



ComEd Standard Program Impact Evaluation Report

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

Presented to
Commonwealth Edison Company

DRAFT

March 9, 2018

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1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Standard 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. The Section 6 (Appendix 1) presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

The Standard Program offers prescriptive financial incentives and a streamlined application to facilitate the implementation of cost-effective energy efficiency improvements for non-residential (commercial and industrial) customers and market segments, with a program network of trade allies and service providers. Eligible measures include energy-efficient indoor and outdoor lighting, HVAC equipment, refrigeration, Energy Management Systems (EMS), commercial kitchen equipment, variable speed drives (VSDs), compressed air equipment and other qualifying products. The program implementation contractor transitioned from DNV-GL to ICF International, Inc, starting June 1, 2017. ICF continues to collaborate with DNV-GL for the program day-to-day operations.

ComEd made some key changes in the Standard Program in PY9. Notable program changes made from PY8 to PY9 include:

- Addition of LED screw-based HID replacements, and additional new measure incentives for new compressed air systems, industrial systems, and new refrigeration measures.
- Decrease of incentives for the LED and T8/T5 reduced watts measures, fluorescent lighting retrofits, induction fixtures, and occupancy and vacancy sensors.
- Removal of metal halide measures, bi-level stairwell, hallway or garage fixtures, sensor-controlled wall pack fixtures, and parking garage bi-level fixtures.
- Established the Energy Management Assistance Offer to provide extra incentive rates for completing one or more projects in six month increments up to two years (incentives starting from 26% with 2% decrement).
- Established the Comprehensive Energy Savings Offer to provide extra incentive rates from 20% with 5% increments, for a completion of comprehensive packages; Tier 1 (three project options) up to Tier 3 (five project options) of eligible selected improvements.
- Established the Office Space Offering, which provides financial incentives to property managers or owners to reduce their tenants' electricity use by improving the efficiency of their equipment in building areas primarily used as office. Qualified PY9 measures and customers were eligible for the incentives, starting June 1 through December 31, 2017.
- Established the Made in Illinois Bonus offer, which provides financial incentives to promote installation of new energy-efficient products that are manufactured or assembled in Illinois. Qualified PY9 measures and customers were eligible for the bonus, starting June 1 through December 31, 2017.
- Beginning June 1, 2017, customers that had a peak demand of or over 10 MW for 30 minutes in ComEd's territory were exempted from participating in the ComEd Energy Efficiency Program. This made a list of Standard customers ineligible part way through PY9, and then a new list being ineligible for the next program year.

The program had 4,677 participants in PY9 and implemented 4,839 projects, involving installation of 7,671 measures as shown in the following table and graph. Lighting projects comprised of 81 percent of

the measure mix and 83 percent of the participants in PY9. Non-lighting projects comprised of 19 percent of the measure mix and 17 percent of the participants in PY9.

Table 2-1. PY9 Volumetric Findings Detail

Participation	Lighting End Use	Non-Lighting End Use	Total
Participants*	4,013	810	4,677
Total Measures†	6,237	1,434	7,671
Installed Projects	4,160	679	4,839

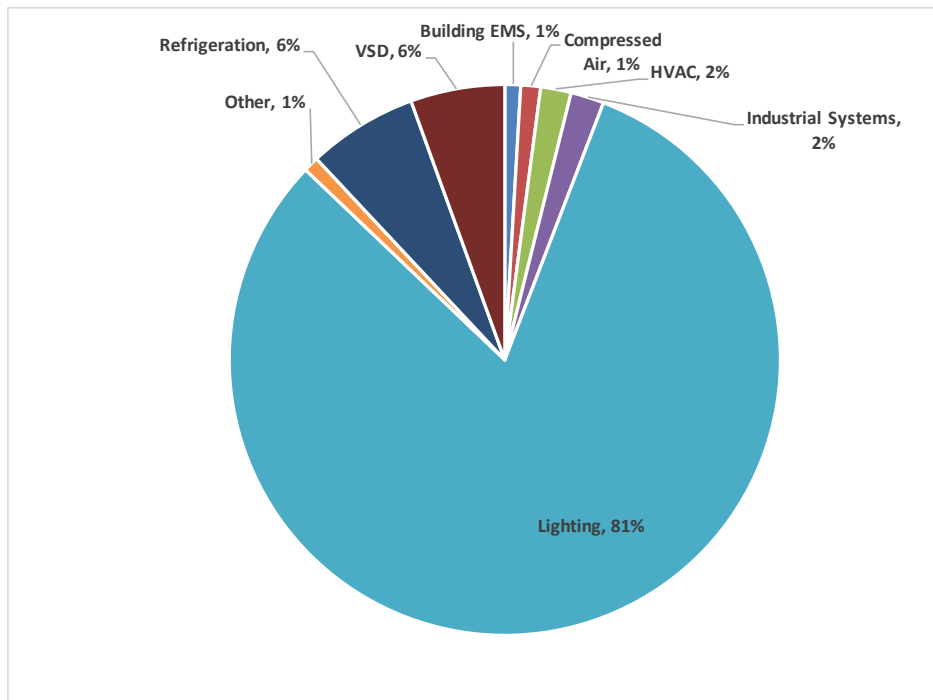
* Based on project name and site address. The 4,677 excludes 146 participants who installed both lighting and non-lighting measures.

† This is a project-level measure count based on type of measure, not quantities installed.

Source: ComEd tracking data and Navigant team analysis.

Figure 2-1 shows the approximate distribution of measures installed in the PY9 Standard Program.

Figure 2-1. Number of Measures Installed by End Use



Source: Evaluation Analysis

3. PROGRAM SAVINGS

Table 3-1 summarizes the incremental energy and demand savings the ComEd Standard Program achieved in PY9.

