ComEd Data Centers Combined Evaluation Report

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

Presented to ComEd

February 14, 2019

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Submitted to:

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1. Introduction

This report combines the key deliverables from the evaluation of the Data Centers Program for PY9. Each of these deliverables were drafted, reviewed and finalized during the course of the PY9 evaluation.

APPENDIX A. ComEd Data Centers PY9 Impact Evaluation Report 2018-04-12 Final

ComEd Data Centers Efficiency Program Impact Evaluation Report

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

Presented to Commonwealth Edison Company

FINAL

April 12, 2018

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List of Tables and Figures

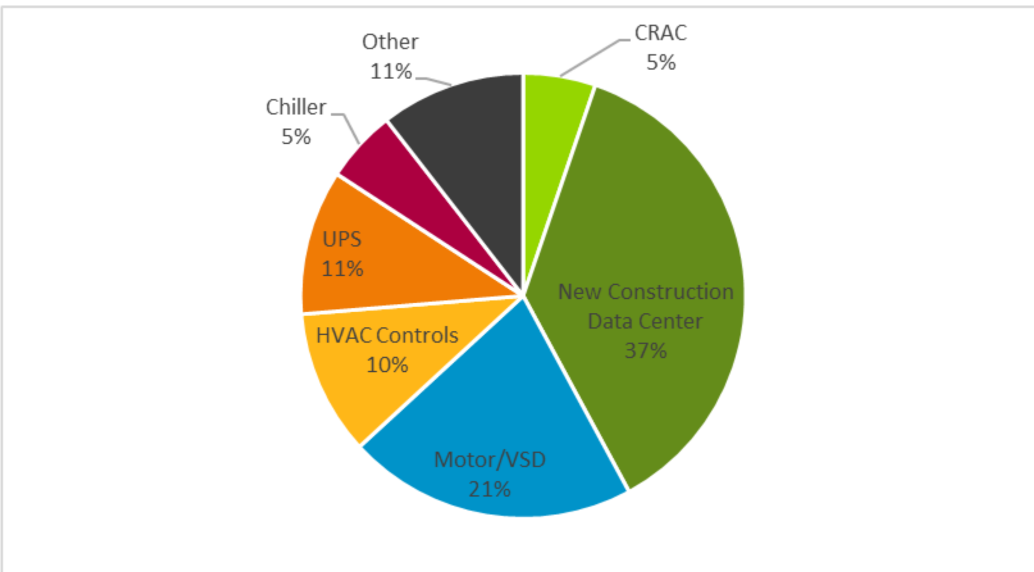
1. Introduction

This report presents the results of the impact evaluation of ComEd's PY9 Data Centers Efficiency Program. It presents a summary of the energy and demand impacts for the total program and broken out by strata. The appendix presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

2. Program Description

The program had 19 participants in PY9 and consisted of mostly HVAC measures, as shown in Figure 2-1. Most sites contain multiple measures that improve the efficiency of the data center including both HVAC measures and IT improvements. The HVAC measures ranged from installing chilled water temperature reset, installing VFDs, installing new chillers and installing a water side economizer. All the projects in the population were mapped to an end use based on the project description. Figure 2-1 provides the distribution of projects by end-use.

Figure 2-1. Distribution of Projects by End Use



Source: Evaluation Analysis

3. Program Savings

Table 3-1 summarizes the incremental energy and demand savings the Data Centers Efficiency 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	46,300,381	N/A	5,123
Program Gross Realization Rate	102%	N/A	87%
Verified Gross Savings	47,111,833	N/A	4,471
Program Net-to-Gross Ratio (NTGR)	0.64	N/A	0.64
Verified Net Savings	30,151,573	N/A	2,861

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The Data Centers Efficiency program does not claim savings by measure and therefore cannot be presented by measure. Savings for the Data Centers Incentive Program are based on a sample and reported at a strata level and do not have measure-level savings. More information about strata- and site-level savings are provided in 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 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 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 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 this custom program that were not specified in the Illinois Technical Reference Manual (IL TRM). 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.

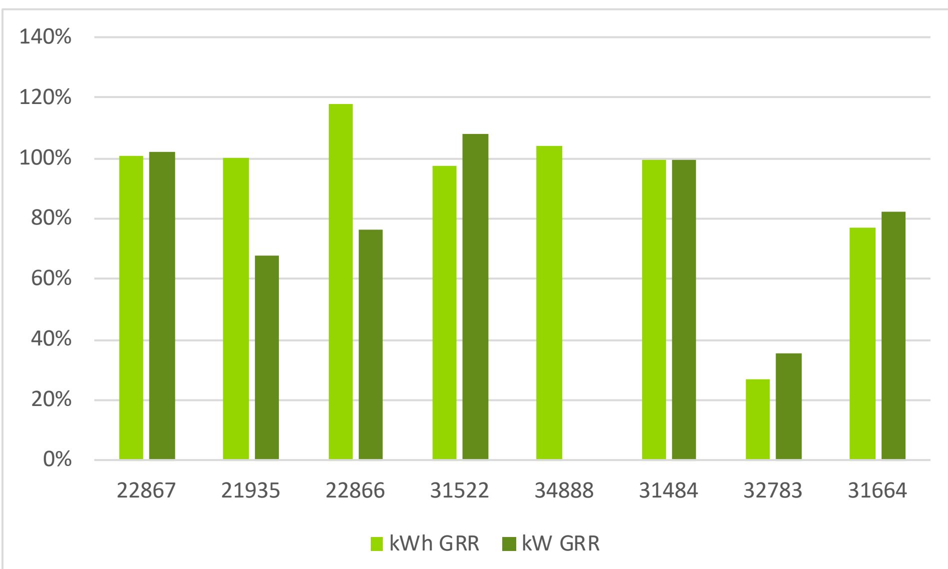
Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Value	Deemed * or Evaluated?
Gross Energy Savings Realization Rate	102%	Evaluated
Gross Peak Demand Savings Realization Rate	87%	Evaluated
NTG Ratio	0.64	Deemed*
Net Energy Savings (kWh)	30,151,573	Evaluated
Net Peak Demand Savings (kW)	2,861	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 below shows a comparison of the energy and demand realization rates for every site. The PY9 energy-savings realization rate results ranged from 0.27 to 1.18, which resulted in a program level realization rate of 1.02. The demand-savings realization rates for the eight projects in the gross sample ranged from 0.0 to 1.08. The realization rate was at or above 1.0 for five of the eight projects examined. For six out of the eight projects, the realization rates were within 10 percent of one for the energy savings; whereas, only three of the eight were within 10 percent of one for the demand savings.

