NAVIGANT

ComEd Smart Building Operations Pilot Impact Evaluation Report

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

Presented to
ComEd

DRAFT

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ComEd Smart Building Operations Pilot Impact Evaluation Report

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1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's CY2018 Smart Building Operations Pilot 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.

2. PROGRAM DESCRIPTION

The Smart Building Operations Pilot Program had one participant in CY2018 and offered one measure. The program achieved energy savings by implementing a software tool on-site at the Shedd Aquarium in Chicago, Illinois. Navigant determined this pilot program is primarily a behavior-based program during communications with the implementer. There were not any individual measures claimed by the program and the energy savings were calculated using whole building information.

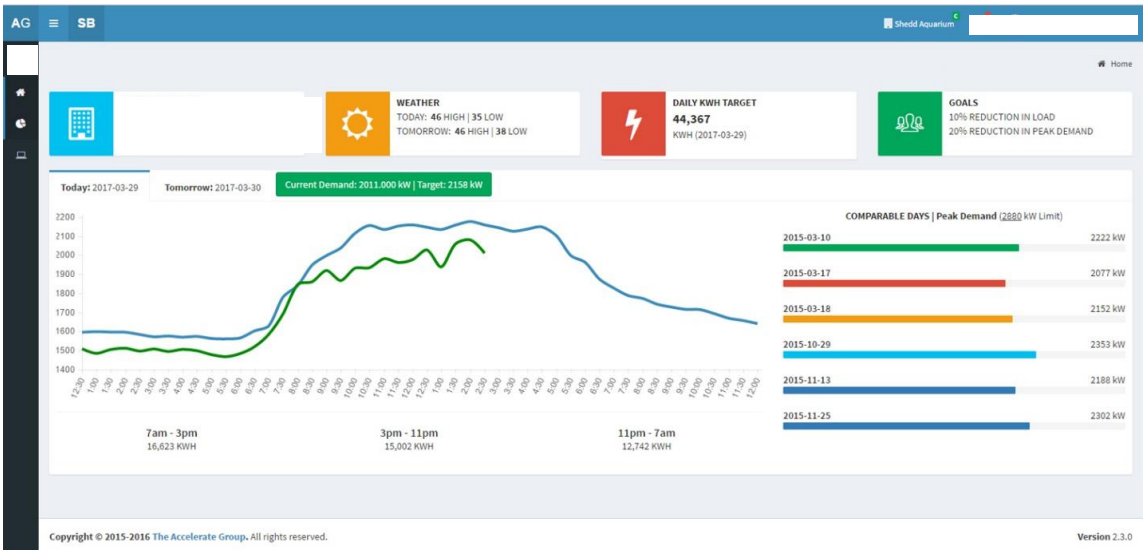
The installed software tool adjusted the baseline to encourage continuous energy savings, essentially encouraging saving more energy the following day. In addition, the building operators made several energy efficiency improvements after implementing the tool including: adjusting pump speeds, adjusting HVAC setpoints, installing lighting controls and lighting operations. The building operators had a list of operational activities they could implement to meet their ongoing energy saving goal.

The software analyzes energy usage data from smart meters and sub-meters to inform and encourage energy efficient building operations decisions[1]. The Smart Building Operations pilot program also coaches the building operators about conservation practices. Accelerate Energy Lab, LLC, a subsidiary of The Accelerate Group implemented the pilot at the Shedd Aquarium. Per the Accelerate Group's Scope of Work[2], the pilot included the following:

1. The implementer provided an operator-facing dashboard (shown in Figure 2-1) to Shedd Aquarium that shows current energy consumption compared to comparable days based on degree hours. This information encouraged the building operators to operate the site more efficiently than historical operation.
2. The dashboard displayed the feeds from on-site meters that provided real-time feedback for building operators and allowed them to track progress over time, as seen in Figure 2-1.
3. The implementer provided the building operators with support for the smart buildings software platform, including the previously-mentioned dashboard, an approved baseline, hourly and daily kWh and peak demand targets, and calculation of performance. The implementer also provided the building operators with consultation on the deployment of real-time metering hardware installation.
4. The implementer compiled baseline data, performance data, and other information requested by ComEd to provide proof of energy savings due to the installation and use of their software.

