



ComEd

Heating, Cooling, and Weatherization Rebates Program Evaluation Report

FINAL

**Energy Efficiency / Demand Response Plan:
Plan Year 8 (PY8)
(6/1/2015-5/31/2016)**

**Presented to
Commonwealth Edison Company**

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E. EXECUTIVE SUMMARY

This report presents a summary of the findings and results from the evaluation of the Commonwealth Edison (ComEd) PY8 Heating, Cooling, and Weatherization Rebates program.

The Heating, Cooling, and Weatherization Rebates Program offers incentives for the installation of qualifying, high efficiency equipment such as central air conditioning systems, heat pumps, furnace blower motors (ECMs), water heaters, and smart thermostats. The program also offers rebates for the installation of qualifying weatherization improvements such as attic and wall insulation, and air and duct sealing.

The Heating, Cooling, and Weatherization Rebates program was implemented by CLEAResult in Nicor Gas/ComEd areas and Franklin Energy (Franklin) in Peoples and North Shore Gas/ComEd areas. The Heating and Cooling incentives were available to ComEd residential customers, and the Weatherization rebates were available to ComEd customers who also receive their natural gas from either Nicor Gas, Peoples Gas, or North Shore Gas companies. The Weatherization rebates are instant rebates that are applied to the customer invoice by a Participating Contractor. There is no Participating Contractor requirement for the Heating and Cooling rebates, and the customers receive a check from ComEd after their rebate application is approved. The PY8 program year includes the time period from June 1, 2015 to May 31, 2016.

E.1. Program Savings

Table E-1 summarizes the electricity savings from the Heating, Cooling, and Weatherization Rebates program.

Table E-1. PY8 Total Program Electric Savings

Savings Category	Energy Savings (MWh)	Peak Demand Savings (MW)	Demand Savings (MW)
Ex Ante Gross Savings	18,102	4.470	NA
Verified Gross Savings	18,770	4.776	8.834
Verified Net Savings	18,743	4.751	8.796

Source: ComEd tracking data and Navigant team analysis.

E.2. Program Savings by Channel and Measure

Table E-2. PY8 Program Results by Measure - CLEARResult

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Demand Reduction (MW)	Verified Gross Realization Rate	NTGR	Verified Net Savings (MWh)	Verified Net Demand Reduction (MW)
Air Source Heat Pump	132.5	0.004	131.9	0.005	100%	0.99†	130.5	0.005
Central AC	3,824.1	2.306	4,209.5	2.922	110%	0.99†	4,167.4	2.893
Ductless Mini-Split	219.2	-0.011	220.9	NA	101%	0.99†	218.6	NA
ECM Furnace Motor	3,604.0	1.044	3,604.0	1.043	100%	0.99†	3,567.9	1.032
Geothermal Heat Pump	34.8	0.017	34.8	0.017	100%	0.99†	34.5	0.016
Heat Pump Water Heater	29.1	0.001	29.1	0.001	100%	0.99†	28.8	0.001
Smart Thermostat	5,074.3	0.000	5,187.9	0.000	102%	0.99†	5,136.0	0.000
Air Sealing	226.6	0.125	259.8	0.127	115%	1.02†	265.0	0.130
Attic Insulation	137.7	0.052	138.2	0.052	100%	1.02†	141.0	0.054
Basement/Side wall Insulation	11.8	0.009	11.8	0.009	100%	1.02†	12.0	0.010
Duct Sealing	6.3	0.005	6.3	0.005	100%	1.02†	6.4	0.005
Wall Insulation	7.6	0.004	7.6	0.004	100%	1.02†	7.8	0.004
Air Sealing - Multifamily	2,971.1	0.220	3,060.4	0.210	103%	1.02†	3,121.6	0.214
Attic Insulation - Multifamily	1,384.7	0.060	1,384.7	0.060	100%	1.02†	1,412.4	0.061
Total	17,663.8	3.837	18,286.9	4.456	104%		18,250.1	4.426

Source: ComEd tracking data and Navigant team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

Table E-3. PY8 Program Results by Measure - Franklin

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Demand Reduction (MW)	Verified Gross Realization Rate	NTGR	Verified Net Savings (MWh)	Verified Net Demand Reduction (MW)
Air Sealing	81.3	0.107	126.2	0.067	155%	1.02†	128.7	0.068
Attic Insulation	25.0	0.030	25.0	0.030	100%	1.02†	25.5	0.031
Duct Sealing	331.8	0.223	331.8	0.223	100%	1.02†	338.5	0.227
Total	438.1	0.360	483.0	0.319	110%		492.7	0.326

Source: ComEd tracking data and Navigant team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

E.3. Program Volumetric Detail

The program incented a total of 42,137 projects between the two program implementers, as shown in the tables below.

Table E-4. PY8 Volumetric Findings Detail - CLEAResult

Measure	Quantity
Air Source Heat Pump	49
Central AC	8,924
Ductless Mini-Split	61
ECM Furnace Motor	5,076
Geothermal Heat Pump	7
Heat Pump Water Heater	17
Smart Thermostat	25,639
Air Sealing	589
Attic Insulation	639
Basement/Sidewall Insulation	22
Duct Sealing	17
Wall Insulation	78
TOTAL	41,118

Source: ComEd tracking data and Navigant team analysis.

Table E-5. PY8 Volumetric Findings Detail - Franklin

Measure	Quantity
Air Sealing	187
Attic Insulation	168
Duct Sealing	664
Total	1,019

Source: ComEd tracking data and Navigant team analysis.

