

ComEd Data Centers Efficiency Program Impact Evaluation Report

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

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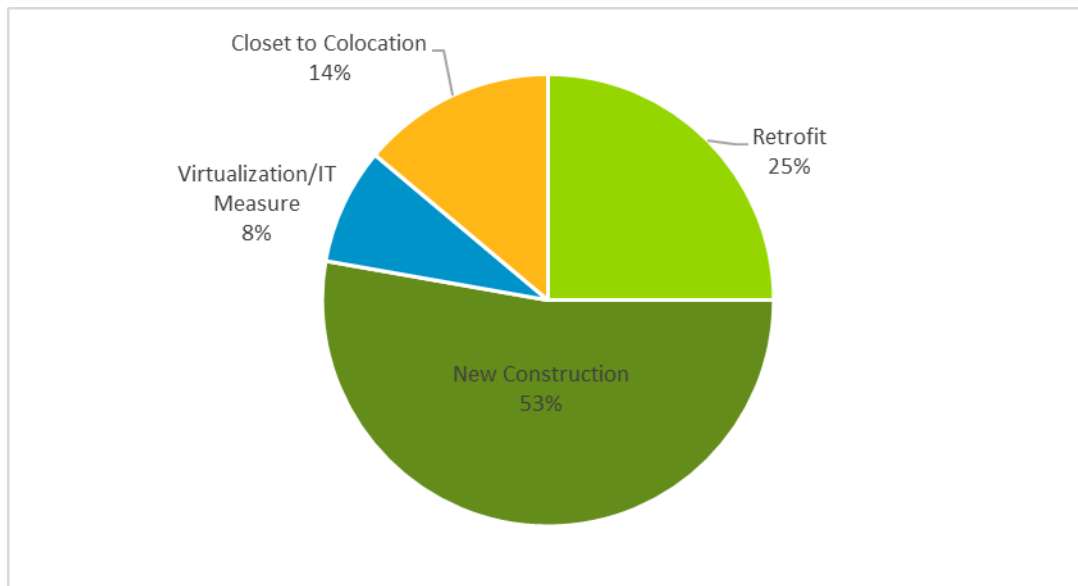
1. INTRODUCTION

This report presents ComEd’s CY2018 Data Centers Efficiency Program impact evaluation results. 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 program had 32 participants in CY2018. As shown in Figure 2-1, over 50% of the projects are data center new construction projects. The retrofit projects ranged from HVAC upgrades, uninterruptible power supply (UPS) replacements, chiller replacements, computer room air-conditioning (CRAC) replacements and HVAC Optimization. There are four closet-to-colocation and two virtualization projects in CY2018.

Figure 2-1. Distribution of Projects by Measure Type



3. PROGRAM SAVINGS DETAIL

Table 3-1 summarizes the incremental energy and demand savings the Data Centers Efficiency Program achieved in CY2018. The program did not achieve any gas savings for CY2018.

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	30,745,276	N/A	3,510
Program Gross Realization Rate	0.83	N/A	1.53
Verified Gross Savings	25,473,522	N/A	5
Program Net-to-Gross Ratio (NTG)	0.68	N/A	0.68
Verified Net Savings	17,321,995	N/A	4
Converted from Gas*			
Ex Ante Gross Savings	0	NA	NA
Program Gross Realization Rate	0	NA	NA
Verified Gross Savings	0	NA	NA
Program Net-to-Gross Ratio (NTG)	0	NA	NA
Verified Net Savings	0	NA	NA
Total Electric Plus Gas			
Ex Ante Gross Savings	30,745,276	N/A	3,510
Program Gross Realization Rate	0.83	N/A	1.53
Verified Gross Savings	25,473,522	N/A	5
Program Net-to-Gross Ratio (NTG)	0.68	N/A	0.68
Verified Net Savings	17,321,995	N/A	4

*Gas savings converted to kWh by multiplying therms * 29.31 (which is based on 100,000 Btu/therm and 3,412 Btu/kWh).

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.

4. CUMULATIVE PERSISTING ANNUAL SAVINGS

The measure-specific and total ex ante gross savings for the Data Centers Efficiency 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 17,321,995 kWh. The Data Centers Program did not achieve any gas savings so the total CPAS savings for this program is listed in Table 4-1.

