



ComEd Street Lighting Impact Evaluation Report

Energy Efficiency / Demand Response Plan:
Program Year 2018 (CY2018)
(1/1/2018-12/31/2018)

Presented to
ComEd

DRAFT

March 25, 2019

Prepared by:

Emily Merchant
Navigant Consulting

Rob Neumann
Navigant Consulting



Submitted to:

ComEd
Three Lincoln Centre
Oakbrook Terrace, IL 60181

Submitted by:

Navigant Consulting, Inc.
150 N. Riverside Plaza, Suite 2100
Chicago, IL 60606

Contact:

Randy Gunn, Managing
Director
312.583.5714
Randy.Gunn@Navigant.com

Jeff Erickson, Director
608.497.2322
Jeff.Erickson@Navigant.com

Rob Neumann, Associate Director
312.583.2176
Rob.Neumann@Navigant.com

Disclaimer: This report was prepared by Navigant Consulting, Inc. ("Navigant") for ComEd based upon information provided by ComEd and from other sources. Use of this report by any other party for whatever purpose should not, and does not, absolve such party from using due diligence in verifying the report's contents. Neither Navigant nor any of its subsidiaries or affiliates assumes any liability or duty of care to such parties, and hereby disclaims any such liability.

TABLE OF CONTENTS

| | |
|---|---|
| 1. Introduction | 1 |
| 2. Program Description | 1 |
| 3. Program Savings Detail | 1 |
| 4. Cumulative Persisting Annual Savings | 2 |
| 5. Program Savings by Measure | 4 |
| 6. Impact Analysis Findings and Recommendations | 5 |
| 6.1 Impact Parameter Estimates | 5 |
| 6.2 Other Impact Findings and Recommendations | 6 |
| 7. Appendix 1. Impact Analysis Methodology | 7 |
| 8. Appendix 2. Impact Analysis Detail | 7 |
| 9. Appendix 3. Total Resource Cost Detail | 9 |

LIST OF TABLES AND FIGURES

| | |
|---|---|
| Figure 2-1. Number of Measures Installed by Type | 1 |
| Figure 4-1. Cumulative Persisting Annual Savings | 4 |
| Figure 8-1. Ex Post Energy Savings for the Top 20 Municipalities | 8 |
| Figure 8-2. Number of Poles by Baseline Fixture Type | 8 |
| Figure 8-3. Number of Heads on Poles | 9 |
| Table 2-1. CY2018 Volumetric Findings Detail | 1 |
| Table 3-1. CY2018 Total Annual Incremental Electric Savings | 2 |
| Table 4-1. Cumulative Persisting Annual Savings (CPAS) – Electric | 3 |
| Table 5-1. CY2018 Energy Savings by Measure | 4 |
| Table 5-2. CY2018 Demand Savings by Measure | 5 |
| Table 6-1. Savings Parameters | 6 |
| Table 9-1. Total Resource Cost Savings Summary | 9 |

1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's CY2018 Street Lighting 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 appendix presents the impact analysis methodology. CY2018 covers January 1, 2018 through December 31, 2018.

2. PROGRAM DESCRIPTION

The LED Street Lighting Program, launched in 2014, encourages early retirement of ComEd-owned High-Pressure Sodium (HPS), Mercury Vapor (MV), and Metal Halide (MH) fixtures serving municipalities and replacing them with Light-Emitting Diode (LED) fixtures. The program had 324 participants in CY2018 and distributed 114,133 measures as shown in the following table and graph. The metrics in Table 2-1 and Figure 2-1 below are broken out by ComEd Street Lights and Public Sector Street Lights.

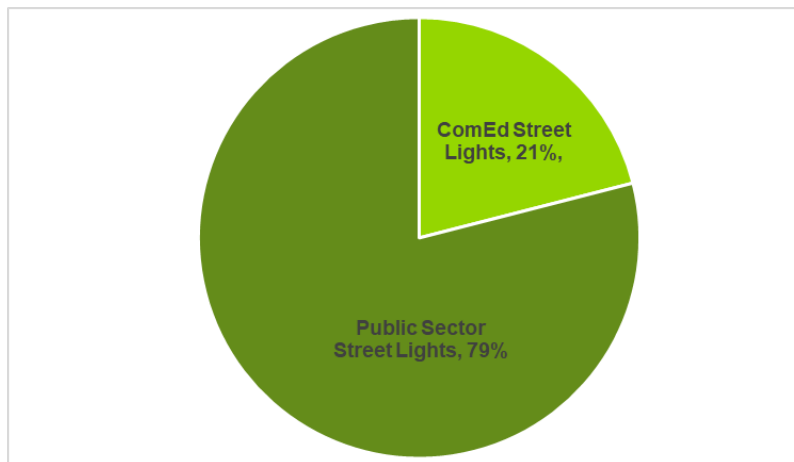
Table 2-1. CY2018 Volumetric Findings Detail