E.4. Results Summary

The following table summarizes the key metrics from PY8.

Table E-6. PY8 Results Summary

Participation	Units	PY8
Net Savings	MWh	18,743
Net Demand Reduction	MW	4.751
Gross Savings	MWh	18,770
Gross Demand Reduction	MW	4.776
Program Realization Rate	%	104%
Program NTG Ratio - Weatherization†	#	1.02
Program NTG Ratio - HVAC†		0.99
Projects Incented	#	42,137

Source: ComEd tracking data and Navigant team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

E.5. Findings and Recommendations

The following provides insight into key program findings and recommendations.¹

Tracking Database

Finding 1. The tracking database contained all the inputs needed to develop the savings estimates. In those cases where using the inputs provided in the tracking database differ from the implementer work papers, it is difficult for Navigant to determine the source of the discrepancy.

Recommendation 1. The implementers should provide actual inputs for a sample of projects for each measure in order to reduce the potential for misunderstanding in verification process.

Finding 2. The tracking database does not track overall demand savings.

Recommendation 2. The implementers should include overall demand savings in the database.

Gross Savings Estimates

Finding 3. The program achieved overall gross savings of 18,770 MWh and peak demand savings of 4.776 MW.

Finding 4. The two implementers used different assumptions for some of the measure inputs. While the assumptions from both implementers are reasonable, this results in two different unit savings values for the same measure in the program.

Recommendation 3. The implementers should share measure level assumptions to ensure consistency across the program.

¹ Numbered findings and recommendations in this section are the same as those found in the Findings and Recommendations section of the evaluation report for ease of reference between each section.

Net Savings Estimates

Finding 5. The program achieved overall net savings of 18,743 MWh and peak demand savings of 4.751 MW.

Program Volumetric Findings

Finding 6. The program incented 42,137 projects in PY8, including 39,773 HVAC projects and 2,364 Weatherization projects.

1. INTRODUCTION

1.1 Program Description

The Heating, Cooling, and Weatherization Rebates program offers incentives for the installation of qualifying, high efficiency equipment such as central air conditioning systems, heat pumps, furnace blower motors (ECMs), water heaters, and smart thermostats. The program also offers rebates for the installation of qualifying weatherization improvements such as attic and wall insulation, and air and duct sealing.

The Heating, Cooling, and Weatherization Rebates program was implemented by CLEARResult in Nicor Gas/ComEd areas and Franklin Energy (Franklin) in Peoples and North Shore Gas/ComEd areas. The Heating and Cooling incentives were available to ComEd residential customers, and the Weatherization rebates were available to ComEd customers who also receive their natural gas from either Nicor Gas, Peoples Gas or North Shore Gas companies. The Weatherization rebates are instant rebates that are applied to the customer invoice by a Participating Contractor. There is no Participating Contractor requirement for the Heating and Cooling rebates, and the customers receive a check from ComEd after their rebate application is approved. The PY8 program year includes the time period from June 1, 2015 to May 31, 2016.

1.2 Evaluation Objectives

The evaluation team identified the following key researchable questions for PY8. The evaluation team will be conducting the program process evaluation in PY9, as described in the PY8-PY9 Evaluation Plan.

1.2.1 Impact Questions

1. What are the program's verified gross savings?
2. What are the program's verified net savings?
3. What is the researched value for net-to-gross (NTG) ratio?
4. What updates are recommended for the Illinois Technical Reference Manual (TRM)?

2. EVALUATION APPROACH

The primary objectives of the evaluation of the ComEd HVAC and Weatherization Rebates program are to: (1) determine gross and net program savings and (2) examine the effectiveness of program processes in achieving savings.

2.1 Overview of Data Collection Activities

The core data collection activities consist of a “desk review” of the program tracking database to determine the program’s net and gross savings using the results of previous net-to-gross evaluation efforts. The full set of data collection activities is shown in the following tables.

Table 2-1. Primary Data Collection Activities

What	Who	Target Completes	Completes Achieved	When	Comments
Program Tracking Database	Participants	Census	Census	August - October 2016	
In Depth Interviews	Program Manager/Implementer Staff	2	2	April – May 2016	

Table 2-2. Additional Resources

Reference Source	Application	Gross Impacts	Process
Illinois Technical Reference Manual		X	

2.2 Verified Savings Parameters

Navigant calculated verified gross and net program impacts for 12 types of measures: Air Source Heat Pump, Central AC, Ductless Mini-Split Heat Pumps, ECM Furnace Motor, Geothermal Heat Pump, Heat Pump Water Heater, Smart Thermostat, Air Sealing, Attic Insulation, Basement/Sidewall Insulation, Duct Sealing, and Wall Insulation. These measures account for all quantifiable PY8 electric savings. Detailed descriptions of engineering algorithms and inputs are included in Section 3.

2.2.1 Verified Gross Program Savings Analysis Approach

Unit savings are calculated using the algorithms from the Illinois TRM v4.0. The Illinois TRM deems most of the savings algorithms for the HVAC and Weatherization Rebates program.

The following table presents the deemed input parameter source that Navigant used by measure. The Illinois TRM v4.0 allows for custom or actual values to be used for some of the input parameters. Navigant based these values on the program tracking database when available.

