



# ComEd Heating, Cooling, and Weatherization Rebates Impact Evaluation Report

Energy Efficiency / Demand Response Plan:  
Plan Year 9 (PY9)

Presented to  
ComEd

**DRAFT**

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## TABLE OF CONTENTS

|   |    |
|---|----|
| 1. Introduction .....                                     | 1  |
| 2. Program Description .....                              | 1  |
| 3. Program Savings.....                                   | 2  |
| 4. Program Savings by Measure.....                        | 3  |
| 5. Impact Analysis Findings and Recommendations .....     | 5  |
| 5.1 Impact Parameter Estimates.....                       | 5  |
| 5.2 Other Impact Findings and Recommendations.....        | 6  |
| 5.2.1 Air Source Heat Pumps .....                         | 6  |
| 5.2.2 Central Air Conditioners .....                      | 7  |
| 5.2.3 Ductless Mini-Split Heat Pumps .....                | 7  |
| 5.2.4 ECM Furnace Motor .....                             | 8  |
| 5.2.5 Geothermal Heat Pump.....                           | 8  |
| 5.2.6 Heat Pump Water Heaters .....                       | 9  |
| 5.2.7 Smart Thermostats .....                             | 9  |
| 5.2.8 Air Sealing .....                                   | 9  |
| 5.2.9 Attic Insulation .....                              | 9  |
| 5.2.10 Basement Insulation .....                          | 10 |
| 5.2.11 Duct Sealing .....                                 | 10 |
| 5.2.12 Wall Insulation .....                              | 11 |
| 6. Appendix 1. Impact Analysis Methodology .....          | 11 |
| 6.1 Verified Gross Program Savings Analysis Approach..... | 11 |
| 6.2 Verified Net Program Savings Analysis Approach.....   | 11 |
| 7. Appendix 2. Impact Analysis Detail.....                | 11 |
| 7.1 Air Source Heat Pump .....                            | 12 |
| 7.2 Central Air Conditioners .....                        | 12 |
| 7.3 Ductless Mini-Split Heat Pumps.....                   | 13 |
| 7.4 ECM Furnace Motors.....                               | 13 |
| 7.5 Geothermal Heat Pump .....                            | 13 |
| 7.6 Heat Pump Water Heater.....                           | 14 |
| 7.7 Smart Thermostats.....                                | 14 |
| 7.8 Air Sealing.....                                      | 14 |
| 7.9 Attic Insulation .....                                | 15 |
| 7.10 Basement Insulation.....                             | 15 |
| 7.11 Duct Sealing.....                                    | 15 |
| 7.12 Wall Insulation .....                                | 16 |
| 8. Appendix 3. TRC Detail.....                            | 16 |

## LIST OF TABLES AND FIGURES

|   |   |
|---|---|
| Figure 2-1. Distribution of HVAC Measures Installed by Type ..... | 1 |
| Figure 2-2 Distribution of Wx Measures Installed by Type .....    | 2 |
| Table 2-1. PY9 HVAC and Wx Volumetric Findings .....              | 1 |
| Table 3-1. PY9 HVAC Total Annual Incremental Savings .....        | 2 |
| Table 3-2. PY9 Wx Total Annual Incremental Savings.....           | 3 |
| Table 4-1. PY9 HVAC Energy Savings by Measure.....                | 3 |
| Table 4-2. PY9 Wx Energy Savings by Measure.....                  | 3 |
| Table 4-3. PY9 HVAC Demand Savings by Measure.....                | 4 |
| Table 4-4. PY9 Wx Demand Savings by Measure .....                 | 4 |
| Table 4-5. PY9 HVAC Peak Demand Savings by Measure .....          | 5 |
| Table 4-6. PY9 Wx Peak Demand Savings by Measure .....            | 5 |

Table 5-1. Verified Gross Savings Parameters.....6

Table 7-1. Air Source Heat Pump Measure Impact Detail .....12

Table 7-2. Central Air Conditioners Measure Impact Detail .....13

Table 7-3. DMS Heat Pumps Measure Impact Detail.....13

Table 7-4. Showerheads Measure Impact Detail.....13

Table 7-5. Geothermal Heat Pump Measure Impact Detail.....14

Table 7-6. Heat Pump Water Heater Measure Impact Detail .....14

Table 7-7. Smart Thermostats Measure Impact Detail .....14

Table 7-8. Air Sealing Measure Impact Detail .....15

Table 7-9. Attic Insulation Measure Impact Detail .....15

Table 7-10. Basement or Sidewall Insulation Measure Impact Detail .....15

Table 7-11. Duct Sealing Measure Impact Detail .....16

Table 7-12. Wall Insulation Measure Impact Detail .....16

## 1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Heating, Cooling (HVAC), and Weatherization (Wx) Rebates Program (HVAC Wx). The report separates the savings from the HVAC rebates and the Wx rebates to better reflect how the program has evolved into two separate programs. The report presents a summary of the energy and demand impacts for the total program and broken out by relevant measure and program structure details, also by HVAC and Wx rebates. The appendix presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

## 2. 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.

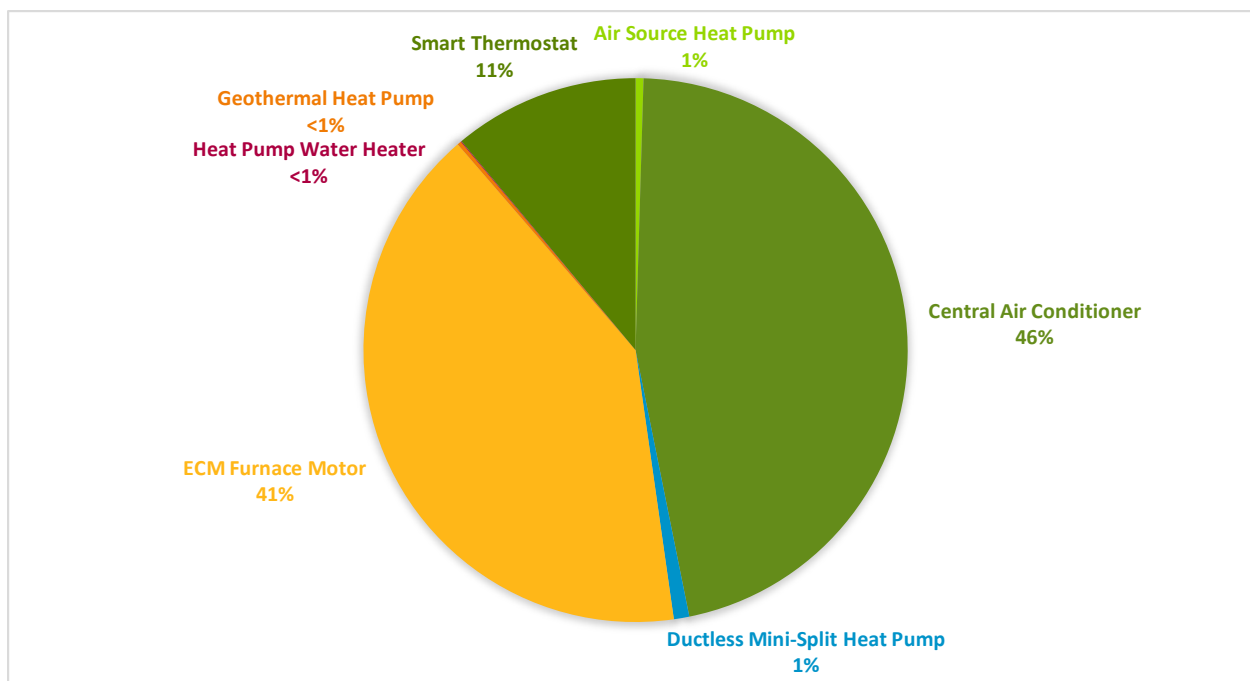
The program had 21,209 HVAC and 2,789 Wx participants in PY9 and distributed 32,853 HVAC and 5,883 Wx measures as shown in the following tables and graphs.

**Table 2-1. PY9 HVAC and Wx Volumetric Findings**

| Participation            | HVAC   | Wx    |
|--------------------------|--------|-------|
| Participants             | 21,209 | 2,789 |
| Total Measures           | 32,853 | 5,883 |
| Number of Units/Projects | 22,069 | 2,804 |

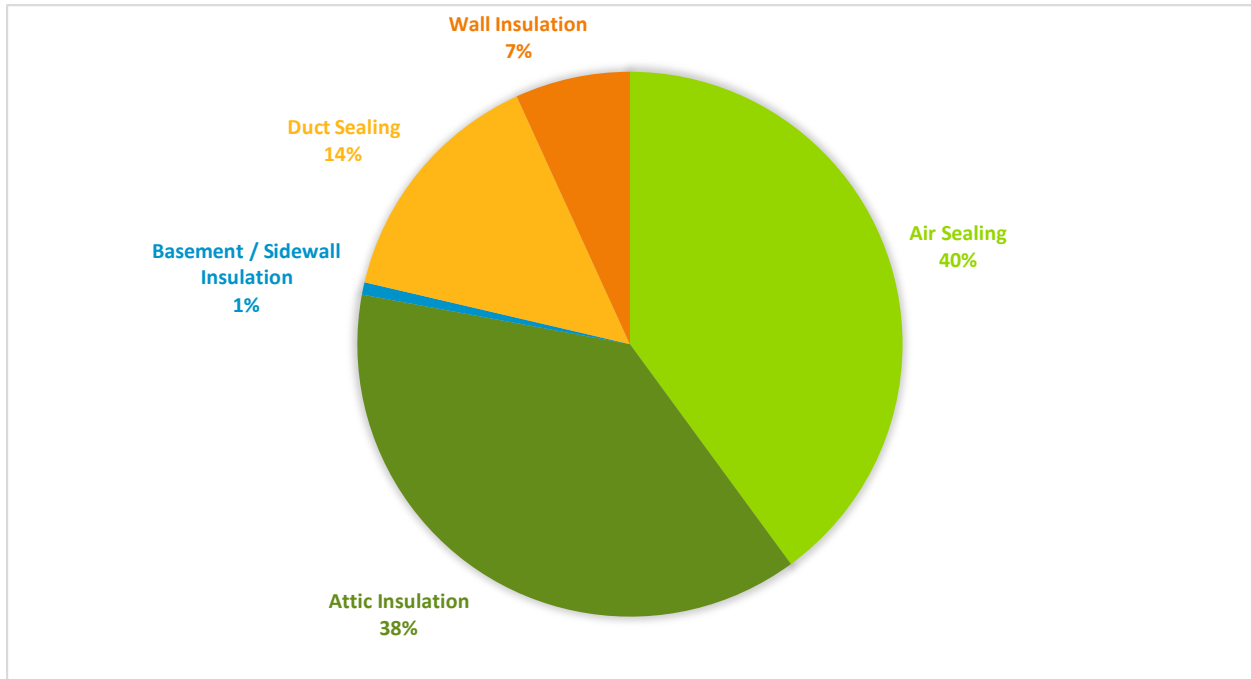
Source: ComEd tracking data and Navigant team analysis.

**Figure 2-1. Distribution of HVAC Measures Installed by Type**



Source: Evaluation Analysis

Figure 2-2 Distribution of Wx Measures Installed by Type



Source: Evaluation Analysis

### 3. PROGRAM SAVINGS

Table 3-1a and 3-1b summarize the incremental energy and demand savings the HVAC Wx Program achieved in PY9.

Table 3-1. PY9 HVAC Total Annual Incremental Savings

| Savings Category                   | Energy Savings (kWh) | Demand Savings (kW) | Peak Demand Savings (kW) |
|------------------------------------|----------------------|---------------------|--------------------------|
| Ex Ante Gross Savings              | 20,045,686           | NA                  | 7,566                    |
| Program Gross Realization Rate     | 98%                  | NA                  | 97%                      |
| Verified Gross Savings             | 19,684,275           | 16,600              | 7,376                    |
| Program Net-to-Gross Ratio (NTGR)* | 0.99                 | 0.99                | 0.99                     |
| Verified Net Savings               | 19,497,479           | 16,445              | 7,305                    |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>. The NTGR for all program measures is 0.99 except Smart Thermostats for which a NTGR is not applicable.

**Table 3-2. PY9 Wx Total Annual Incremental Savings**

| Savings Category                   | Energy Savings (kWh) | Demand Savings (kW) | Peak Demand Savings (kW) |
|------------------------------------|----------------------|---------------------|--------------------------|
| Ex Ante Gross Savings              | 1,214,845            | NA                  | 735                      |
| Program Gross Realization Rate     | 105%                 | NA                  | 84%                      |
| Verified Gross Savings             | 1,273,791            | 1,321               | 616                      |
| Program Net-to-Gross Ratio (NTGR)* | 1.01                 | 1.01                | 1.01                     |
| Verified Net Savings               | 1,286,529            | 1,334               | 622                      |

Source: ComEd tracking data and Navigant team analysis.

\*A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

## 4. PROGRAM SAVINGS BY MEASURE

The program includes seven HVAC measures and five Wx measures as shown in the following tables. The Furnace Blower Motor (ECM) and the Air Sealing measures contributed the most savings to the HVAC and Wx portions of the program, respectively.