| Participation | ComEd Street Lights | Public Sector Street Lights | Total |
|--------------------|---------------------|-----------------------------|---------|
| Participants* | 77 | 247 | 324 |
| Total Measures | 23,963 | 90,170 | 114,133 |
| Number of Units | 23,963 | 90,374 | 114,337 |
| Number of Projects | 53 | 223 | 276 |

*The number of participants is greater than the number of projects because the number of participants was based on unique account numbers and often there were multiple account numbers associated with one project number.

Source: ComEd tracking data and Navigant team analysis.

Figure 2-1. Number of Measures Installed by Type



Source: ComEd tracking data and Navigant team analysis.

3. PROGRAM SAVINGS DETAIL

Table 3-1 summarizes the incremental energy and demand savings the Street Lighting Program achieved in CY2018. There were no reported summer peak demand savings for this program. Total verified net savings for CY2018 are 86,043,658 kWh. There were no gas savings from the program.

Table 3-1. CY2018 Total Annual Incremental Electric Savings

| Savings Category | Energy Savings (kWh) | Demand Savings (kW) | Summer Peak Demand Savings (kW)* |
|----------------------------------|----------------------|---------------------|----------------------------------|
| Electricity | | | |
| Ex Ante Gross Savings | 86,056,163 | 19,999.11 | N/A |
| Program Gross Realization Rate | 100% | 100% | N/A |
| Verified Gross Savings | 86,043,658 | 19,996.44 | N/A |
| Program Net-to-Gross Ratio (NTG) | 1.00 | 1.00 | N/A |
| Verified Net Savings | 86,043,658 | 19,996.44 | N/A |
| Converted from Gas* | | | |
| Ex Ante Gross Savings | N/A | NA | NA |
| Program Gross Realization Rate | N/A | NA | NA |
| Verified Gross Savings | N/A | NA | NA |
| Program Net-to-Gross Ratio (NTG) | N/A | NA | NA |
| Verified Net Savings | N/A | NA | NA |
| Total Electric Plus Gas | | | |
| Ex Ante Gross Savings | 86,056,163 | 19,999.11 | NA |
| Program Gross Realization Rate | 100% | 100% | NA |
| Verified Gross Savings | 86,043,658 | 19,996.44 | NA |
| Program Net-to-Gross Ratio (NTG) | 1.00 | 1.00 | NA |
| Verified Net Savings | 86,043,658 | 19,996.44 | NA |

* There were no reported gas or summer peak demand savings for this program.

NA = Not applicable

Note: Demand is defined as the difference in kW in the baseline and energy efficient period for the measures installed in CY2018.

Source: ComEd tracking data and Navigant team analysis.

4. CUMULATIVE PERSISTING ANNUAL SAVINGS

The measure-specific and total ex ante gross savings for the Street Lighting Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2018 are shown in the following tables and figure. The total CPAS across all measures is 86,043,658 kWh. The program reported zero CPAS equivalent of gas savings. The CPAS in Table 4-1 below decline after four years because the LED Streetlighting Work Paper dated January 2, 2019 states that street lighting measures with a MV fixture as the baseline must be reduced to an HPS fixture after four years. From year five to year 12, which is the effective useful life of street lights, the baseline is an HPS fixture.