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

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		
Data Centers	Retrofit	17.4	3,507,285	0.68	41,440,218	2,384,954	2,384,954	2,384,954	2,384,954	2,384,954	2,384,954	2,384,954	2,384,954	2,384,954	
Data Centers	New Construction	17.0	19,174,542	0.68	221,975,227	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	
Data Centers	Virtualization/IT Measure	5.4	1,862,902	0.68	6,806,969	1,266,773	1,266,773	1,266,773	1,266,773	1,266,773	236,551	236,551	0	0	
Data Centers	Closest to Colocation	15.0	928,793	0.68	9,473,688	631,579	631,579	631,579	631,579	631,579	631,579	631,579	631,579	631,579	
CY2018 Program Total Electric CPAS			25,473,522		279,696,102	17,321,995	17,321,995	17,321,995	17,321,995	17,321,995	16,291,773	16,291,773	16,055,222		
CY2018 Program Expiring Electric Savings‡							-	-	-	-	1,030,222	1,030,222	1,266,773		

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Data Centers	Retrofit	2,384,954	2,308,982	2,308,982	2,308,982	2,308,982	2,291,773	1,212,595	1,212,595	1,212,595	1,212,595	1,212,595	0	0
Data Centers	New Construction	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	13,038,688	5,278,980	5,278,980	5,278,980	5,278,980	5,278,980	0	0
Data Centers	Virtualization/IT Measure	0	0	0	0	0	0	0	0	0	0	0	0	0
Data Centers	Closest to Colocation	631,579	631,579	631,579	631,579	631,579	631,579	0	0	0	0	0	0	0
CY2018 Program Total Electric CPAS		16,055,222	15,979,250	15,979,250	15,979,250	15,979,250	15,962,041	6,491,576	6,491,576	6,491,576	6,491,576	6,491,576	-	-
CY2018 Program Expiring Electric Savings‡		1,266,773	1,342,745	1,342,745	1,342,745	1,342,745	1,359,954	10,830,419	10,830,419	10,830,419	10,830,419	10,830,419	17,321,995	17,321,995

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

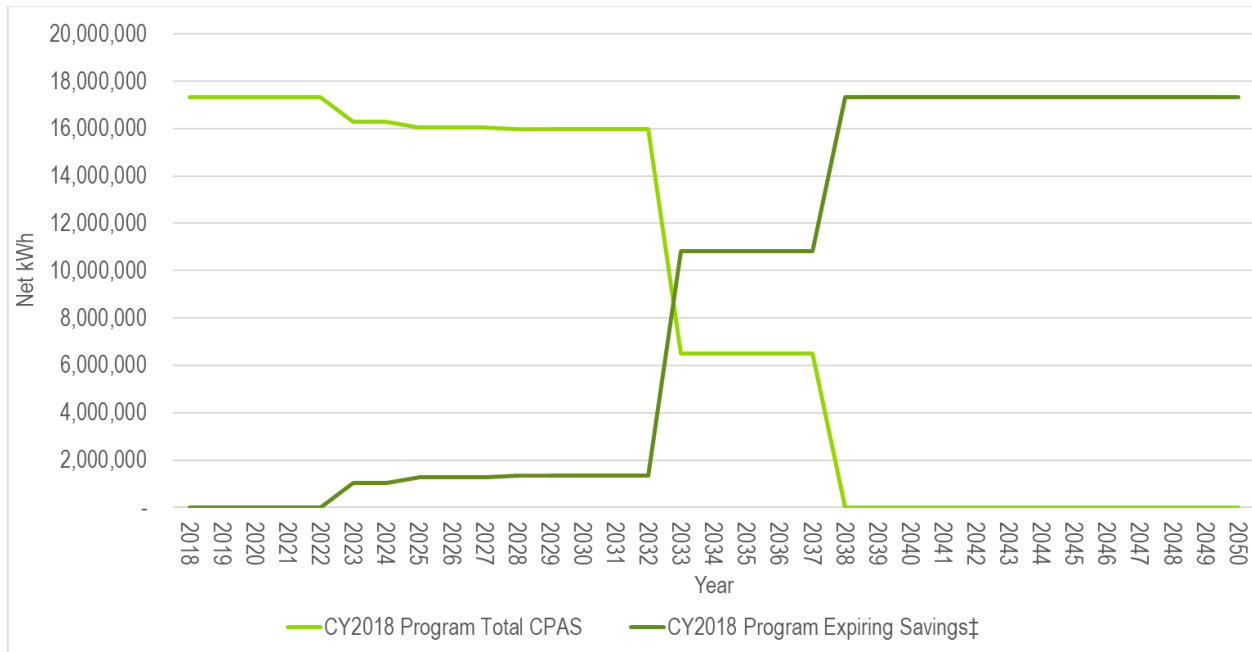
* A deemed value. Source: ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.xlsx, which is to be found on the IL SAG web site here: <http://ilsag.info/net-to-gross-framework.html>.