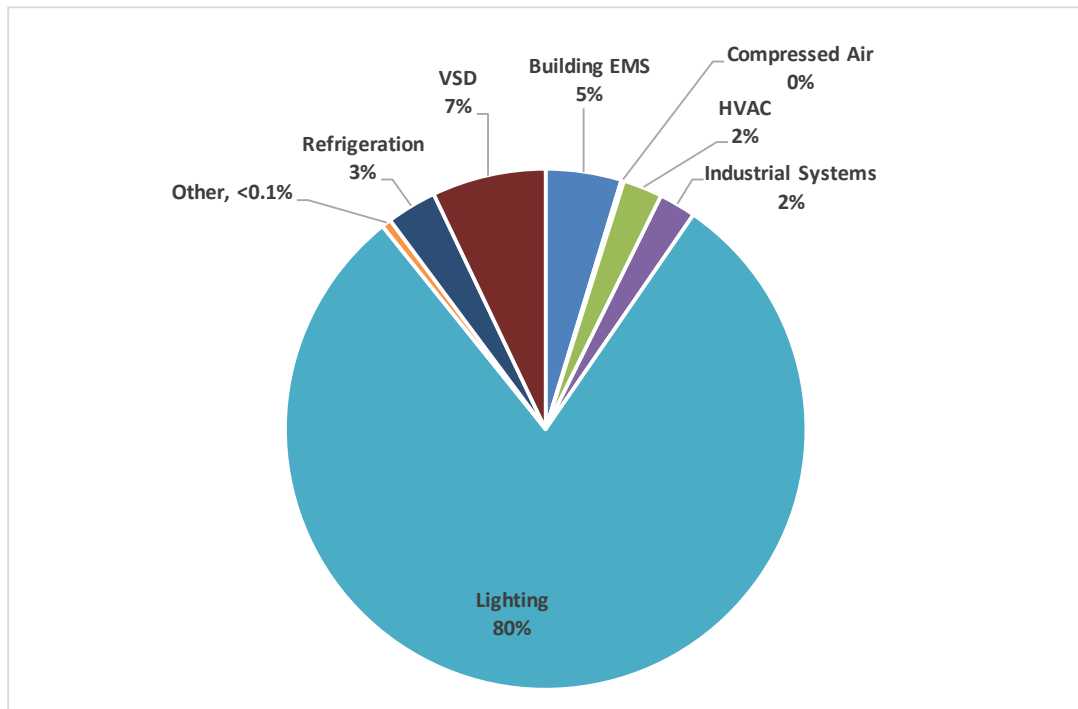
Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (MWh)	Demand Savings (MW)	Peak Demand Savings (MW)
Ex Ante Gross Savings	400,169	NA	55.676
Program Gross Realization Rate	95%	NA	79%
Verified Gross Savings	380,931	84.539	43.858
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies
Verified Net Savings	265,887	58.950	30.636

Source: ComEd tracking data and Navigant team analysis.

Figure 2-2 shows the distribution of verified net energy savings by end use.

Figure 3-1. Program Net Energy Savings by End Use



Source: Evaluation Analysis

4. PROGRAM SAVINGS BY MEASURE

The following tables show program electric and demand savings by measure end use based on the monitoring and verification (M&V) sample grouping of lighting and non-lighting end uses. The lighting measures contributed the most savings, with 80 percent of the verified gross and net MWh savings. The non-lighting measures contributed 20 percent, of which seven percent were realized from VSDs, five percent from EMS measures, and the remaining eight percent from other end uses.

Table 4-1. PY9 Energy Savings by Measure

End Use Type	Research Category	Ex Ante Gross Savings (MWh)	Verified Gross Realization Rate*	Verified Gross Savings (MWh)	NTGR†	Verified Net Savings (MWh)	Effective Useful Life (EUL)‡
Lighting	Lighting	290,050	105%	304,485	0.70	213,139	8 - 16
Non-Lighting	Building EMS	110,119	69%	76,446	0.69	52,748	5 - 20
	Compressed Air						
	HVAC						
	Industrial Systems						
	Other Refrigeration VSD						
Total		400,169	95%	380,931	NA	265,887	NA

* Based on evaluation research.

† 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.

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)
Lighting	Lighting	NA	NA	61.802	0.70	43.261
Non-Lighting	Building EMS	NA	NA	22.737	0.69	15.689
	Compressed Air					
	HVAC					
	Industrial Systems					
	Other Refrigeration VSD					
Total		NA	NA	84.539	NA	58.950

*The implementation contractor did not report demand reduction in the tracking data.

† 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>.

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 Peak Net Demand Reduction (MW)
Lighting	Lighting	36.493	102%	37.365	0.70	26.156
Non-Lighting	Building EMS					
	Compressed Air					
	HVAC					
	Industrial Systems	19.183	34%	6.493	0.69	4.480
	Other Refrigeration					
	VSD					
	Total	55.676	79%	43.858	NA	30.636

* Based on evaluation research findings.

† 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>.

Source: ComEd tracking data and Navigant team analysis.

5. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

5.1 Impact Parameter Estimates

Verified gross and net savings (energy and coincident peak demand) resulting from the PY9 Standard Program were calculated using algorithms as defined by the Illinois TRM version v5.0 or ComEd PY9 Workpapers.¹ Table 5-1 presents the key parameters and the references used in the verified gross and net savings calculations, and indicate which were examined through PY9 evaluation research and which were deemed.

¹ ComEd Standard Program Year 9 Measures Workpapers, Version 2.0, Effective June1, 2016.

Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Data Source	Deemed* or Evaluated?
Installed Quantities	Program tracking data analysis; PY9 evaluation on-site M&V	Evaluated
Deemed Lighting Measure Savings Parameters: Hours of Use (HOU), Peak Load Coincidence Factor, Energy and Demand Interactive Effects	Illinois TRM v5.0	Deemed
Lighting Measure Delta Watts (where deemed by the Illinois TRM)	Illinois TRM v5.0	Deemed
Lighting Measure Delta Watts not deemed by the Illinois TRM	Program documentation and PY9 M&V	Evaluated
Deemed HVAC, Food Service/Other, and Refrigeration Measures, principally: Electric Chillers, PTAC/PTHP, HVAC VSDs, Air Compressor with Integrated VSD, EC Motors, Anti-Sweat Heater Controls	Illinois TRM v5.0	Deemed
Non-deemed Non-Lighting Measures, principally: Industrial VSD, EMS Control Systems, Refrigeration Display Case/Doors; Refrigerated Cycling Dryers, Demand Control Ventilation, Laboratory measures	Program documentation and PY9 M&V	Evaluated
Gross Realization Rates	PY9 evaluation M&V and Program tracking data analysis	Evaluated
Lighting and Non-Lighting NTG Ratios	Illinois Stakeholder Advisory Group process	Deemed†

* State of Illinois Technical Reference Manual version 2.0 from <http://www.ilsag.info/technical-reference-manual.html>.

† Source: ComEd_NTG_History_and_PY8_Recommendation_2014-02-28_Final_EMV_Recommendations.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>

5.2 Other Impact Findings and Recommendations

Verified Gross Impacts and Realization Rate

Finding 1. The Standard Program evaluation sampled lighting and non-lighting projects separately. The lighting end uses achieved an energy savings realization rate of 105 percent. This is primarily a result of several large advanced lighting control projects having increases in verified energy savings based on the trend data from the lighting management system.

Recommendation 1. Navigant recommends that the analysis files used to quantify the Advanced Lighting Control (M&V) ex ante savings be included in the project documentation. Additional information regarding the lighting control system such as baseline information should be captured by the program. In some projects, the baseline wattage in the trend data is the

inefficient fixture wattage (pre-installation) while in others it appears to be the new LED fixture wattage.

Finding 2. The non-lighting end use achieved an overall energy savings realization rate of 69 percent. This result is due to adjustments of verified savings of building energy management systems (EMS) and variable speed drives (VSDs) projects. The details of these reductions are covered in subsequent findings.

Finding 3. The non-lighting end use achieved an overall demand savings realization rate of 34 percent. This result is primarily due to adjustments in demand savings for chiller replacements and variable speed drives (VSDs) projects. The details of these reductions are covered in Findings 6 and 7.

Finding 4. The sampled EMS projects received an energy savings realization rate of 57 percent with project-level realization rates ranging from 0% to 444% (see Table 7-2 for details). The verified savings estimates are based on billing analyses using daily billing or 30-minute interval data, depending on the project. The reasons for the adjustments to verified energy savings estimates has been outlined and discussed in the monthly meetings with the program implementation contractor and ComEd and in a separate memo².

Recommendation 2. Historically, the EMS projects have a realization rate below 100 percent since EMS became a prescriptive measure in PY5. The evaluation team recommends making changes to the EMS deemed savings approach to move the average realization rate for EMS closer to 100 percent. This could include:

- Reducing the deemed savings percentage for the EMS measure.
- Disaggregating the deemed savings percentages by influencing factors such as building type, building size, HVAC system and implemented control strategies.
- Gathering more information on the baseline conditions which factor heavily into the performance of this measure.
- Consider establishing a savings threshold above which projects are processed as custom projects.

Finding 5. The sampled HVAC VSD projects achieved an energy savings realization rate of 49 percent, with project-level realization rates ranging from 0 to 122 percent (see Table 7-3 for details). The verified energy savings adjustments were commonly based on the following:

- VSDs were found to be operating at a fixed speed.
- VSDs were found to not be modulating based on feedback controls.
- VSDs were installed in process applications instead of on HVAC pump or fan motors.
- Resulting from on-site verification, the baseline control types for some projects were determined to be different from those listed in the tracking data.
- Updating the assumed hours of operation to actual hours, based on site verifications or application information.

Recommendation 3. Navigant recommends updating the program post-inspection protocols to include verification of feedback controls and their operation.

Finding 6. The PY9 ComEd workpapers for VSD pumps do not include the 65 percent load factor used to calculate the brake horsepower (BHP) of the pump. This error results in demand realization rate of 65 percent. This finding is present in many of the VSD pump measures, significantly impacting the demand savings realization rate of the non-lighting sample.

Recommendation 4. Navigant recommends updating the ComEd workpapers to include the load factor.

Finding 7. The deemed savings for HVAC chillers have three issues that require updating. First, the PY9 ComEd workpapers use a baseline of IECC 2012 code, while the IL TRM v5.0

² ComEd Standard - Evaluation Response to Concerns on M&V Approach_2018-01-16.docx

requires IECC 2015 as the baseline. For this reason, the sampled chiller measures achieved an energy realization rate less than 100 percent. Secondly, the workpapers appear to use heating equivalent full-load hours (EFLHs) instead of cooling EFLHs. Thirdly, the ex ante demand savings are calculated with integrated part-load value (IPLV) efficiency instead of full-load efficiency, as specified in the IL TRM v5.0.

Recommendation 5. Navigant recommends updating the chiller savings estimates used by the program to reflect the applicable IL TRM algorithms.

Finding 8. Two sampled projects that involve VSDs installed evaporator and condenser fans in refrigerated warehouses - those installed VSDs applications do not meet program requirements for HVAC VSDs and result in no claimed savings. Refrigerated warehouses are highly energy-intensive facilities and the VSD projects should result in significantly more energy savings than in typical HVAC applications.

Recommendation 6. Navigant recommends creating a separate measure for this application or processing this as a custom project under the Custom Program.

Finding 9. The “VSD on Industrial Process Fan or Pump \leq 200 HP” savings methodology within the ComEd PY9 workpapers³ is not suitable to apply to industrial process motors. The workpapers’ measure description states that “application on compressed air, process motors and data centers are not applicable.” The words “industrial” or “process” are not mentioned (other than to exclude it) in the workpaper, only “motors that do not fall into any of the mapped categories” which Navigant interprets to act as a catch-all to account for miscellaneous HVAC fan or pump motors.

Recommendation 7. The evaluation team recommends that this measure be processed as a custom measure due to the wide variety of applications and additional considerations that are required of industrial process projects. If this is to be a prescriptive measure, the workpaper should be rewritten to better represent the VSDs in industrial applications.

Finding 10. The Closed Refrigerated Case Lighting workpapers use an interactive factor 1.22 for both freezers and coolers, while the IL TRM v5.0 uses 1.29 for coolers and 1.50 for freezers.⁴

Recommendation 8. The evaluation team recommends that this workpaper be updated to reflect the interactive factors in the lighting input table in the IL TRM v5.0.

Finding 11. The Open Refrigerated Case Lighting workpapers use an interactive factor 1.15 for both freezers and coolers, while the IL TRM v5.0 uses 1.29 for coolers and 1.50 for freezers.⁴

Recommendation 9. The evaluation team recommends that this workpaper be updated to reflect the interactive factors in the lighting input table in the IL TRM v5.0.

Finding 12. The Refrigerated Air Dryers in the IL TRM v5.0 contain an error in the algorithm. The TRM uses the CFM value at 50 percent of the rated dryer capacity, but the 50 percent load assumption is also accounted for in the energy consumption ratios (EC50). Correcting this increases the verified energy savings.

Recommendation 10. The evaluation team recommends correcting this TRM error in the ComEd workpapers. The evaluation team will bring this error to the attention of the TRM Technical Advisory Committee (TAC).

Finding 13. Project 35626 contained a VSD air compressor that was an oil-free unit. Oil-free compressors do not require the blowdown cycle that oil-cooled compressors utilize to prevent the aeration of the oil. Oil-free compressors can cycle on and off as needed and have efficient and responsive load or no-load controls. Oil-free compressors do not utilize inlet modulation controls and should have more efficient baseline control assumptions.

³ ComEd Standard Program Year 9 Measures Workpapers, Version 2.0, Effective June 1, 2016.

⁴ Illinois Statewide Technical Reference Manual v5.0, p. 340-341.

Recommendation 11. The evaluation team recommends that projects involving oil-free compressors be processed as a custom or a separate measure.

Tracking System Review

Finding 14. Eight projects involved installing multiple VSD air compressors. Since multiple VSD air compressors installed on the same compressed air system are not likely to achieve the deemed energy savings, this scenario is not incented. The incentive worksheet criteria state that “Air compressors purchased or installed for backup or redundant systems do not qualify.”

Recommendation 12. Navigant recommends that additional program verification be conducted to ensure that the VSD air compressors are installed on separate systems when applications involve multiple air compressors.

Participation

Finding 15. The program had 4,677 participants in PY9 and incented 7,671 measures through implementation of 4,839 projects. Of the 4,839 projects, lighting projects comprised 81 percent of the measure mix and 83 percent of the participants in PY9. Non-lighting projects comprised 19 percent of the measure mix and 17 percent of the participants in PY9. The program made strides to implement 11 comprehensive projects under the Energy Management Assistance Offer and the Comprehensive Energy Savings Offer, but no project was realized under the Office Space Offering or the Made in Illinois Bonus offering in PY9.

Recommendation 13. Navigant recognizes ComEd is implementing changes to the additional program offering and incentives for other existing program measures. Navigant conducted process survey with customers who participated in the comprehensive offering. We will provide our findings from the process survey in a separate memo to improve these offerings.

Finding 16. The program exceeded its adjusted gross planning energy target of 391 GWh due to the 7 additional months of program extension. The reported gross energy savings was 400 GWh (102 percent), although this got adjusted to 97 percent after evaluation adjustment of gross savings).

6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

6.1 Verified Gross Program Savings Analysis Approach

The evaluation estimates of gross savings and stratified measure level realization rates are presented in this section of the report. The savings verification process sought to verify eligibility, quantity, and compliance with claimed deemed per unit savings values defined in the Illinois TRM (v5.0). This process verified that the TRM was applied correctly and consistently by the program, that the measure level inputs to the algorithm were correct, and that the quantity of measures claimed through the program are correct, in place and operational. Gross impact evaluation of non-deemed measures involved retrospective evaluation adjustments to gross savings on custom variables. For measures with custom variables, ComEd provided work paper documentation of savings, but verified savings were based on engineering review, billing or interval data review, and on-site M&V (including metering) of sampled measures to determine eligibility and savings.

Other evaluation activities to verify gross energy savings and produce a research realization rate estimate for the Standard Program involved the following steps:

1. Implemented a stratified random sampling design of lighting and non-lighting measures to select 125 projects (consisting of 60 lighting and 65 non-lighting projects) from the population of 4,389 Standard project applications and 4,382 Standard measures. Sampling was done in three waves

with three sub-strata based on kWh size. Sample sizes were designed to provide a 90/10 confidence and precision level for program-level savings separately for lighting and non-lighting gross savings verification. Table 6-1 summarizes the sample selection for the M&V activities. Additional details of the sampling approach and disposition are provided in Table 6-2 and Table 6-3.