Table 4-1. Cumulative Persisting Annual Savings (CPAS) – Electric

| End Use Type | Research Category | EUL | CY2018 Verified Gross Savings | NTG* | Lifetime Net Savings† | Verified Net kWh Savings | | | | | | | | | | |
|--|-----------------------------|------|-------------------------------|------|-----------------------|--------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|
| | | | | | | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | | |
| Lighting | ComEd Street Lights | 12.0 | 18,265,843 | 1.00 | 198,564,259 | 18,265,843 | 18,265,843 | 18,265,843 | 18,265,843 | 15,687,611 | 15,687,611 | 15,687,611 | 15,687,611 | 15,687,611 | | |
| Lighting | Public Sector Street Lights | 12.0 | 67,777,815 | 1.00 | 811,517,669 | 67,777,815 | 67,777,815 | 67,777,815 | 67,777,815 | 67,550,801 | 67,550,801 | 67,550,801 | 67,550,801 | 67,550,801 | | |
| CY2018 Program Total Electric CPAS | | | 86,043,658 | | 1,010,081,927 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 83,238,412 | 83,238,412 | 83,238,412 | 83,238,412 | 83,238,412 | | |
| CY2018 Program Expiring Electric Savings‡ | | | | | | | - | - | - | 2,805,246 | 2,805,246 | 2,805,246 | 2,805,246 | 2,805,246 | | |

| End Use Type | Research Category | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|--|-----------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Lighting | ComEd Street Lights | 15,687,611 | 15,687,611 | 15,687,611 | | | | | | | | | |
| Lighting | Public Sector Street Lights | 67,550,801 | 67,550,801 | 67,550,801 | | | | | | | | | |
| CY2018 Program Total Electric CPAS | | 83,238,412 | 83,238,412 | 83,238,412 | - | - | - | - | - | - | - | - | - |
| CY2018 Program Expiring Electric Savings‡ | | 2,805,246 | 2,805,246 | 2,805,246 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 | 86,043,658 |

Note: The green highlighted cell shows program total first year electric savings.

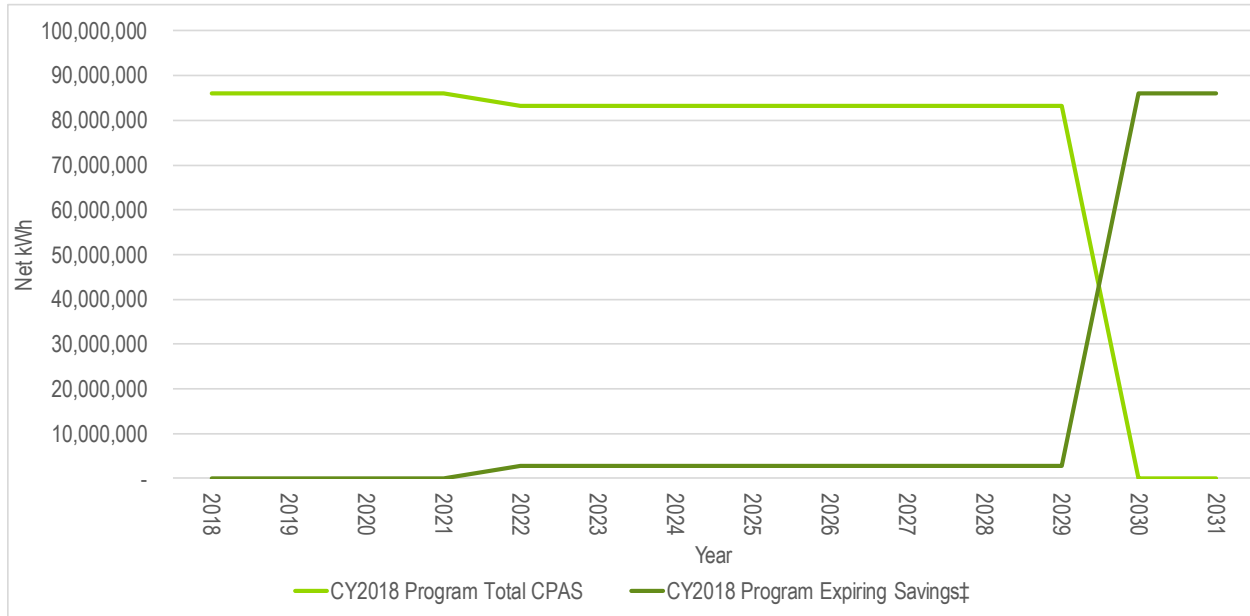
* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>.

† Lifetime savings are the sum of CPAS savings through the EUL.

‡ Expiring savings are equal to CPAS Y_{n-1} - CPAS N_y + Expiring Savings Y_{n-1}.