Table 2-3. Verified Savings Parameter Data Sources

Gross Savings Input Parameters	Deemed Input Data Source
Air Source Heat Pump	Illinois TRM v4.0 – Section 5.3.1
Central AC	Illinois TRM v4.0 – Section 5.3.3
Ductless Mini-Split Heat Pumps	Illinois TRM v4.0 – Section 5.3.12
ECM Furnace Motor	Illinois TRM v4.0 – Section 5.3.5
Geothermal Heat Pump	Illinois TRM v4.0 – Section 5.3.8
Heat Pump Water Heater	Illinois TRM v4.0 – Section 5.4.3
Smart Thermostat	Custom Calculation based on Navigant memo ²
Air Sealing	Illinois TRM v4.0 – Section 5.6.1
Attic Insulation	Illinois TRM v4.0 – Section 5.6.4
Basement/Sidewall Insulation	Illinois TRM v4.0 – Section 5.6.2
Duct Sealing	Illinois TRM v4.0 – Section 5.3.4
Wall Insulation	Illinois TRM v4.0 – Section 5.6.4

2.2.2 Verified Net Program Savings Analysis Approach

Verified net energy and demand (coincident peak and overall) savings were calculated by multiplying the verified gross savings estimates by a net-to-gross ratio (NTGR). In PY8, the NTGR estimates used to calculate the net verified savings were defined by the Illinois Stakeholder Advisory Group (SAG) as documented in a spreadsheet.³

2.3 Process Evaluation

Because the Heating, Cooling and Weatherization Rebates program underwent substantial changes in PY8, the Evaluation team, ComEd and CLEAResult staff agreed to conduct the process evaluation in PY9. Process evaluation activities will consist of participant and trade ally telephone surveys, and will begin in January 2017.

² Source: Navigant memo to ComEd, “PY8/PY9 Advanced Thermostat Savings Estimates”, April 22, 2016.

³ Source: A deemed value. ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

3. GROSS IMPACT EVALUATION

Navigant's review of the ex ante calculations for the ComEd PY8 Heating, Cooling and Weatherization Rebates program resulted in verified gross savings of 18,770 MWh and peak demand savings of 4.776 MW. The verified gross realization rate for energy savings is 104 percent. The verified gross realization rate for peak demand savings is 107 percent.

3.1 Tracking System Review

CLEARResult's and Franklin's tracking systems and savings documentation for PY8 consisted of (1) a spreadsheet containing measure type, quantity, energy and demand savings and (2) excel documents containing the algorithms and methodologies used to calculate savings.

Key findings include:

1. Overall, Navigant received all applicable data needed in order to conduct the gross impact analysis.
2. There were small discrepancies in the inputs Navigant and CLEARResult and Franklin used for calculating savings. Notably there were differences in the Air Sealing measure.
3. It was sometimes difficult for Navigant to find the source of the discrepancies because the actual savings calculations are embedded in the CLEARResult and Franklin databases; these databases were not accessible to Navigant.

3.2 Program Volumetric Findings

The program incented 41,118 projects through CLEARResult and 1,019 projects through Franklin. The volumetric findings are detailed in Table 3-1 and Table 3-2 and presented visually in Figure 3-1 and Figure 3-2

Table 3-1. PY8 Volumetric Findings Detail - CLEARResult

Measure	Quantity	Unit
Air Source Heat Pump	49	# Units
Central AC	8,924	# Units
Ductless Mini-Split Heat Pumps	61	# Units
ECM Furnace Motor	5,076	# Units
Geothermal Heat Pump	7	# Units
Heat Pump Water Heater	17	# Units
Smart Thermostat	25,639	# Units
Air Sealing	589	# Projects
Attic Insulation	639	# Projects
Basement/Sidewall Insulation	22	# Projects
Duct Sealing	17	# Projects
Wall Insulation	78	# Projects
TOTAL	41,118	

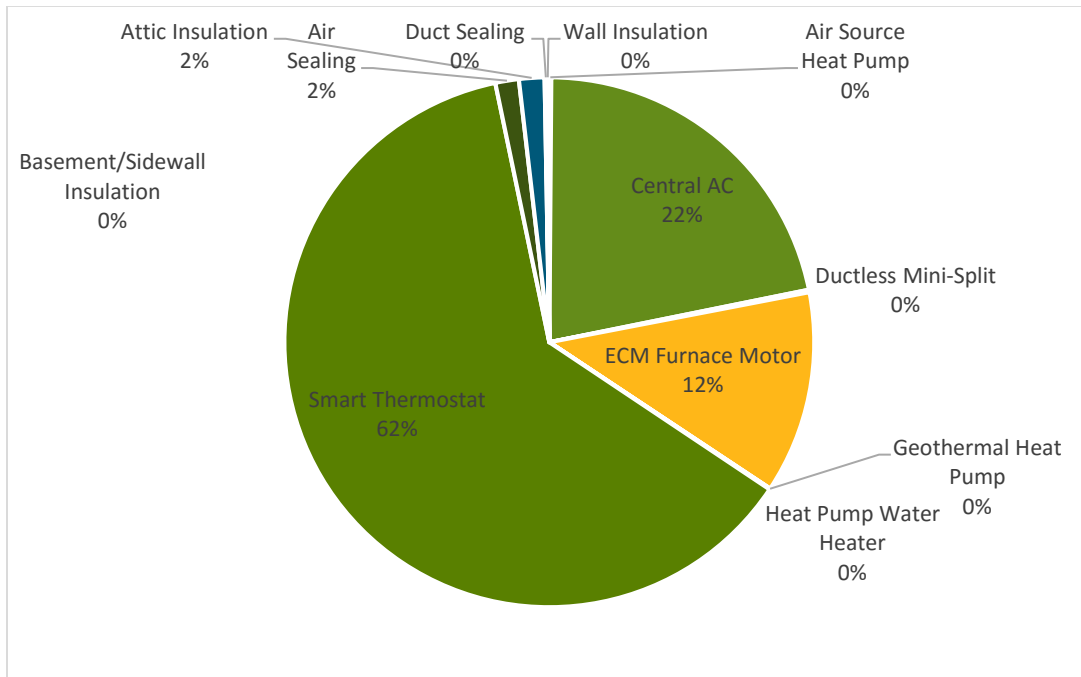
Source: ComEd tracking data and Navigant team analysis.

