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ComEd Public Sector Public Housing Authority Efficient Living Program Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Plan Year 9 (PY) Bridge Period (June 2, 2017 to December 31, 2017)

Presented to Commonwealth Edison Company

FINAL

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1. Introduction

This report presents the impact evaluation results of ComEd's Public Housing Authority (PHA) Efficient Living Program for the PY9 bridge period, June 2, 2017 through December 31, 2017. It summarizes overall program energy and demand impacts, verified savings calculation methodologies, program findings, and program recommendations.

2. Program Description

The PHA Program provides incentives to PHAs throughout the ComEd service territory to perform energy efficiency upgrades. The program includes HVAC, lighting, building envelope, plug load, and custom measures.

3. Program Savings

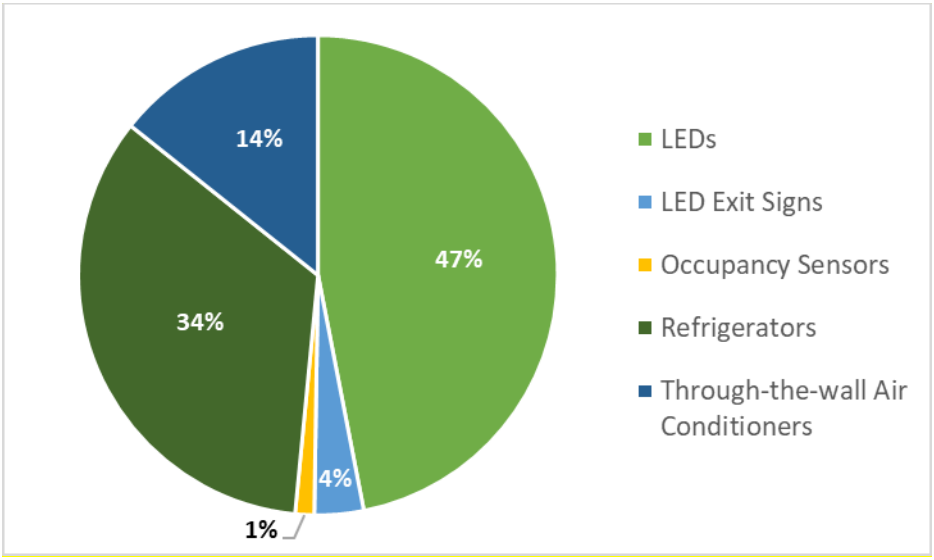
The PY9 bridge participants and measures are shown in the following tables and graphs. Note that since the program tracking database does not provide measure quantity by measure type, we present measure quantities for 14 of the 18 Bridge period projects for which we had additional project documentation. The Evaluation Team is unable to provide this level of granularity for all PHA projects.

Table 3-1. PY9 Volumetric Findings Detail

Participation	Quantity
Participants*	16
Installed Projects†	18
Installed Projects in Sample	14
Total Measures	2,414
Interior LEDs‡	653
Exterior LEDs‡	111
Linear LEDs‡	369
LED Exit Signs‡	80
Occupancy Sensors‡	31
Through-the-wall Air Conditioner‡	345
Refrigerator‡	825

* Participants are defined as the total number of unique Customer Names
† Unique projects are defined as the total number of unique Project IDs
‡ Total number of measures installed for the 14 sampled projects
Source: ComEd tracking data and Navigant team analysis.

Figure 3-1. Percent of Measures Installed by Type



Source: Evaluation Analysis for 14 projects included in sample

Table 3-2 summarizes the energy and demand savings the PHA program achieved in the PY9 bridge period.

Table 3-2. PY9 Total Annual Incremental Savings

	Energy Savings (kWh)	Demand Savings (kW)
Ex Ante Gross Savings	454,887	115.20
Program Gross Realization Rate	96%	67%
Verified Gross Savings	435,059	77.46
Program Net-to-Gross Ratio (NTGR)	100%	100%
Verified Net Savings	435,059	77.46

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

Table 4-1 summarizes the ex ante and verified gross electric savings by measure for the 14 desk review projects, and the total program savings after extrapolating to the population. Section 6 (Appendix 1) outlines the savings methodology for deriving verified savings and Section 7 (Appendix 2) summarizes the differences between ex ante and verified savings calculations.