Source: Navigant analysis

Figure 4-1. Cumulative Persisting Annual Savings



‡ Expiring savings are equal to $CPAS_{Y_{n-1}} - CPAS_{Y_n} + Expiring\ Savings_{Y_{n-1}}$.
 Source: Navigant analysis

5. PROGRAM SAVINGS BY MEASURE

The program includes two measures: ComEd Street Lights and Public Sector Street Lights. The Public Sector Street Lights measure contributed the most energy and demand savings in CY2018. Both measures only had reported electric savings and demand savings, no peak demand savings or gas savings. Electric savings by public sector and not are shown in Table 5-1 and demand savings by measure in Table 5-2. Peak demand savings by measure and gas savings by measure are not documented in tables since there are no peak demand or gas savings. Street lights are typically controlled by a photocell and are almost always off during daylight hours, therefore this load occurs outside of the utility system peak and the coincident demand factor (CF) is zero.

Table 5-1. CY2018 Energy Savings by Measure

| Research Category | Ex Ante Gross Savings (kWh) | Verified Gross Realization Rate | Verified Gross Savings (kWh) | NTG* | Verified Net Savings (kWh) | Effective Useful Life |
|-----------------------------|-----------------------------|---------------------------------|------------------------------|-------------|----------------------------|-----------------------|
| ComEd Street Lights | 18,277,436 | 100% | 18,265,843 | 1.00 | 18,265,843 | 12.0 |
| Public Sector Street Lights | 67,778,727 | 100% | 67,777,815 | 1.00 | 67,777,815 | 12.0 |
| Total | 86,056,163 | 100% | 86,043,658 | 1.00 | 86,043,658 | 12.0 |

* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.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 5-2. CY2018 Demand Savings by Measure

| End Use Type | Research Category | Ex Ante Gross Demand Reduction (kW) | Verified Gross Realization Rate | Verified Gross Demand Reduction (kW) | NTG* | Verified Net Demand Reduction (kW) |
|--------------|-----------------------------|-------------------------------------|---------------------------------|--------------------------------------|-------------|------------------------------------|
| Lighting | ComEd Street Lights | 4,247.60 | 100% | 4,245.14 | 1.00 | 4,245.14 |
| Lighting | Public Sector Street Lights | 15,751.51 | 100% | 15,751.29 | 1.00 | 15,751.29 |
| Total | | 19,999.11 | 100% | 19,996.44 | 1.00 | 19,996.44 |

* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.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.

6. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

6.1 Impact Parameter Estimates

Energy and demand savings were estimated using the following formulas as specified in the LED Streetlighting Work Paper dated January 2, 2019:

Equation 1. Energy Savings

$$\text{kWh Savings} = [(Watts_{base} - Watts_{EE})/1000] * Hours * Quantity$$

Equation 2. Demand Savings

$$\text{kW Savings} = [(Watts_{base} - Watts_{EE})/1000] * Quantity$$

Equation 3. Peak Demand Savings

$$\text{kW Savings} = [(Watts_{base} - Watts_{EE})/1000] * CF * Quantity$$

Where:

$Watts_{base}$ = Baseline lighting fixture wattage

$Watts_{EE}$ = Energy efficient lighting fixture wattage

$Hours$ = Annual hours of use

$Quantity$ = Quantity of measures

CF = Coincidence factor

The lifetime energy and demand savings were estimated by multiplying the verified savings by the effective useful life (EUL) for each measure. The EUL of street lights is 12 years, in accordance with Version 7 of the Illinois Technical Reference Manual (TRM). According to the work paper, if the baseline is a MV fixture then the savings in the last eight years of the EUL must be adjusted to an equivalent HPS fixture. As a result, the savings in the first four years are higher than the last eight years of the EUL.

Table 6-1 below provides a summary of the savings parameters used in the ex post gross savings analysis, including the value, units, whether it was deemed or evaluated, and the source. The source for the analysis was Version 7 of the Illinois Technical Reference Manual (TRM).

