NAVIGANT

ComEd Industrial Systems Optimization Program Impact Evaluation Report

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

Presented to
ComEd

FINAL

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ComEd Industrial Systems Optimization Program Impact Evaluation Report

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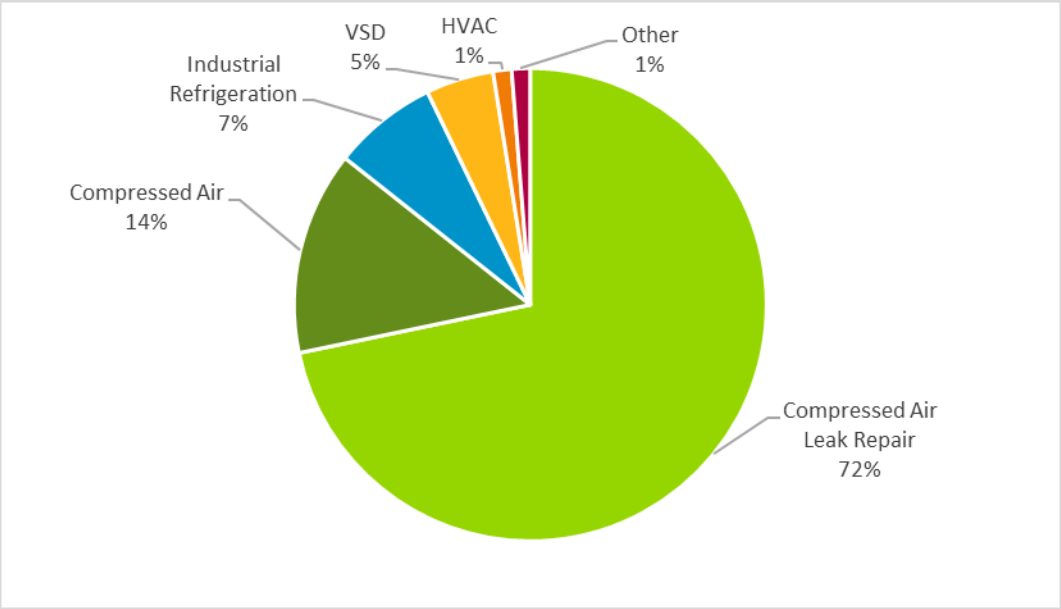
1. Introduction

This report presents ComEd's CY2018 Industrial Systems Optimization 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 Industrial Systems Optimization Program offers a combination of technical assistance and financial incentives. The technical assistance includes an industrial systems study which assesses the performance of the facility's industrial compressed air, process cooling, and refrigeration systems to ensure efficient, economical operation. The program had 109 participants in CY2018, and the projects primarily consisted of compressed air measures, representing around 86% of the installed measures. Air leak repairs made up approximately 72% of the CY2018 measures. Other measures included industrial refrigeration, HVAC, VSDs and other measures. The evaluation team mapped all the projects in the population to a measure group based on the project description. Figure 2-1 below provides the distribution of projects by measure group.

Figure 2-1. Distribution of Projects by Measure Type



Source: Evaluation analysis

3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the Industrial Systems Optimization Program achieved in CY2018. Verified net savings for CY2018 is 17,990,719 kWh. 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	27,591,795	N/A	3,314
Program Gross Realization Rate	0.82	N/A	0.72
Verified Gross Savings	22,488,399	N/A	2,398
Program Net-to-Gross Ratio (NTG)	0.80	N/A	0.80
Verified Net Savings	17,990,719	N/A	1,918
Converted from Gas*			
Ex Ante Gross Savings	0	N/A	N/A
Program Gross Realization Rate	0	N/A	N/A
Verified Gross Savings	0	N/A	N/A
Program Net-to-Gross Ratio (NTG)	0	N/A	N/A
Verified Net Savings	0	N/A	N/A
Total Electric Plus Gas			
Ex Ante Gross Savings	27,591,795	N/A	3,314
Program Gross Realization Rate	0.82	N/A	0.72
Verified Gross Savings	22,488,399	N/A	2,398
Program Net-to-Gross Ratio (NTG)	0.80	N/A	0.80
Verified Net Savings	17,990,719	N/A	1,918

*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 applicable
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 Industrial Systems Optimization Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2018 are shown in the following tables and figure. The CPAS table also shows dual baseline savings for early replacement project IDS-81. The dual baseline project had two measures (HVAC and VSD) with Remaining Useful Life (RUL) of two years. The savings for those two measure categories goes down slightly from year 2020. The total CPAS across all measures for CY2018 is 17,990,719 kWh, as shown in Table 4-1. The Industrial Systems Optimization Program did not achieve any gas savings in CY2018.

