



ComEd

LED Street Lighting Program Evaluation Report

FINAL

**Energy Efficiency / Demand Response Plan:
Plan Year 8 (PY8)
(6/1/2015-5/31/2016)**

**Presented to
Commonwealth Edison Company**

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E. EXECUTIVE SUMMARY

This report presents a summary of the findings and results from the impact evaluation of the PY8¹ LED Street Lighting program. The LED Street Lighting program encourages early retirement of ComEd owned High Pressure Sodium (HPS) and Mercury Vapor (MV) fixtures serving municipalities with Light-Emitting Diode (LED) fixtures. Participation for PY8 and PY9 is limited to those municipalities whose street light account is less than 100kW. The 100kW limitations exist because IPA is the source of the funding for the program. Approximately 73,000 HID lighting fixtures are ComEd-owned and rented by non-competitively declared municipalities². ComEd’s criteria for selecting a LED replacement fixture considers the fixture height (normally 25-30 feet) and the road way configuration at the fixture location (number of lanes and intersection versus mid-block).

ComEd’s criteria for selecting municipalities included:

- Municipality was in the advanced metering infrastructure portion of ComEd’s territory.
- Municipality had more than 50 fixtures.³

The LED Street Lighting program launched in June 2014. The program was marketed to municipalities primarily through outreach by ComEd External Affairs personnel. PY7 was a pilot year before the program scaled up in PY8. The PY7 pilot included two municipalities each with total demand under 100 kW, and replaced 735 lights. The program expanded to 41 municipalities in PY8. In PY8, the program replaced 10,077 lights, exceeding its goal of replacing 10,000 lights in PY8.

The program also exceeded their PY8 net energy savings target of 5,474 MWh by nine percent with 5,978 MWh. This report describes the impact evaluation of the PY8 program with recommendations for program enhancements.

E.1. Program Savings

Table E-1 summarizes the electricity savings from the LED Street Lighting program. Navigant used information collected by ComEd from 41 municipal streetlight billing accounts to calculate ex ante gross energy savings. The tracking system did not include ex ante demand savings or peak demand savings. Navigant reviewed the tracking system data and calculations to verify the energy gross savings to be 5,978 MWh.

Table E-1. PY8 Total Program Savings

Savings Category	Energy Savings (MWh)	Demand Savings (MW)	Peak Demand Savings (MW)
Ex-Ante Gross Savings	5,973	0	0
Verified Gross Savings	5,978	1.46	0.99*
Verified Net Savings	5,978	1.46	0.99

Source: ComEd tracking data and Navigant team analysis.

*Note that the coincidence factor used to calculate peak demand savings used was 0.86 which was taken from the ComEd LED Street Lighting Program Year 7 Report.

¹ The PY8 program year began June 1, 2015 and ended May 31, 2016.

² ComEd defines non-competitive municipalities as accounts with under 100kW of total demand.

³ Email from ComEd Program Manager, January 4, 2017.

E.2. Program Savings by Measure Type

Table E-2. PY8 Program Results by Measure Type

Savings Category	51 Watt LED	72 Watt LED	143 Watt LED
Ex-Ante Gross Energy Savings (MWh)	5,193	613	167
Ex-Ante Gross Peak Demand Reduction (MW) ‡	NR	NR	NR
Verified Gross Energy Savings (MWh)	5,198	614	167
Verified Gross Peak Demand Savings (MW)	0.86	0.10	0.03
Verified Gross Energy Realization Rate (%)	100*	100*	100*
Net to Gross Ratio (NTGR) †	1.00	1.00	1.00
Verified Net Energy Savings (MWh)	5,198	614	167
Verified Net Peak Demand Reduction (MW)	0.86	0.10	0.03

Source: ComEd tracking data and Navigant team analysis.

*Note that the ex-ante and verified numbers are slightly different even though the realization rate is rounded to 100 percent.

† A deemed value. Source: ComEd_NTG_History_and_PY8_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>

‡ NR = Not reported.

E.3. Impact Estimate Parameters for Future Use

Navigant validated ComEd’s hours of use. ComEd used an average of 342 hours of use per month, which results in 4,104 hours of use per year. Navigant calculated the total annual hours of darkness to be 4,303 using the Astronomical Applications Department, U.S. Naval Observatory⁴. Based on the small overall difference, Navigant agrees ComEd’s value is reasonable. Navigant and ComEd agreed that the EM&V team will use an agreed upon value of hours of use of 4,104 hours for street lighting and use this value for the future evaluation years.

Table E-3. Impact Estimate Parameters for Future Use

Parameter	Value	Data Source
NTG	1.00	ComEd_NTG_History_and_PY8_Recommendation_2016-02-26_Final_EMV_Recommendations.xlsx
Coincidence Factor	0.68	Evaluation results from PY7
Hours of Use (Annually)	4,104	Evaluation results from PY7
RR	1.00	Evaluation results

Source: Evaluation Analysis

E.4. Program Volumetric Detail

The program had 41 participants in PY8 and distributed 10,077 measures as shown in the following table.

⁴ U.S. Naval Observatory, Astronomical Applications Department web site: http://aa.usno.navy.mil/data/docs/Dur_OneYear.php. Accessed 3/31/2016.

Table E-4. PY8 Volumetric Findings Detail

Participation	Total
Participants†	41
Street Light Replacements	10,077

Source: ComEd tracking data and Navigant team analysis.

†Municipalities

E.5. Results Summary

The following table summarizes the key metrics from PY8.

Table E-5. PY8 Results Summary

Participation	Units	PY8
Verified Net Energy Savings	MWh	5,978
Verified Net Demand Reduction	MW	1.46
Verified Gross Energy Savings	MWh	5,978
Verified Gross Demand Reduction	MW	1.46
Program Realization Rate	%	100
Program NTG Ratio †	#	1.0
Measure 51-Watt LED installed	#	9,093
Measure 72-Watt LED installed	#	781
Measure 143-Watt LED installed	#	203
Customers Touched	#	41

Source: ComEd tracking data and Navigant team analysis.

† A deemed value. Source: ComEd_NTG_History_and_PY8_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>

E.6. Findings and Recommendations

The following provides insight into key program findings and recommendations.⁵ In general, the program was a success and exceeded the program’s goal of installing 10,000 LED fixtures by installing 10,077 LED fixtures. The program replaced fixtures across 41 municipalities and resulted in 5,978 MWh of energy savings and 0.99 MW of peak demand savings.

Program Participation

Finding 1. The program replaced street lighting in 41 municipalities and installed 10,077 LED street lights.

⁵ This is a subset of our findings and recommendations. Numbering on the findings and recommendations in this section are the same as those found in the Findings and Recommendations section of the evaluation report for ease of reference between each section.

Program Savings

Finding 2. Overall, the LED Street Lighting Program achieved verified gross savings of 5,978 MWh with a corresponding verified gross realization rate of 100 percent for energy savings.

Finding 3. Overall, the program achieved 109 percent of its planning target of 5,474 net MWh with verified net savings of 5,978 MWh.

Finding 4. Overall, the verified net peak demand reduction was 0.99 MW and the verified total net demand reduction was 1.46 MW.

Tracking Data

Finding 5. The tracking data had a few minor flaws that only require small changes but could improve the verification process.

Recommendation 1.

- Combine data for all municipalities into one dataset if feasible.
- Add a column indicating in which program year the fixture replacement occurred.
- Ensure that naming conventions are consistent across municipalities (i.e., “Survey, CET Wattage” column had several different naming conventions for the same type of fixture).
- Use a VLOOKUP equation based on the fixture name for the “Base” and “New Wattage” columns rather than hard coding the input which will help prevent data entry errors.
- Use an equation for the “Wattage Savings” column rather than hard coding.
- Calculate kWh savings for each fixture as opposed to just at the municipality level.
- Add a separate column for the “Quantity” of fixtures installed/replaced.

Finding 6. Navigant found that the program replaced existing LEDs with lower wattage LEDs. The program replaced (4) 140-W LEDs with (4) 72-W LEDs.

Recommendation 2. Navigant recommends that ComEd update program documentation to include cases where existing LEDs streetlights are replaced by energy efficient LED streetlights.

Finding 7. Navigant found three specific measure line data entry issues that resulted in the difference in verified energy savings including:

- Four measure lines did not have new fixture wattage included and therefore the wattage savings for those measures was not calculated.
- One measure line did not have the wattage savings calculated since the wattage savings cell was hard coded to zero.
- One measure line reported the baseline wattage for a 70-W HPS to be 85 watts and not 82 watts.