**Table 4-1. PY9 HVAC Energy Savings by Measure**

| Enduse Type | Research Category          | Ex Ante Gross Savings (kWh) | Verified Gross Realization Rate | Verified Gross Savings (kWh) | NTGR* | Verified Net Savings (kWh) | Technical Measure Life | Persistence | Effective Useful Life (EUL)† |
|-------------|----------------------------|-----------------------------|---------------------------------|------------------------------|-------|----------------------------|------------------------|-------------|------------------------------|
| HVAC        | Air Source Heat Pump       | 332,299                     | 91%                             | 301,295                      | 0.99  | 298,282                    | NA                     | NA          | 18                           |
| HVAC        | Central Air Conditioning   | 6,578,322                   | 101%                            | 6,650,000                    | 0.99  | 6,583,500                  | NA                     | NA          | 18                           |
| HVAC        | Ductless Heat Pumps        | 1,957,556                   | 97%                             | 1,900,953                    | 0.99  | 1,881,943                  | NA                     | NA          | 18                           |
| HVAC        | Furnace Blower Motor (ECM) | 9,541,690                   | 100%                            | 9,541,690                    | 0.99  | 9,446,273                  | NA                     | NA          | 20                           |
| HVAC        | Ground Source Heat Pump    | 586,404                     | 43%                             | 253,807                      | 0.99  | 251,269                    | NA                     | NA          | 25                           |
| Hot Water   | Heat Pump Water Heaters    | 31,532                      | 101%                            | 31,784                       | 0.99  | 31,466                     | NA                     | NA          | 13                           |
| HVAC        | Smart Thermostats          | 1,017,883                   | 99%                             | 1,004,745                    | NA‡   | 1,004,745                  | NA                     | NA          | 10                           |
|             | Total                      | 20,045,686                  | 98%                             | 19,684,275                   | 0.99  | 19,497,479                 |                        |             |                              |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

† EUL is a combination of technical measure life and persistence.

‡ The IL TRM algorithm calculates net savings for smart thermostats

**Table 4-2. PY9 Wx Energy Savings by Measure**

| Enduse Type    | Research Category              | Ex Ante Gross Savings (kWh) | Verified Gross Realization Rate | Verified Gross Savings (kWh) | NTGR* | Verified Net Savings (kWh) | Technical Measure Life | Persistence | Effective Useful Life (EUL)† |
|----------------|--------------------------------|-----------------------------|---------------------------------|------------------------------|-------|----------------------------|------------------------|-------------|------------------------------|
| Weatherization | Air Sealing                    | 638,289                     | 129%                            | 825,718                      | 1.01  | 833,975                    | NA                     | NA          | 15                           |
| Weatherization | Attic Insulation               | 319,907                     | 69%                             | 219,608                      | 1.01  | 221,804                    | NA                     | NA          | 25                           |
| Weatherization | Basement / Sidewall Insulation | 4,060                       | 41%                             | 1,672                        | 1.01  | 1,689                      | NA                     | NA          | 25                           |
| HVAC           | Duct Sealing                   | 214,590                     | 98%                             | 210,903                      | 1.01  | 213,012                    | NA                     | NA          | 20                           |
| Weatherization | Wall Insulation                | 37,999                      | 42%                             | 15,889                       | 1.01  | 16,048                     | NA                     | NA          | 25                           |
|                | Total                          | 1,214,845                   | 105%                            | 1,273,791                    | 1.01  | 1,286,529                  |                        |             |                              |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

† EUL is a combination of technical measure life and persistence.

**Table 4-3. PY9 HVAC Demand Savings by Measure**

| Enduse Type | Research Category          | Ex Ante Gross Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Demand Reduction (kW) | NTGR* | Verified Net Demand Reduction (kW) |
|-------------|----------------------------|-------------------------------------|---------------------------------|--------------------------------------|-------|------------------------------------|
| HVAC        | Air Source Heat Pump       | NR†                                 | NA                              | 23                                   | 0.99  | 23                                 |
| HVAC        | Central Air Conditioning   | NR                                  | NA                              | 9,039                                | 0.99  | 8,948                              |
| HVAC        | Ductless Heat Pumps        | NR                                  | NA                              | 172                                  | 0.99  | 170                                |
| HVAC        | Furnace Blower Motor (ECM) | NR                                  | NA                              | 5,929                                | 0.99  | 5,870                              |
| HVAC        | Ground Source Heat Pump    | NR                                  | NA                              | 290                                  | 0.99  | 287                                |
| Hot Water   | Heat Pump Water Heaters    | NR                                  | NA                              | 13                                   | 0.99  | 12                                 |
| HVAC        | Smart Thermostats          | NR                                  | NA                              | 1,135                                | NA‡   | 1,135                              |
|             | Total                      | NR                                  | NA                              | 16,600                               | 0.99  | 16,445                             |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

† NR = Not Reported

‡ The IL TRM algorithm calculates net savings for smart thermostats

**Table 4-4. PY9 Wx Demand Savings by Measure**

| Enduse Type    | Research Category              | Ex Ante Gross Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Demand Reduction (kW) | NTGR* | Verified Net Demand Reduction (kW) |
|----------------|--------------------------------|-------------------------------------|---------------------------------|--------------------------------------|-------|------------------------------------|
| Weatherization | Air Sealing                    | NR†                                 | NA                              | 880                                  | 1.01  | 889                                |
| Weatherization | Attic Insulation               | NR                                  | NA                              | 399                                  | 1.01  | 403                                |
| Weatherization | Basement / Sidewall Insulation | NR                                  | NA                              | 3                                    | 1.01  | 3                                  |
| HVAC           | Duct Sealing                   | NR                                  | NA                              | 15                                   | 1.01  | 15                                 |
| Weatherization | Wall Insulation                | NR                                  | NA                              | 25                                   | 1.01  | 26                                 |
|                | Total                          | NR                                  | NA                              | 1,321                                | 1.01  | 1,334                              |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

† NR = Not Reported



**Table 4-5. PY9 HVAC Peak Demand Savings by Measure**

| Enduse Type | Research Category          | Ex Ante Gross Peak Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Peak Demand Reduction (kW) | NTGR*       | Verified Peak Net Demand Reduction (kW) |
|-------------|----------------------------|--|---------------------------------|---|-------------|---|
| HVAC        | Air Source Heat Pump       | 32                                       | 33%                             | 11  | 0.99        | 11                                      |
| HVAC        | Central Air Conditioning   | 4,146                                    | 102%                            | 4,212                                     | 0.99        | 4,170                                   |
| HVAC        | Ductless Heat Pumps        | 48                                       | -22%                            | -11                                       | 0.99        | -10                                     |
| HVAC        | Furnace Blower Motor (ECM) | 2,768                                    | 100%                            | 2,763                                     | 0.99        | 2,735                                   |
| HVAC        | Ground Source Heat Pump    | 155                                      | 87%                             | 135                                       | 0.99        | 134                                     |
| Hot Water   | Heat Pump Water Heaters    | 1  | 101%                            | 2   | 0.99        | 1                                       |
| HVAC        | Smart Thermostats          | 414                                      | 64%                             | 264                                       | NA†         | 264                                     |
|             | <b>Total</b>               | <b>7,566</b>                             | <b>97%</b>                      | <b>7,376</b>                              | <b>0.99</b> | <b>7,305</b>                            |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

† The IL TRM algorithm calculates net savings for smart thermostats

**Table 4-6. PY9 Wx Peak Demand Savings by Measure**

| Enduse Type    | Research Category              | Ex Ante Gross Peak Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Peak Demand Reduction (kW) | NTGR*       | Verified Peak Net Demand Reduction (kW) |
|----------------|--------------------------------|--|---------------------------------|---|-------------|---|
| Weatherization | Air Sealing                    | 560                                      | 73%                             | 410                                       | 1.01        | 414                                     |
| Weatherization | Attic Insulation               | 147                                      | 126%                            | 186                                       | 1.01        | 188                                     |
| Weatherization | Basement / Sidewall Insulation | 1  | 122%                            | 1   | 1.01        | 1                                       |
| HVAC           | Duct Sealing                   | 7  | 98%                             | 7   | 1.01        | 7                                       |
| Weatherization | Wall Insulation                | 20                                       | 60%                             | 12  | 1.01        | 12                                      |
|                | <b>Total</b>                   | <b>735</b>                               | <b>84%</b>                      | <b>616</b>                                | <b>1.01</b> | <b>622</b>                              |

Source: ComEd tracking data and Navigant team analysis.

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

## 5. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

### 5.1 Impact Parameter Estimates

Navigant estimated verified unit savings for each program measure using impact algorithms found in the version 5 of the Illinois Technical Reference Manual<sup>1</sup> (TRM v5.0). Table 5-1 presents the key parameters and the references used in the verified gross and net savings calculations. Detailed breakdowns of the measure quantities and per unit savings values are provided in the Appendix 2.

<sup>1</sup> State of Illinois Technical Reference Manual version 5.0 from <http://www.ilsag.info/technical-reference-manual.html>.

**Table 5-1. Verified Gross Savings Parameters**

| Gross Savings Input Parameters                                    | Value  | Deemed* or Evaluated? |
|---|--------|-----------------------|
| Measure Quantities  | Varies | Evaluated             |
| Measure Type and Eligibility                                      | Varies | Deemed                |
| Savings Input Assumption  | Varies | Deemed                |
| Gross Savings per Unit  | Varies | Deemed                |
| Verified Realization Rate on Ex-Ante Gross Savings (Non-Lighting) | Varies | Deemed                |
| NTGR†   | Varies | Deemed                |

\* State of Illinois Technical Reference Manual version 5.0 from <http://www.ilsag.info/technical-reference-manual.html>.

† Deemed values. Source: ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html.x->

## 5.2 Other Impact Findings and Recommendations

Findings and recommendations for the PY9 HVAC and Wx Program by measure are listed below. Some of the measure-level findings by Navigant were addressed by the implementer in the PY9 Wave 1 analysis but not corrected for by the implementer in the end of year analysis. This resulted in several repeat findings and recommendations from the PY9 Wave 1 analysis.

### 5.2.1 Air Source Heat Pumps

**Finding 1.** The TRM specifies separate savings algorithms for Air Source Heat Pumps (ASHP) “time of sale” projects and “early replacement” projects. For several “early replacement” projects with high energy savings, the implementer used the “time of sale” savings algorithm. This resulted in a lower realization rate for ASHP.

**Recommendation 1.** Navigant recommends calculating the energy and demand savings using the proper TRM savings algorithm with regards to “time of sale” and “early replacement” ASHP projects.

**Finding 2.** For most of the ASHP projects with low energy realization rates, the implementer applied a “special case” approach regarding which TRM savings algorithm to apply (“time of sale” or “early replacement”). The implementer detailed the issues for these “special case” projects, presented below.

1. *When a customer installs an ASHP to replace non-electric heat in an early retirement scenario, cooling savings are achieved due to efficiency gains on the cooling side; however, the customer is adding electric load for heating. Because the early retirement savings calculation considers the baseline to be the current equipment for first year savings, the gains from cooling (positive  $\Delta kWh_{cooling}$ ) are offset by the additional load for heating (negative  $\Delta kWh_{heating}$  because  $1/HSPF_{base} = 0$ ), resulting in overall negative first year savings for the project.*
2. *When a customer installs an ASHP to replace electric heating with no existing cooling in an early retirement scenario, heating savings are achieved due to efficiency gains on the heating side; however, the customer is adding electric load for cooling. Because the early retirement savings calculation considers the baseline to be the current equipment for first year savings, the gains from heating (positive  $\Delta kWh_{heating}$ ) are offset by the additional load for cooling (negative  $\Delta kWh_{cooling}$  because  $1/SEER_{base} = 0$ ), resulting in overall negative first year savings for the project.<sup>2</sup>*

<sup>2</sup> ComEd and CLEAResult Proposed Methodology for Air Source Heat Pump Savings Calculations Memo, May 17, 2017

Navigant applied the “Time of sale” savings algorithm to these special case projects in the evaluation. However, Navigant’s Wave 1 Review made a supplemental recommendation that the implementer clarify the type of *heating* unit for records where “Existing\_HVAC\_Type” is populated with “Central Air Conditioner” to help identify when to apply the “time of sale” savings algorithm.

**Recommendation 2.** Although the “special case” ASHP projects no longer present negative energy savings values, most of them still have low energy and demand realization rates. All “special case” situations had Central Air Conditioner as the “Existing\_HVAC\_Type”. As stated in Finding 2, Navigant recommended that the implementer clarify the type of *heating* unit for records where “Existing\_HVAC\_Type” is Central Air Conditioner. The implementer did not correct this in the final set of data delivered to Navigant, and this could be a source of error for the low energy and peak demand realization rates for the “special case” projects. Navigant recommends that the implementer provide a set of these “special case” projects with associated inputs used for calculation to identify the source of the discrepancy.

### 5.2.2 Central Air Conditioners

**Finding 3.** For Central Air Conditioner (CAC) savings, the IL TRM v5.0 specifies two savings algorithms: “time of sale” and “early replacement” depending on the type of project. Navigant found many projects where the implementer used the “early replacement” algorithm and where there was a discrepancy with Navigant’s evaluated savings. For the majority of those projects, using the “time of sale” savings algorithm resolved the discrepancy. Applying the incorrect “early replacement” savings algorithm to “time of sale” projects increased the energy and demand realization rates.