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

‡ Expiring savings are equal to CPAS Yn-1 - CPAS Yn + Expiring Savings Yn-1.

Source: Navigant analysis

Figure 4-1. Total Cumulative Persisting Annual Savings



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

5. PROGRAM SAVINGS BY MEASURE

The evaluation analyzed savings for the Data Centers Efficiency Program at a strata level rather than the measure level or installation type. For more information about strata- and site-level savings see Appendix 2. The tables below show savings by type of installation, but reflect the gross realization rate for the program, as the evaluation did not calculate a measure-level or installation type-level gross realization rate. The evaluation did not calculate gas savings.

Table 5-1. CY2018 Energy Savings by Measure

End Use Type	Research Category	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTG *	Verified Net Savings (kWh)	Effective Useful Life
Data Center	Retrofit	4,233,119	0.83	3,507,285	0.68	2,384,954	17.4
Data Center	New Construction	23,142,720	0.83	19,174,542	0.68	13,038,688	17.0
Data Center	Virtualization/IT Measure	2,248,430	0.83	1,862,902	0.68	1,266,773	5.4
Data Center	Closet to Colocation	1,121,007	0.83	928,793	0.68	631,579	15.0
Total		30,745,276	0.83	25,473,522	0.68	17,321,995	16.1

* 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 Summer Peak Demand Savings by Measure

End Use Type	Research Category	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (kW)	NTG*	Verified Net Peak Demand Reduction (kW)
Data Center	Retrofit	649	1.53	990	0.68	673
Data Center	New Construction	2,238	1.53	3,417	0.68	2,323
Data Center	Virtualization/IT Measure	480	1.53	733	0.68	498
Data Center	Closet to Colocation	143	1.53	219	0.68	149
Total		3,510	1.53	5,359	0.68	3,644

* 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

The evaluation team performed engineering calculations to derive evaluated gross energy and demand savings based on data collected during the on-site M&V visit or the desk review process. The savings are site specific and therefore require site-specific calculators and algorithms in conjunction with data collected from the site. The evaluation team used the data obtained during the M&V efforts to verify measure installation, determine installed measure characteristics, assess operating hours and relevant modes of operation, identify the characteristics of the replaced equipment, where possible, support the selection of baseline conditions and perform ex post savings calculations. Each site-specific evaluation used peak kW savings calculation methodology consistent with PJM summer peak demand requirements¹ to calculate the peak kW reduction. The lifetime energy and demand savings are estimated by multiplying the verified savings by the effective useful life for each measure.

The EM&V team conducted research to validate the non-deemed parameters for the Data Centers Program that were not specified in the Illinois Technical Reference Manual (IL TRM). The results are shown in Table 6-1.