Recommendation 3. Navigant recommends that ComEd develop a standardized template for data tracking to help eliminate data entry errors.

Impact Analysis

Finding 8. The calculated summary kWh values for three municipalities were incorrect.

- One municipality did not have an energy summary.
- One municipality reported kW savings and not kWh savings.
- One municipality’s savings calculations were hard coded and the hard coded value did not equal the total of the individual measures. It was not clear how the hard coded value was calculated.

Recommendation 3. [Same as above] Navigant recommends that ComEd develop a standardized template for data tracking to help eliminate data entry errors.

Finding 9. Four of the fixtures did not have an ex ante baseline wattage consumption because the implementer could not read the nameplate of the baseline fixture. For this evaluation, Navigant generated an average baseline wattage based on the other baseline fixtures replaced through the program.

Recommendation 4. Develop a procedure for when baseline nameplate information is not legible.

Finding 10. Baseline fixture pictures did not offer enough clarity to verify exact fixture replacements, however Navigant believes the burden of collecting close-up fixture pictures outweighs the benefit. Navigant will continue to verify savings based on ComEd's current reporting method. Additionally, to the extent possible, Navigant will use Google Earth to verify baseline fixtures using the latitude and longitude co-ordinates provided by ComEd.

1. INTRODUCTION

1.1 Program Description

The LED Street Lighting program encourages early retirement of ComEd owned High Pressure Sodium (HPS) and Mercury Vapor (MV) fixtures serving municipalities with Light-Emitting Diode (LED) fixtures. Participation for PY08 and PY09 is limited to those municipalities whose street light account is less than 100kW. The 100kW limitations exist because IPA is the source of the funding for the program. Approximately 73,000 HID lighting fixtures are ComEd-owned and rented by non-competitively declared municipalities⁶. ComEd's criteria for selecting a LED replacement fixture considers the fixture height (normally 25-30 feet) and the road way configuration at the fixture location (number of lanes and intersection versus mid-block).

ComEd's criteria for selecting municipalities included:

- Municipality was in the advanced metering infrastructure portion of ComEd's territory.
- Municipality had more than 50 fixtures.⁷

The LED Street Lighting program launched in June 2014. The program was marketed to municipalities primarily through outreach by ComEd External Affairs personnel. PY7 was a pilot year before the program scaled up in PY8. The PY7 pilot included two municipalities each with total demand under 100 kW, and replaced 735 lights. The program expanded to 41 municipalities in PY8. In PY8, the program replaced 10,077 lights, exceeding its goal of replacing 10,000 lights in PY8.

1.2 Evaluation Objectives

The evaluation team identified the following key researchable questions for PY8.

1.2.1 Impact Questions

1. What are the program's annual total verified gross savings?
2. Are the ex ante per unit gross impact savings correctly calculated in the tracking system and reasonable for this program?

⁶ ComEd defines non-competitive municipalities as accounts with under 100kW of total demand.

⁷ Email from ComEd Program Manager, January 4, 2017.

2. EVALUATION APPROACH

The evaluation approach for the PY8 LED Street Lighting program included reviewing tracking system data and savings calculations.

2.1 Overview of Data Collection Activities

The core data collection activity included verification of the program tracking data and savings calculations (Table 2-1)

Table 2-1. Primary Data Collection Activities

What	Who	When	Comments
Program Tracking Database Review	Navigant	November – December 2016	Reviewed installation file for 41 participating municipalities

2.2 Verified Savings Parameters

Verified gross and net savings (energy and coincident peak demand) resulting from the PY8 program were calculated using the following algorithms as defined by the Illinois TRM version 4.0⁸

2.2.1 Verified Gross Program Savings Analysis Approach

Navigant performed the following steps to verify gross energy savings of the LED Street Lighting program:

1. Conducted an engineering review of the tracking system data and the energy savings estimates for the installed measures.
2. Verified the savings algorithm to be:

$$kWh_{savings} = Q * \Delta W * HOU$$

Where:

- Q = Quantity of Lights
- ΔW = Baseline fixture wattage minus the new LED fixture wattage
- HOU = Hours of use

3. Validated ComEd's hours of use: ComEd used an average of 342 hours of use per month, which results in 4,104 hours of use per year. Navigant calculated the total hours of darkness for 2014 to be 4,303 hours per year using the Astronomical Applications Department, U.S. Naval Observatory⁹. Darkness refers to sunrise and sunset, which is conventionally referred to the times when the upper edge of the disk of the Sun is on the horizon. Atmospheric conditions are assumed to be average, and the location is in a level region on the Earth's surface. Since there is no LED street lighting or street lighting measure in the Illinois TRM and since Navigant's hours of use calculation is within 10 percent of ComEd's value, Navigant accepted ComEd's number for this evaluation.
4. Verified gross savings are the product of verified per unit savings and verified measure quantities. The following table presents the parameters that were used in the verified gross and net savings calculations and indicates which were examined through evaluation activities and which were deemed.