Table 4-1. PY9 Bridge Energy Savings by Measure

Research Category	Measure	Ex Ante Gross Savings (kWh)	Verified Gross Savings (kWh)	Realization Rate	
Interior LEDs	LED - 10W A19 Dimmable	937	729	78%	91%
	LED - 5.5W Pin-Based	5,010	4,709	94%	
Exterior LEDs	LED - Wall Pack	11,373	16,444	145%	180%
	LED - Pole Lighting	17,819	31,964	179%	
	LED - Canopy	2,116	4,525	214%	
	LED - Bollard	2,010	6,031	300%	
	LED - Spotlight	569	1,973	347%	
Linear LEDs	LED - Linear (2')	1,264	1,117	88%	110%
	LED - Linear (4')	27,281	31,014	114%	
	LED - Linear (1x2)	206	210	102%	
	LED - Linear (1x4)	11,446	11,680	102%	
LED Exit Signs	LED - Exit Sign	6,312	4,558	72%	72%
Occupancy Sensors	Occupancy Sensors	1,236	1,757	142%	142%
Through-the-wall Air Conditioner	Through-the-wall Air Conditioner	14,538	7,818	54%	54%
Refrigerator	Refrigerator	345,360	303,442	88%	88%
Desk Review Total (n=14)*		**447,475**	**427,971**	**96%**	**96%**
Program Total (n=18)†		**454,887**	**435,059**	**96%**	**96%**

*Total ex ante and verified savings for the 14 projects (and all measures) where project documentation was received. The Evaluation Team compared ex ante and verified savings for the 14 projects to arrive at a 96% realization rate.
†Total ex ante savings for all 18 PHA projects from the ComEd tracking database. Total program verified savings was determined by multiplying the total ex ante savings (454,887 kWh) by the realization rate (96%).
Source: ComEd tracking data and Navigant team analysis

Table 4-2 summarizes the ex ante and verified gross demand reduction by measure for the 14 desk review projects, and the total program savings after extrapolating to the population.

Table 4-2. PY9 Bridge Demand Savings by Measure

Research Category	Measure	Ex Ante Gross Demand Reduction (kW)	Verified Gross Demand Reduction (kW)	Realization Rate	
Interior LEDs	LED - 10W A19 Dimmable	0.09	0.07	73%	92%
	LED - 5.5W Pin-Based	0.47	0.45	96%	
Exterior LEDs	LED - Wall Pack	-	-	N/A	N/A
	LED - Pole Lighting	-	-	N/A	
	LED - Canopy	-	-	N/A	
	LED - Bollard	-	-	N/A	
	LED - Spotlight	-	-	N/A	
Linear LEDs	LED - Linear (2')	0.02	0.13	839%	3982%
	LED - Linear (4')	0.05	3.74	7588%	
	LED - Linear (1x2)	0.01	0.03	170%	
	LED - Linear (1x4)	0.05	1.41	2653%	
LED Exit Signs	LED - Exit Sign	0.72	0.34	48%	48%
Occupancy Sensors	Occupancy Sensors	0.55	0.68	123%	123%
Through-the-wall Air Conditioner	Through-the-wall Air Conditioner	40.44	11.00	27%	27%
Refrigerator	Refrigerator	52.16	45.74	88%	88%
Desk Review Total (n=14)*		**94.58**	**63.59**	**67%**	**67%**
Program Total (n=18)†		**115.20**	**77.46**	**67%**	**67%**

* Total ex ante and verified savings for the 14 projects (and all measures) where project documentation was received. The Evaluation Team compared ex ante and verified savings for the 14 projects to arrive at a 67% realization rate.
† Total ex ante savings for all 18 PHA projects from the ComEd tracking database. Total program verified savings was determined by multiplying the total ex ante savings (115.20 kW) by the realization rate (67%).
Source: ComEd tracking data and Navigant team analysis

Refer to Section 7 (Appendix 2) for a more detailed discussion identifying discrepancies between ex ante and verified savings calculations.

5. Program Impact Analysis Findings and Recommendations

This section shows the impact analysis findings and recommendations.

Finding 1. The program tracking database did not contain measure level detail (e.g., measure quantity, measure name) needed to fully evaluate the impacts. As a solution, the Evaluation Team requested project documentation for all (n=18) completed PHA projects to collect as much information as possible to calculate verified savings. The Evaluation Team received project documentation for 14 projects.

Recommendation 1. Carefully record and track all project and measure level details including, but not limited to, measure name, measure quantity, baseline conditions, efficient conditions, heating fuel, whether cooling is present, and any other requested information per the data request.