[1] Smart Buildings Operations Pilot – Scope of work October 2018 provided by implementer
[2] Scope of Work – Smart Buildings Software_Shedd Aquarium 9-12-18.pdf provided by implementer

Figure 2-1. Screenshot of Operator Facing Dashboard



3. Cumulative Persisting Annual Savings

The measure-specific and total ex ante gross savings for the Smart Building Operations Pilot Program and the cumulative persisting annual savings (CPAS) for the measure installed in CY2018 are shown in the following table and figure. The total CPAS across all measures is 895,325 kWh. There were no calculated gas savings.

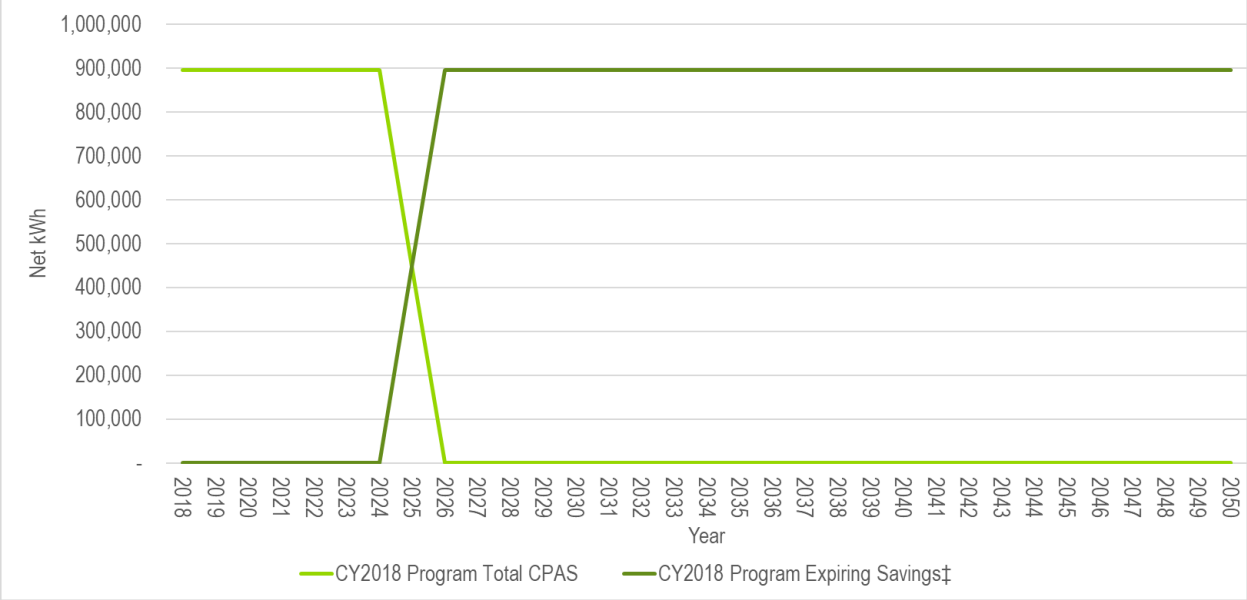
Table 3-1. Cumulative Persisting Annual Savings (CPAS)

End Use Type	Research Category	EUL	Verified Gross Savings	NTG*	Lifetime Net Savings†	Verified Net kWh Savings 2018	2019	2020	2021	2022	2023	2024	2025
Custom	Software Tool	7.5	895,325	1.00	6,714,938	895,325	895,325	895,325	895,325	895,325	895,325	895,325	447,663
CY2018 Program Total Electric CPAS			**895,325**		**6,714,938**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**447,663**
CY2018 Program Expiring Electric Savings‡							-	-	-	-	-	-	**447,663**

End Use Type	Research Category	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Custom	Software Tool													
CY2018 Program Total Electric CPAS		-	-	-	-	-	-	-	-	-	-	-	-	-
CY2018 Program Expiring Electric Savings‡		**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**	**895,325**