Table 3-2. PY8 Volumetric Findings Detail - Franklin

Measure	Quantity	Unit
Air Sealing	187	# Projects
Attic Insulation	168	# Projects
Duct Sealing	664	# Projects
Total	1,019	# Projects

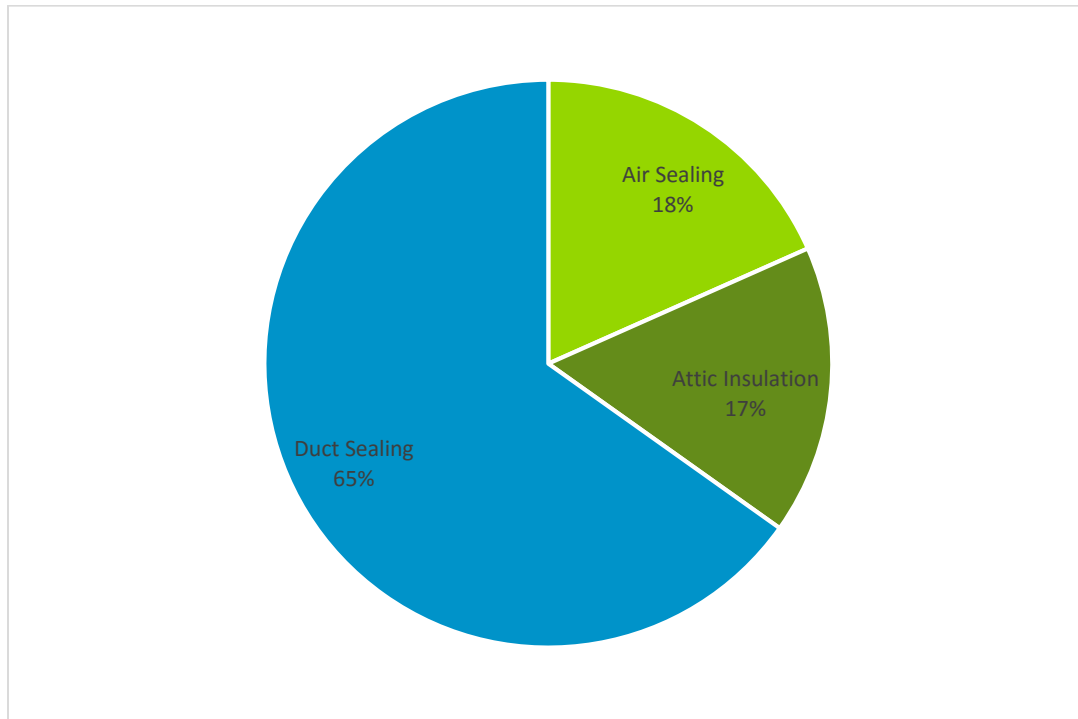
Source: ComEd tracking data and Navigant team analysis.

Figure 3-1. Number of Measures Installed by Type - CLEAResult



Source: Evaluation Analysis

Figure 3-2. Number of Measures Installed by Type - Franklin



Source: Evaluation Analysis

3.3 Gross Program Impact Parameter Estimates

As described in Section 2, energy and demand savings are estimated using the Illinois TRM v4.0. The evaluation team conducted research to validate the parameters that were not specified in the Illinois TRM v.4. The savings parameters are shown in the following table.

Table 3-3. Verified Gross Savings Parameters

Gross Savings Input Parameters	Deemed† or Evaluated?
Quantity	Evaluated
Measure Type and Eligibility	Evaluated
Gross Savings per Unit, Sampled Deemed Measures	Deemed
Gross Savings per Unit, Sampled Non-Deemed Measures	Evaluated

† State of Illinois Technical Reference Manual version 4.0 from <http://www.ilsag.info/technical-reference-manual.html>.

The differences between the ex ante and ex post savings estimates are discussed by measure below.

3.3.1 Air Source Heat Pump

For this measure, Navigant and the implementer used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.3.1 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-1. Air Source Heat Pump TRM Algorithm

$$\Delta kWh = ((FLH_{cooling} * Capacity_{cooling} * (1/SEER_{base} - 1/SEER_{ee})) / 1000) + ((FLH_{heat} * Capacity_{heating} * (1/HSPF_{base} - 1/HSPF_{ee})) / 1000)$$

Where,

- FLH_cooling = Full load hours of air conditioning
- Capacity_cooling = Cooling Capacity of Air Source Heat Pump (Btu/hr)
- SEER_exist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)
- SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)
- SEER_ee = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)
- FLH_heat = Full load hours of heating
- Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/hr)
- HSPF_exist = Heating System Performance Factor⁸⁴⁸ of existing heating system (kBtu/kWh)
- HSPF_base = Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)
- HSPF_ee = Heating System Performance Factor of efficient Air Source Heat Pump

3.3.2 Central AC

For this measure, Navigant and the implementer used the measure level inputs deemed by the Illinois TRM v4.0 – Section 5.3.3 to calculate energy savings.

