



# ComEd Fridge & Freezer Recycling Program Impact Evaluation Report

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

Presented to  
ComEd

**DRAFT**

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## 1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Fridge & Freezer Recycling (FFR) Program. It presents a summary of the energy and demand impacts for the total program and broken out by relevant measure and program structure details. Section 6 presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

## 2. PROGRAM DESCRIPTION

The FFR Program is designed to achieve energy savings through the retirement and recycling of older, inefficient refrigerators, freezers, and room air conditioners (ACs). The primary objectives of the program are to decrease the retention of high energy-use refrigerators and freezers and to deliver long-term energy savings. A secondary objective is to dispose of these older units in an environmentally safe manner. The program projected that 71,500 units would be collected and recycled in the PY9 19-month program year. The associated PY9 ex ante net savings target was 33,375 MWh

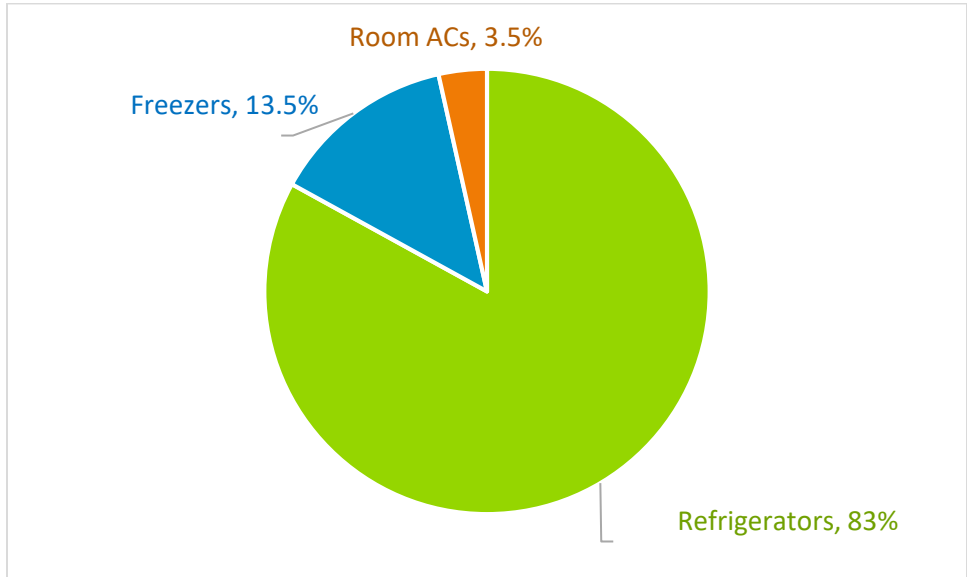
According to program tracking data, there were 71,031 participants in PY9 contributing a total of 81,633 recycled measures to the program. The PY9 volumes are higher than PY7 and PY8, due to the 19-month duration of PY9, and the program's five-month suspension during PY8. These values are shown in Table 2-1 and Figure 2-1 below.

**Table 2-1. PY9 Volumetric Findings Detail**

Participation	Program-Reported Number of Units	% of Total Units
<b>Number of Participants</b>	71,031	100%
<b>Units by Measure Type</b>		
Refrigerators	67,767	83.0%
Freezers	11,016	13.5%
Room ACs	2,850	3.5%
<b>Total Measures</b>	81,633	100.0%

Source: ComEd tracking data and Navigant team analysis.

Figure 2-1. Number of Measures Recycled by Type



Source: Evaluation Analysis

### 3. PROGRAM SAVINGS

Table 3-1 summarizes the energy and demand savings that the Fridge & Freezer Recycling Program achieved in PY9. Verified gross savings are approximately four percent higher than ex ante gross savings. Both ex ante and verified gross energy savings were computed using the equations specified in the TRM. However, a difference in the ex ante and verified refrigerator and freezer TRM savings calculation methods emerges due to an equation variable that indicates whether the appliance was located in a conditioned space. The verified gross savings calculations use the proportion of appliances located in conditioned space that are derived from the customer telephone surveys, whereas ex ante gross savings calculations are based on appliance locations in the program tracking database. The telephone survey findings use responses to a counterfactual question to the decision maker regarding where the unit would have been located if the program had not picked it up. While appliance locations in the program tracking database use the responses to a question posed by the truck driver at the time the unit is picked up (“How was this unit used during most of the past 12 months?”). The “no program” unit location based on the telephone survey’s counterfactual response by the decision maker is the appropriate value for the gross savings calculation. The TRM also stipulates the use of a part-use factor for refrigerator and freezer savings calculations. Both the ex ante and verified estimates used the PY7 Research Findings part-use factors.

Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (MWh)	Demand Savings (MW)	Peak Demand Savings (MW)
Ex Ante Gross Savings	63,752	8.681	8.681
Program Gross Realization Rate	1.04	1.04	1.036
Verified Gross Savings	66,334	8.994	8.994
Program Net-to-Gross Ratio (NTGR)	0.52	0.52	0.516
Verified Net Savings	34,336	4.638	4.638

Source: ComEd tracking data and Navigant team analysis.

## 4. PROGRAM SAVINGS BY MEASURE

The program includes three measure types as shown in Table 4-1, Table 4-2 and Table 4-3 below. The Refrigerator measure contributed the greatest portion of energy savings (88 percent). Freezers accounted for another 11 percent, while the Room A/C measure comprised one percent. This breakdown of savings is almost identical to the proportions in PY4, PY5, PY6, PY7 and PY8.

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

End Use Type	Research Category	Ex Ante Gross Energy Savings (MWh)	Verified Gross Realization Rate	Verified Gross Energy Savings (MWh)	NTGR *	Verified Net Energy Savings (MWh)	Technical Measure Life	Persistence	Effective Useful Life (EUL)†
Refrigerators	Refrigerators	56,010	104%	58,357	0.51	29,762	8	1.0	8
Freezers	Freezers	7,075	103%	7,311	0.58	4,240	8	1.0	8
Room A/C	Room A/C	667	100%	667	0.50	333	4	1.0	4
Total‡		63,752	104%	66,334	0.52	34,336	8	1	8

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

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

‡ Note that the numbers do not sum exactly due to rounding.

Source: ComEd tracking data and Navigant team analysis

**Table 4-2. PY9 Demand Savings by Measure**

End Use Type	Research Category	Ex Ante Gross Demand Reduction (MW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (MW)	NTGR*	Verified Net Demand Reduction (MW)
Refrigerators	Refrigerators	6.907	104%	7.196	0.51	3.670
Freezers	Freezers	0.830	103%	0.857	0.58	0.497
Room A/C Units	Room A/C Units	0.944	100%	0.941	0.50	0.470
Total†		8.681	104%	8.994	0.52	4.638

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

† Note that the numbers do not sum exactly due to rounding.

Source: ComEd tracking data and Navigant team analysis.

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

End Use Type	Research Category	Ex Ante Gross Peak Demand Reduction (MW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (MW)	NTGR*	Verified Net Peak Demand Reduction (MW)
Refrigerators	Refrigerators	6.907	104%	7.196	0.51	3.670
Freezers	Freezers	0.830	103%	0.857	0.58	0.497
Room A/C Units	Room A/C Units	0.944	100%	0.941	0.50	0.470
Total‡		8.681	104%	8.994	0.52	4.638

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

† Note that numbers do not sum exactly due to rounding.

Source: ComEd tracking data and Navigant team analysis.

## 5. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

### 5.1 Impact Parameter Estimates

The Navigant team used the procedures specified in the Illinois TRM version 5.0 to calculate the verified gross energy savings. These procedures use regression equations to calculate energy savings, which are shown in Section 6. (Appendix 1. Impact Analysis Methodology). Section 7 (Appendix 2. Impact Analysis

Detail) shows the input parameters used by the Navigant team to calculate verified energy and peak demand savings. Note that all the factors in the regression equations below are derived from pooled data from metering studies conducted by several Midwestern utilities, including one done by ComEd in PY4.

The following table details all the custom and deemed inputs used for calculating the energy and demand savings for each measure as well as their source.