Table 6-1. Verified Gross Savings Parameters

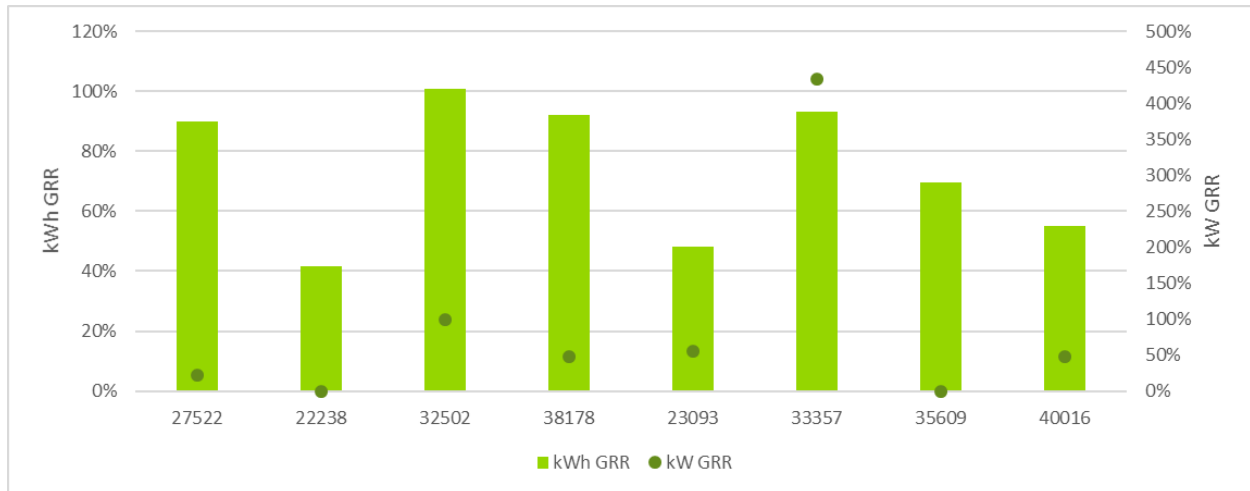
Gross Savings Input Parameters	Value	Deemed * or Evaluated?
Gross Energy Savings Realization Rate	0.83	Evaluated
Gross Peak Demand Savings Realization Rate	1.53	Evaluated
NTG Ratio	0.68	Deemed*
Net Energy Savings (kWh)	17,321,995	Evaluated
Net Peak Demand Savings (kW)	3,644	Evaluated

† 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>.

¹ PJM defines the coincident summer peak period as 1:00-5:00 PM Central Prevailing Time on non-holiday weekdays, during the months of June through August.

Figure 6-1 shows a comparison of the energy and demand realization rates for every site. The CY2018 energy savings realization rate results ranged from 0.42 to 1.01, which resulted in a program level realization rate of 0.83. The energy gross realization rate was at or above 1.0 for only one of the eight projects examined. For four out of the eight projects, the energy gross realization rates were within 10% of one for the energy savings. The demand savings realization rates for the eight projects in the gross sample ranged from 0.0 to 4.33, resulting in a program level realization rate of 1.53.

Figure 6-1. Energy and Demand Realization Rates



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 are a few projects (22238, 23093 and 40016) where the ex ante savings are overestimated due to calculation errors or have issues surrounding the assumptions used in the ex ante calculations.

Recommendation 1: The evaluation team recommends using additional quality control procedures to identify the deficiencies in the ex ante calculations. Whenever possible, the savings should be validated using an alternate approach to double check the savings.

Finding 2: There are two projects where the Power Factor (PF) values used in the ex ante savings calculations are incorrect.

Recommendation 2: Evaluation team recommends that the program use a PF of 0.98 for equipment controlled with Variable Speed Drives (VSDs) and a PF of 0.92 be used for CRAC units that are equipped with Electronically Commutated Motors ECMs in cases where nameplate data or measurement data are not available.

Finding 3: The evaluation found that the implementation team calculated demand savings as average demand rather than peak demand for multiple projects.

Recommendation 3: Peak demand kW for weather-dependent measures should be calculated using peak hours consistent with PJM's definition of coincident summer peak period (1:00-5:00 P.M. Central Prevailing Time on non-holiday weekdays, during the months of June through August).

Finding 4: Evaluation found that the baseline for new construction projects was not properly updated.

Recommendation 4: The evaluation team recommends that the implementers should develop a baseline guidance document for new construction projects that is consistent with the 2016 PGE& Data Center Baseline and Measurement and Verification (M&V) Guidelines document².

Finding 5: Evaluation found that closet-to-colocation projects did not track the colocation data center projects that closet servers move to properly.