Note: The green highlighted cell shows program total first year electric savings.
* A deemed value. Source: Memo, March 2019, forthcoming, 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 Yn-1 - CPAS Yn + Expiring Savings Yn-1.
Source: Navigant analysis

Figure 3-1. Cumulative Persisting Annual Savings



‡ Expiring savings are equal to CPAS Yn-1 - CPAS Yn + Expiring Savings Yn-1.
Source: Navigant analysis

4. Program Savings Detail

Table 4-1 summarizes the incremental energy and demand savings the Smart Buildings Operations Pilot Program achieved in CY2018. The implementation contractor did not report demand or peak demand savings. The evaluation determined demand savings using the PJM Interconnect weighted temperature-humidity index (WTHI) for the ComEd service territory.

Table 4-1. CY2018 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Summer Peak Demand Savings (kW)
Electricity			
Ex Ante Gross Savings	916,261	NA	NA
Program Gross Realization Rate	98%	NA	NA
Verified Gross Savings	895,325	NA	99.40
Program Net-to-Gross Ratio (NTG)	1.00	NA	1.00
Verified Net Savings	895,325	NA	99.40
Converted from Gas*			
Ex Ante Gross Savings	0	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	0	NA	NA
Program Net-to-Gross Ratio (NTG)	1.00	NA	NA
Verified Net Savings	0	NA	NA
Total Electric Plus Gas			
Ex Ante Gross Savings	916,261	NA	NA
Program Gross Realization Rate	98%	NA	NA
Verified Gross Savings	895,325	NA	99.40
Program Net-to-Gross Ratio (NTG)	1.00	NA	1.00
Verified Net Savings	895,325	NA	99.40

* Gas savings converted to kWh by multiplying therms * 29.31 (which is based on 100,000 Btu/therm and 3,412 Btu/kWh).
NA = Not Available
Note: The coincident Summer Peak period is defined as 1:00-5:00 PM Central Prevailing Time on non-holiday weekdays, June through August.
Source: ComEd tracking data and Navigant team analysis.

5. Program Savings by Measure

The evaluation team analyzed savings for the program at a site level and did not calculate measure-level savings.

6. Impact Analysis Findings and Recommendations

6.1 Impact Parameter Estimates

The program does not have relevant impact parameters.

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. There was a discrepancy in the baseline hours and temperatures used. The implementer used the post condition's historical temperature and hour data, whereas

Navigant used TMY3 data as the baseline. The post condition had significantly more hours during the hotter temperature ranges as compared to the TMY3 data set.

Recommendation 1. Navigant recommends the implementer ensure consistency between the temperature data used in savings calculations. Typically, TMY3 data is considered the industry standard because it represents averaged conditions that make up a typical year.

Finding 2. The flow of needed information from the implementer to evaluator was not smooth. After several data requests, Navigant still had not received detailed documentation that provides the implementer's calculation methodology or project description.

Recommendation 2. Navigant recommends the implementer ensure that all relevant documents are submitted to Navigant upfront to ensure a timely, informed and efficient evaluation.

Finding 3. There was missing data for dates 5/11/18-5/28/18 without associated explanations.

Recommendation 3. Navigant recommends the implementer document sources and missing values in all submitted data sets so that evaluators can validate the savings methods.

Finding 4. This pilot program reduced overall site usage by approximately five percent with the use of low-cost, no-cost measures.

Finding 5. This pilot program achieved maximum savings after a year of implementation. The maximum kWh savings was during the post period from October 1, 2016 to October 1, 2017 (1,166,021 kWh). The kWh savings from October 1, 2017 to October 1, 2018 is 824,085 which is 341,936 kWh less than the previous year.

7. Appendix 1. Impact Analysis Methodology

This section discusses the impact analysis methodology Navigant used for the Smart Building Operations Pilot Program. The program implemented the project beginning June 1, 2016. All data from June 1, 2016 to October 1, 2018 are considered post-installation.