2. Conducted on-site visits and measurement and verification (M&V) activities on a sample of 37 Standard projects (16 lighting and 21 non-lighting) selected from the 125 projects to support deemed and non-deemed measure savings verification and measure-level research. On-site measurement and verification included participant interviews, baseline assessment, installed equipment verification, and performance measurement. Measurement may include spot measurements, run-time hour data logging, review of participant energy management system trend data, and post-installation interval metering. Our approach to selecting M&V strategies follows the International Performance Measurement and Verification Protocol (IPMVP); Option A or Option B are typically selected.
3. Performed an engineering review of project files and energy savings estimates on the remaining 88 projects (44 lighting and 44 non-lighting) to support deemed and non-deemed measure savings verification and program-level research.
4. Conducted a quality control review of the research findings impact estimates and the associated draft site reports and implement any necessary revisions.
5. Produced an estimate of verified gross savings (kWh and kW) using the TRM or research for savings verification.
6. Produced a gross realization rate for the stratified sample and extrapolated to the program population using a ratio estimation method to yield ex post evaluation-adjusted gross energy savings. Gross realization rates were developed for energy and demand savings.

6.1.1 Sampling Design for Savings Verification

The sample draw for PY9 gross impact evaluation was designed to provide a 90/10 level confidence and relative precision for gross impact realization rate results for lighting measures, non-lighting measures, and the overall program. Strata were defined by project size (separately for lighting and non-lighting projects) based on ex ante gross energy savings boundaries that placed about one-third of program-level savings into each stratum (large, medium, and small).

Sampling was done in three waves. The first wave of sampling projects was conducted on 74 projects with a status of paid in a May 30, 2017 database extract when the program had completed about half of the PY9 participation target. The second wave of 45 sample projects was drawn from October 25, 2017 tracking system extract of projects paid after the May 30, 2017 extract. The final third wave of six projects was drawn from the final PY9 tracking data.

Table 6-1 below provides the sample selection by end use category and stratification. Overall the sample represented 17 percent (67,963 MWh) of the population ex ante savings of 400,169 MWh. A total of 60 lighting projects were selected, including 42 projects in wave 1 and 18 projects in wave 2. Sixty-five (65) non-lighting end use projects were selected including 32 projects in wave 1, 27 projects in wave 2, and six projects in wave 3.

Table 6-1. Profile of the PY9 Population and Gross Savings Verification Sample by End Use Strata

Population Group	Sampling Strata	Population			Sample		
		Number of Projects (N)	Ex Ante Claimed Gross Savings, MWh	kWh Weights	Number of Projects (n)	Ex Ante MWh % of Population	Sampled MWh
Lighting	1	103	90,404	0.312	20	20,826	23%
	2	374	97,730	0.337	20	4,280	4%
	3	3683	101,916	0.351	20	1,363	1%
Lighting Subtotal		4,160	290,050	1.000	60	26,469	9%
Non-Lighting	1	27	45,233	0.410	20	31,365	69%
	2	88	31,660	0.288	23	8,006	25%
	3	564	33,226	0.302	22	2,123	6%
Non-Lighting Subtotal		679	110,119	1.000	65	41,494	38%
Program Total		4,839	400,169	1.000	125	67,963	17%

Source: ComEd tracking data and Navigant team analysis.

Table 6-2 below provides a comparison of the population profile to the sample, analyzed by measure technology types for sampled projects that align with end uses. The project count of the sample provides an indication of the end use distribution of sampled projects due to the ex ante MWh weighting approach of sampled projects to develop the population mean for the realization rate.

Table 6-2. Profile of the PY9 Population and Gross Savings Verification Sample by End Use Type

Population Group	Number of Project (N)	Ex Ante Claimed Gross Savings, MWh	MWh Weights	Number of Project (n)	Ex Ante MWh	Sample MWh Weights	Sampled MWh % of Population
Lighting	4,160	290,050	72%	60	26,469	39%	9%
Building.EMS	61	24,460	6%	12	11,263	17%	46%
HVAC.VSD	123	38,254	10%	17	18,042	27%	47%
HVAC	92	14,650	4%	13	7,255	11%	50%
Industrial.Systems	133	12,671	3%	10	1,135	2%	9%
Other	39	3,233	1%	3	417	1%	13%
Refrigeration	213	16,265	4%	10	3,381	5%	21%
Compressed.Air	16	496	0%	0	0	0%	0%
ROOFTOP	2	89	0%	0	0	0%	0%
TOTAL	4,839	400,169	100%	125	67,963	100%	17%

Source: Utility tracking data and Navigant analysis.

Navigant compared the sample building type distribution to the program population to check if the sample reasonably represents the population distribution. Navigant used an iterative approach to draw a sample until we could capture a reasonable representation of building type distribution after wave 3. This approach did not support 90/10 gross impact realization rate results at the business type level, but nonetheless provided useful information for the most prominent building types. Details are shown in Table 6-3.

Table 6-3. Profile of the PY9 Population and Gross Savings Sample by Business Type

Population Group	Gross MWh, Population	Population MWh Weights	Project Count, Sample	Number of Project (n)	Gross MWh, Sample	Sample MWh Weights
College	3,186	1%	1	1%	239	0%
Heavy Industry	27,526	7%	11	9%	5,309	8%
Warehouse	54,632	14%	14	11%	7,808	11%
Retail - Strip Mall	101,034	25%	20	16%	9,767	14%
Healthcare Clinic	9,543	2%	6	5%	4,224	6%
Office - Mid Rise	63,209	16%	23	18%	25,057	37%
Hotel/Motel - Common	12,808	3%	6	5%	4,678	7%
Convenience Store	15,938	4%	11	9%	2,319	3%
Restaurant	5,030	1%	3	2%	234	0%
Light Industry	35,018	9%	15	12%	4,625	7%
Elementary School	2,315	1%	2	2%	416	1%
Miscellaneous	69,930	17%	13	10%	3,287	5%
Total	400,169	100%	125	100%	67,963	100%

Source: Utility tracking data and Navigant analysis.