Recommendation 5: To ensure that grid savings are not double counted, colocation data centers which have closet-to-colocation projects moving into them must be tracked. This may eliminate the possibility of over counting savings for those colocation data centers which might have already received incentives or may receive future incentives based on the increased loads from closet projects. If a colocation is receiving phased incentives based on critical loads, the closet-to-colocation baseline Power Usage Effectiveness (PUE) should be equal to the colocation project baseline. The colocation can then receive incentives as a result of its PUE improvement over baseline.

7. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

7.1 Gross Impact (M&V) Sample

Consistent with the evaluation plan, the evaluation team used a stratified random sampling approach to select the gross impact sample of eight projects. The evaluation team sorted projects based upon the level of ex ante kWh savings and placed the projects in three strata.

Table 7-1 provides a profile of the gross impact M&V sample for the Data Centers Efficiency Program in comparison with the program population. Shown below is the resulting sample that was drawn that consists of eight projects. These projects make up approximately 15 million kWh, which represents 50% of the ex ante impact claim for the program population. Also shown are the ex ante-based kWh sample weights for each of the three strata.

Table 7-1. CY2018 Gross Impact Sample by Strata

Sampling Strata	Population Summary			Sample		
	Number of Tracking Records (N)	Ex ante kWh Impact Claimed	kWh Weights	Number of Tracking Records (n)	Ex ante kWh	Sampled % of Population kWh
1	2	8,016,703	0.26	2	8,016,703	100%
2	6	12,470,551	0.41	3	6,285,087	50%
3	24	10,258,022	0.33	3	1,116,925	11%
CY2018 Total	32	30,745,276		8	15,418,715	50%

Source: Navigant

² http://www.calmac.org/publications/2016_PG%26E_Data_Center_Baseline_and_M%26V_Guidelines.pdf

7.2 Roll-up of Savings

There are two basic statistical methods for combining individual gross realization rates from the sample projects into an estimate of verified gross kWh savings for the population when stratified random sampling. These two methods are referred to as “separate” and “combined” ratio estimation.³ In the case of a separate ratio estimator, a separate gross kWh savings realization rate is calculated for each stratum and then combined. In the case of a combined ratio estimator, evaluation completes a single gross kWh savings realization rate calculation without first calculating separate gross realization rates by stratum.

The evaluation team used the separate ratio estimation technique to estimate verified gross impacts for the Data Centers Efficiency Program. The separate ratio estimation technique follows the steps outlined in the California Evaluation Framework⁴, which identifies best practices in program evaluation. The evaluation team matched these steps to the stratified random sampling method that they used to create the sample for the program. The evaluation team used the standard error to estimate the error bound around the estimate of verified gross impacts.

8. APPENDIX 2. IMPACT ANALYSIS DETAIL

8.1 Savings by Strata

The Data Centers Efficiency Program sample includes eight sites, across three strata. Breakdown of energy and demand savings by strata are shown in Table 8-1 and Table 8-2.

Table 8-1. CY2018 Energy Savings by Strata

Sample Strata	Sample Size	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTG *	Verified Net Savings (kWh)
1	2	8,016,703	0.72	5,794,696	0.68	3,940,393
2	3	12,470,551	0.86	10,757,944	0.68	7,315,402
3	3	10,258,022	0.87	8,920,882	0.68	6,066,199
Total		30,745,276	0.83	25,473,522	0.68	17,321,995

Source: Navigant

³ A full discussion and comparison of separate vs. combined ratio estimation can be found in Sampling Techniques, Cochran, 1977, pp. 164-169.

⁴ Tec Market Works, “The California Evaluation Framework,” Prepared for the California Energy Commission, June 2004. Available at <http://www.calmac.org>

Table 8-2. CY2018 Demand Savings by Strata

Sample Strata	Sample Size	Ex Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTG*	Verified Net Demand Reduction (kW)
1	2	622	0.26	163	0.68	111
2	3	1,801	0.65	1,167	0.68	793
3	3	1,087	3.71	4,029	0.68	2,740
Total		3,510	1.53	5,359	0.68	3,644

Source: Navigant

8.2 Savings by Project

The Data Centers Efficiency Program sample consists of eight projects. Table 8-3 provides the ex ante and ex post energy savings for all the projects in the sample.