**Recommendation 3.** Navigant recommends applying the correct TRM savings algorithm (either “Time of Sale” or “Early Replacement”) to all CAC project calculations.

### 5.2.3 Ductless Mini-Split Heat Pumps

**Finding 4.** Navigant found that Ductless Mini-Split (DMS) Heat Pump (DMSHP) projects with discrepancies for both energy and demand are due to having the value “none” for “Existing\_HVAC\_Type”. The energy and demand savings algorithms defined by the IL TRM v5.0 for DMSHP are below:

$$\begin{aligned} \Delta kWh &= \Delta kWh_{\text{heat}} + \Delta kWh_{\text{cool}} \\ \Delta kWh_{\text{heat}} &= (\text{Capacity}_{\text{heat}} * \text{EFLH}_{\text{heat}} * (1/\text{HSPF}_{\text{exist}} - 1/\text{HSPF}_{\text{ee}})) / 1000 \\ \Delta kWh_{\text{cool}} &= (\text{Capacity}_{\text{cool}} * \text{EFLH}_{\text{cool}} * (1/\text{SEER}_{\text{exist}} - 1/\text{SEER}_{\text{ee}})) / 1000 \end{aligned}$$

$$\Delta kW = \text{Capacity}_{\text{cool}} * (1/\text{EER}_{\text{exist}} - 1/\text{EER}_{\text{ee}}) / 1000 * \text{CF}$$

Projects with “none” for “Existing\_HVAC\_Type” will result in negative  $\Delta kWh_{\text{cool}}$  and  $\Delta kW$  values. For these projects,  $\Delta kWh_{\text{cool}}$  is negative because there was no existing cooling system prior to the installation of the DMSHP. In this situation, according to the IL TRM v5.0, the  $1/\text{SEER}_{\text{exist}}$  value is equal to zero. This results in a negative  $\Delta kWh_{\text{cool}}$  value and thus a lower energy ( $\Delta kWh$ ) savings and realization rate. Similarly, the demand savings for these projects result in  $1/\text{EER}_{\text{exist}}$  equal to zero according to the IL TRM v5.0, thus resulting in negative  $\Delta kW$  values and negative realization rates.

**Recommendation 4:** Navigant recommends that the implementer account for the negative cooling energy savings as well as the negative demand savings for projects with “none” for “Existing\_HVAC\_Type”. Regarding the  $1/\text{SEER}_{\text{exist}}$  and the  $1/\text{EER}_{\text{exist}}$  values, section 5.3.12 reference 400 in the IL TRM v5.0 states that “If there is no existing cooling in place but the incentive encourages installation of a new DMSHP with cooling, the added cooling load should be subtracted from any heating benefits”.

### 5.2.4 ECM Furnace Motor

**Finding 5.** For several ECM Furnace Motor projects, the peak demand savings (kW) have discrepancies between the ex ante implementer and verified Navigant calculated values. This could be because the implementer used incorrect “FLH Cooling” values, or the full load hours of air conditioning to calculate some of the ECM Furnace Motor projects savings. These values are determined by the geographic location of the project and its associated “Cooling Zone”. An example of this is for Rebate ID-1011178. The deemed “FLH\_Cooling” value for this project is an average of the other zones in the IL TRM, equal to 629 hours. If this “FLH\_Cooling” value is updated from the average (629 hours) to Climate Zone 2- Chicago (“FLH\_Cooling” = 570 hours), then the realization rate is equal to 100 percent. Another example of “Cooling Zone” and resulting “FLH\_cooling” error is Rebate ID-1068262. The “Cooling Zone” for this project should be 1 – Rockford (FLH\_cooling = 512 hours). However, the ex ante calculation used an “FLH\_Cooling” value of 470, perhaps meant to be 570, which is Cooling Zone 2 – Chicago. These errors both increased and decreased the energy savings and demand realization rates depending on which “FLH\_Cooling” value was used by the implementer.

**Recommendation 5.** Navigant recommends that the implementer apply the correct Cooling Zone and associated FLH\_cooling value to all projects.

### 5.2.5 Geothermal Heat Pump

**Finding 6.** The IL TRM v5.0 specifies that the “Existing\_Heating\_Type” determines Ground Source Heat Pump or Geothermal Heat Pump (GHP) Heating System Performance Factor of new replacement baseline heating systems ( $HSPF_{base}$ ) and Heating System Performance Factor of existing heating system ( $HSPF_{exist}$ ). End of year PY9 tracking data includes projects with “Existing\_Heating\_Type” of Geothermal Heat Pump, New Construction, and Gas or Propane. The IL TRM v5.0 includes  $HSPF_{base}$  and  $HSPF_{exist}$  deemed values only for Air Source Heat Pump and Electric Resistance existing heating systems. The IL TRM v5.0 does not specify  $HSPF_{base}$  and  $HSPF_{exist}$  deemed values for projects with “Existing\_Heating\_Type” of New Construction, Gas or Propane, or Geothermal Heat Pump. Due to the uncertainty of these values which are not deemed in the IL TRM v5.0, Navigant attempted to use reasonable values to complete the evaluation calculations. This lowered the energy and demand realization rates.

**Recommendation 6.** Due to the lack of deemed  $HSPF_{base}$  and  $HSPF_{exist}$  values for certain “Existing\_Heating\_Type” selections in the IL TRM v5.0, Navigant is unsure of the values used in the implementers savings calculations. Navigant recommends that the implementer provide all  $HSPF_{base}$  and  $HSPF_{exist}$  values used for all “Existing\_Heating\_Type” selections.

**Finding 7.** According to the IL TRM v5.0, a Geothermal Heat Pump project’s “Existing\_Cooling\_Type” determines savings algorithm inputs  $SEER_{base}$ ,  $SEER_{exist}$ ,  $EER_{base}$ , and  $EER_{exist}$ . Similar to finding 6 above, the TRM does not specify deemed values associated with certain responses to “Existing\_Cooling\_Type”. Two of these “Existing\_Cooling\_Type” selections lacking associated deemed input values are Geothermal Heat Pump and New Construction. Similar to Finding 6, because of the uncertainty of these values which are not deemed in the IL TRM v5.0, Navigant attempted to use reasonable values to complete the evaluation calculations. This lowered the energy and demand realization rates.

**Recommendation 7.** Navigant recommends that the implementer provide all  $SEER_{base}$ ,  $SEER_{exist}$ ,  $EER_{base}$ , and  $EER_{exist}$  values used for all “Existing\_Cooling\_Type” selections for GHP projects.