7.1.1 Data Acquisition

The Accelerate Energy Lab provided energy consumption data from the site from January 1, 2015 through October 2018. The implementer provided associated temperature data during the pre-installation period on a half-hour basis. Navigant acquired analogous post-installation weather data from the National Oceanic and Atmospheric Administration (NOAA).

The pre-period timeframe for both temperature and energy consumption was from January 1, 2015 to January 1, 2016. Navigant reviewed all available data following installation to estimate annual energy savings, i.e. June 2016 through October 1, 2018. There was a section of data missing energy consumption data from 5/11/18 until 5/28/18 which was removed from analysis. The implementer cited data recording failure for the missing data.

NOAA Data

The pre-period data provided by the implementer contained the corresponding temperature in degrees Fahrenheit for each corresponding timestamp. Navigant verified that these temperatures aligned with National Oceanic and Atmospheric Administration (NOAA) data from Chicago O'Hare International Airport.

The provided post-period data did not contain the temperature information at the Shedd Aquarium site. Navigant acquired supplementary, post-installation, hourly NOAA data for the Chicago O'Hare station.

Typical Meteorological Year Data
Because weather changes from year-to-year and affects the savings of weather-dependent measures, evaluators normalize savings with "typical" weather data. Navigant acquired typical meteorological year (TMY3[3]) weather data from the National Renewable Energy Laboratory (NREL) to estimate average energy consumption of the site for a typical year. Navigant utilized actual temperature data and TMY3 data to calculate the energy savings in a typical year from the pilot.

TMY3 data contains one year of hourly data that best represents weather conditions for a certain location over a multiyear period. For the impact analysis, Navigant used TMY3 data to estimate the number of hours a year in which the ambient temperature is within a certain range. Navigant used TMY3 data for the Chicago O'Hare weather station, to be consistent with the actual temperatures correlated with energy consumption data.

7.1.2 Analysis and Persistence

Analysis
The goal of the evaluation was to estimate kWh savings at the site. Our methodology correlated energy use with actual ambient outdoor temperatures then applied these correlations to a "typical" temperature data set. Navigant paired the hourly NOAA temperature data with the corresponding hourly power consumption values from the site. Energy savings are often driven by temperature, so site energy savings were estimated at different temperature increments. Navigant designated temperature bins in five-degree increments from -10 to 100 degrees Fahrenheit and counted the number of hours in each temperature bin in the TMY3 data.

Navigant averaged the pre-period site kW consumption data for all hours in each temperature bin. This same process was repeated for the post-period site consumption data. Navigant multiplied the average kW savings for each temperature range with its respective TMY3 hours to calculate typical annual savings in kWh.

Table 7-1. Sample of Temperature Bins and the Corresponding Data from Table of Calculations

Temp Bins	TMY Hours	2015 Power Use (Pre) (kWh)	06/01/16 - 10/01/18 Power Use (Post) (kWh)	Difference (Pre-Post) (kWh)	kWh Savings
30	364	1,615	1,571	45	16,302
35	404	1,643	1,611	33	13,148
40	296	1,682	1,652	30	8,857
45	235	1,700	1,656	44	10,415
50	352	1,756	1,678	77	27,261
55	354	1,825	1,723	102	36,050

Navigant calculated kW savings by taking the difference between the pre and post power use for each respective temperature bin. Multiplying this difference by the TMY hour count resulted in the total kWh savings over the whole year since the TMY3 hours are representative of the whole year.

[3] TMY3 data are a compilation of actual weather data between 1990 and 2006 that have been assembled into a full year that represents typical temperatures, precipitation and solar radiation. TMY3 data replace TMY2 data that were based on older weather data.