Figure 5-1. Energy and Demand Realization Rates



5.2 Other Impact Findings and Recommendations

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

Finding 1: The evaluation team identified two sites where a regression analysis was performed by the implementation team on binned energy consumption data. While this will generally result in better correlations with higher R^2 values, bins may contain widely varying numbers of data points. This can cause certain data points to carry a higher weight than other points in the regression which might bias the results.

Recommendation 1: The implementation team's regression analysis should not be performed on binned data. If the correlation on the non-binned data does not show a strong correlation, then using simple average is more appropriate.

Finding 2: The evaluation found that the implementation team calculated demand savings as average demand rather than peak demand for multiple projects.

Recommendation 2: Peak demand kW for weather-dependent measures should be calculated using peak hours defined as 1PM to 5PM, non-holiday weekdays from June through August.

Finding 3: The phased new construction data center projects should be treated consistently, regardless of the IT loading of the project. The ability to true up savings in subsequent phases should not be grounds for inconsistency in calculated savings.

Recommendation 3: Phased new construction data center projects should account for all components of the data center in their calculations, including cooling systems, IT load, and UPS. This will ensure consistency across evaluation periods, and ensure the accuracy of claimed savings in that program year.

Finding 4: Most data center projects will not see fans with significant variability in their speed. For these projects, the relationship between power and fan speed can be approximated to be linear. However, when projects with variable fan speeds of more than a few percent are identified, savings should be calculated accordingly, as the fan power to speed relationship can no longer be considered linear, and will see an exponential relationship.

Recommendation 4: Variability in fan speeds should be considered when calculating savings for fan power. When fan speeds vary by more than a few percent, the relationship between fan power and speed is found to be exponential, requiring a more sophisticated approach, like a binned approach, to calculate savings.

Finding 5: The evaluation found two projects in the PY9 sample where ex-ante metered data which was not consistent with typical operation for the facility. In one facility (31164), the customer reported that the post-installation period of operation was not representative of the typical operation because of issues with the Building Automation System (BAS). In another facility, the metering data showed the CRAH fans running at nearly a consistent speed and power until the last five days of operation (31484). The customer reported that this may have been a result of floor panel adjustments.

Recommendation 5: The evaluation team realizes that it is not always possible to foresee changes in system operation, but whenever possible, the site contact should always be interviewed prior to metering to determine whether current operation will be representative of typical operation. Additionally, when discrepancies are identified in metered data, like seen in 31484, it is recommended that a thorough explanation be noted, so that a grounded determination can be made on how to handle the discrepancies.

Finding 6: The evaluation found one project where the implementation team took a simple ratio of IT loads for normalizing savings. This is not an ideal method of normalizing IT-load savings, as this simple ratio may over- or-underestimate the effects of incremental changes in IT load.

Recommendation 6: The implementation team should consider the actual effect of IT loads on mechanical requirements when normalizing savings. Using PUE as the dependent variable will make normalizing for changes in IT load more straightforward. The evaluation team recognizes that PUE may vary with changing IT loads, so care must be taken to account of incremental changes in PUE.

6. Appendix 1. Impact Analysis Methodology

6.1 Sampling

6.1.1 Profile of Population

The table below presents the three sampling strata used in the evaluation of the Data Centers Efficiency program. This was based on a total of 19 tracking records. Table 6-1 presents the number of records by stratum, along with the claimed ex-ante gross MWh and kW.

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	16,274,747	1,809	1	1,255,476
2	19,129,513	2,626	2	1,339,066
3	10,896,121	687	16	754,719
PY9 Total	46,300,381	5,123	19	3,349,261

Source: Evaluation Team analysis

6.1.2 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 6-2 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 forty million kWh of the ex-ante impact claim, which represents 87 percent 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 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	1	16,274,747	0.35	1	16,274,747	100%
2	2	19,129,513	0.41	2	19,129,513	100%
3	16	10,896,121	0.24	5	4,758,812	44%
PY9 Total	19	46,300,381	-	8	40,163,072	87%

Source: Evaluation Team analysis

6.1.3 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 is used. 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 Data Centers Efficiency 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.

7. