NAVIGANT

ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report

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

Presented to
ComEd

FINAL

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1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Luminaire Level Lighting Control (LLLC) IPA 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 appendices present the impact analysis methodology and the total resource cost detail. PY9 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

The LLLC Program encouraged small commercial and industrial customers[1] to install LED fixtures with integrated advanced lighting control capabilities. These control capabilities included occupancy sensors, daylight harvesting, continuous dimming, and networking. The LLLC Program offered a streamlined mechanism for the adoption of advanced lighting control capabilities in the small business market.

The program had 227 participants in PY9 and distributed 20,700 measures as shown in the following table and figures.

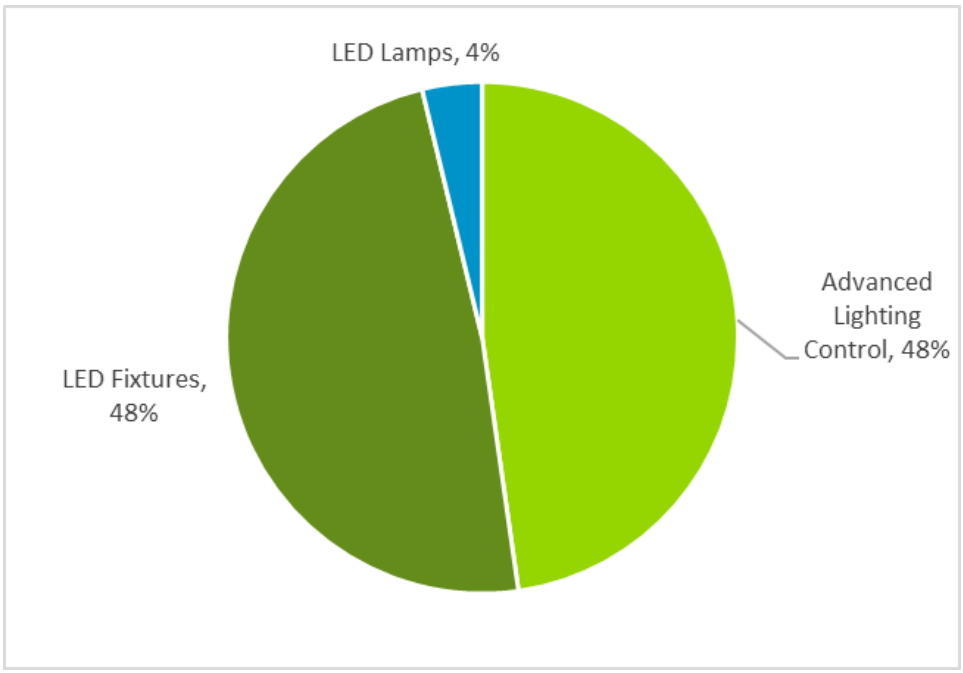
Table 2-1. PY9 Volumetric Findings Detail

Participation	PY9
Participants	227
Total Measures	20,700
Average Number of Units/Projects	91.2
Installed Projects	227
Installed Advanced Lighting Control	9,881
Installed LED Fixtures	10,037
Installed LED Lamps	782

Source: ComEd tracking data and Navigant team analysis.

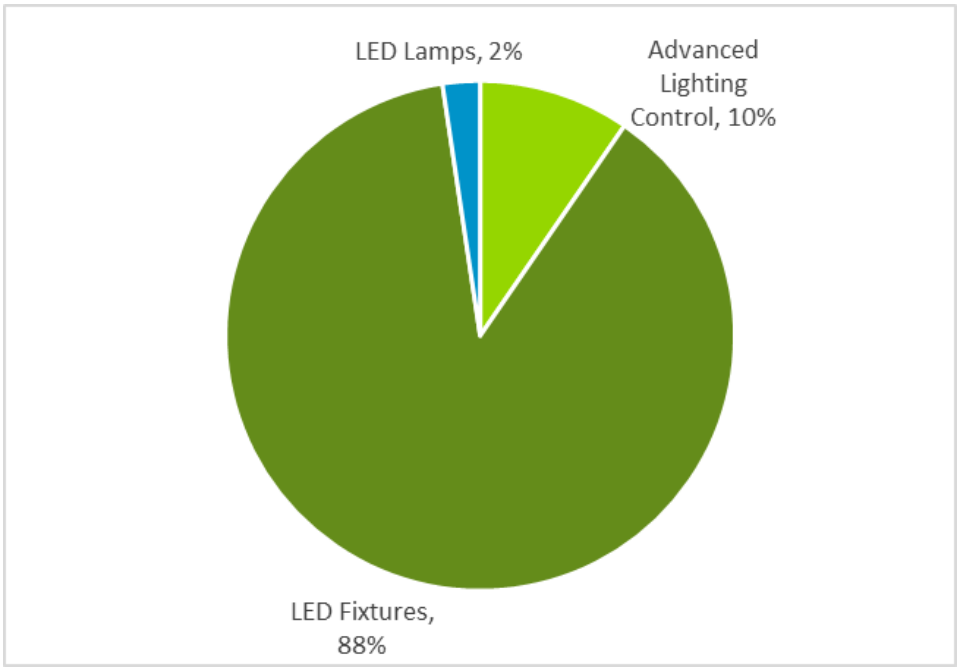
[1] "Small commercial and industrial" customers are defined as customers with peak demands of 100 kW or less.