Equation 3-2. Time of Sale Energy Savings

$$kWh Savings = \left(FLH_{cool} \times Btu/hr \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}} \right) \right) / 1000$$

Equation 3-3. Early Replacement Energy Savings

$$kWh\ Savings = \left(FLH_{cool} \times Btu/hr \times \left(\frac{1}{SEER_{exist}} - \frac{1}{SEER_{ee}} \right) \right) / 1000$$

Where:

- FLH = Full load hours for cooling; based on location and dwelling type
- Btu/hr = Air-conditioner unit capacity
- SEER_{base} = Seasonal energy efficiency ratio (SEER) rating of base air-conditioner unit;
- SEER_{ee} = SEER rating of energy efficient air-conditioner unit
- EER_{base} = EER rating of base air-conditioner unit, calculated based on SEER_{base}
- EER_{ee} = EER rating of energy efficient air-conditioner unit
- SEER_{exist} = SEER rating of existing air-conditioner unit
- EER_{exist} = EER rating of existing air-conditioner unit

Navigant found that existing SEER values” were under estimated in the ex ante estimates. Many of the units should have been assigned the actual existing SEER, which would result in higher unit savings, according to the Illinois TRM v4.0. Adjusting for the existing SEER resulted in a measure level energy realization rate of 110 percent.

3.3.3 Ductless Mini-Split Heat Pumps

For this measure, Navigant and the implementer used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.3.12 to calculate energy savings. The realization rate for this measure is 101 percent.

Equation 3-4. Ductless Mini-Split Heat Pump Algorithm

$$\Delta kWh = \Delta kWh_{heat} + \Delta kWh_{cool}$$

Where,

- $\Delta kWh_{heat} = PLD \times AHHL \times HF \times (1/HSPF_{exist} - 1/HSPF_{ee}) \times 3.413$
- $\Delta kWh_{cool} = Capacity_{cool} \times HF \times (1/SEER_{exist} - 1/SEER_{ee}) \times EFLH_{cool}$

- PLD = Percent Load Displaced.
- AHHL = Annual Household Heating Load in kWh
- HF = Household factor, to adjust heating consumption for non-single-family households
- Capacity_{cool} = the cooling capacity of the ductless heat pump unit in kBtu/hr
- HSPF_{ee} = HSPF rating of new equipment
- HSPF_{exist} = HSPF rating of existing equipment
- SEER_{ee} = SEER rating of new equipment
- SEER_{exist} = SEER rating of existing equipment
- EFLH_{cool} = Equivalent Full Load Hours for cooling

3.3.4 ECM Furnace Motor

For this measure, Navigant and the implementer used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.3.5 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-5. ECM Furnace Motor Algorithm

$$\Delta kWh = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings}$$

Where,

Heating Savings = Blower motor savings during heating season
 Cooling Savings = Blower motor savings during cooling season
 Shoulder Season Savings = Blower motor savings during shoulder seasons

3.3.5 Geothermal Heat Pump

For this measure, Navigant and the implementer used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.3.8 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-6. Geothermal Heat Pump Algorithm

$$\Delta kWh = [\text{Cooling savings}] + [\text{Heating savings}] + [\text{DHW savings}]$$

Where,

$$\Delta kWh = [(\text{FLHcool} * \text{Capacity_cooling} * (1/\text{SEERbase} - (1/\text{EERPL})/1000) + [\text{Elecheat} * \text{FLHheat} * \text{Capacity_heating} * (1/\text{HSPFbase} - (1/\text{COPPL} * 3.412))]/1000) + [\text{ElecDHW} * \% \text{DHWD} \text{Displaced} * (((1/\text{EFELEC}) * \text{GPD} * \text{Household} * 365.25 * \gamma \text{Water} * (\text{TOUT} - \text{TIN}) * 1.0) / 3412)]$$

FLHcool = Full load cooling hours
 Capacity_cooling = Cooling Capacity of Ground Source Heat Pump (Btu/hr)
 SEERbase = SEER Efficiency of new replacement baseline unit
 SEERexist = SEER Efficiency of existing cooling unit (early replacement)
 SEERASHP = SEER Efficiency of new baseline Air Source Heat Pump unit (for fuel switch)
 EERPL = Part Load EER Efficiency of efficient GSHP unit980
 ElecHeat = 1 if existing building is electrically heated, 0 if existing building is not electrically heated
 FLHheat = Full load heating hours
 Capacity_heating = Heating Capacity of Ground Source Heat Pump (Btu/hr)
 HSPFbase = Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)
 HSPF_exist = Heating System Performance Factor of existing heating system (kBtu/kWh)
 HSPFASHP = Heating Season Performance Factor for new ASHP baseline unit (for fuel switch)
 COPPL = Part Load Coefficient of Performance of efficient unit
 ElecDHW = 1 if existing DHW is electrically heated, 0 if existing DHW is not electrically heated
 %DHWDDisplaced = Percentage of total DHW load that the GSHP will provide
 EFELEC = Energy Factor (efficiency) of electric water heater
 GPD = Gallons Per Day of hot water use per person
 Household = Average number of people per household
 γWater = Specific weight of water
 TOUT = Tank temperature
 TIN = Incoming water temperature from well or municipal system