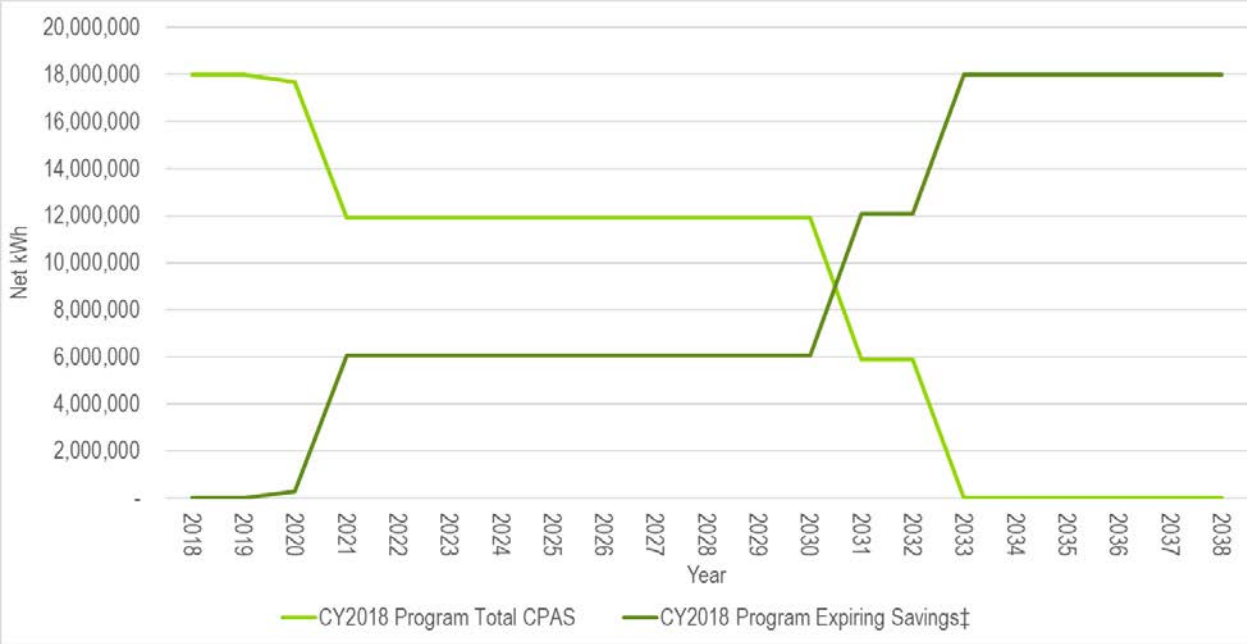
Table 4-1. Cumulative Persisting Annual Savings (CPAS)

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	2026
Industrial Systems	Compressed Air Leak Repair	3	7,220,169	0.80	17,328,405	5,776,135	5,776,135	5,776,135	-	-				
Industrial Systems	Compressed Air	13	6,030,760	0.80	62,719,903	4,824,608	4,824,608	4,824,608	4,824,608	4,824,608	4,824,608	4,824,608	4,824,608	4,824,608
Industrial Systems	Industrial Refrigeration	15	2,563,174	0.80	30,758,089	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539
Industrial Systems	VSD	15	2,061,258	0.80	23,404,076	1,649,007	1,649,007	1,546,620	1,546,620	1,546,620	1,546,620	1,546,620	1,546,620	1,546,620
Industrial Systems	HVAC	13	1,733,043	0.80	15,891,769	1,386,434	1,386,434	1,192,627	1,192,627	1,192,627	1,192,627	1,192,627	1,192,627	1,192,627
Industrial Systems	Other	15	2,879,995	0.80	34,559,945	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996
CY2018 Program Total Electric CPAS			22,488,399		184,662,186	17,990,719	17,990,719	17,694,526	11,918,391	11,918,391	11,918,391	11,918,391	11,918,391	11,918,391
CY2018 Program Expiring Electric Savings‡							-	296,193	6,072,328	6,072,328	6,072,328	6,072,328	6,072,328	6,072,328