Figure 2-1. Percentage of Measures Installed by Type



Source: Evaluation Analysis

Figure 2-2. Percentage of Program Savings by Measure



Source: Evaluation Analysis

3. Program Savings

Table 3-1 summarizes the incremental energy and demand savings the LLLC Program achieved in PY9. The program achieved an energy realization rate of 99 percent, primarily due to adjustments of building

type and other algorithm input factors (see Section 5.2 for more details). The program achieved a demand realization rate of 101 percent, primarily due to claiming demand savings for Project PRJ-909496 (see Finding 3).

Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	9,041,310	NR	1,751
Program Gross Realization Rate	99%	NA	101%
Verified Gross Savings	8,993,491	2,787	1,761
Program Net-to-Gross Ratio (NTGR)	0.90	0.90	0.90
Verified Net Savings	8,094,142	2,508	1,585

NR = not reported
Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The program includes three measure categories as shown in the following tables. The LED Fixtures contributed the most savings.

Table 4-1. PY9 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)†
Lighting	Advanced Lighting Control	864,758	99%	856,074	0.90	770,467	NA	NA	15.0
Lighting	LED Fixtures	7,968,425	100%	7,931,599	0.90	7,138,439	NA	NA	10.5
Lighting	LED Lamps	208,127	99%	205,818	0.90	185,237	NA	NA	11.5
	Total‡	9,041,310	99%	8,993,491	0.90	8,094,142	NA	NA	10.9

* 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.
‡ Numbers do not sum exactly due to rounding.
Source: ComEd tracking data and Navigant team analysis.

Table 4-2. PY9 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)
Lighting	Advanced Lighting Control	NR	NA	707	0.90	637
Lighting	LED Fixtures	NR	NA	2,019	0.90	1,817
Lighting	LED Lamps	NR	NA	60	0.90	54
	Total†	NR	NA	2,787	0.90	2,508

NR = not reported
* 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.
† 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

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)
Lighting	Advanced Lighting Control	367	99%	365	0.90	329
Lighting	LED Fixtures	1,346	101%	1,356	0.90	1,221
Lighting	LED Lamps	38	105%	40	0.90	36
	Total†	1,751	101%	1,761	0.90	1,585

* 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.
† 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

Energy and demand savings are estimated using the following algorithms, as specified in the TRM. For additional detail on these measures, see Section 6 (Appendix 1).

5.1.1 LED Lamps and Fixtures[2]

$$\Delta kWh = \frac{Watts_{Base} - Watts_{EE}}{1000} * Hours * WHF_e * ISR$$

$$\Delta kW = \frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * WHF_d * CF$$

5.1.2 LED Controls[3]

$$\Delta kWh = kW_{Controlled} * Hours * (ESF_{Post} - ESF_{Pre}) * WHF_e$$

$$\Delta kW = kW_{Controlled} * WHF_d * (CF_{Baseline} - CF_{OS})$$

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

The EM&V team conducted research to validate the parameters that were not specified in the TRM. The results are shown in the following table.

[2] IL TRM v5.0, 4.5.4 LED Bulbs and Fixtures
[3] Based on IL TRM v5.0, 4.5.10 Occupancy Sensor Lighting Controls. The ESF term has been updated to (ESF_{Post} - ESF_{Pre}), based on the *Sample Calcs_Advanced Lighting Control Program_Sept 6_FixtureAdds* Excel file provided with the Wave 1 data.

Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Deemed or Evaluated?
Quantity	Evaluated
Measure Type and Eligibility	Evaluated
Gross Savings per Unit	Evaluated
Verified Realization Rate on Ex Ante Gross Savings	*Evaluated*

5.2 Other Impact Findings and Recommendations

Finding 1. For some measures, the ex ante algorithm input factors such as operation hours, interactive factors and coincidence factors, do not match the TRM values for the ex ante building type. The ex ante inputs are based on the room type instead of the building type. For these measures, the verified savings are based on the building types verified by online research. The measures affected by this finding are identified in Table 7-1.