3.3.6 Heat Pump Water Heater

For this measure, Navigant and the implementer used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.4.3 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-7. Heat Pump Water Heater Algorithm

$$\Delta kWh = (((1/EF_{BASE} - 1/EF_{EFFICIENT}) * GPD * Household * 365.25 * \gamma_{Water} * (T_{OUT} - T_{IN}) * 1.0) / 3412) + kWh_{cooling} - kWh_{heating}$$

Where,

EF_{BASE} = Energy Factor (efficiency) of standard electric water heater according to federal standard

EF_{EFFICIENT} = Energy Factor (efficiency) of Heat Pump water heater

GPD = Gallons Per Day of hot water use per person

Household = Average number of people per household

γ_{Water} = Specific weight of water

T_{OUT} = Tank temperature

T_{IN} = Incoming water temperature from well or municipal system

kWh_{cooling} = Cooling savings from conversion of heat in home to water heat

kWh_{heating} = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

3.3.7 Smart Thermostat

For this measure, Navigant and the implementer used deemed numbers outlined in the Navigant's Smart Thermostat Memo to calculate energy savings. The deemed savings are outlined in Table 3-4. The realization rate for this measure is 102 percent.

Table 3-4. PY8 Smart Thermostat Savings

KNOWN COOLING															
			Known Heating								Unknown Heating				
			Gas Heating Therms		Gas Heating Kwh		Elec Res Htg kWh		ASHP		Unk Heat		Unk Heat		Unknown Building
	Htg%	Chg%	SF	MF	SF	MF	SF	MF	SM	MF	SF	MF	SF	MF	
Manual Baseline	8.8%	4.8%	88.4	57.5	188.0	148.5	1933.8	1294.3	1175.4	799.2	76.9	50.0	398.3	285.2	373.4
Programmable Baseline	5.6%	4.8%	56.3	36.6	158.4	129.3	1269.4	862.4	784.5	545.1	48.9	31.8	292.2	216.2	275.5
Unknown Baseline	6.7%	4.8%	67.3	43.8	168.6	135.9	1497.8	1010.9	918.9	632.5	58.6	38.1	328.6	239.9	309.1
UNKNOWN COOLING															
			Known Heating								Unknown Heating				
			Gas Heating Therms		Gas Heating Kwh		Elec Res Htg kWh		ASHP		Unk Heat		Unk Heat		Unknown Building
	Htg%	Chg%	SF	MF	SF	MF	SF	MF	SM	MF	SF	MF	SF	MF	
Manual Baseline	8.8%	4.8%	88.4	57.5	174.1	136.1	1920.0	1270.9	N/A	N/A	76.9	50.0	384.4	272.8	359.9
Programmable Baseline	5.6%	4.8%	56.3	36.6	144.5	116.9	1255.5	839.0	N/A	N/A	48.9	31.8	278.3	203.8	261.9
Unknown Baseline	6.7%	4.8%	67.3	43.8	154.7	123.5	1391.2	904.3	N/A	N/A	58.6	38.1	314.8	227.5	295.6

3.3.8 Air Sealing

For this measure, Navigant and the implementers used the equation below which is deemed by Illinois TRM v4.0 – Section 5.6.1 to calculate energy savings.

Equation 3-8. Air Sealing Algorithm

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$\Delta kWh_{cooling}$ = If central cooling, reduction in annual cooling requirement due to air sealing
 = $\frac{(((CFM50_{existing} - CFM50_{new})/N_{cool}) * 60 * 24 * CDD * DUA * 0.018)}{(1000 * \eta_{Cool})} * LM$

CFM50_existing = Infiltration at 50 Pascals as measured by blower door before air sealing.
 = Actual

CFM50_new = Infiltration at 50 Pascals as measured by blower door after air sealing.
 = Actual

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural condition

CDD = Cooling Degree Days

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

η_{Cool} = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

LM = Latent multiplier to account for latent cooling demand

$\Delta kWh_{heating}$ = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing (or $\Delta Therms * F_e * 29.3$ if gas heat)

= $\frac{(((CFM50_{existing} - CFM50_{new})/N_{heat}) * 60 * 24 * HDD * 0.018)}{(\eta_{Heat} * 3,412)}$

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

HDD = Heating Degree Days

η_{Heat} = Efficiency of heating system

$\Delta Therms$ = Therm savings as calculated in Natural Gas Savings

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

CLEARResult used the HDD identified in v5 of the Illinois TRM, which resulted in an upwards evaluation adjustment. The realization rate for this measure for the CLEARResult projects is 115 percent.

Franklin did not appear to add the additional savings from reduction in furnace fan usage. The realization rate for this measure for the Franklin projects is 155 percent.

3.3.9 Attic Insulation

For this measure, Navigant and the implementers used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.6.4 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-9. Attic Insulation Algorithm

$$\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heating})$$

Where,

$kWh_{cooling} = \frac{(1/R_{old} - 1/R_{attic}) * A_{attic} * (1 - Framing_factor_{attic}) * 24 * CDD * DUA}{(1000 * \eta_{Cool})}$

$$kWh_{heating} = (1/R_{old} - 1/R_{attic}) * A_{attic} * (1-Framing_factor_attic) * ADJ_{Attic} * 24 * HDD] / (\eta_{Heat} * 3412)$$

R_{attic} = R-value of new attic assembly (including all layers between inside air and outside air).
 $Framing_factor_attic$ = Adjustment to account for area of framing
 A_{attic} = Total area of insulated ceiling/attic (ft²)
 CDD = Cooling Degree Days
 DUA = Discretionary Use Adjustment
 η_{Cool} = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)
 $kWh_{heating}$ = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation
 HDD = Heating Degree Days
 η_{Heat} = Efficiency of heating system
 ADJ_{Attic} = Adjustment for attic insulation to account for prescriptive engineering algorithms over claiming savings.