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

Measure	Custom* Input Parameters	Deemed† Input Parameters	Deemed† Input Data Source
Refrigerators	Part-Use Factor	Regression coefficients and intercepts for Unit Energy Consumption calculations, CDD/HDD zonal values, Summer Peak Coincidence Factor	IL TRM v5.0 Section 5.1.8
Freezers	Part-Use Factor	Regression coefficients and intercepts for Unit Energy Consumption calculations, CDD/HDD zonal values, Summer Peak Coincidence Factor	IL TRM v5.0 Section 5.1.8
Room Air Conditioners	N/A	Full Load Hours (FLH), Btu/H, EERexist, Summer Peak Coincidence Factor	IL TRM v5.0 Section 5.1.9

\* Based on the PY7 participating customer survey data

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

Source: Evaluation team

## 5.2 Other Impact Findings and Recommendations

The impact evaluation research findings and recommendations for measures included in the FFR Program are listed below.

### 5.2.1 Program Savings Target Attainment

**Finding 1.** The evaluation-verified gross energy savings is 66,334 MWh, while evaluation-verified net savings were 34,336 MWh. Gross peak demand savings were 8.994 MW and net savings were 4.638 MW.

**Finding 2.** Based on this, the program met its 19-month PY9 net energy savings target of 33,375 MWh.

**Finding 3.** The evaluation-verified gross peak demand savings were 8.994 MW and net savings were 4.638 MW. There was no associated ex ante demand savings goal for the program.

### 5.2.2 Gross Realization Rates

**Finding 4.** Verified gross savings including the part-use factor, are approximately four percent higher than ex ante gross savings, which is the equivalent of a gross realization rate of 1.04. Gross realization rates (GRRs) by measure type showed a small amount of variation, with a refrigerator value of 1.04, a freezer value of 1.03 and a room air conditioner value of 1.00.

**Finding 5.** The Navigant team’s method to account for the proportion of appliances located in conditioned space uses responses to counterfactual questions of the decision maker. The implementation contractor’s method uses a response to a single question posed by the truck driver at the time of pickup. The Navigant team’s method using a “no program” unit location based on the survey’s counterfactual responses by the decision maker is the appropriate value for the gross savings calculation.

**Recommendation 1.** The Navigant team recommends that the implementer modify their question timing and wording so that the approaches used by the implementer and the evaluation team converge in the future. This convergence should help to close the gap further between the ex ante and verified savings values.

### 5.2.3 Program Participation

**Finding 6.** The PY9 FFR Program recycled a total of 81,644 units. Based on this, the program easily met its 19-month PY9 unit participation target of 71,500 units. Given this, program marketing and promotion efforts appear to be on track, and the \$50 incentive level is effective at achieving the desired level of participation.

**Recommendation 2.** Given the program’s relatively flat targets in CY2018-CY2021, the program should retain its current marketing and incentive approaches.

## 6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

The Navigant team calculated verified gross and net savings using the following regression specifications as defined by the IL TRM v5.0 in PY9.

### 6.1 Refrigerators

$$\Delta kWh = [83.32 + (Age * 3.68) + (Pre-1990 * 485.04) + (Size * 27.15) + (Side-by-side * 406.78) + (Proportion of Primary Appliances * 161.86) + (CDD/365.25 * unconditioned * 15.37) + (HDD/365.25 * unconditioned * -11.07)] * Part Use Factor$$

Where:

- Age = Age of retired unit
- Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)
- Size = Capacity (cubic feet) of retired unit
- Side-by-side = Side-by-side dummy (= 1 if side-by-side, else 0)
- Single-Door = Single-Door dummy (= 1 if Single-Door, else 0)
- Primary Usage = Primary Usage Type (in absence of the program) dummy (= 1 if Primary, else 0)
- Interaction: Located in Unconditioned Space x CDD/365.25 (=1 \* CDD/365.25 if in unconditioned space)
- CDD = Cooling Degree Days<sup>1</sup>
- Interaction: Located in Unconditioned Space x HDD/365.25 (=1 \* HDD/365.25 if in unconditioned space)
- HDD = Heating Degree Days<sup>2</sup>
- Part Use Factor = To account for those units that are not running throughout the entire year.

<sup>1</sup> Dependent on geographic location.

<sup>2</sup> Dependent on geographic location.