Recommendation 1. Navigant recommends updating the savings algorithms to be based on the ex ante building type, which should reflect the building types listed in the IL TRM v5.0.

Finding 2. Navigant found that measures whose building type was identified as "Miscellaneous" in the tracking data had ex ante annual operation hours value which do not correspond to any building type in the IL TRM v5.0. While the hours did not match any building type, the other input factors such as interactive factors and coincidence factor matched the IL TRM default values for the "Unknown" building type. Subsequently, Navigant communicated with the implementation team, and determined that these projects used custom hours, as previously agreed.

Recommendation 2. Navigant recommends creating a separate building type (e.g., "Unknown – Custom") in the tracking system to identify the projects that utilize custom hours of operation.

Finding 3. No demand savings were reported for Project PRJ-909496. The verified peak demand savings for this project totaled 18 kW.

Recommendation 3. Navigant recommends updating the tracking data to include the demand savings for this project.

Finding 4. The final tracking data did not include the correct quantities for many of the advanced lighting control measures which were provided during Wave 1. The implementation team provided this detail in updated tracking database.

Recommendation 4. Navigant recommends that the implementation team continue to track the quantities of advanced lighting control measures and include the same in the tracking database.

Recommendation 5. Navigant also recommends that the implementer communicate any changes to the tracking data fields associated with savings verification to the evaluation team. This communication can confirm whether the change will affect the ability of the evaluation team to verify savings.

Finding 5. Navigant found that Project PRJ-960021 has three lines of program tracking data whose ex ante savings reflect that of another line of tracking data within the project. For example, the ex ante savings for measure MC-2228187 reflects the verified savings of measure MC2228208. This issue does not impact the project-level realization rate. See Table 7-2 for more details.

Recommendation 6. Navigant recommends accurate tracking and correction of these savings discrepancies.

Finding 6. Project PRJ-1689229 has "Project Submitted Date" of November 28, 2018. This date is in error and is assumed to be November 28, 2017. This project was not excluded from the verified savings total.

Recommendation 7. Navigant recommends accurate tracking and correction of the "Project Submitted Date" in the tracking data.

Finding 7. The energy savings algorithm for fixture replacement does not account for reduced hours of operation due to existing control types. The ex ante savings reflect operation at the full TRM default hours, however an existing control type would have reduced the annual operation hours. This finding, which was noted in the Wave 1 Review, affects seven measures across two projects.

Recommendation 8. Navigant recommends that the fixture replacement algorithms be updated to account for the LED controls. The updated algorithms are below, where ESF_{Pre} is the Energy Savings Factor due to the pre-replacement lighting controls.[4]

$$\Delta kWh = \frac{Watts_{Base} - Watts_{EE}}{1000} * Hours * (1 - ESF_{Pre}) * WHF_e * ISR$$

Finding 8. The ex ante savings of measure MC-3573476 reflects a fixture replacement but the measure is listed as "controls" under the column titled "Replacement Fixture/Control." The verified savings is based on this measure being a control.

Recommendation 9. Navigant recommends accurately tracking and correcting the measure type in the tracking system or updating the ex ante savings to reflect controls savings.

Finding 9. In measure MC-2228226, the efficient lamp wattage is listed as 28W, but the fixture is identified as "LED014-LAMP," which corresponds to a wattage of 14W. The verified savings is based on an installed lamp wattage of 14W.

Recommendation 10. Navigant recommends accurately tracking and correcting the wattage in the tracking data.

6. Appendix 1. Impact Analysis Methodology

As described in Section 5, energy and demand savings were estimated using Illinois TRM v5.0. The Illinois TRM deems most input parameters for lighting measures. The values are provided below.