Table 6-1. Savings Parameters

| Gross Savings Input Parameters | Value | Units | Deemed or Evaluated? | Source |
|--------------------------------|--------|------------|----------------------|---|
| Watts _{base} | Varies | Watts | Evaluated | Tracking database and LED Streetlighting Work Paper dated January 2, 2019 |
| Watts _{EE} | Varies | Watts | Evaluated | Tracking database |
| Quantity | Varies | # measures | Evaluated | Tracking database |
| Hours of Use | 4,303 | Hours/year | Deemed | LED Streetlighting Work Paper dated January 2, 2019 |
| CF | 0 | Unitless | Deemed | LED Streetlighting Work Paper dated January 2, 2019 |
| NTG | 1.00 | Unitless | Deemed | IL SAG Consensus* |
| Effective Useful Life (EUL) | 12 | Years | Deemed | LED Streetlighting Work Paper dated January 2, 2019 |

* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>.

6.2 Other Impact Findings and Recommendations

The evaluation team has developed several recommendations based on findings from the CY2018 evaluation, as follows:

Finding 1. The new lamp wattages in the savings calculator did not align with the tracking data for three of the four reviewed projects. Due to the limited project documentation available to Navigant to review, it was difficult to determine whether the tracking data was out of date or if the savings calculators were out of date.

Recommendation 1. Navigant recommends providing more transparency in the savings calculator so as to clearly indicate if it is the final version or a preliminary draft. In addition, Navigant recommends that the implementer only provide the final version of the documentation that aligns with the tracking data.

Finding 2. Navigant was unable to reproduce the Watts Reduced in the tracking data for one of the 276 projects. The Watts Reduced value was listed as 1,289 watts in the tracking data, but recalculating the watts reduced value based on the Existing System Wattage, New Lamp Wattage, and Number of Heads on Pole (i.e. quantity) resulted in a Watts Reduced value of 1,077 watts.

Recommendation 2. Navigant suggests that the implementer do a cross-check of the individual fixture wattages and fixture quantities to confirm that they multiply out to the same Watts Reduced value as listed in the tracking data.

Finding 3. The Existing Lamp Wattage, Existing System Wattage, New Lamp Wattage, and Number of Heads on Pole were missing for three of the Public Sector Street Lights projects. There was a value for the Watts Reduced in the tracking data and Navigant was able to reproduce the ex ante gross energy savings using the Watts Reduced value instead of the individual fixture wattages.

Recommendation 3. Navigant recommends that the implementer verify that there are no missing fixture wattage or quantity values in the tracking database.

Finding 4. At least three of the projects have incorrect Wattages entered in the database field for Existing Lamp Wattage. For one such instance the lamp wattages increase by one watt for each row of the project, which is likely due to an error resulting in dragging down the value in a cell to multiple rows. The Existing System Wattage, which is used in the savings calculation, was a consistent and correct wattage; therefore, this did not affect the savings.

Recommendation 4. Navigant recommends that the implementer do spot-checks of the fixture wattages to confirm that no erroneous values have been entered.

Finding 5. One of the projects had the same wattage for the Existing Lamp Wattage and the Existing System Wattage column, which is unusual. The Existing System Wattage is typically higher or lower to account for the ballast factor. This is likely an issue with human error during the data entry process.

Recommendation 5. Navigant recommends that the implementer ensure that the ballast factor is accounted for when appropriate.

Finding 6. The incentive paid does not appear to track with energy savings achieved. More specifically, the incentive dollars invested per kWh ranges from a low of approximately 20 cents per kWh up to over one dollar per kWh. Perhaps Navigant is missing a key driver behind this variation, but the same observation holds true when the incentive is normalized by Baseline Lamp Watts as well as Total Watts Reduced per project.

Recommendation 6. Navigant recommends that the implementer confirm incentives are applied consistently and per program design.

Finding 7. This program has winter peak demand savings that are not reported in the tracking system.

Recommendation 7. ComEd should track and report winter peak demand savings in the tracking system so Navigant can evaluate and report those demand savings.

Finding 8. Nearly all the errors found in Navigant's review of the program database are attributable to simple human error in data entry.

Recommendation 8. Navigant recommends that the implementer include some simple, yet automated data QC that notifies the user if inputs are in conflict, outside of a set range, or otherwise spurious due to a probable human error.

7. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

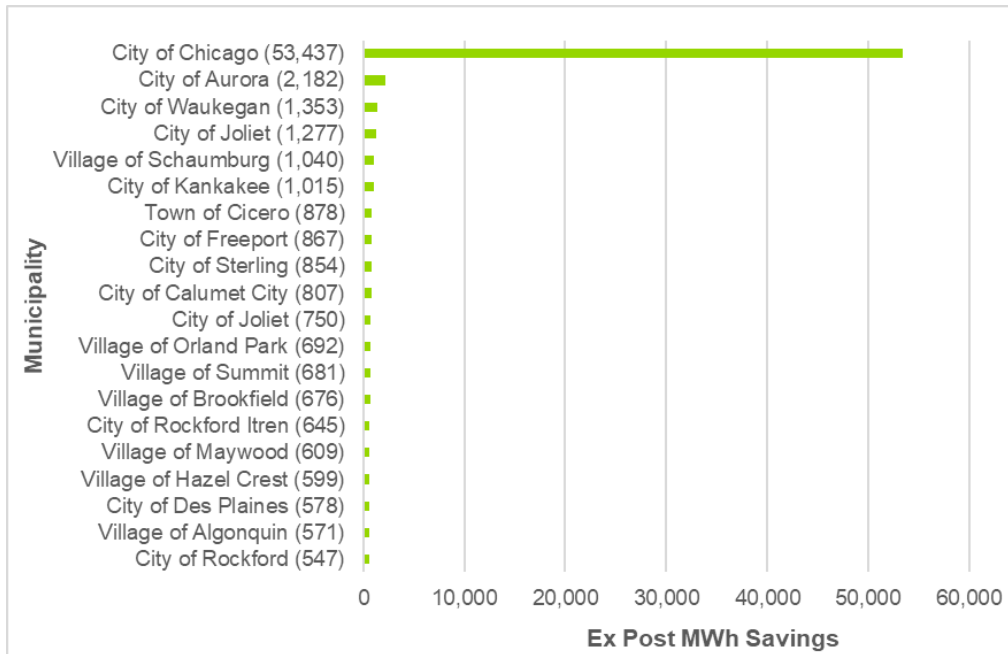
The evaluation team conducted an engineering review to verify the ex ante gross savings. This included a detailed review of the tracking data and a review of the savings calculators that were provided for four projects.

- **Savings Calculator Review:** Navigant compared the fixture quantities, existing lamp wattages, existing system wattages, new lamp wattages, and incentives in the savings calculators against the tracking data.
- **Tracking Data Review:** Navigant recalculated the savings based on the inputs included in the tracking data. Next, Navigant reviewed the tracking data for missing values, outliers, and reasonable values. Finally, Navigant compared the input assumptions in the tracking database against the LED Streetlighting Workpaper dated January 2, 2019.

8. APPENDIX 2. IMPACT ANALYSIS DETAIL

Figure 8-1, Figure 8-2, and Figure 8-3 below provide additional detail on the findings from the impact analysis. Figure 8-1 shows the ex post energy savings for the top 20 municipalities. A total of 106 municipalities participated in CY2018 and of those, the City of Chicago made up 63% of the savings.

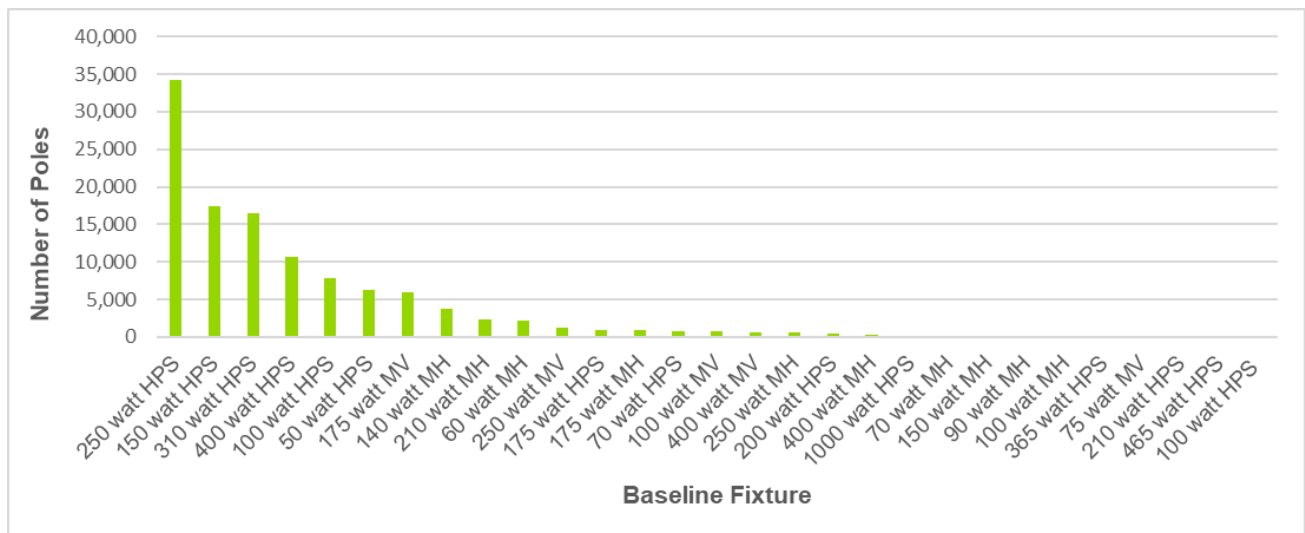
Figure 8-1. Ex Post Energy Savings for the Top 20 Municipalities