Table 8-3. CY2018 Energy Savings by Project

Sampled Application ID	Sample Strata	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTG *	Verified Net Savings (kWh)
27522	1	5,088,400	0.90	4,577,708	0.68	3,112,841
22238	1	2,928,303	0.42	1,216,988	0.68	827,552
32502	2	2,773,115	1.01	2,789,926	0.68	1,897,150
38178	2	2,152,268	0.92	1,979,235	0.68	1,345,880
23093	2	1,359,704	0.48	652,782	0.68	443,892
33357	3	866,031	0.93	805,142	0.68	547,497
35609	3	194,051	0.70	134,986	0.68	91,790
40016	3	56,843	0.55	31,205	0.68	21,219
Total		15,418,715	NA	12,187,972	0.68	8,287,821

Source: Navigant

Table 8-4 provides the ex ante and ex post demand savings for all the projects in the sample.

Table 8-4. CY2018 Demand Savings by Project

Sampled Application ID	Sample Strata	Ex-Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTG*	Verified Net Demand Reduction (kW)
27522	1	622	0.23	142	0.68	97
22238	1	0	-	0	0.68	0
32502	2	286	0.99	284	0.68	193
38178	2	509	0.48	242	0.68	165
23093	2	113	0.56	63	0.68	43
33357	3	21	4.33	92	0.68	62
35609	3	0	-	0	0.68	0
40016	3	6	0.48	3	0.68	2
Total		1558	NA	826	0.68	562

Source: Navigant

The evaluation team has provided ComEd with site-specific M&V reports for each verified project. These site-specific impact evaluation reports summarize the ex ante savings in the end of year summary submitted, as well as the ex post M&V plan, data collected at the site, and all the calculations and parameters used to estimate savings. Table 8-3 and Table 8-4 above summarize the results for each project. The evaluation team uncovered some issues in six of the eight projects, which resulted in energy or demand realization rates with a discrepancy of greater than 10% from a realization rate of 1.0. Some key observations from these site-specific evaluation results are discussed below for each project that saw large differences in savings.

- Project #22238: Ex post energy savings are much lower because of a cell reference error in the ex ante calculation spreadsheet. This error resulted in increase in baseline energy usage by approximately 1,625,000 kWh. The ex post demand kW savings are lower because the ex ante savings did not include month of June. The ex post analysis considered hours of operation between 1:00 P.M. and 5:00 P.M. for the months of June through August.
- Project #23093: Ex ante savings double counted the UPS losses in the baseline calculations. This resulted in overestimating total project savings by about 1,153,000 kWh.
- Project #35069: There are several reasons for the reduction in ex post savings for this project. Ex ante savings did not extrapolate the metered data to annual operation correctly. Conditions captured in ex ante metered data provided majority of the cooling by free cooling and minimal mechanical cooling. Along with this, the Power Factor and Interactive cooling load are also adjusted in the ex post analysis.
- Project # 40016: Ex ante savings for this project are overestimated because of a calculation error. The calculation spreadsheet estimated the Cooling Load Factor (15%) but did not use it in the baseline calculations.
- Project # 27522: The ex post demand kW savings are much lower because the ex ante savings used the average annual PUE instead of limiting the analysis to summertime afternoon hours. The average annual PUE of 1.25 used in the ex ante calculation is much lower than the 1.5 PUE calculated for hours between 1:00 P.M. and 5:00 P.M. for the months of June through August.

- Project # 38178: Ex post demand savings for this project are lower than the ex ante demand savings because of a calculation error in the ex ante savings calculation spreadsheet.
- Project # 33357: The demand kW savings are much higher because the ex ante calculation used average unit baseline CRAC unit power without accounting for the number of units running during normal operation.

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	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Data Center	Retrofit	Project	9	17.4	4,233,119	649	3,507,285	990
Data Center	New Construction	Project	19	17.0	23,142,720	2,238	19,174,542	3,417
Data Center	Virtualization/IT Measure	Project	3	5.4	2,248,430	480	1,862,902	733
Data Center	Close to Colocation	Project	5	15	1,121,007	143	928,793	219

Source: ComEd tracking data and Navigant team analysis.