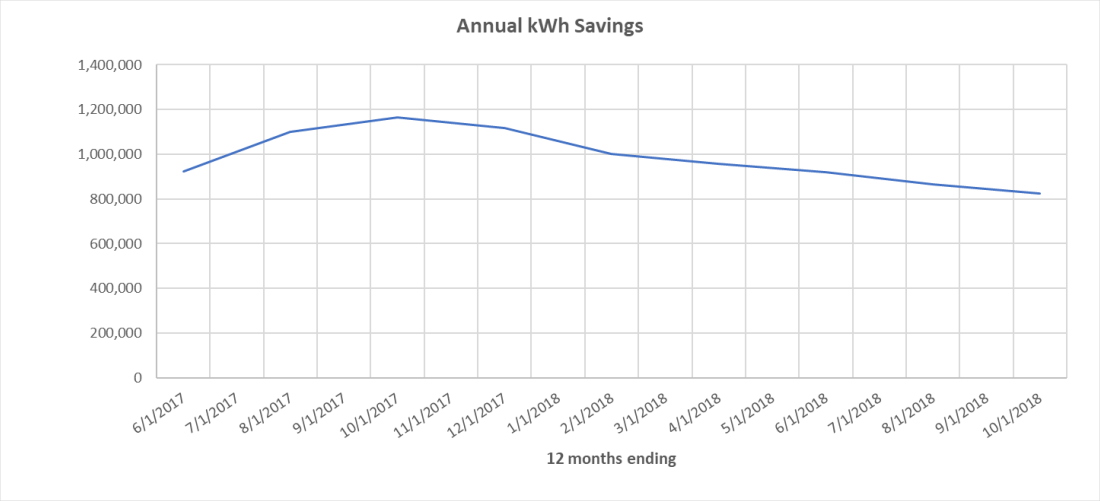
Savings Persistence
Navigant investigated annual savings for multiple post periods and observed persistence of savings over time. The pre-period remains the same while the post period is shifted to gain an understanding of savings over time. **Error! Reference source not found.** shows savings increasing after the initial 12-month post-installation period (ending June 1, 2017) since the site operators more effectively implement energy savings during the first four months of the project and sustained those savings levels for the first year.

After this initial improvement, though, savings begin to decrease. There are various possible reasons for this reduction. We list a few possibilities:

- Discontinuation of conservation actions that are detrimental to operations, in some way
- Building operator fatigue
- Constrained building operator resources
- Building operator turn-over

Savings persistence is a significant concern for a program such as Smart Building Operations Pilot that relies on behavior modification.

Figure 7-1. Annual kWh Savings



Navigant used 28 months, from June 1, 2016 to October 1, 2018, as post data since the implementer did not provide the pre and post used in their calculations. The annual energy savings during this period were **895,325 kWh**.

Navigant estimated site energy usage during occupied and unoccupied hours based on the hours of operation at Shedd Aquarium.

Figure 7-2. Hours of Operation for Shedd Aquarium

8. Appendix 2. Impact Analysis Detail

The following tables show the results of the impact analysis methodology outlined in the Analysis and Persistence section. The kWh energy savings were calculated for both occupied hours and unoccupied hours in the year and summed to determine the total kWh savings for the year. The power use columns in green are the average power consumption values for each temperature range. The kWh savings are calculated by multiplying the TMY Hours by the Difference (Pre-Post kW). The total kWh savings is the sum of the kWh savings at each temperature range.

Table 8-1. Energy Savings During Unoccupied Hours (375,125 kWh)