**Finding 8.** According to the IL TRM v5.0, a Geothermal Heat Pumps project’s “Existing\_Heating\_Type” also determines if the existing building is electrically heated or not. This savings algorithm input is “ElecHeat”, and is equal to 1 for existing buildings that are electrically heated, and equal to 0 for existing buildings that were not electrically heated. The implementers seem to use “ElecHeat” = 1 for all projects. However, there is a group of

projects with Gas or Propane fueled “Existing\_Heating\_Type” which should have “ElecHeat” = 0. By properly applying the “ElecHeat” values to all projects, the energy savings realization rate decreased.

**Recommendation 8.** Navigant recommends that the implementer apply “ElecHeat” = 0 to all GHP projects with “Existing\_Heating\_Type” of Gas or Propane systems.

### 5.2.6 Heat Pump Water Heaters

**Finding 9.** A potential source of error for Heat Pump Water Heater (HPWH) projects could be the Coefficient of Performance (COP) of electric heating system ( $COP_{HEAT}$ ) value. The implementer stated in the Wave 1 Review that they use a weighted average which assumes an 82/18 split of Electric Resistance ( $COP_{HEAT} = 1$ ) and Heat Pump ( $COP_{HEAT} = 2.13$ ) resulting in a weighted average  $COP_{HEAT}$  of 1.2 which they apply to all projects with electric heat. If this  $COP_{HEAT}$  values was applied by the implementer again in the end of year analysis, it lowered the realization rates for Natural Gas “Existing\_HVAC\_Type” projects and increased the realization rates for Electric “Existing\_HVAC\_Type” projects.

**Recommendation 9.** Navigant recommends applying a  $COP_{HEAT} = 0$  for all HPWH projects with “Existing\_HVAC\_Type” of Natural Gas, and a  $COP_{HEAT} = 1.39$  for projects with “Existing\_HVAC\_Type” of Electric. The  $COP_{HEAT}$  of 1.39 should be used instead of the implementers 1.2 since the IL TRM v5.0 states  $COP_{HEAT}$  of unknown electric heating systems is equal to 1.39.

### 5.2.7 Smart Thermostats

**Finding 10.** The implementer’s Smart Thermostat peak demand calculations apply the Summer System Peak (SSP) coincidence factor (CF) of 0.34 to all Smart Thermostat (ST) projects. This lowered the peak demand realization rate.

**Recommendation 10.** Navigant recommends that the PJM CF of 0.233 should be applied to all peak demand ST calculations instead.

**Finding 11.** According to the implementer’s calculations, Smart thermostat projects with “Existing\_HVAC\_Type” of Electric Resistance (no CAC) are claiming positive ex ante gross demand savings. However, the IL TRM v5.0 specifies that projects with “Existing\_HVAC\_Type” of Electric Resistance (no CAC) have no previous cooling system, and thus  $1/EER = 0$ , causing no demand savings.

**Recommendation 11.** Navigant recommends that the implementer update  $1/EER = 0$  for all projects with no existing cooling system, or to provide the used  $1/EER$  value in the ex ante calculations if it represents a reasonable estimate.

### 5.2.8 Air Sealing

**Finding 12:** For Air Sealing measures, projects implemented by CLEAResult had a realization rate of 100 percent. For projects implemented by Franklin, Navigant found a realization rate of 153 percent. Franklin used a deemed value of 0.164 kWh / CFM reduction to calculate savings for all projects, which assumes that the variables used in the calculation are constant across all projects. The tracking data provides enough information to use inputs specific to each project.

**Recommendation 12:** Navigant recommends that Franklin update their algorithms and use the inputs provided in the tracking data to calculate energy savings.

### 5.2.9 Attic Insulation

**Finding 13:** Attic Insulation projects implemented by CLEAResult had an overall realization rate of 100 percent; projects implemented by Franklin had an overall realization rate of 27

percent. In reviewing the tracking data provided by Franklin, Navigant found that all measures are using a value of 1.00 kWh / Measure Quantity to calculate savings. Navigant assumed that Measure Quantity is the square feet of the area insulated. Navigant also reviewed the measure build provided by Franklin. Navigant agrees with the calculations in the measure build and believes there is an error in the inputs to the tracking data and not in the algorithms for calculating energy savings.

**Recommendation 13:** Review the tracking data inputs, and determine where the error in the tracking system is. Please provide feedback to Navigant if there is an error in measure quantity, as this affects the verified savings calculations.

### 5.2.10 Basement Insulation

**Finding 14:** For Basement Insulation projects implemented by CLEARResult, the realization rate was 71 percent. Navigant was unable to isolate the source of the discrepancies causing the difference between the ex ante and ex post savings estimates for basement and sidewall insulation measures. However, the difference in the savings estimates may be partially attributed to the tracking data not providing values for the length and height of the walls being insulated. Navigant assumed that the quantity installed represented the area of the wall being insulated and divided the area by the implementer's total wall height assumption of eight feet to calculate the length of the wall. Navigant presented this finding in the Wave 1 Review memo and CLEARResult said they would conduct an engineering review of their savings methodology. Based on a comparison of the early and final tracking data, it appears that CLEARResult was not able to make these changes before the end of the program year.

**Recommendation 14:** Navigant recommends that CLEARResult conduct an engineering review of their savings methodology to determine if there is an error in the determination of the total area insulated.

**Finding 15:** For projects implemented by Franklin, the realization rate was 41 percent. Navigant found that all measures are using a value of 1.00 kWh / Measure Quantity to calculate savings. Navigant assumed that Measure Quantity is the square feet of the area insulated. Navigant also reviewed the measure build provided by Franklin. Navigant agrees with the calculations in the measure build and believes there is an error in the inputs to the tracking data and not in the algorithms for calculating energy savings.

**Recommendation 15:** Navigant recommends that Franklin review the tracking data inputs, and determine where the error in the tracking system is. Please provide feedback to Navigant if there is an error in measure quantity, as this affects the verified savings calculations.

### 5.2.11 Duct Sealing

**Finding 16:** For projects implemented by Franklin, the realization rate was 100 percent. For projects implemented by CLEARResult, the realization rate was 81 percent. Navigant was unable to isolate the source of the discrepancies causing the difference between the ex ante and ex post savings estimates for duct sealing measures. When reviewing the measure build calculator provided by CLEARResult, Navigant found that measure build includes a Thermal Regain Factor (TRF) factor. Navigant did not use a TRF factor as it is not defined in the algorithm for energy savings in the TRM.

**Recommendation 16:** Navigant recommends that CLEARResult conduct an engineering review of their calculators and determine if a TRF factor is being used. If so, and the factor is not equal to 1, Navigant recommends that CLEARResult remove this factor from their algorithms or provide additional justification to Navigant as to why this factor is being used.