**Table 6-1. Energy Savings for Refrigerators**

Independent Variable	Coefficient	Source
Intercept	83.324	TRMv.5.0
Age (years)	3.678	TRMv.5.0
Pre-1990	485.037	TRMv.5.0
Size (Cubic Feet)	27.149	TRMv.5.0
Side-by-side	406.779	TRMv.5.0
Primary Unit	161.857	TRMv.5.0
Unconditioned Space X CDD	15.366	TRMv.5.0
Unconditioned Space X HDD	-11.067	TRMv.5.0
Part Use Factor	0.79	PY7 evaluation

## 6.2 Freezers

$$\Delta kWh = [132.12 + (Age * 12.13) + (Pre-1990 * 156.18) + (Size * 31.84) + (Chest * -19.71) + (CDDs * unconditioned * -12.76) + (HDDs * unconditioned * 9.78)] * Part Use Factor$$

Total kWh saved =  $\Delta kWh$  \* Number of Units \* Installation Rate

Where:

- Age = Age of retired unit
- Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)
- Size = Capacity (cubic feet) of retired unit
- Side-by-side = Side-by-side dummy (= 1 if side-by-side, else 0)
- Single-Door = Single-Door dummy (= 1 if Single-Door, else 0)
- Chest = Chest freezer dummy (=1 if chest freezer, else 0)
- Primary Usage = Primary Usage Type (in absence of the program) dummy (= 1 if Primary, else 0)
- Interaction: Located in Unconditioned Space x CDDs = Proportion of units in unconditioned spaces interacted with CDDs
- Interaction: Located in Unconditioned Space x HDDs = Proportion of units in unconditioned spaces interacted with HDDs
- Part Use Factor = To account for those units that are not running throughout the entire year.

After energy savings based on full load hours have been computed, a part-use factor is then applied. This factor is based on the value from the most recent part-use factor participant survey results available at the start of the PY9 program year, in this case, the PY7 evaluation.

**Table 6-2. Energy Savings for Freezers**

Independent Variable	Coefficient	Source
Intercept	132.12	TRM v. 5.0
Age (years)	12.13	TRM v. 5.0
Pre-1990	156.18	TRM v. 5.0
Size (cubic feet)	31.84	TRM v. 5.0
Chest	-19.71	TRM v. 5.0
Unconditioned Space X CDD	-12.76	TRM v. 5.0
Unconditioned Space X HDD	9.78	TRM v. 5.0
Part-use factor	0.79	PY7 evaluation

### 6.3 Refrigerator and Freezer Summer Coincident Peak Demand Savings

$$\Delta kW = kWh/8760 * CF$$

Where:

- kWh = Savings provided in algorithm above
- CF = Coincident factor defined as summer kW/average kW
  - = 1.081 for Refrigerators
  - = 1.028 for Freezers

### 6.4 Room Air Conditioner Energy Savings

Room AC gross energy savings are estimated using the algorithm specified in IL TRM version 5.0 and shown below.

$$\Delta kWh = ((FLH_{RoomAC} * BtuH * (1/EER_{exist}))/1000)$$

Where:

- FLH<sub>RoomAC</sub> = Full Load Hours of room air conditioning unit
- = dependent on location, see below

Climate Zone (City based upon)	FLH <sub>RoomAC</sub>
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average	248

- BtuH = unit capacity [BTU/h] is a nameplate value
- = Size of retired unit
- = Actual. If unknown assume 8500 Btu/hr

- EER<sub>exist</sub> = unit efficiency [EER] of the recycled unit
- = Efficiency of existing unit
- = 7.7

## 6.5 Room Air Conditioner Summer Coincident Peak Demand Savings

Room AC gross summer coincident peak demand (kW) savings is estimated using the algorithm specified in TRM version 5.0 and shown below.

$$\Delta kW = (\text{BtuH} * 1/\text{EER}_{\text{exist}})/1000 * \text{CF}$$

Where:

$$\text{CF} = \text{Summer Peak Coincidence Factor for measure} = 0.3$$

The lifetime energy and demand savings are estimating by multiplying the verified savings by the effective useful life for each measure.

The EM&V team conducted research in previous evaluations to validate the parameters that were not specified in the TRM (such as the Net-to-Gross ratio). The results are shown in the following table.

For the PY9 evaluation, the program tracking database and the TRM version 5.0 provide all the inputs needed to calculate verified gross savings. The source of the part-use factor is the PY7 evaluation.

## 6.6 Verified Gross Program Savings Analysis Approach

Savings estimates were developed for the full population of units collected in PY9 to estimate PY9 Unit Energy Consumption (UECs). The ex post savings estimates of energy (kWh) savings rely on regression equations as specified in the TRM version 5.0. Gross energy savings are expressed in terms of full-year UECs. UEC estimates were made using a regression-based approach that models full-year energy savings as a function of unit characteristics (i.e., age, size, configuration, defrost mode, and unit location prior to being recycled).