[4] IL TRM v5.0, 4.5.10 Occupancy Sensor Lighting Controls

Table 6-1. IL TRM v5.0 Lighting Algorithm Input Values

Building/Space Type	Fixture Annual Operating Hours	Screw-Based Lamp Annual Operating hours	Waste Heat Cooling Energy (WHF_e)	Waste Heat Cooling Demand (WHF_d)	Coincidence Factor
Assisted Living	7,862	5,950	1.14	1.30	0.66
Convenience Store	4,672	3,650	1.09	1.26	0.76
Garage, 24/7 lighting	8,766	8,766	1.00	1.00	1.00
Grocery	4,650	3,650	1.05	1.22	0.73
Healthcare Clinic	3,890	4,207	1.40	1.85	0.65
Manufacturing Facility	4,618	2,629	1.02	1.04	0.81
Multifamily	6,138	5,950	1.14	1.32	0.64
Hotel/Motel - Common	6,138	4,542	1.20	1.24	0.73
Office – Mid Rise	3,068	3,088	1.26	1.61	0.52
Office: Small/Low Rise	2,698	3,088	1.11	1.31	0.52
Restaurant	5,571	4,784	1.17	1.31	0.68
Retail - Strip Mall	4,093	2,935	1.12	1.29	0.71
Warehouse	5,242	4,293	1.00	1.22	0.68
Unknown	3,379	3,612	1.09	1.36	0.58
Low-Use Small Business	2,954	2,954	1.31	1.53	0.66

Source: IL TRM v5.0, filtered by participating building types.

6.1 LED Lamps and Fixtures[5]

$$\Delta kWh = \frac{Watts_{Base} - Watts_{EE}}{1000} * Hours * WHF_e * ISR$$

$$\Delta kW = \frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * WHF_d * CF$$

Where:

$Watts_{Base}$	= *Input wattage of existing or baseline system*
$Watts_{EE}$	= *Input wattage of proposed system*
Hours	= *Annual operating hours*
WHF_e	= *Waste heat factor for energy*
ISR	= *In Service Rate*
IF_{kWh}	= *Lighting-HVAC interaction factor*
WHF_d	= *Waste heat factor for demand*
CF	= *Summer peak coincidence factor*

[5] IL TRM v5.0, 4.5.4 LED Bulbs and Fixtures

Table 6-2. LED Lamps and Fixtures Custom and Deemed Values Comparison

Value	Variable	Source	Deemed/Custom
Varies	$Watts_{Base}$	*Program Tracking Data*	Custom
Varies	$Watts_{EE}$	*Program Tracking Data*	Custom
See Table 6-1	Hours	*IL TRM v5.0, 4.5.3-4*	Deemed
See Table 6-1	WHF_e	*IL TRM v5.0, 4.5.3-4*	Deemed
1.0	ISR	*IL TRM v5.0, 4.5.3-4*	Deemed
See Table 6-1	WHF_d	*IL TRM v5.0, 4.5.3-4*	Deemed
See Table 6-1	CF	*IL TRM v5.0, 4.5.3-4*	Deemed

6.2 LED Controls[6]

$$\Delta kWh = kW_{Controlled} * Hours * (ESF_{Post} - ESF_{Pre}) * WHF_e$$

$$\Delta kW = kW_{Controlled} * WHF_d * (CF_{Baseline} - CF_{OS})$$

Where:

$kW_{Controlled}$ = *Total lighting load connected to the control in kilowatts*
Hours = *Total operating hours*
ESF_{Pre} = *Energy savings factor of existing control*
ESF_{Post} = *Energy savings factor of installed control*
WHF_e = *Waste heat factor for energy*
WHF_d = *Waste heat factor for demand*
IF_{kWh} = *Lighting-HVAC interaction factor*
$CF_{Baseline}$ = *Baseline summer peak coincidence factor*
CF_{OS} = *Retrofit summer peak coincidence factor*

Table 6-3. LED Controls Custom and Deemed Values Comparison

Value	Variable	Source	Deemed/Custom
Varies	$kW_{Controlled}$	*Program Tracking Data*	Custom
See Table 6-1	Hours	*IL TRM v5.0, 4.5.10*	Deemed
0%, 24%	ESF_{Pre}	*Program Tracking Data*	Custom
31%	ESF_{Post}	*IL TRM v5.0, 4.5.10*	Deemed
See Table 6-1	WHF_e	*IL TRM v5.0, 4.5.10*	Deemed
See Table 6-1	WHF_d	*IL TRM v5.0, 4.5.10*	Deemed
0	IF_{kWh}	*Program Tracking Data*	Deemed
See Table 6-1	$CF_{Baseline}$	*IL TRM v5.0, 4.5.10*	Deemed
0.15	CF_{OS}	*IL TRM v5.0, 4.5.10*	Deemed

[6] Based on IL TRM v5.0, 4.5.10 Occupancy Sensor Lighting Controls. The ESF term has been updated to (ESF_{Post} - ESF_{Pre}), based on the *Sample Calcs_Advanced Lighting Control Program_Sept 6_FixtureAdds* Excel file provided with the Wave 1 data.