⁸ Source: <http://www.ilsag.info/technical-reference-manual.html>

⁹ U.S. Naval Observatory, Astronomical Applications Department web site: http://aa.usno.navy.mil/data/docs/Dur_OneYear.php. Accessed 3/31/2016.

Table 2-2. Verified Savings Parameter Data Sources

Gross Savings Input Parameters	Data Source	Deemed † or Evaluated?
Installed Quantities	Program tracking data analysis	Evaluated
Lighting Measure Hours of Use (HOU) (4,104)	ComEd calculation verified by evaluation research	Evaluated
Lighting Measure Delta Watts by Fixture Type	Program tracking data analysis	Evaluated
Gross Realization Rate	Program tracking data analysis	Evaluated
NTG – Electric and Gas	ComEd calculation	Deemed

† A deemed value. Source: ComEd_NTG_History_and_PY8_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>

2.2.2 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 NTGR. In PY8, the NTGR estimate used to calculate the net verified savings was defined through a negotiation process through SAG as documented in a spreadsheet.¹⁰

The NTG value for this program is deemed to be 1.0 given that participants have no ability to implement without ComEd's assistance.

¹⁰ Source: ComEd_NTG_History_and_PY8_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>

3. GROSS IMPACT EVALUATION

The PY8 LED Street Lighting program achieved overall verified gross savings of 5,978 MWh at a gross realization rate of 1.00. This section presents results of our evaluation activities to verify program savings.

3.1 Tracking System Review

Navigant conducted a consistency check on the LED Street Lighting program tracking data to validate the PY8 data. The tracking data included the fixtures that were removed and the newly installed LED fixtures. We examined values for per unit energy savings at the measure level in the following manner:

- Reviewed project documentation for quantities and replacement wattage values.
- Verified hours of use.
- Adjusted six line items as data was incorrectly hard coded.
- Combined data for all 41 participants into one dataset.
- Checked the installation date and removed projects that were installed in PY9.
- Removed non-qualifying fixtures where appropriate.

3.2 Program Volumetric Findings

The program had 41 participants in PY8 and installed 10,077 measures as shown in the following table.

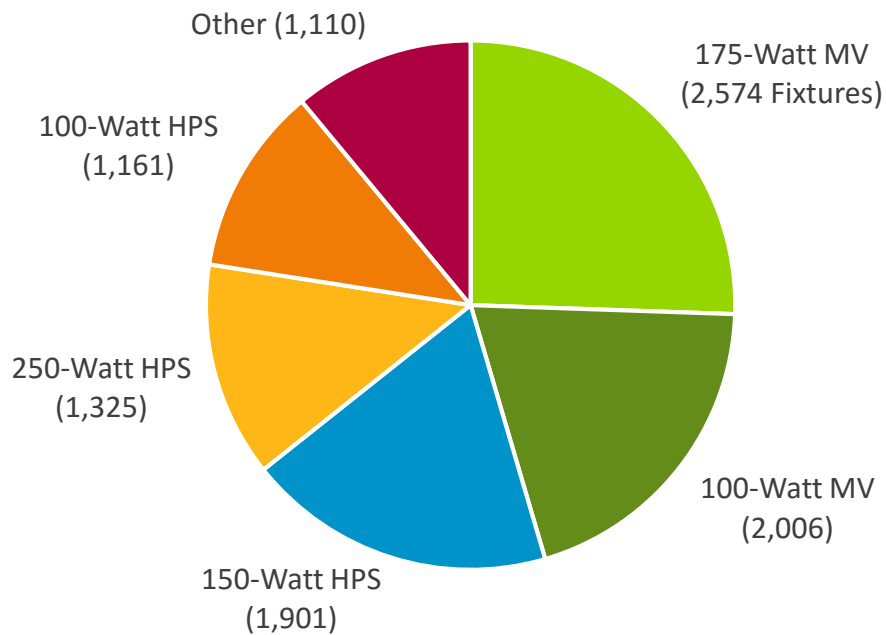
Table 3-1. PY8 Volumetric Findings Detail

Participation	Total
Participants†	41
Street Light Replacements	10,077

Source: ComEd tracking data and Navigant team analysis.

