*

Where:

FLH_cooling = Full load hours for air conditioning (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

CF = Coincidence Factor = 0.915

B. Appendix: Program Savings for Cost Effectiveness Analysis

Table 53 presents total net 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 agreement between AIC and ICC staff that heating penalties would not be included in savings calculations for goal attainment. Total net program savings decreased by 0.1% for kWh and 1.2% for therms after the application of waste heat factors.

Table 53. PY6 WNCF Net Impacts (Including Heating Penalties)

Measure	Electric Savings (kWh)	Demand Savings (kW)	Gas Savings (Therms)
Total	616,350	529	171,323

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 1,842 lamps based on the specific heating fuel type and installed lamp type. The heating fuel type is known for 59% (1,093 lamps) of the installed lighting measures. For the remaining 749 lamps with unknown space heating fuel types, waste heat factors were applied based on the percentage of installed lighting measures where heating fuel types are known. Therefore, 21 lamps (2.0%) were applied waste heat factors for electric resistance heating, 6 lamps (0.5%) were applied waste heat factors for heat pumps, and 1,066 lamps (97.5%) were applied waste heat factors for gas heating. These percentages for lighting measures with known heating fuel types are shown in Table 54.

Table 54. PY6 WNCF Known Heating Fuel Type for Lighting Measures

Heating Fuel	Heating Equipment	% of Htg Fuel Type Known
Electric	Electric Resistance	2.0%
Electric	Heat Pump	0.5%
Gas	Furnace/Boiler	97.5%

The total heating penalty for lighting measures is 848 kWh and 1,829 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 16 EC motors incented within the program for a total heating penalty of 228 therms.

The evaluation team will provide AIC with measure specific gross impacts that include waste heat factors as part of the provision of inputs for cost effectiveness calculations.

For more information, please contact:

Vincent Greco
Project Manager

617 492 1400 tel
617 497 7944 fax
vgreco@opiniondynamics.com

1000 Winter Street
Waltham, MA 02451