### 5.2.12 Wall Insulation

**Finding 17:** For Wall Insulation projects implemented by CLEAResult, the realization rate was 89%. Navigant found that CLEAResult was incorrectly reporting AFUE as a whole number and not a decimal percentage. Navigant corrected this in the ex ante calculations.

**Recommendation 17:** Navigant recommends that CLEAResult review the inputs for AFUE and ensure they are a percent as stated in the TRM.

**Finding 18:** For projects implemented by CLEAResult, Navigant was unable to isolate any other sources of error. In the Wave 1 Review memo, CLEAResult stated that they would conduct an engineering review of the savings methodology. Based on the tracking data provided, no changes were made.

**Recommendation 18:** Navigant recommends that CLEAResult continues with their engineering review to determine the discrepancy in energy savings.

**Finding 19:** For projects implemented by Franklin, the realization rate was 13 percent. Navigant found that all measures are using a value of 1.00 kWh / Measure Quantity to calculate savings. Navigant assumed that Measure Quantity is the square feet of the area insulated. Navigant also reviewed the measure build provided by Franklin. Navigant agrees with the calculations in the measure build and believes there is an error in the inputs to the tracking data and not in the algorithms for calculating energy savings.

**Recommendation 19:** Navigant recommends that Franklin review the tracking data inputs, and determine where the error in the tracking system is. Please provide feedback to Navigant if there is an error in measure quantity, as this affects the verified savings calculations.

## 6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

### 6.1 Verified Gross Program Savings Analysis Approach

Navigant determined verified gross savings for each program measure by:

1. Reviewing the savings algorithm inputs in the measure workbook for agreement with the TRM v 5.0.
2. Validating that the savings algorithm was applied correctly.
3. Cross-checking per-unit savings values in the tracking data with the verified values in the measure workbook or in Navigant's calculations if the workbook did not agree with the TRM.
4. Multiplying the verified per-unit savings value by the quantity reported in the tracking data.

### 6.2 Verified Net Program Savings Analysis Approach

Navigant calculated verified net energy and demand (coincident peak and overall) savings by multiplying the verified gross savings estimates by a net-to-gross ratio (NTGR). In PY9, the NTGR estimates used to calculate the net verified savings were based on past evaluation research and defined by a consensus process through SAG, as documented in a spreadsheet.<sup>3</sup>

## 7. APPENDIX 2. IMPACT ANALYSIS DETAIL

Navigant downloaded the final tracking data and measure workbook for the MFES PY9 impact evaluation from the ComEd Evaluation Share file site. Navigant relied on the following documents to verify the per-unit savings for each program measure:

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<sup>3</sup> Source ComEd\_NTG\_History\_and\_PY9\_Recommendations\_2016-02-26\_Final.xlsx, which is to be found on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>

- Final PY9 tracking database file:
  - HVAC: "HVAC\_PY9\_EOY\_Evaluation\_Data\_Rev3\_02162018.xlsx"
  - Wx: "Wx\_PY9\_EOY\_Evaluation\_Data\_Rev0\_01182018.xlsx"
- Illinois Technical Reference Manual (TRM v5.0) for deemed input parameters or secondary evaluation research to verify any custom inputs used in the ex ante calculations.

The following sections provide an outline of the differences between the ex ante and verified savings estimates for each measure by end-use. Each section contains a table that provides the quantity installed<sup>4</sup>, ex ante and ex post values, and realization rates. Note that these values are reported in kWh, as opposed to MWh which are used for reporting in the above sections.

## 7.1 Air Source Heat Pump

Air source heat pumps had a realization rate of 91 percent and accounted for two percent of HVAC energy savings and one percent of the entire HVAC Wx program energy savings. There were two project types associated with Air Source Heat Pumps, Early Retirement and Time of Sale. There was a third project type which was incorporated into the analysis and is described in depth in Section 5.2 in Finding and Recommendation 2. The high realization rate for Early Retirement projects was due to the use of incorrect Project Type for several projects in the ex ante savings calculation. The explanation of the realization rate of 53 percent for the Special Case ASHP projects is also described in Section 5.2 in Finding and Recommendation 2.

**Table 7-1. Air Source Heat Pump Measure Impact Detail**

| Measure | Project Type              | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|---------------------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| ASHP    | Early Retirement          | 27                 | 141,753                     | 110%                                | 155,319                      |
| ASHP    | Time of Sale              | 86                 | 97,678                      | 99%                                 | 96,901                       |
| ASHP    | Special Case (Forced TOS) | 41                 | 92,868                      | 53%                                 | 49,074                       |
| ASHP    | Total                     | 154                | 332,299                     | 91%                                 | 301,295                      |

Source: ComEd tracking data and Navigant team analysis.

## 7.2 Central Air Conditioners

Central Air Conditioners had a realization rate of 101 percent and accounted for 34 percent of the HVAC energy savings and 32 percent of the entire HVAC Wx program energy savings. There were Time of Sale and Early Retirement CAC project types implemented in PY9. The project type determined which savings algorithm was used to calculate energy savings. The incorrect project type was applied to a small number of the projects which resulted in a higher overall realization rate.

<sup>4</sup> This quantity represents the values provided in the tracking data and are not grouped by unit as shown in Table 2-1.



**Table 7-2. Central Air Conditioners Measure Impact Detail**

| Measure | Project Type     | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|------------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CAC     | Time of Sale     | 9,581              | 2,433,356                   | 102%                                | 2,433,840                    |
| CAC     | Early Retirement | 5651               | 4,144,966                   | 100%                                | 4,216,160                    |
| CAC     | Total            | 15,320             | 6,578,322                   | 101%                                | 6,650,000                    |

Source: ComEd tracking data and Navigant team analysis.

### 7.3 Ductless Mini-Split Heat Pumps

Ductless Mini-Split (DMS) Heat Pumps (DMSHP) had a realization rate of 97 percent and accounted for 10 percent of the HVAC energy savings and nine percent of the entire HVAC Wx program energy savings. Two types of DMS Heat Pumps were installed for this measure, Air Source Heat Pump and Electric Resistance units. The Electric Resistance units had a higher realization rate of 98 percent compared to the Air Source Heat Pump units of 91 percent.

**Table 7-3. DMS Heat Pumps Measure Impact Detail**

| Measure | Project Type         | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|----------------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| DMS     | Electric Resistance  | 75                 | 1,706,059                   | 98%                                 | 1,671,440                    |
| DMS     | Air Source Heat Pump | 227                | 251,325                     | 91%                                 | 229,513                      |
| DMS     | Total                | 302                | 1,957,556                   | 97%                                 | 1,900,953                    |

Source: ComEd tracking data and Navigant team analysis.