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Industrial Systems	Compressed Air Leak Repair												
Industrial Systems	Compressed Air	4,824,608	4,824,608	4,824,608	4,824,608								
Industrial Systems	Industrial Refrigeration	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539	2,050,539						
Industrial Systems	VSD	1,546,620	1,546,620	1,546,620	1,546,620	1,546,620	1,546,620						
Industrial Systems	HVAC	1,192,627	1,192,627	1,192,627	1,192,627								
Industrial Systems	Other	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996	2,303,996						
CY2018 Program Total Electric CPAS		11,918,391	11,918,391	11,918,391	11,918,391	5,901,156	5,901,156						
CY2018 Program Expiring Electric Savings‡		6,072,328	6,072,328	6,072,328	6,072,328	12,089,563	12,089,563	17,990,719	17,990,719	17,990,719	17,990,719	17,990,719	17,990,719

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 team analyzed savings for the Industrial System Optimization 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 measure type, but reflect the gross realization rate for the program, as the evaluation team did not calculate a measure level gross realization rate, nor 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
Industrial Systems	Compressed Air Leak Repair	8,858,675	0.82	7,220,169	0.80	5,776,135	3.0
Industrial Systems	Compressed Air	7,399,348	0.82	6,030,760	0.80	4,824,608	13.0
Industrial Systems	Industrial Refrigeration	3,144,847	0.82	2,563,174	0.80	2,050,539	15.0
Industrial Systems	VSD	2,529,029	0.82	2,061,258	0.80	1,649,007	15.0
Industrial Systems	HVAC	2,126,330	0.82	1,733,043	0.80	1,386,434	13.0
Industrial Systems	Other	3,533,566	0.82	2,879,995	0.80	2,303,996	15.0
	Total	27,591,795	0.82	22,488,399	0.80	17,990,719	10.5

* 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)
Industrial Systems	Compressed Air Leak Repair	1,183	0.72	856	0.80	685
Industrial Systems	Compressed Air	1,066	0.72	771	0.80	617
Industrial Systems	Industrial Refrigeration	385	0.72	278	0.80	223
Industrial Systems	VSD	286	0.72	207	0.80	165
Industrial Systems	HVAC	163	0.72	118	0.80	94
Industrial Systems	Other	231	0.72	167	0.80	134
	Total	3,314	0.72	2,398	0.80	1,918

* 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; 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 requirements[1] 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 Industrial Systems Optimization 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

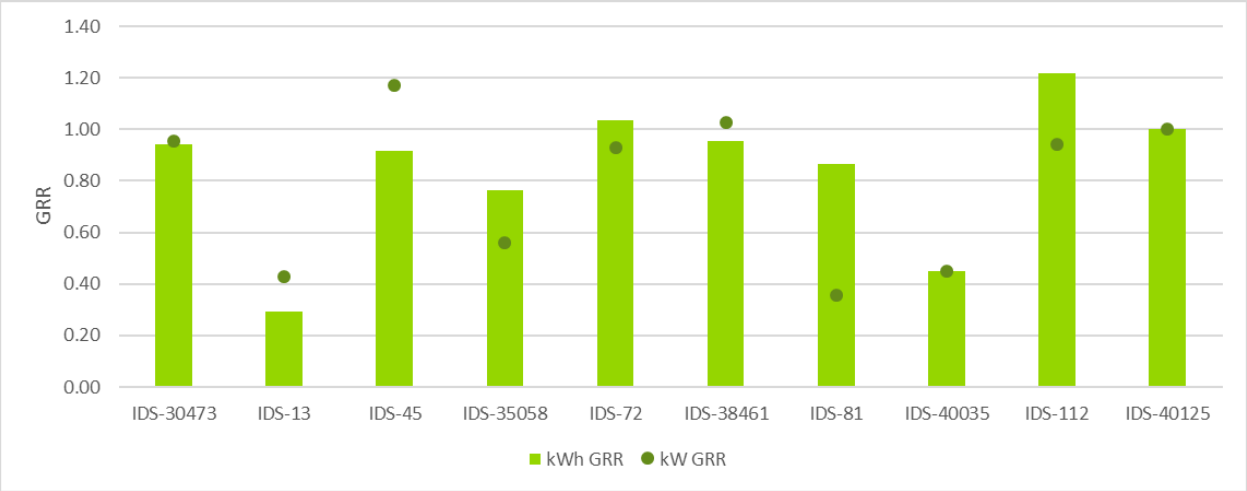
Gross Savings Input Parameters	Value	Deemed or Evaluated?
Gross Energy Savings Realization Rate	0.82	Evaluated
Gross Peak Demand Savings Realization Rate	0.72	Evaluated
NTG Ratio	0.80	Deemed †
Net Energy Savings (kWh)	17,990,719	Evaluated
Net Peak Demand Savings (kW)	1,918	Evaluated