Source: ComEd tracking data and Navigant team analysis.

Figure 8-1 below shows that a majority of the projects had an HPS fixture as the baseline, with the most common being a 250 watt HPS.

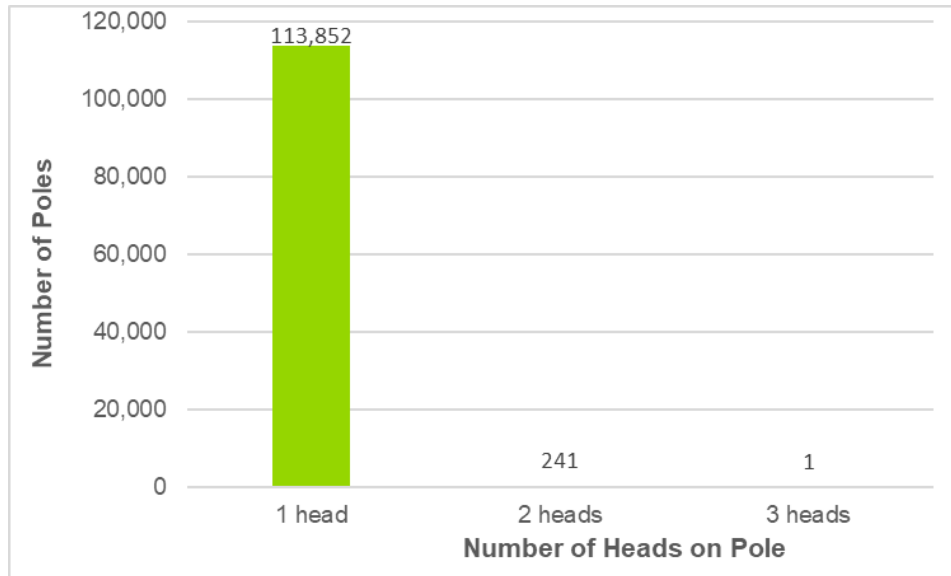
Figure 8-2. Number of Poles by Baseline Fixture Type



Source: ComEd tracking data and Navigant team analysis.

Figure 8-3 below shows that a majority of the poles incentivized in CY2018 had one head per pole, which exceeded the number of poles with two to three heads per pole by a significant margin.

Figure 8-3. Number of Heads on Poles



Source: ComEd tracking data and Navigant team analysis.

9. APPENDIX 3. TOTAL RESOURCE COST DETAIL

Table 9-1, below, shows the Total Resource Cost (TRC) table. It includes only the cost-effectiveness analysis inputs available at the time of finalizing this 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.

Table 9-1. Total Resource Cost Savings Summary

| End Use Type | Research Category | Units | Quantity | Effective Useful Life | Verified Gross Savings (kWh) | NTG* | Verified Net Savings (kWh) | Verified Net Demand Reduction (kW)† | Verified Gross Peak Demand Reduction (kW) |
|--------------|-----------------------------|-------|----------|-----------------------|------------------------------|------|----------------------------|-------------------------------------|---|
| Lighting | ComEd Street Lights | Lamp | 23,963 | 12.0 | 18,265,843 | 1.00 | 18,265,843 | 4,245.14 | NA |
| Lighting | Public Sector Street Lights | Lamp | 90,374 | 12.0 | 67,777,815 | 1.00 | 67,777,815 | 15,751.29 | NA |

* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>.

† There were no gross peak demand savings reported in CY2018.

Source: ComEd tracking data and Navigant team analysis.