### 7.4 ECM Furnace Motors

ECM Furnace motors had an overall realization rate of 100 percent and contributed to 48 percent of the HVAC savings and 46 percent of the entire HVAC Wx program’s energy savings.

**Table 7-4. Showerheads Measure Impact Detail**

| Measure | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| ECM     | Each       | 13,439             | 9,541,690                   | 100%                                | 9,541,690                    |

Source: ComEd tracking data and Navigant team analysis.

### 7.5 Geothermal Heat Pump

Geothermal heat pumps had a realization rate of 43 percent and accounted for one percent of HVAC energy savings and one percent of the entire HVAC Wx program energy savings. There were two home types for GHP projects, Retrofit and New Construction. The majority of the GHP projects (83 percent) were Retrofit jobs. Both Retrofit and New Construction projects had low realization rates of 46 percent

and 18 percent, respectively. These low realization rates are accounted for in Findings and Recommendations 6-8 in Section 5.2.

**Table 7-5. Geothermal Heat Pump Measure Impact Detail**

| Measure | Home Type        | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|------------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| GHP     | Retrofit         | 64                 | 525583.976                  | 46%                                 | 242810.457                   |
| GHP     | New Construction | 13                 | 60820.029                   | 18%                                 | 10996.8588                   |
| GHP     | Total            | 77                 | 586,404                     | 43%                                 | 253,807                      |

Source: ComEd tracking data and Navigant team analysis.

## 7.6 Heat Pump Water Heater

Heat Pump Water Heaters had a realization rate of 101 percent and accounted for 0.16 percent of HVAC energy savings and 0.15 percent of the entire HVAC Wx program energy savings.

**Table 7-6. Heat Pump Water Heater Measure Impact Detail**

| Measure | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|---------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| HPWH    | Each       | 16                 | 31,532                      | 101%                                | 31,784                       |

Source: ComEd tracking data and Navigant team analysis.

## 7.7 Smart Thermostats

Smart Thermostats had a realization rate of 99 percent and accounted for five percent of the HVAC energy savings and five percent of the entire HVAC Wx program energy savings. The main discrepancy found for Smart Thermostats was the use of incorrect coincidence factors (CF). Table 7-4 below shows the difference in peak demand savings between the use of PJM and SSP CF factors. The SSP CF was used in ex ante calculations, and thus resulted in a low verified gross peak realization rate when the PJM CF factor was applied.

**Table 7-7. Smart Thermostats Measure Impact Detail**

| Measure | Coincidence Factor (CF) | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) | Ex Ante Gross Peak Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Peak Demand Reduction (kWh) |
|---------|-------------------------|--------------------|-----------------------------|-------------------------------------|------------------------------|--|---------------------------------|--|
| ST      | 0.233 (PJM)             | 3,633              | 1,017,883                   | 99%                                 | 1,004,745                    | 414.292                                  | 64%                             | 264.473                                    |
| ST      | 0.34 (SSP)              | 3,633              | 1,017,883                   | 99%                                 | 1,004,745                    | 414.292                                  | 93%                             | 385.927                                    |

Source: ComEd tracking data and Navigant team analysis.

## 7.8 Air Sealing

Air Sealing had a realization rate of 129 percent. Air sealing projects implemented by CLEAResult and Franklin had separate realization rates of 100 percent and 153 percent, respectively. Air sealing projects

accounted for 65 percent of the Wx energy savings and four percent of the entire HVAC Wx program energy savings.

**Table 7-8. Air Sealing Measure Impact Detail**

| Implementer | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|-------------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CLEARresult | Δ CFM      | 1,250,780          | Varies                      | 100%                                | Varies                       |
| Franklin    | Δ CFM      | 2,143,224          | 0.164                       | 153%                                | Varies                       |

Source: ComEd tracking data and Navigant team analysis.

## 7.9 Attic Insulation

Attic Insulation had a realization rate of 69 percent. Attic Insulation projects implemented by CLEARresult and Franklin had separate realization rates of 100 percent and 27 percent, respectively. Air sealing projects accounted for 17 percent of the Wx energy savings and one percent of the entire HVAC Wx program energy savings.

**Table 7-9. Attic Insulation Measure Impact Detail**

| Implementer | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|-------------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CLEARresult | Area       | 1,330,643          | Varies                      | 100%                                | Varies                       |
| Franklin    | Area       | 135,626            | 1.00                        | 27%                                 | Varies                       |

Source: ComEd tracking data and Navigant team analysis.

## 7.10 Basement Insulation

Basement or Sidewall Insulation had a realization rate of 41 percent. Basement or Sidewall Insulation projects implemented by CLEARresult and Franklin both had realization rates of 41 percent and the energy savings accounted for 0.16 percent of the Wx energy savings and 0.01 percent of the entire HVAC Wx program energy savings.

**Table 7-10. Basement or Sidewall Insulation Measure Impact Detail**

| Implementer | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|-------------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CLEARresult | Area       | 15,773             | Varies                      | 41%                                 | Varies                       |
| Franklin    | Area       | 2,821              | 1.00                        | 41%                                 | Varies                       |

Source: ComEd tracking data and Navigant team analysis.

## 7.11 Duct Sealing

Duct Sealing had a realization rate of 98 percent. Duct Sealing projects implemented by CLEARresult and Franklin had separate realization rates of 81 percent and 100 percent, respectively. Duct Sealing

accounted for 17 percent of the Wx energy savings and one percent of the entire HVAC Wx program energy savings.

**Table 7-11. Duct Sealing Measure Impact Detail**

| Implementer | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|-------------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CLEARresult | Each       | 25                 | Varies                      | 81%                                 | Varies                       |
| Franklin    | Δ CFM      | 298,327            | 0.653                       | 100%                                | 0.653                        |

Source: ComEd tracking data and Navigant team analysis.

## 7.12 Wall Insulation

Wall insulation had a realization rate of 42 percent. Wall Insulation projects implemented by CLEARresult and Franklin had separate realization rates of 89 percent and 13 percent, respectively. The savings accounted for one percent of the Wx energy savings and 0.08 percent of the entire HVAC Wx program energy savings.

**Table 7-12. Wall Insulation Measure Impact Detail**

| Implementer | Unit Basis | Quantity Installed | Ex Ante Gross Savings (kWh) | Verified Gross kWh Realization Rate | Verified Gross Savings (kWh) |
|-------------|------------|--------------------|-----------------------------|-------------------------------------|------------------------------|
| CLEARresult | Area       | 69,096             | Varies                      | 89%                                 | Varies                       |
| Franklin    | Area       | 23,595             | 1.00                        | 13%                                 | Varies                       |

Source: ComEd tracking data and Navigant team analysis.

## 8. APPENDIX 3. TRC DETAIL

[We will add this section in the second draft.]