† 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 0.29 to 1.22, which resulted in a program level weighted realization rate of 0.82. The energy gross realization rate was at or above 1.0 for three of the ten projects examined. For another three out of the ten projects, the energy gross realization rates were within 10% of one for the energy savings. The demand savings realization rates for the ten projects in the gross sample ranged from 0.32 to 1.17, resulting in a program level realization rate of 0.72.

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: The baseline system for Project IDS-81 in the ex ante analysis was selected incorrectly.

Recommendation 1: Extra care should be taken during the baseline selection process. The evaluation team recommends using prevalent code or Industry Standard Practice (ISP) as the baseline to estimate savings for systems at or near the end of their useful life or for systems in need of constant repair.

Finding 2: There were a few projects (IDS-13 and IDS-40035) with major issues surrounding the methodology or assumptions used in the ex ante savings calculation.

Recommendation 2: The evaluation team recommends using additional quality control procedures to identify potential deficiencies in the ex ante calculations. Whenever possible, particularly for large projects, the savings should be validated using an alternate approach as a validity check. At a minimum, the results should be reviewed to ensure they are reasonable for the project parameters. If there are any doubts about the methodology or savings calculations, the implementation team should pass it through the evaluation team for early feedback before the savings are finalized.

Finding 3: There were several projects (IDS-13, IDS-40035, IDS-30473, and IDS-35058) where the project scope was either not clearly defined or the scope was not fully considered in the ex ante calculations.

Recommendation 3: For projects where the existing systems are significantly modified /or equipment is replaced, e.g. IDS-13, the baseline equipment and function must be clearly

defined to ensure accurate baseline characterization. For compressed air projects, the documentation should clearly describe the changes made that resulted in CFM reduction and only the CFM reduction attributable to the energy efficiency measure should be included in the savings calculation. If equipment is added as a requirement for the project to function (e.g. blowers replacing compressed air for project IDS-30473), the energy penalty or benefit should be included in the savings estimates.

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 ten 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 Industrial Systems Optimization Program in comparison with the program population. Shown below is the resulting sample that was drawn that consists of ten projects. These projects make up approximately 13 million kWh, which represents 47% 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

Population Summary				Sample		
Sampling Strata	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	3	8,653,232	0.31	3	8,653,232	100%
2	9	9,595,357	0.35	3	3,316,717	35%
3	97	9,343,206	0.34	4	1,042,342	11%
CY2018 Total	109	27,591,795	-	10	13,012,291	47%

Source: ComEd tracking data and Navigant team analysis.

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.[2] 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 Industrial Systems Optimization Program. The separate ratio estimation technique follows the steps

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

outlined in the California Evaluation Framework[3], 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 Industrial Systems Optimization Program sample includes ten 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	3	8,653,232	0.78	6,792,098	0.80	5,433,678
2	3	9,595,357	0.90	8,667,783	0.80	6,934,226
3	4	9,343,206	0.75	7,028,518	0.80	5,622,815
Total		27,591,795	0.82	22,488,399	0.80	17,990,719

Source: ComEd tracking data and Navigant team analysis.

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	3	1,148	0.88	1,010	0.80	808
2	3	958	0.79	753	0.80	603
3	4	1,208	0.52	634	0.80	507
Total		3,314	0.72	2,398	0.80	1,918

Source: ComEd tracking data and Navigant team analysis.

8.2 Savings by Project

The Industrial Systems Optimization Program sample consists of ten projects. Table 8-3 provides the ex ante and ex post energy savings for all the projects in the sample.