3.3.10 Wall Insulation

For this measure, Navigant and the implementers used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.6.4 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-10. Wall Insulation Algorithm

$$\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heating})$$

Variables as described as in the Attic Insulation measure and

Where,

$$\Delta kWh_{cooling} = [((1/R_{old} - 1/R_{wall}) * A_{wall} * (1-Framing_factor_{wall}) * 24 * CDD * DUA) / (1000 * \eta_{Cool})]$$

$$kWh_{heating} = [((1/R_{old} - 1/R_{wall}) * A_{wall} * (1-Framing_factor_{wall}) * ADJ_{Wall}) * 24 * HDD] / (\eta_{Heat} * 3412)$$

R_{wall} = R-value of new wall assembly (including all layers between inside air and outside air).
 R_{old} = R-value value of existing assemble and any existing insulation.
 $Framing_factor_{wall}$ = Adjustment to account for area of framing
 ADJ_{Wall} = Adjustment for wall insulation to account for prescriptive engineering algorithms over claiming savings.

3.3.11 Basement/Sidewall Insulation

For this measure, Navigant and the implementers used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.6.2 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-11. Basement/Sidewall Insulation Algorithm

$$\Delta kWh = (\Delta kWh_{cooling} + \Delta kWh_{heating})$$

Where,

$$\Delta kWh_{cooling} = ((\Delta CFM25DL) / ((CapacityCool / 12,000) * 400)) * FLH_{cool} * CapacityCool) / 1000 / \eta_{Cool}$$

$$\Delta kWh_{Fan} = (\Delta Therms * Fe * 29.3)$$

$\Delta kWh_{cooling}$ = If central cooling, reduction in annual cooling requirement due to insulation
 $= (((1/R_{old_AG} - 1/(R_{added}+R_{old_AG})) * L_{basement_wall_total} * H_{basement_wall_AG} * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * \eta_{Cool})$
 R_{added} = R-value of additional spray foam, rigid foam, or cavity insulation.
 R_{old_AG} = R-value value of foundation wall above grade.
 $L_{basement_wall_total}$ = Length of basement wall around the entire insulated perimeter (ft)
 $H_{basement_wall_AG}$ = Height of insulated basement wall above grade (ft)
 $Framing_factor$ = Adjustment to account for area of framing when cavity insulation is used
 CDD = Cooling Degree Days
 DUA = Discretionary Use Adjustment
 η_{Cool} = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)
 $\Delta kWh_{heating}$ = $(((1/R_{old_AG} - 1/(R_{added}+R_{old_AG})) * L_{basement_wall_total} * H_{basement_wall_AG} * (1-Framing_factor)) + ((1/(R_{old_BG} - 1/(R_{added}+R_{old_BG})) * L_{basement_wall_total} * (H_{basement_wall_total} - H_{basement_wall_AG}) * (1-Framing_factor))) * 24 * HDD) / (3,412 * \eta_{Heat}) * ADJ_{Basement}$
 R_{old_BG} = R-value value of foundation wall below grade (including thermal resistance of the earth)
 $H_{basement_wall_total}$ = Total height of basement wall (ft)
 HDD = Heating Degree Days
 η_{Heat} = Efficiency of heating system
 $ADJ_{Basement}$ = Adjustment for basement wall insulation to account for prescriptive engineering algorithms over claiming savings.

3.3.12 Duct Sealing

For this measure, Navigant and the implementers used the equation below which is deemed by the Illinois TRM v4.0 – Section 5.3.4 to calculate energy savings. The realization rate for this measure is 100 percent.

Equation 3-12. Duct Sealing Insulation Algorithm

$$\Delta kWh = (((DE_{after} - DE_{before}) / DE_{after}) * FLH_{cool} * Capacity_{Cool}) / 1000 / \eta_{Cool} + (\Delta Therms * F_e * 29.3)$$

Where,

DE_{after} = Distribution Efficiency after duct sealing
 DE_{before} = Distribution Efficiency before duct sealing
 FLH_{cool} = Full load cooling hours
 $Capacity_{Cool}$ = Capacity of Air Cooling system (Btu/hr)
 η_{Cool} = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)
 $\Delta Therms$ = Therm savings as calculated in Natural Gas Savings
 F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

3.4 Verified Gross Program Impact Results

The resulting total program verified gross savings is 18,287 MWh and 4.456 MW for CLEAResult and 483 MWh and 0.319 MW for Franklin Energy as shown in the following tables.

