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ComEd Industrial Systems Optimization Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Plan Year 9 (PY9)

Presented to
Commonwealth Edison Company

FINAL

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

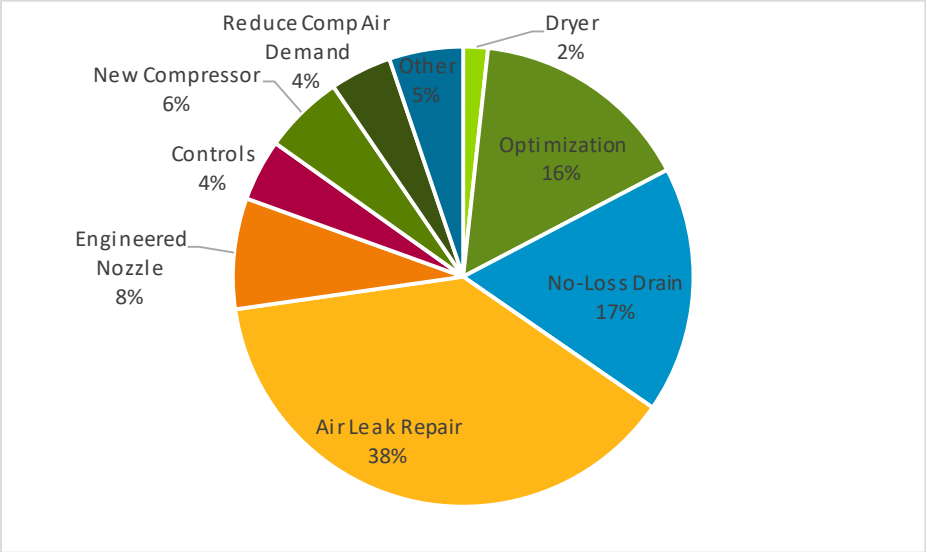
1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Industrial Systems Optimization Program. It presents a summary of the energy and demand impacts for the total program broken out by relevant measure and program structure details. Section 6 (Appendix 1) presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

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 92 participants in PY9 and the measures consisted primarily of compressed air. Air leaks and no-loss drains made up approximately 55% of the measures in the program. Other measures included installing new compressors, VSDs, and optimizing or adding new controls. 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. Number of Measures Installed by Type



Source: Evaluation Analysis

3. PROGRAM SAVINGS

Table 3-1 summarizes the incremental energy and demand savings the Industrial Systems Optimization Program achieved in PY9.

Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	38,665,705	N/A	4,954
Program Gross Realization Rate	84%	N/A	85%
Verified Gross Savings	32,523,735	N/A	4,211
Program Net-to-Gross Ratio (NTGR)	0.80	N/A	0.80
Verified Net Savings	26,018,988	N/A	3,368

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

Reported and evaluated savings for the Industrial Systems Optimization Program are at the site level and do not include measure-level savings. For more information about site-level savings see Section 7 (Appendix 2).

5. Impact Analysis Findings and Recommendations

5.1 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 audit or the desk review process. The savings are site-specific and 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 evaluation used peak kW savings calculation methodology that was consistent with PJM peak summer demand requirements[1] for each project to calculate the peak kW reduction. The team estimated the lifetime energy and demand savings 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 this custom program that the TRM did not specify. The results are shown in Table 5-1.

[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.

Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Value	Deemed or Evaluated?
Gross Energy Savings Realization Rate	0.84	Evaluated
Gross Peak Demand Savings Realization Rate	0.85	Evaluated
NTG Ratio	0.80	Deemed*
Net Energy Savings (kWh)	26,018,988	Evaluated
Net Peak Demand Savings (kW)	3,368.488	Evaluated

* 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

Figure 5-1 shows a comparison of the energy and demand realization rates for every site. The PY9 energy-savings realization rate results ranged from 0.28 to 1.21, which resulted in a program-level energy realization rate of 0.84. The demand-savings realization rates for the ten projects in the gross sample ranged from 0.24 to 1.16. Only three out of the ten projects had realization rates within 10 percent of one for the energy savings; whereas, four of the ten were within 10 percent of one for the demand savings.