Gross peak demand (kW) savings were also calculated according to the algorithm specified in the TRM version 5.0. The coincidence factors in the TRM version 5.0 were calculated using the regression equations to predict consumption on summer peak days.

Both energy (kWh) and peak demand (kW) savings estimates were made based on the characteristics of the population of units collected by the program during PY9. In addition, gross energy savings estimates were adjusted for part-use, by applying part-use factors from the PY7 evaluation.

## 6.7 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 PY9, the NTGR estimates used to calculate the net verified savings were based on past evaluation research and approved through the Illinois Stakeholder Advisory Group consensus process.<sup>3</sup>

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<sup>3</sup> A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_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>

## 6.8 Survey Questions Used to Determine Part-Use Factor

The survey question structure used by the evaluation team to determine the part-use factor for a refrigerator or a freezer is designed to determine what the participant would have done with the unit if the program hadn't picked it up. The structure of the questions asked is as follows:

- At the time this MEASURE was picked up, were you using it as your main MEASURE, or had it been a secondary or spare?
- How long had you been using this MEASURE as a secondary or spare?
- Thinking just about the past year, was the spare MEASURE plugged in and running all the time, for special occasions only, during certain months of the year only, or was it never plugged in and running?
- If you add up the total time your spare MEASURE was plugged in and running during the last 12 months that you had it, about how many total months would that be?
- Was the MEASURE running during the summer or was it mainly running during other times of the year?
- Where would the MEASURE have been located if it had not been removed by ComEd? If the MEASURE was your primary unit, we're interested in whether you would have left it in the kitchen or moved it to another room.

In contrast, the program implementer relies on a single question, which is presented by the truck driver at the time the unit is picked up:

- "How was this unit used during most of the past 12 months?"

## 7. APPENDIX 2. IMPACT ANALYSIS DETAIL

Table 7-1 summarizes the program savings by measure. The verified net-to-gross ratio (NTGR) is based on deemed values including the Program Induced Replacement (PIR) component. The deemed values for PIR, which are pertinent to refrigerators and freezers only, are based on research conducted in the PY7 evaluation and were calculated using a procedure that is consistent with that specified in the Illinois Technical Reference Manual (TRM), version 5.0. Note that there are separate SAG-approved NTG values for refrigerators and freezers, delineated by whether the unit is assigned a Retailer NTGR or a Non-Retailer NTGR. The NTG ratios in the table below, which have been used to determine Verified Net savings, are a weighted average of the Retailer and Non-Retailer NTG ratio values for each appliance type. These NTG ratios, before the PIR is applied, are 0.54 for refrigerators (based on a weighted average of Retailer NTGR of 0.22 and Non-Retailer NTGR of 0.62), 0.60 for freezers (based on a weighted average of Retailer NTGR of 0.25 and Non-Retailer NTGR of 0.63) and 0.50 for room ACs. After adjusting for the PIR values, the total program NTG ratio is 0.52.

**Table 7-1: PY9 Total Annual Incremental Savings, Detailed Calculation**

Savings Category	Refrigerators	Freezers	Room A/Cs
Ex-Ante Gross Savings (MWh)	56,010	7,075	667
Ex-Ante Gross Peak Demand Reduction (MW)	6.907	0.830	0.944
Deemed Part-Use Factor	0.95	0.74	1.00
Verified Gross Savings (MWh)	58,357	7,311	667
Verified Gross Peak Demand Reduction (MW)	7.196	0.857	0.941
Verified Gross Realization Rate	104%	103%	100%
Deemed Net to Gross Ratio (NTGR) *	0.54	0.60	0.50
Program Induced Replacement (PIR) *	-2.90%	-1.30%	N/A
Final Net to Gross Ratio (NTGR and PIR) *	0.51	0.58	0.50
Verified Net Savings (MWh)	29,762	4,240	333
Verified Net Demand Reduction (MW)	3.6702	0.4972	0.4703

\* A deemed value. Source: ComEd\_NTG\_History\_and\_PY9\_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>  
 Source: ComEd tracking data and Navigant team analysis.

## 8. APPENDIX 3. TRC DETAIL

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