6.1.2 Engineering Review of Project Files

For each selected project, the M&V team performed an in-depth application review to assess the engineering methods, parameters and assumptions used to generate all ex-ante impact estimates. For each measure in the sampled project, engineers estimated ex post gross savings based on their review of documentation and engineering analysis.

To support this review, ComEd provided project documentation in electronic format for each sampled project. Documentation included some or all scanned files of hardcopy application forms and supporting documentation from the applicant (invoices, measure specification sheets, and vendor proposals), pre-inspection reports and photos (when required), post inspection reports and photos (when conducted), calculation spreadsheets, a project summary report, and important email and memoranda.

6.1.3 On-Site Data Collection

The Monitoring and Verification (M&V) team completed on-site surveys for a subset of 37 of the 125 customer applications sampled, including 16 lighting and 21 non-lighting projects. For most projects, on-site sources include interviews that are completed at the time of the on-site, visual inspection of the systems and equipment, EMS data downloads, spot measurements, and short-term monitoring (e.g., less than four weeks).

The M&V team developed an analysis plan for each project selected for on-site data collection. Each plan explains the general gross impact approach used (including monitoring plans), provides an analysis of the current inputs (based on the application and other available sources at that time), and identifies sources that will be used to verify data or obtain newly identified inputs for the ex post gross impact approach.

The engineer assigned to each project first calls to set up an appointment with the customer. During the on-site audit, the engineer collects data identified in the analysis plan, including monitoring records (such as instantaneous spot watt measurements for relevant equipment, measured temperatures, data from equipment logs and EMS/SCADA system downloads), equipment nameplate data, system operation

sequences and operating schedules, and a careful description of site conditions that might contribute to baseline selection.

6.1.4 Site-Specific Impact Estimates

After all the field data is collected, including any monitoring data, the M&V team develops annual energy and demand impacts based on the on-site data, monitoring data, application information, and, in some cases, billing or interval data. Each program engineering analysis is based on calibrated engineering models that make use of hard copy application review and on-site gathered information surrounding the equipment installed through the program (and the operation of those systems).

Energy and demand savings calculations are accomplished using methods that include short-term monitoring-based assessments, simulation modeling (e.g., DOE-2), bin models, application of ASHRAE methods and algorithms, analysis of pre- and post-installation billing and interval data, and other specialized algorithms and models.

For this study, summer peak hours are defined as non-holiday weekdays between 1:00 P.M. and 5:00 P.M. Central Prevailing Time (CPT) from June 1 to August 31. Winter peak hours are defined as non-holiday weekdays between 6:00 A.M. and 8:00 A.M. CPT, and between 5:00 P.M. and 7:00 P.M. CPT, from January 1 to February 28. This is in accordance with the PJM manual 18, *PJM Capacity Market*, effective October 16, 2015.⁵

Peak demand savings for both baseline and post retrofit conditions are the average demand kW savings for the 1:00 P.M. to 5:00 P.M. CPT weekday time period for summer, and 6:00 A.M. to 8:00 A.M. CPT and 5:00 P.M. to 7:00 P.M. CPT weekday time period for winter.⁶ If this energy savings measure is determined to have weather dependency, then the summer peak kW savings are based on the zonal weighted temperature humidity index (WTHI) standard, and the winter peak kW savings are based on the zonal wind speed-adjusted temperature (WWP) standards posted by PJM (there is also PJM Zonal Winter Weather Standards similar to summer WTHI). The zonal WTHI and WWP are the mean of the zonal WTHI values or WWP values on the days in which PJM peak load occurred in the past sixteen years (1998-2014). This mean ComEd WTHI value is 81.6 kW? demand savings for summer and is the difference in kW between the baseline and post retrofit conditions. Similarly, the ComEd WWP value is 14.5 kW? demand savings for winter and is the difference in kW between the baseline and post retrofit conditions.

After completion of the engineering analysis, the M&V team prepares a site-specific draft impact evaluation report that summarizes the M&V plan, the data collected at the site, and all the calculations and parameters used to estimate savings. Each draft site report underwent engineering review and comment, providing feedback to each assigned engineer for revisions or other improvements. Each assigned engineer then revised the draft reports as necessary to produce the final site reports.

The results of the on-site M&V and engineering file reviews determined the measure-level verified gross savings for the sampled projects.

6.1.5 Research Findings Realization Rates for the PY9 Standard Program

The M&V team used a stratified ratio estimation technique to estimate evaluation research findings gross energy savings for the Standard Program. The research findings use all available data collected through M&V to make a gross savings estimate, without being constrained by algorithms or assumptions defined in the Illinois TRM. The stratified ratio estimation technique follows the steps outlined in the California

⁵ Manual 18b, page 65-67: (<https://www.pjm.com/~media/documents/manuals/m18.ashx>)

⁶ The Winter Weather Standard is the dry bulb temperature adjusted (by 0.5 °F) for wind speed above 10 mph. The measurements were for Hour Ending 19:00 on RTO peak days.”

Evaluation Framework⁷. These steps are matched to the stratified random sampling method that was used to create the sample for the program savings verification effort. A standard error was used to estimate the error bound around the estimate of evaluation research findings gross energy savings realization rate. The research findings gross realization rates and relative precision at 90 percent confidence interval for lighting and non-lighting end uses are summarized in Table 6-4 below.