Figure 5-1. Energy and Demand Realization Rates

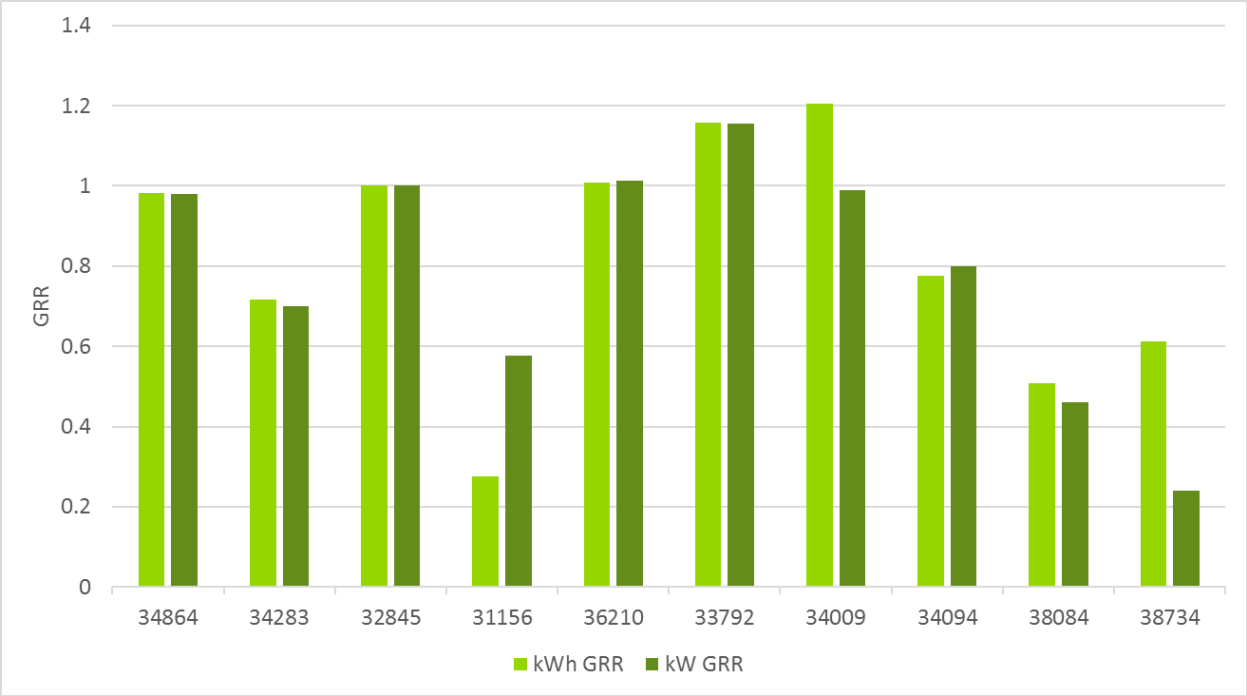
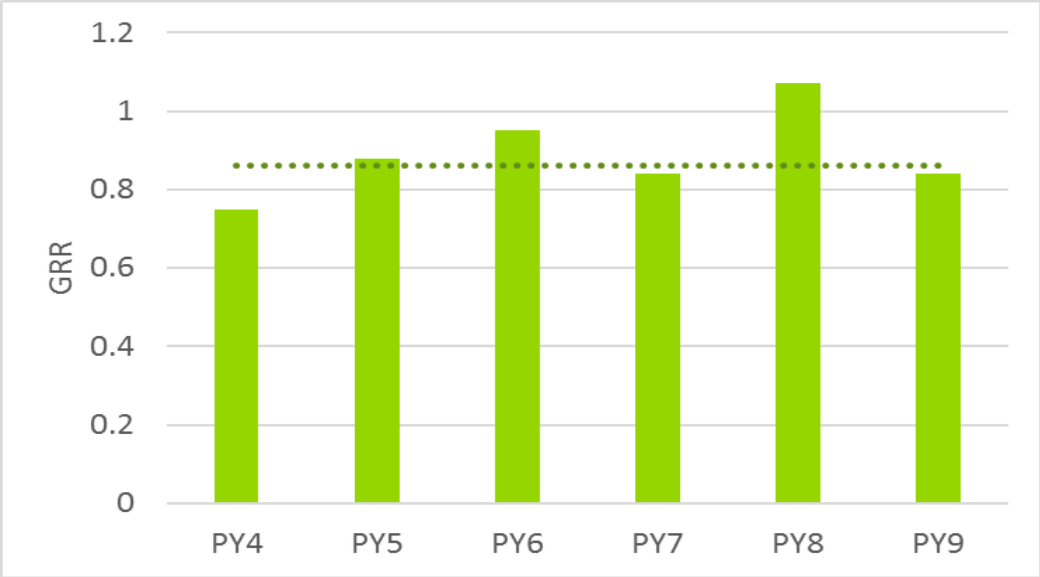