Table 3-5. PY8 Verified Gross Impact Savings Estimates by Measure Type - CLEARResult

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Peak Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Peak Demand Reduction (MW)	Verified Gross Realization Rate
Air Source Heat Pump	132.5	0.004	131.9	0.005	100%
Central AC	3,824.1	2.306	4,209.5	2.922	110%
Ductless Mini-Split	219.2	-0.011	220.9	NA	101%
ECM Furnace Motor	3,604.0	1.044	3,604.0	1.043	100%
Geothermal Heat Pump	34.8	0.017	34.8	0.017	100%
Heat Pump Water Heater	29.1	0.001	29.1	0.001	100%
Smart Thermostat	5,074.3	0.000	5,187.9	0.000	102%
Air Sealing	226.6	0.125	259.8	0.127	115%
Attic Insulation	137.7	0.052	138.2	0.052	100%
Basement/Sidewall Insulation	11.8	0.009	11.8	0.009	100%
Duct Sealing	6.3	0.005	6.3	0.005	100%
Wall Insulation	7.6	0.004	7.6	0.004	100%
Air Sealing – Multifamily	2,971.1	0.220	3,060.4	0.210	103%
Attic Insulation – Multifamily	1,384.7	0.060	1,384.7	0.060	100%
TOTAL	17,663.8	3.837	18,286.9	4.456	104%

Source: Evaluation Team analysis.

Table 3-6. PY8 Verified Gross Impact Savings Estimates by Measure Type - Franklin

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Peak Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Peak Demand Reduction (MW)	Verified Gross Realization Rate
Air Sealing	81.3	0.107	126.2	0.0666	155%
Attic Insulation	25.0	0.030	25.0	0.0299	100%
Duct Sealing	331.8	0.223	331.8	0.2228	100%
Total	438.1	0.360	483.0	0.319	110%

Source: Evaluation Team analysis.

4. NET IMPACT EVALUATION

SAG determined⁴ that the NTG values for this program should be deemed prospectively and used to calculate verified net savings. The table below shows the deemed NTG values and the PY8 verified net savings.

Table 4-1. PY8 Verified Net Impact Savings Estimates by Measure Type - CLEARResult

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Demand Reduction (MW)	Verified Gross Realization Rate	NTGR	Verified Net Savings (MWh)	Verified Net Demand Reduction (MW)
Air Source Heat Pump	132.5	0.004	131.9	0.005	100%	0.99†	130.5	0.005
Central AC	3,824.1	2.306	4,209.5	2.922	110%	0.99†	4,167.4	2.893
Ductless Mini-Split	219.2	-0.011	220.9	NA	101%	0.99†	218.6	NA
ECM Furnace Motor	3,604.0	1.044	3,604.0	1.043	100%	0.99†	3,567.9	1.032
Geothermal Heat Pump	34.8	0.017	34.8	0.017	100%	0.99†	34.5	0.016
Heat Pump Water Heater	29.1	0.001	29.1	0.001	100%	0.99†	28.8	0.001
Smart Thermostat	5,074.3	0.000	5,187.9	0.000	102%	0.99†	5,136.0	0.000
Air Sealing	226.6	0.125	259.8	0.127	115%	1.02†	265.0	0.130
Attic Insulation	137.7	0.052	138.2	0.052	100%	1.02†	141.0	0.054
Basement/Sidewall Insulation	11.8	0.009	11.8	0.009	100%	1.02†	12.0	0.010
Duct Sealing	6.3	0.005	6.3	0.005	100%	1.02†	6.4	0.005
Wall Insulation	7.6	0.004	7.6	0.004	100%	1.02†	7.8	0.004
Air Sealing - Multifamily	2,971.1	0.220	3,060.4	0.210	103%	1.02†	3,121.6	0.214
Attic Insulation - Multifamily	1,384.7	0.060	1,384.7	0.060	100%	1.02†	1,412.4	0.061
Total	17,663.8	3.837	18,286.9	4.456	104%		18,250.1	4.426

Source: Evaluation Team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

⁴Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

Table 4-2. PY8 Verified Net Impact Savings Estimates by Measure Type - Franklin

Research Category	Ex Ante Gross Savings (MWh)	Ex-Ante Gross Demand Reduction (MW)	Verified Gross Savings (MWh)	Verified Gross Demand Reduction (MW)	Verified Gross Realization Rate	NTGR	Verified Net Savings (MWh)	Verified Net Demand Reduction (MW)
Air Sealing	81.3	0.107	126.2	0.067	155%	1.02†	128.7	0.068
Attic Insulation	25.0	0.030	25.0	0.030	100%	1.02†	25.5	0.031
Duct Sealing	331.8	0.223	331.8	0.223	100%	1.02†	338.5	0.227
Total	438.1	0.360	483.0	0.319	110%		492.7	0.326

Source: Evaluation Team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

5. FINDINGS AND RECOMMENDATIONS

This section summarizes the key impact findings and recommendations.

Tracking Database

Finding 1. The tracking database contained all the inputs needed to develop the savings estimates. In those cases where using the inputs provided in the tracking database differ from the implementer work papers, it is difficult for Navigant to determine the source of the discrepancy.

Recommendation 1. The implementer should provide actual inputs for a sample of projects for each measure in order to reduce the potential for misunderstanding in verification process.

Finding 2. The tracking database does not track overall demand savings.

Recommendation 2. The implementer should include overall demand savings in the database.

Gross Savings Estimates

Finding 3. The program achieved overall gross savings of 18,770 MWh and peak demand savings of 4.776 MW.

Finding 4. The two implementers used different assumptions for some of the measure inputs. While the assumptions from both implementers are reasonable, this results in two different unit savings values for the same measure in the program.

Recommendation 3. The implementers should share measure level assumptions to ensure consistency across the program.

Net Savings Estimates

Finding 5. The program achieved overall net savings of 18,743 MWh and peak demand savings of 4.751 MW.

Program Volumetric Findings

Finding 6. The program incented 42,137 projects in PY8, including 39,773 HVAC projects and 2,364 Weatherization projects.