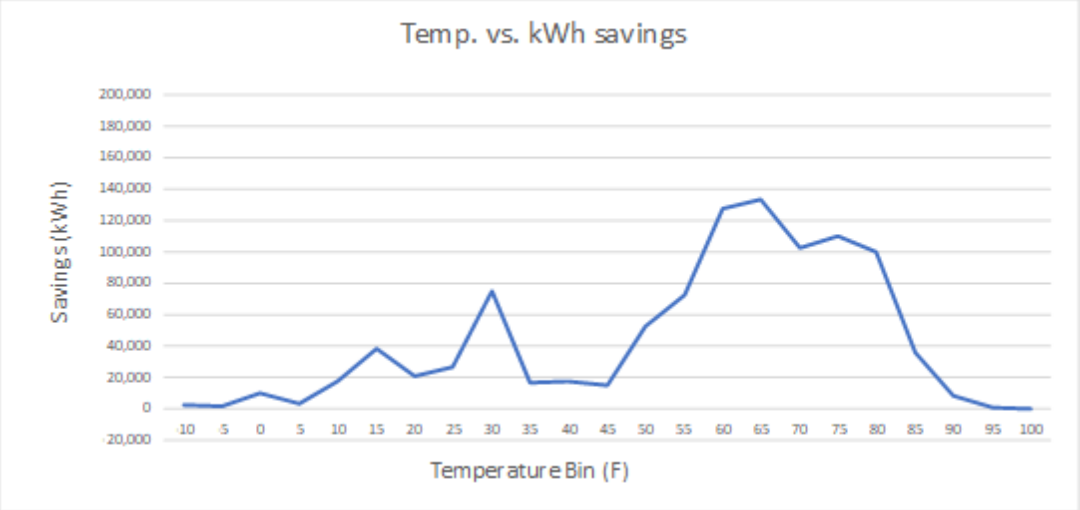
Temp Bins (bottom)	TMY Hours	2015 Power Use (Pre)	06/01/16 - 10/01/18 Power Use (Post)	Difference (Pre-Post)	kWh Savings
-10	16	1,821	1,652	168	2,695
-5	43	1,791	1,729	62	2,648
0	41	1,752	1,638	114	4,685
5	47	1,685	1,631	54	2,533
10	79	1,670	1,644	26	2,057
15	219	1,648	1,569	79	17,227
20	165	1,635	1,547	88	14,567
25	211	1,622	1,556	66	13,821
30	364	1,615	1,571	45	16,302
35	404	1,643	1,611	33	13,148
40	296	1,682	1,652	30	8,857
45	235	1,700	1,656	44	10,415
50	352	1,756	1,678	77	27,261
55	354	1,825	1,723	102	36,050
60	438	1,895	1,751	144	63,050
65	387	2,018	1,826	192	74,232
70	182	2,091	1,919	171	31,185
75	139	2,161	1,972	189	26,205
80	42	2,237	2,043	194	8,151
85	1	2,118	2,079	38	38
90	-	-	2,142	-2142	-
95	-	-	-	-	-
100	-	-	-	-	-
Total					**375,125**

Table 8-2. Energy Savings During Occupied Hours (520,200 kWh)

Temp Bins	TMY Hours	2015 Power Use (Pre) (kWh)	06/01/16 - 10/01/18 Power Use (Post) (kWh)	Difference (Pre-Post) (kWh)	kWh Savings
-10	9	2,022	2,053	-31	-278
-5	11	2,043	2,013	30	327
0	27	2,069	1,997	72	1,949
5	61	2,011	1,965	46	2,821
10	78	2,027	1,927	100	7,809
15	163	2,011	1,931	80	13,046
20	155	1,975	1,903	72	11,110
25	191	1,997	1,925	72	13,775
30	395	2,002	1,892	110	43,308
35	461	2,003	1,951	52	24,080
40	299	2,027	1,972	56	16,654
45	173	2,042	1,996	46	7,929
50	289	2,080	1,990	90	25,957
55	323	2,111	2,014	97	31,183
60	410	2,198	2,102	96	39,311
65	380	2,310	2,191	119	45,253
70	356	2,439	2,287	152	54,024
75	392	2,542	2,364	177	69,533
80	386	2,627	2,434	193	74,348
85	159	2,690	2,503	187	29,763
90	26	2,794	2,486	307	7,987
95	1	2,908	2,597	311	311
100	-	-	-	-	-
Total					**520,200**

Summing up the energy savings from the unoccupied hours and the occupied hours gives total savings of **895,325 kWh**. Most of the energy savings occurred during the temperature range 50 to 90 degrees Fahrenheit.

Figure 8-1. Temperature vs. kWh Savings



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. Effective useful life (EUL) information in this table is subject to change and is not final. The Smart Building Operations Pilot Program is similar to a retrocommisioning project which has program life of 7.5 years.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Custom	Software Tool	Project	1	7.5	916,261	NA	895,325	99.4

† EUL is a combination of technical measure life and persistence.
Source: ComEd tracking data and Navigant team analysis.