Figure 5-2 below compares the overall program-level energy gross realization rates over the past years. PY9 realization rate of 0.84 is low compared to the previous year, but it is comparable to the median (0.86) of GRR over the past six years. Following the recommendations and early feedback provided by the evaluation team on the large and complicated projects is likely to increase the GRR closer to 1.0 for future program cycles.

Figure 5-2. Energy Gross Realization Rates Across Program Years

Average GRR from PY4 to PY9 = 0.86



5.2 Other Impact Findings and Recommendations

The evaluation team has developed several recommendations based on findings from the PY9 evaluation; they are as follows:

Finding 1. There was one site (34283) where the pre- and post- metering and analysis showed inconsistencies in calculation structure and methodology between the multiple datasets. This resulted in errors in the ex ante analysis. Compressors that were not part of the project scope were included in the metered data. Similarly, there were differences in the logging method, where one set of metering data included logged amps, while the other set included power logging.

Recommendation 1. The evaluation team recommends ensuring consistency in analysis methodology and logging where possible. This may require verifying the pre-installation meter data to ensure that a similar approach is taken. This will provide clarity when analyzing the pre-case and the post-case. Providing the metering configuration in documentation will alleviate the questions surrounding the metering data.

Finding 2. The evaluation reduced savings for one facility (31156) significantly as the savings relied heavily on compressor sequencing that was occurring manually. Relying on the customer to optimally sequence the compressors is unreliable as there are any number of factors that can cause inefficient operation.

Recommendation 2. Adding a compressed air controller that can select the most appropriate compressor based on system demands to a customer's system would be beneficial, especially in cases where there are large swings in compressed air load. These situations will ensure that a customer still sees project savings while not requiring constant monitoring. This is especially advantageous when the customer does not have dedicated staff who are compressed air system experts.

Finding 3. One project (31156) had installed high efficiency air gun nozzles to reduce the compressed air demand. The onsite evaluation found that the workers did not like the added weight of the nozzles on the air guns. Also, the shape of the nozzles was inappropriate for

the job. This resulted in workers removing most of the nozzles and re-attaching the old nozzles. This resulted in reduced savings.

Recommendation 3. Discussions with personnel using equipment prior to the installation of the equipment would be useful. In this case, installing a few high-efficiency air nozzles as a test could have determined that the nozzles were not the right application. Secondly, many energy efficiency programs require the removal of old equipment so that re-installing that old equipment would not be possible.

Finding 4. Several projects used idealized or standard assumptions in their savings that did not match the site-specific conditions as documented in the project files. These included a project utilizing a leak repair template (34094) and several projects making assumptions about compressor operation (33792 & 31156). For these projects, and project 38734, the savings calculations from the ex ante model were not validated using the actual meter data. Project 34283 provided metered data that was not validated, where one of the flow meters resulted in an inaccurate CFM reading. Project 34283 did not account for the artificial demand, which raised the project savings by over 20%. Project 38084 assumed that the compressed air system trimming would occur with one dedicated compressor. However, the data shows multiple compressors trimmed in parallel. Project 34009 inadvertently removed the leak savings from the final claimed savings while 34094 did not include the energy usage of the installed fans.

Recommendation 4. The evaluation reiterates a past recommendation that the program engineers should review graphical representations of the metered data. We also want to note that standardized assumptions are acceptable, but they should always be validated through comparisons to metering, especially when that data is already available. Sanity checking and quality control of data, even metering data, are key to ensuring that savings calculations are valid and accurate. CAGI data sheets are a useful source of compressor data and should be utilized for sanity check measures.

6. Appendix 1. Impact Analysis Methodology

6.1 Sampling

6.1.1 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 as shown in Table 6-1.