[3] Tec Market Works, "The California Evaluation Framework," Prepared for the California Energy Commission, June 2004. Available at http://www.calmac.org

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)
IDS-30473	1	4,875,098	0.94	4,587,560	0.80	3,670,048
IDS-13	1	2,025,265	0.29	596,160	0.80	476,928
IDS-45	1	1,752,869	0.92	1,608,378	0.80	1,286,702
IDS-35058	2	1,437,177	0.77	1,100,743	0.80	880,594
IDS-72	2	1,225,303	1.04	1,271,023	0.80	1,016,818
IDS-38461	2	654,237	0.95	624,327	0.80	499,462
IDS-81	3	570,757	0.87	494,460	0.80	395,568
IDS-40035	3	365,308	0.45	163,884	0.80	131,107
IDS-112	3	89,673	1.22	109,164	0.80	87,331
IDS-40125	3	16,604	1.00	16,604	0.80	13,283
Total		13,012,291	NA	10,572,303	0.80	8,457,842

NA = Not applicable
* 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 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)
IDS-30473	1	760	0.96	727	0.80	582
IDS-13	1	231	0.43	99	0.80	79
IDS-45	1	157	1.17	184	0.80	147
IDS-35058	2	169	0.56	95	0.80	76
IDS-72	2	140	0.93	130	0.80	104
IDS-38461	2	75	1.03	77	0.80	62
IDS-81	3	30	0.36	11	0.80	8
IDS-40035	3	42	0.45	19	0.80	15
IDS-112	3	14	0.94	13	0.80	11
IDS-40125	3	5	1.00	5	0.80	4
Total		1,623	NA	1,360	0.80	1,088

NA = Not applicable
* 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.

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 five of the ten 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 IDS-13: Ex post energy savings are much lower because of the adjustments made to the baseline chiller energy usage. Ex ante savings calculations assumed that the three chillers operated at full load 85% of the time without accounting for the observed actual loading of the chillers. The actual chiller load for these chillers varied from 24% to 77%. After adjusting the ex post analysis, the gross realization rate for energy and demand savings reduced to 0.28 and 0.41 respectively.

- Project IDS-35058: The ex ante savings reduction is due to adjustments made to estimate the baseline and proposed energy usage. Ex ante calculations attempted to normalize for plant production by estimating compressor air demand and power to establish baseline and proposed conditions. The ex post calculation did not identify a significant correlation between production and CFM, and therefore used a simple average of compressor power to estimate baseline usage. The post case used a similar approach as the ex ante analysis but corrected a mistake in the number of days used to estimate annual savings.

- Project IDS-81: The ex post energy savings are slightly lower than the ex ante savings because of the changes made to the baseline chiller power calculations. Based on the investigative report and interview with the customer, the existing towers were in poor condition. This project is considered as early replacement with Remaining Useful Life (RUL) of two years. After the early replacement period, the savings are calculated using new cooling towers without Variable Speed Drive (VSD) as baseline.

- Project IDS-40035: The reduction in savings for this project is due to differences in the methodology of savings calculations. Specifically, the ex ante analysis compared the energy usage of the pre and post case operating demands for the compressed air system but did not normalize to changes in operation not due to the leak repair. The evaluation analysis removed these effects and calculated the effect on the operation of the compressed air system due to the removal of the leak CFM load.

- Project IDS-112: The ex post savings for this project are higher than the ex ante savings because of the increase in the system operating hours and from a compressor running during non-production hours.

9. 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 the evaluation team later.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)	Verified Gross Savings Therms	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG Ratio (kWh)	NTG Ratio (kW)	NTG Ratio (Therms)	Verified Net Savings (kWh)	Verified Net Peak Demand Reduction (kW)	Verified Net Savings Therms	Net Heating Penalty (kWh)	Net Heating Penalty (Therms)
Industrial Systems	Compressed Air Leak Repair	Measures	170	3.0	7,220,169	856	0	0	0	0.80	0.80	NA	5,776,135	685	0	0	0
Industrial Systems	Compressed Air	Measures	33	13.0	6,030,760	771	0	0	0	0.80	0.80	NA	4,824,608	617	0	0	0
Industrial Systems	Industrial Refrigeration	Measures	17	15.0	2,563,174	278	0	0	0	0.80	0.80	NA	2,050,539	223	0	0	0
Industrial Systems	VSD*	Measures	11	15.0	2,061,258	207	0	0	0	0.80	0.80	NA	1,649,007	165	0	0	0
Industrial Systems	HVAC*	Measures	3	13.0	1,733,043	118	0	0	0	0.80	0.80	NA	1,386,434	94	0	0	0
Industrial Systems	Other	Measures	3	15.0	2,879,995	167	0	0	0	0.80	0.80	NA	2,303,996	134	0	0	0

NA = Not applicable
* The savings for this measure varies over time. See the CPAS tables.
Source: ComEd tracking data and Navigant team analysis.