Table 6-4. Research Gross kWh Realization Rates and Relative Precision at 90% Confidence Level

Population Group	Sampling Strata	Mean kWh RR	Relative Precision at 90% Level of Confidence ± %, kWh	Mean KW RR	Relative Precision at 90% Level of Confidence ± %, KW
Lighting	1	1.05	7%	1.00	3%
	2	1.07	8%	1.10	14%
	3	1.04	10%	0.98	12%
<i>Lighting Overall</i>		1.05	4%	1.02	7%
Non-Lighting	1	0.49	22%	0.24	23%
	2	0.71	20%	0.30	25%
	3	0.96	12%	0.42	57%
<i>Non-Lighting Overall</i>		0.69	9%	0.34	39%
PY9 Program Overall		0.95	6%	0.79	8%

Source: Utility tracking data and Navigant analysis.

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.⁸ The deemed NTGR for lighting end use is 0.70, and 0.69 for non-lighting end use.

7. APPENDIX 2. IMPACT ANALYSIS DETAIL

The resulting total program verified gross savings is 380,931 MWh and 43.858 MW as shown in the following table. The table presents savings at the measure group level including groups where the estimate is not statistically significant at the 90/10 level. The verified net savings are 265,887 MWh and 30.636 MW.

⁷ TecMarket Works, et al., *The California Evaluation Framework*, Chapter 13, Sampling. June 2004

⁸ 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.htm>

Table 7-1. PY9 Verified Gross and Net Impact Savings Estimates by Program Channel

Program Group	Sample Size	Gross Energy Savings (MWh)	90/10 Significance	Gross Peak Demand Savings (MW)	90/10 Significance
Lighting Measures					
Ex-Ante Gross Savings		290,050		36.494	
Verified Gross Realization Rate	60	105%*	Yes	102%*	Yes
Verified Gross Savings		304,485		37.365	
NTGR†		0.7		0.7	
Verified Net Savings		213,139		26.156	
Non-Lighting Measures					
Ex-Ante Gross Savings		110,119		19.183	
Verified Gross Realization Rate	65	69%*	Yes	34%*	No
Verified Gross Savings		76,446		6.493	
NTGR†		0.69		0.69	
Verified Net Savings		52,748		4.48	
PY9 Program Total					
Ex-Ante Gross Savings		400,169		55.676	
Verified Gross Realization Rate	125	95%*	Yes	79%*	Yes
Verified Gross Savings		380,931		43.858	
NTGR†		Varies		Varies	
Verified Net Savings		265,887		30.636	

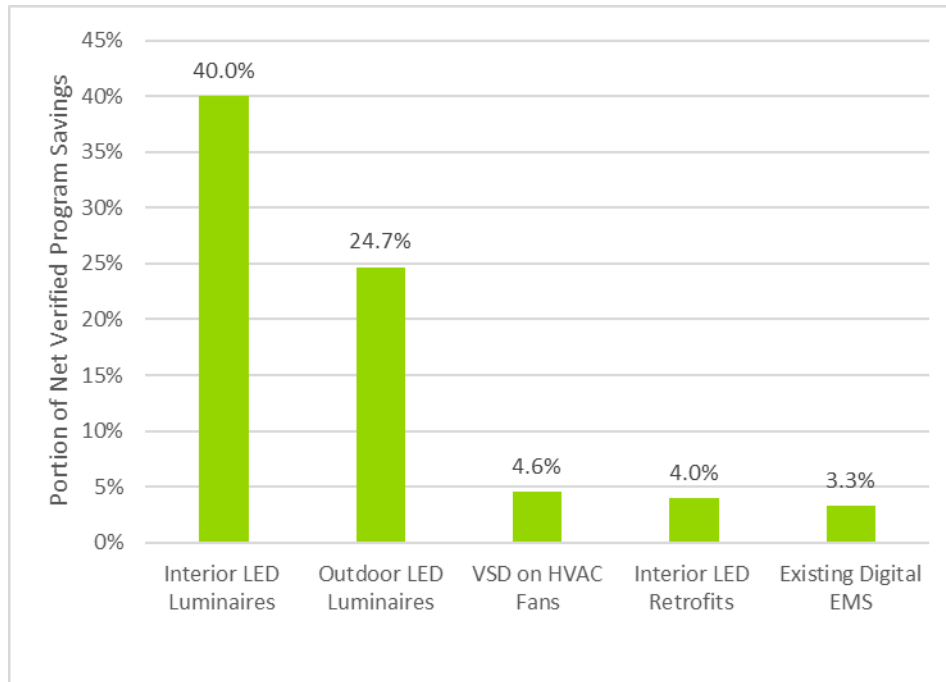
* Based on evaluation research findings.

† 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>.

Source: Evaluation Team analysis.

Table 7-2 illustrates the contribution to the net MWh savings by the top five measures in the program. LED lighting measures contributed approximately 69 percent of the total net savings (overall lighting contributed 80 percent). Variable speed drives (VSDs) on HVAC fans was second with approximately five percent of the net savings (overall VSDs contributed 7 percent), and followed by existing digital EMS.

Table 7-2. Top 5 Measures by Net Verified Energy Savings



Source: Evaluation Team analysis.

Table 7-3 below presents the verified gross energy savings realization rate, the percent of sample energy savings, and any notes or recommendations Navigant had to address discrepancies by measure. Navigant has also assigned a priority (high, medium or low) based on evaluation risk and percent of program savings. Note that these percentages were weighted to calculate the overall program level gross realization rates presented in the body of the report.