7. Appendix 2. Impact Analysis Detail

Table 7-1. Measures Impacted by Finding 1

Measure ID	Ex Ante Building Type	Ex Ante Room Name	Ex Ante Input Basis*	Verified Building Type
MC-3071616	Hotel/Motel - Common	Warehouse	Warehouse	Warehouse
MC-3071617	Hotel/Motel - Common	Warehouse	Warehouse	Warehouse
MC-2121197	Office: Small/Low Rise	Office	Manufacturing Facility	Manufacturing Facility
MC-2121199	Office: Small/Low Rise	Office	Manufacturing Facility	Manufacturing Facility
MC-3956415	Restaurant	Open Area	Office – Low Rise	Office: Small/Low Rise
MC-3956416	Restaurant	Open Area	Office – Low Rise	Office: Small/Low Rise
MC-3549423	Convenience Store	Dining/Bathrooms/Kitchen	Restaurant	Restaurant
MC-3549427	Convenience Store	Dining/Bathrooms/Kitchen	Restaurant	Restaurant
MC-3549416	Convenience Store	Dining	Restaurant	Restaurant
MC-3549420	Convenience Store	Kitchen	Restaurant	Restaurant
MC-3549415	Convenience Store	Dining	Restaurant	Restaurant
MC-3549417	Convenience Store	Kitchen	Restaurant	Restaurant
MC-3783240	Restaurant	Lighting	NA†	Restaurant
MC-2592987	Low-use Small Business	Warehouse	NA†	Low-use Small Business
MC-2592992	Low-use Small Business	Warehouse	NA†	Low-use Small Business
MC-2592997	Low-use Small Business	Warehouse	NA†	Low-use Small Business
MC-2593023	Low-use Small Business	Warehouse	NA†	Low-use Small Business
MC-3999163	Office - Mid Rise	Interior	Office – Low Rise	Office: Small/Low Rise
MC-3999166	Office - Mid Rise	Interior	Office – Low Rise	Office: Small/Low Rise
MC-3999149	Office - Mid Rise	Interior	Office – Low Rise	Office: Small/Low Rise
MC-3999154	Office - Mid Rise	Interior	Office – Low Rise	Office: Small/Low Rise
MC-2423990	Office: Small/Low Rise	Server Room	Healthcare Clinic	Office: Small/Low Rise
MC-2423991	Office: Small/Low Rise	Server Room	Healthcare Clinic	Office: Small/Low Rise
MC-2423984	Office: Small/Low Rise	Office	Healthcare Clinic	Office: Small/Low Rise
MC-2423988	Office: Small/Low Rise	Office	Healthcare Clinic	Office: Small/Low Rise

* This column reflects IL TRM v5.0 building type that corresponds to the algorithm input values provided in the program tracking data.
† NA refers to a measure whose algorithm input values do not exactly correspond to a building type in the IL TRM v5.0.
Source: ComEd tracking data and Navigant team analysis.

Table 7-2. Measures Impacted by Finding 5

Project ID	Measure ID	Ex Ante Gross Savings (kWh)	Verified Gross Savings (kWh)
PRJ-960021	MC-2228187	1,604	2,887
	MC-2228195	2,887	2,374
	MC-2228208	2,374	1,604
	Total	6,864	6,864

Source: ComEd tracking data and Navigant team analysis.

Table 7-3. Measures Impacted by Finding 7

Project ID	Measure ID	Ex Ante Gross Savings (kWh)	Verified Gross Savings (kWh)
PRJ-909496	MC-1046999	154	117
	MC-1047043	154	117
	MC-1047041	6,678	5,075
	MC-1047001	154	117
PRJ-1593355	MC-3955046	57,599	43,775
	MC-3955050	14,049	10,677
	MC-3955055	12,615	9,588

Source: ComEd tracking data and Navigant team analysis.

8. Appendix 3. Total Resource Cost Detail

Table 8-1, the Total Resource Cost (TRC) variable table, only includes cost-effectiveness analysis inputs available at the time of finalizing the PY9 LLLC 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 to evaluation later. EULs are subject to change and are not final.

Table 8-1. Total Resource Cost Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life*†	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Lighting	Advanced Lighting Control	Controlled Wattage	9,881	15.0	864,758	367	820,907	365
Lighting	LED Fixtures	Fixture	10,037	11.0	7,968,425	1,346	7,537,368	1,356
Lighting	LED Lamps	Lamp	782	11.6	208,127	38	203,246	40

* The EUL reference for Advanced Lighting Controls is ComEd Effective Useful Life Research, April 2, 2018.
† The EUL reference for LED fixtures and lamps is the Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0, available at: http://www.ilsag.info/technical-reference-manual.html.