Finding 2. The program-tracking database did not indicate the existing equipment condition for HVAC measures, nor did it identify the project type (e.g., time-of-sale or early retirement).

Recommendation 2. Collect existing equipment characteristics (e.g., manufactured year, age, size, type, make/model, etc.) to ensure savings estimates are most accurately represented for each project type. In the event this information is unknown, the Evaluation Team conservatively defaults to time-of-sale (TOS) calculations.

Finding 3. The Evaluation Team requested project documentation for all (n=18) completed PHA projects but only received project documentation for 14 projects.

Recommendation 3. Establish a system that allows for ease of accessibility to all project records and documentation.

Finding 4. Some measure calculations relied on IL-TRM default values instead of the actual installed and existing measure characteristics.

Recommendation 4. Prioritize actual installed measure specifications and/or existing equipment conditions (when known) when calculating measure savings. In the event this information is unknown, we then recommend relying on assumptions provided in the IL-TRM.

Finding 5. The program generated post-inspection reports that summarize findings from verification site visits. Measure quantities, savings, and incentive amounts are adjusted based on these findings. However, IL-TRM in-service rates (ISRs) are applied on top of these adjustments when calculating ex ante savings.

Recommendation 5. Calculate savings for the verified measure quantities per post-inspection results and exclude the application of IL-TRM ISRs for all projects receiving post inspections.

Finding 6. The Evaluation Team discovered calculation errors and the misapplication of variable assumptions for multiple measures.

Recommendation 6. Review and QC all calculations prior to reporting final savings values. Simplify calculation workbooks for ease of identifying calculation errors.

Finding 7. The program-tracking database did not indicate the existing equipment condition for HVAC measures, nor did it identify the project type (e.g., TOS, early retirement).

Recommendation 7. Collect existing equipment characteristics (e.g., manufactured year, age, size, type, make/model, etc.) to ensure savings estimates are most accurately represented for each project type. In the event this information is unknown, the Evaluation Team conservatively defaults to TOS calculations.

6. Appendix 1. Impact Analysis Methodology

This section summarizes the evaluation steps to establish verified gross and net savings for the PHA Program:

Step 1: Reviewed data in the program tracking database. Reviewed contents of the program tracking database and found that energy and demand savings were reported in aggregate (i.e., total savings for multiple measures) at the participant level. The database did not include measure level detail (e.g., measure name, quantity, etc.) needed to calculate verified savings.

Step 2: Requested project documentation for all program participants. Requested project documentation for all PHA participants to inform project and measure level detail. The evaluation Team received complete project documentation for 14 of the 18 requested projects.[1]

Step 3: Conducted desk review of all projects received. Reviewed project documentation for the 14 projects including post-inspection reports, final payment approval applications, and savings calculation

[1] The implementer provided all available documentation and materials.

workbooks to gather as much information as possible for each installed measure. We also verified the total project savings and incentive amounts reported in the tracking database are consistent with those found in the final payment approval applications. Table 6-1 shows that the total ex ante savings from the program database is consistent with the savings reported in project documentation for the 14 projects.

Table 6-1. PY9 Bridge Ex Ante Savings Summary

	Program Tracking Database		Project Documentation	
	kWh	kW	kWh	kW
Ex Ante Gross Savings (n=14)	447,475	94.58	447,475	94.58

Step 4: Calculated verified gross savings. Calculated verified savings for the 14 projects by applying algorithms from the IL-TRM V6.0 and information collected from actual installed measure specifications (manufacturer specifications included in the payment approval application). Table 6-2 summarizes the total verified savings for the 14 projects.

Table 6-2. PY9 Bridge Verified Savings Summary

	kWh	kW
Verified Gross Savings (n=14)	427,971	63.59

Step 5: Calculated realization rates. Established realization rates by dividing the total verified gross savings by the total ex ante gross savings for the 14 projects. The realization rates presented in Table 6-3 were generated to extrapolate to the population to determine overall program verified gross savings (see Step 6).

Table 6-3. PY9 Bridge Realization Rates

	Ex Ante		Verified		Realization Rate	
	kWh	kW	kWh	kW	kWh	kW
Gross Savings (n=14)	447,475	94.58	427,971	63.59	96%	67%

Step 6: Extrapolated to the population. Applied the realization rates (Step 5) to the total ex ante energy and peak demand savings provided in the program tracking database for all 18 PHA projects to arrive at the total program verified gross savings (Table 6-4).