†Municipalities

Figure 1. Quantity (Total Fixture Count) and Type of Baseline Fixtures Replaced

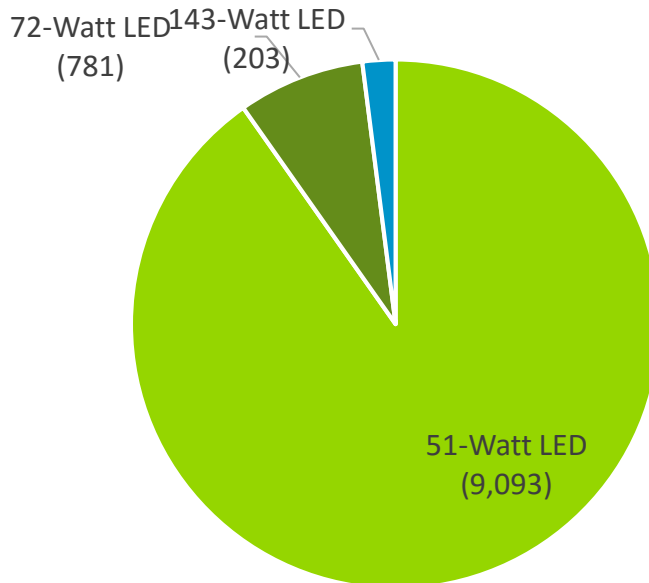


Source: Evaluation Analysis

*MV = Mercury Vapor, HPS = High-Pressure Sodium

**Other includes the following fixture types: 70-W HPS, 140-W LED, 250-W MV, 400-W MV, 400-W HPS, 1,000-W HPS, and fixtures with illegible information

Figure 2. Quantity (Total Fixture Count) and Type of Retrofited Fixtures Installed



Source: Evaluation Analysis

Table 3-2. Quantity and Type of Replacements

Fixture Type	51-Watts	72-Watt	(2) 51-Watt	143-Watt	(2) 72-Watt	Grand Total
70-Watt HPS	262					262
100-Watt HPS	1,098	51		10		1,159
100-Watt MV	1,971	33		2		2,006
140-Watt LED		4				4
150-Watt HPS	1,685	180		12		1,877
No Baseline Data	4					4
175-Watt MV	2,418	124		30		2,572
(2) 100-Watt HPS			1			1
250-Watt MV	325	49		16		390
250-Watt HPS	1,092	194		37		1,323
(2) 150-Watt HPS			12			12
(2) 175-Watt MV			1			1
400-Watt MV	123	91		46		260
400-Watt HPS	87	53		49		189
(2) 250-Watt HPS					1	1
1,000-Watt HPS				1		1
Total	9,065	779	14	203	1	10,062*

Source: Evaluation Analysis

*Note: Total fixture count is 10,077 fixtures. There were 15 double fixtures that are only counted once in this table.

3.3 Gross Program Impact Parameter Estimates

As described in Section 2, energy and demand savings are estimated using the following formula as specified in the TRM:

$$kWh_{savings} = Q * \Delta W * HOU$$

$$kW_{peak\ savings} = Q * \Delta W * CF$$

The evaluation, measurement, and verification (EM&V) team conducted research to validate the parameters since they were not specified in the TRM. The results are shown in the following table.

Table 3-3. Verified Gross Savings Parameters

Gross Savings Input Parameters	Value	Deemed for Evaluated?
Quantity	Varies	Evaluated
Hours of Use	342/Month	Evaluated
Coincidence Factor	0.68	Evaluated
Measure Type and Eligibility	Varies	Evaluated
Gross Savings per Unit	Varies	Evaluated
Verified Realization Rate on Ex-Ante Gross Savings (Lighting)	1.0	Evaluated

†State of Illinois Technical Reference Manual version 4.0 from http://www.ilsag.info/il_trm_version_4.html

3.4 Verified Gross Program Impact Results

The resulting total program verified gross savings is 5,978 MWh and 0.99 MW as shown in the following table.