Table 6-1. PY9 Program Participation by Sampling Strata

Sampling Strata	Ex Ante kWh Impact Claimed	Ex Ante kW Impact Claimed	Tracking Records	Incentive Paid to Applicant
1	14,366,945	1,654	4	962,688
2	10,967,538	1,377	12	418,378
3	13,331,222	1,923	76	285,179
PY9 Total	38,665,705	4,954	92	1,666,246

Source: Evaluation Team analysis

Table 6-2 provides a profile of the gross impact M&V sample for the Industrial Systems Optimization Program in comparison with the program population. The table shows the resulting sample, which consists of ten projects. These projects make up approximately 14 million kWh of the ex ante impact

claim, which represents 38 percent of the ex ante impact claimed for the program population. The table also shows the ex ante-based kWh sample weights for each of the three strata.

Table 6-2. PY8 Gross Impact Sample by Strata

Population Summary				Completed Interviews		
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	4	14,366,945	0.37	3	11,091,509	77%
2	12	10,967,538	0.28	3	1,988,915	18%
3	76	13,331,222	0.34	4	1,524,241	11%
PY9 Total	92	38,665,705	-	10	14,604,665	38%

Source: Evaluation Team analysis

6.1.2 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 using 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 team 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 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.

[2] A full discussion and comparison of separate vs. combined ratio estimation can be found in Sampling Techniques, Cochran, 1977, pp. 164-169.
[3] Tec Market Works, "The California Evaluation Framework," Prepared for the California Energy Commission, June 2004. Available at http://www.calmac.org

7. APPENDIX 2. IMPACT ANALYSIS DETAIL

The Industrial Systems Optimization Program sample includes 10 sites across three strata, as shown in Table 7-1. Most of the ex post energy and demand savings are in strata one, which account for approximately 78% of the ex post energy savings and approximately 76% of the ex post demand savings. Each site's savings can be broken down into various high efficiency industrial measure, such as VFDs, new compressors and leak repairs.

Table 7-1. PY9 Energy Savings by Strata

Strata	Sample Size	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTGR *	Verified Net Savings (kWh)	Technical Measure Life	Persistence	Effective Useful Life (EUL)†
1	3	14,366,945	92%	13,219,244	0.80	10,575,396	7	1	7
2	3	10,967,538	78%	8,585,451	0.80	6,868,361	7	1	7
3	4	13,331,222	80%	10,719,039	0.80	8,575,231	7	1	7
	Total	38,665,705	84%	32,523,735	0.80	26,018,988	7	1	7

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† EUL is a combination of technical measure life and persistence.
Source: ComEd tracking data and Navigant team analysis.

Table 7-2. PY9 Peak Demand Savings by Strata

Strata	Sample Size	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (kW)	NTGR*	Verified Net Peak Demand Reduction (kW)
1	3	1,654	91%	1,513	0.80	1,210
2	3	1,377	98%	1,354	0.80	1,083
3	4	1,923	70%	1,344	0.80	1,075
Total		4,954	85%	4,211	0.80	3,368

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.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 7-3 and Table 7-4 show the savings by site. Most of the savings are due to project 34864; which accounts for approximately 39% of the ex post gross energy savings and ex post demand savings.

Table 7-3. PY9 Energy Savings by Site

Sampled Application ID	Sample Strata	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTGR *	Verified Net Savings (kWh)
34864	1	5,731,351	98%	5,625,044	0.80	4,500,035
34283	1	2,755,041	72%	1,975,305	0.80	1,580,244
32845	1	2,605,117	100%	2,605,117	0.80	2,084,094
31156	2	736,596	28%	203,496	0.80	162,797
36210	2	649,426	101%	655,399	0.80	524,319
33792	2	602,893	116%	698,039	0.80	558,431
34009	3	510,496	121%	615,592	0.80	492,474
34094	3	258,868	78%	200,753	0.80	160,602
38084	3	503,680	51%	255,388	0.80	204,310
38734	3	251,197	61%	153,841	0.80	123,073
Total		14,604,665	NA	12,987,974	0.80	10,390,379

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.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 7-4. PY9 Peak Demand Savings by Site