Table 6-4. PY9 Bridge Total Program Gross Savings

	Ex Ante		Realization Rate		Verified	
	kWh	kW	kWh	kW	kWh	kW
Gross Savings (n=18)	454,887	115.20	96%	67%	435,059	77.46

Step 7: Calculated verified net savings. Calculated verified net savings by applying the deemed net-to-gross ratio of 100%, resulting in net savings equal to verified gross savings.

7. Appendix 2. Impact Analysis Detail

The evaluation team carefully reviewed the differences between ex ante and verified savings calculations and variable assumptions for all program measures across the 14 projects where documentation was received. Table 7-1 identifies the reasons for discrepancies between ex ante and verified gross savings. We provide more detail following the table.

Table 7-1. Reasons for Differences in Realization Rates per Measure

Research Category	Measure	Gross Realization Rate		Reason for Discrepancy					
		kWh	kW	Hours of Use	In-Service Rate	Coincidence Factor	Baseline Wattage	Efficient Wattage	Other
Interior LEDs	LED - 10W A19 Dimmable	78%	73%	✓	✓	✓	✓		
	LED - 5.5W Pin-Based	94%	96%	✓	✓	✓			
Exterior LEDs	LED - Wall Pack	145%	N/A	✓			✓		
	LED - Pole Lighting	179%	N/A	✓			✓		
	LED - Canopy	214%	N/A	✓			✓		
	LED - Bollard	300%	N/A	✓					
	LED - Spotlight	347%	N/A	✓			✓		
Linear LEDs	LED - Linear (2')	88%	839%					✓	Per lamp demand savings represented as total savings
	LED - Linear (4')	114%	7588%					✓	
	LED - Linear (1x2)	102%	170%		✓				
	LED - Linear (1x4)	102%	2653%		✓				
LED Exit Signs	LED - Exit Sign	72%	48%			✓		✓	
Occupancy Sensors	Occupancy Sensors	142%	123%			✓			- Did not apply WHFe - Wattage controlled
Through-the-wall AC	Through-the-wall Air Conditioner	54%	27%						- Project Type - Conversion Error
Refrigerator	Refrigerator	88%	88%						- Missing savings calculations

We identified the sources of the differences between ex ante and verified savings for the measures provided in Table 7-1. Note that while certain inputs may increase savings, others decrease savings. The combination of all inputs brings about the overall realization rate for a specific measure. We describe the differences in the ex ante and verified savings calculations in detail below.

Interior LED Discrepancies:

Hours of Use: The implementer switched the hours of use (HOU) from the IL-TRM for the 10W A19 Dimmable LEDs and the 5.5W Pin-Based LEDs (

- Table 7-2).

Table 7-2. Interior Lighting Hours of Use

		Hours of Use		
Research Category	Measure	Ex Ante	IL-TRM	Ex Post
Interior LEDs	LED - 10W A19 Dimmable	850	759	759
	LED - 5.5W Pin-Based	759	850	850

- **In-Service Rates:** The implementer applied IL-TRM In-Service Rates (ISRs) even though post-inspection reports verify the actual number of installed measures. The evaluation team used the measure quantity included in the post-inspection reports

- **Coincidence Factor:** The implementer switched the coincidence factors (CF) from the IL-TRM for the 10W A19 Dimmable LEDs and the 5.5W Pin-Based LEDs (Table 7-3).

Table 7-3. Interior Lighting Coincidence Factors

		Coincidence Factors		
Research Category	Measure	Ex Ante	IL-TRM	Ex Post
Interior LEDs	LED - 10W A19 Dimmable	0.071	0.078	0.078
	LED - 5.5W Pin-Based	0.078	0.071	0.071

- **Baseline Wattage:** The implementer applied a baseline wattage of 60W for the 10W A19 Dimmable LEDs, whereas the evaluation team applied the halogen equivalent wattage of 43W. Since standard screw-base dimmable LEDs are not EISA exempt, the evaluation team felt it was appropriate to use the EISA halogen equivalent wattage for these measures.

Exterior LED Discrepancies:

- **Hours of Use:** The implementer applied 1,634 HOU for all exterior lighting measures (source unknown), where the evaluation team applied the HOUs from the IL-TRM.

- **Baseline Wattage:** The implementer applied baseline wattages that do not include ballast factors. The evaluation team applied baseline fixture wattages (i.e. including ballast factor) from the IL-TRM based on the actual lumen output per manufacturer specifications.