Table 3-4. PY8 Verified Gross Impact Savings Estimates

	Gross Energy Savings (MWh)	Gross Peak Demand Savings (MW)
Ex-Ante Gross Savings	5,973	NR†
Verified Gross Realization Rate	1.00	N/A
Verified Gross Savings	5,978	0.99

Source: Evaluation Team analysis.

†NR = Not reported.

4. NET IMPACT EVALUATION

Verified net savings are shown in Table 4-1. **Error! Reference source not found.**SAG determined¹¹ that the NTG value for this program is 1.0.

Table 4-1. PY8 Net Impact Savings Estimates

	Net Energy Savings (MWh)	Net Peak Demand Savings (MW)
Ex-Ante Net Savings	5,973	NR†
Verified Net Realization Rate	1.00	N/A
Verified Net Savings	5,978	0.99

Source: Evaluation Team analysis.

†NR = Not reported.

¹¹Source: ComEd_NTG_History_and_PY8_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>

5. PROCESS EVALUATION

Navigant did not conduct a process evaluation for this program.

6. FINDINGS AND RECOMMENDATIONS

Program Participation

Finding 1. The program replaced street lighting in 41 municipalities and installed 10,077 LED street lights.

Program Savings

Finding 2. Overall, the LED Street Lighting Program achieved verified gross savings of 5,978 MWh with a corresponding verified gross realization rate of 100 percent for energy savings.

Finding 3. Overall, the program achieved 109 percent of its planning target of 5,474 net MWh with verified net savings of 5,978 MWh.

Finding 4. Overall, the verified net peak demand reduction was 0.99 MW and the verified total net demand reduction was 1.46 MW.

Tracking Data

Finding 5. The tracking data had a few minor flaws that only require small changes but could improve the verification process.

Recommendation 1.

- Combine data for all municipalities into one dataset if feasible.
- Add a column indicating in which program year the fixture replacement occurred.
- Ensure that naming conventions are consistent across municipalities (i.e., “Survey, CET Wattage” column had several different naming conventions for the same type of fixture).
- Use a VLOOKUP equation based on the fixture name for the “Base” and “New Wattage” columns rather than hard coding the input which will help prevent data entry errors.
- Use an equation for the “Wattage Savings” column rather than hard coding.
- Calculate kWh savings for each fixture as opposed to just at the municipality level.
- Add a separate column for the “Quantity” of fixtures installed/replaced.

Finding 6. Navigant found that the program replaced existing LEDs with lower wattage LEDs. The program replaced (4) 140-W LEDs with (4) 72-W LEDs.

Recommendation 2. Navigant recommends that ComEd update program documentation to include cases where existing LEDs streetlights are replaced by energy efficient LED streetlights.

Finding 7. Navigant found three specific measure line data entry issues that resulted in the difference in verified energy savings including:

- Four measure lines did not have new fixture wattage included and therefore the wattage savings for those measures was not calculated.
- One measure line did not have the wattage savings calculated since the wattage savings cell was hard coded to zero.
- One measure line reported the baseline wattage for a 70-W HPS to be 85 watts and not 82 watts.

Recommendation 3. Navigant recommends that ComEd develop a standardized template for data tracking to help eliminate data entry errors.

Impact Analysis

Finding 8. The calculated summary kWh values for three municipalities were incorrect.

- One municipality didn’t have an energy summary.
- One municipality reported kW savings and not kWh savings.

- One municipality's savings calculations were hard coded and the hard coded value did not equal the total of the individual measures. It was not clear how the hard coded value was calculated.

Recommendation 3. [Same as above] Navigant recommends that ComEd develop a standardized template for data tracking to help eliminate data entry errors.

Finding 9. Four of the fixtures did not have an ex ante baseline wattage consumption because the implementer could not read the nameplate of the baseline fixture. For this evaluation, Navigant generated an average baseline wattage based on the other baseline fixtures replaced through the program.

Recommendation 4. Document a procedure for when baseline nameplate information is not legible.

Finding 10. Baseline fixture pictures did not offer enough clarity to verify exact fixture replacements, however Navigant believes the burden of collecting close-up fixture pictures outweighs the benefit. Navigant will continue to verify savings based on ComEd's current reporting method. Additionally, to the extent possible, Navigant will use Google Earth to verify baseline fixtures using the latitude and longitude co-ordinates provided by ComEd.