Sampled Application ID	Sample Strata	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (kW)	NTGR*	Verified Net Peak Demand Reduction (kW)
34864	1	655	98%	642	0.80	514
34283	1	322	70%	226	0.80	181
32845	1	303	100%	303	0.80	242
31156	2	40	58%	23	0.80	19
36210	2	101	101%	102	0.80	82
33792	2	78	116%	90	0.80	72
34009	3	73	99%	72	0.80	58
34094	3	42	80%	33	0.80	27
38084	3	65	46%	30	0.80	24
38734	3	22	24%	5	0.80	4
Total		1,700	NA	1,527	0.80	1,221

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† Based on evaluation research findings.
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 Final Application 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 7-3 summarizes the results for each project. The evaluation team uncovered

some issues in seven of the ten projects, resulting in a realization rate that differs from 100%. This could have resulted in a larger discrepancy in realization rate if the realization rates were not offset by other large discrepancies that swung the other way. Some key observations from these site-specific evaluation results are discussed below for each project which saw large differences in savings.

- Project #34283: Three major findings attributed to the difference in savings for this project. The baseline operating data included compressors that were not included in the project scope, and therefore overestimated the energy consumption during the baseline period. The metered data for one of the flow controllers was not reporting accurate readings. Finally, the ex ante savings did not account for the reduction in artificial demand, which increased savings.
- Project #31156: This project is manually controlled, making it difficult for the savings to persist. Over the course of the project, the operation of the air compressors changed and resulted in degraded system performance.
- Project #34009: The largest change in savings comes from changing the operating hours for the leaks to 8,736 from 7,077 hours. The other changes to the savings were due to the operating conditions found during the on-site inspection.
- Project #34094: The evaluation team used a similar approach to the ex ante calculations, but made a few adjustments, including changing the compressor curve to the actual curve and considering the compressor fixed demand. In addition, the team fixed an error in the calculations of the kWh/lb, thereby decreasing the energy savings.
- Project #38084: The savings were reduced due to the ex ante analysis assuming that a reduction in CFM demand would result in a direct reduction in the CFM of the VFD trim compressor. However, based on the provided data, only a portion of the CFM reduction resulted in a reduction in the VFD compressor.
- Project #33792: The savings for this project were increased based on the metered operation of the system. The original analysis calculated the savings based on an “idealized” operation of the system. During much of the operating time this was reasonable. However, during some of the operating period Compressor 1 would operate unloaded for a period without providing useful CFM to the system. Adding in the savings for reducing the CFM to nearly eliminate the operation of Compressor 1 also nearly eliminates the time that this compressor ran unloaded.
- Project #38734: The evaluated savings were significantly reduced compared to the ex ante savings levels. The ex ante modeled system operation was not validated with the available metered data and overestimated the savings. Ex post savings were estimated using combination of metered data (wet operation) and the ex ante model (dry operation).

8. APPENDIX 4. TRC

Total Resource Cost (TRC) related data for the ten projects in the Industrial Systems Optimization Program sample can be found in Table 8-1.

Table 8-1. TRC Table. Total Resource Cost Savings Summary[4]

Application ID	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)
34864	Refrigerant Dryer	Each	1	7	5,731,351	655	5,625,044	642
34283	Compressor Controller	Each	1	10	2,755,041	322	1,975,305	226
32845	New Compressor	Each	1	11	2,605,117	303	2,605,117	303
31156	New Compressor	Each	1	10	736,596	40	203,496	23
36210	Repair Air Leaks	Each	1	2	649,426	101	655,399	102
33792	Repair Air Leaks	Each	1	3	602,893	78	698,039	90
34009	Repair Air Leaks	Each	1	5	510,496	73	615,592	72
34094	Reduce Comp Air Demand	Each	1	13	258,868	42	200,753	33
38084	Repair Air Leaks	Each	1	2	503,680	65	255,388	30
38734	VFD Drive	Each	1	7	251,197	22	153,841	5

[4] For projects with multiple measures, Weighted Average Measure Life (WAML) is listed in the table. WAML is estimated using verified ex-post measure savings as the weight. Also, the TRC table only includes cost-effectiveness analysis inputs available at the time of finalizing this PY9 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 at a later date. Further, EULs are subject to change and are not final due to ongoing analysis.