Linear LED Discrepancies:

- **In-Service Rates:** The implementer applied IL-TRM In-Service Rates (ISRs) even though post-inspection reports verify the actual number of installed measures. The evaluation team used the measure quantity included in the post-inspection reports.

- **Efficient Wattage:** The implementer applied efficient wattages per the IL-TRM where the evaluation team applied the actual wattage of the installed measure per manufacturer specifications.

- **Total Demand Savings:** The implementer mistakenly forgot to multiply the deemed demand savings for all linear LEDs by the measure quantity when calculating the total demand savings.

LED Exit Sign Discrepancies:

- **Coincidence Factor:** The implementer applied a coincidence factor of 1.0 for all LED exit signs, where the evaluation team applied the CF of 0.66 from the IL-TRM for the building type specified in the project documentation (Uncooled Buildings).

- **Efficient Wattage:** The implementer applied efficient wattages per the IL-TRM where the evaluation team applied the actual wattage of the installed LED exit signs per manufacturer specifications.

Occupancy Sensor Discrepancies:

- **Coincidence Factor:** The CF for occupancy sensors within the IL-TRM are represented as the difference between the baseline coincidence factor ($CF_{baseline}$) and the occupancy sensor coincidence factor (CF_{os}). The implementer mistakenly applied the demand waste heat factor value (WHFd) in place of the $CF_{baseline}$ variable.

- **Waste Heat Factors:** The implementer excluded energy waste heat factors (WHFe) while calculating energy savings. The evaluation team applied the IL-TRM WHFe of 1.14.

Through-the-wall Air Conditioner Discrepancies:

- **Project Type:** Ex ante energy savings assume 66% of projects are time-of-sale (TOS) and 33% of projects are early retirement (ER) based on weights derived from effective useful life (EUL) and remaining useful life (RUL) from the IL-TRM. Additionally, ex ante demand savings assume 100% of projects are ER. Since the actual project type is unknown, verified savings conservatively default to TOS calculations.

- **CEER[2] to EER Conversion***:* Ex ante calculations mistakenly applied the conversion factor used to convert EER to CEER, however, the efficiency factor provided in the manufacturer specifications were already given in units of CEER.

Refrigerator Discrepancies:

- **Missing Savings Calculations***:* Received project documentation did not include the ex ante savings calculations and assumptions. Therefore, the evaluation team was unable to assess the reasons for savings discrepancies. We plan to investigate these differences in the next

[2] Combined Energy Efficiency Ratio (CEER): CEER is defined as the ratio of measured cooling output (in BTU per hour) to measured average electrical energy input (in Watts) and measured standby/off-mode power consumption (in Watts). https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Draft%20Version%203%201%20Room%20Air%20Conditioner%20Specification.pdf

evaluation cycle since refrigerator savings account for the majority (77%) of program energy savings.

8. Appendix 3. Total Resource Cost Detail

The Total Resource Cost (TRC) variable table only includes cost-effectiveness analysis inputs available at the time of finalizing the PY9 bridge impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided at a later date. Further, detail in this table (e.g., Effective Useful Life (EUL)) other than final PY9 bridge savings and program data are subject to change and are not final.

The PHA Program tracking database reports energy and demand savings in aggregate (i.e., total savings across multiple measures) and does not include measure level detail (e.g., measure name, quantity, etc.). As a result, the evaluation team is limited to summarizing details at the research category level for the 14 sampled projects only. Table 8-1 summarizes the total resource cost savings for the 14 of the 18 PHA Program projects.

Table 8-1. Total Resource Cost Savings Summary[1]

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Gross Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Lighting	Interior LEDs	Lamps	653	10	5,948	0.56	5,439	0.52
Lighting	Exterior LEDs	Fixtures	111	13	33,886	-	60,936	-
Lighting	Linear LEDs	Varies	369	8	40,197	0.13	44,020	5.31
Lighting	LED Exit Signs	Each	80	16	6,312	0.72	4,558	0.34
Lighting	Occupancy Sensors	Each	31	8	1,236	0.55	1,757	0.68
HVAC	Through-the-wall Air Conditioner	Each	345	12	14,538	40.44	7,818	11.00
Appliances	Refrigerator	Each	825	12	345,360	52.16	303,442	45.74

[1] Includes details for the 14 sampled PHA projects. Unable to provide this level of detail for all 18 PHA projects based on the information provided in the program tracking database.
Source: ComEd tracking data and Navigant team analysis