Table 7-3. Summary of Evaluation Findings by End Use Results

End Use Type	% of Sample Savings	kWh Realization Rate	Comments	Recommendation	Priority
Building EMS	17.49%	50%	Building EMS projects were typically adjusted based on billing analysis results. Projects whose billing analysis resulted in negative savings, were considered to have a verified savings of zero (projects #32868, #35081, and #32714 had their verified savings set to zero).	<p>Consider reducing the deemed savings percentage.</p> <p>Consider revising the savings methodology to account for influencing factors such as building size (ft²), HVAC type and implemented control strategies.</p> <p>Consider updating EMS approach to gather additional information on the pre-installation condition, which is influential to the RR estimate.</p>	High

End Use Type	% of Sample Savings	kWh Realization Rate	Comments	Recommendation	Priority
Compressed Air	0.04%	135%	The sampled compressed air measures consisted of refrigerated dryers and no-loss condensate drains. The IL TRM v5.0 contains an algorithm error that underestimates the savings.	The refrigerated compressed air dryer workpaper should be updated to correct the error found in the IL TRM.	High
HVAC	9.70%	48%	The sampled HVAC measures were primarily chiller projects, which received significant adjustments. 1. The baseline was updated to IECC 2015. 2. The demand savings algorithm was updated to use full-load efficiency values. 3. The EFLH have been updated to reflect the IL TRM v5.0 values for cooling. 4. The installed efficiency values were updated to reflect project documentation. Project #33017 had the verified savings set to zero.	The HVAC chiller workpaper requires updating to address points 1-3. The installed efficiency value should use the information provided by manufacturer.	High
Industrial Systems	1.63%	94%	The sampled industrial systems measures were all VSD air compressors, with one injection molding machine. The VSD air compressors were typically updated with actual operating hours. The hybrid injection molding machine did not meet program requirements and resulted in no verified savings. Projects #33622 and #35745 had the verified savings set to zero	The program review process should be updated to better screen projects based on product criteria.	Medium
Lighting	38.92%	105%	Several advanced lighting control projects resulted in increased verified savings. This is due to updating with lighting control system trend data and changing hours and interactive factors to reflect actual building type. Project 35832 had a significant change in installed wattage	The advanced lighting control project documentation should include the M&V savings calculation based on trend data.	Medium

End Use Type	% of Sample Savings	kWh Realization Rate	Comments	Recommendation	Priority
			which resulted in an additional 200,000 kWh. The update was based on using correct fixture spec sheets.		
Other	0.63%	69%	The guest room energy management (GREM) system measure is tracked per controller but the energy savings is calculated per ton controlled.	The GREM measure should include tonnage information in the tracking data.	Low
Refrigeration	4.98%	78%	The realization rate is significantly impacted by Project #33323, which involved a large quantity of new refrigerated cases not qualifying due to the project being new construction. The PY9 ComEd workpapers indicate that the savings are for existing cases only.	The New Cooler and Freezer Display Cases with Doors workpaper should be updated to reflect new construction applications.	Low
VSD	26.60%	72%	VSD measures commonly required adjustments for the following reasons: 1. Units did not qualify for program due to operating at fixed speed, not having feedback controls or non-HVAC application (projects #31925 had the verified savings set to zero). 2. The baseline control types were updated to actual. 3. The operation hours were updated to actual. 4. The demand savings algorithm was updated to reflect the IL TRM. The "BHP" and "PLR _{FF,Peak} " terms were not applied correctly in the PY9 ComEd workpapers.	The program post-inspection protocol should be updated to verify VSD modulation based on feedback, in addition to installation and motor size. The VSD workpapers should be updated to reflect the IL TRM.	High

Source: Evaluation analysis.

In the following tables Navigant highlights the variation in the realization rates for the high priority HVAC, VSD, and EMS sample projects.

Table 7-4. EMS Sample Realization Rates

Project ID	Ex Ante Gross Energy Savings (MWh)	Verified Gross Energy Savings (MWh)	Realization Rate
30976	3,016	473	16%
35081	2,604	0	0%
31175	1,672	380	23%
31293	1,114	1,108	99%
33001	675	2,994	444%
32868	584	0	0%
33535	553	553	100%
32909	310	398	128%
32120	239	108	45%
31813	229	229	100%
32367	229	229	100%
32714	39	0	0%
Total	11,263	6,471	57%

Source: Evaluation analysis.

Table 7-5. HVAC_VSD Sample Realization Rates

Project ID	Ex Ante Gross Energy Savings (MWh)	Verified Gross Energy Savings (MWh)	Realization Rate
31305	4,784	1,215	25%
33406	3,076	442	14%
30977	2,369	2,386	101%
35305	2,100	557	27%
33790	1,144	600	52%
30350	1,002	831	83%
35817	582	693	119%
32911	525	392	75%
35342	412	258	62%
32853	377	269	71%
31925	374	0	0%
34726	344	237	69%
32315	302	310	103%

35545	225	275	122%
35649	196	196	100%
34729	169	110	65%
32002	60	60	100%
Total	18,042	8,830	49%

Source: Evaluation analysis.

Table 7-6. HVAC Sample Realization Rates

Project ID	Ex Ante Gross Energy Savings (MWh)	Verified Gross Energy Savings (MWh)	Realization Rate
37139	1,494	814	54%
37259	927	204	22%
34082	695	533	77%
33701	693	422	61%
35358	604	0	0%
30976	548	401	73%
33017	491	0	0%
36071	286	158	55%
34929	281	210	75%
35279	191	119	62%
31802	118	70	59%
31802	118	70	59%
32174	100	70	70%
32120	23	50	215%
35432	11	3	30%
Total	6,582	3,123	47%

Source: Evaluation analysis.

8. APPENDIX 3. TRC DETAIL

PY9 TRC detail will be provided in the second draft of this report.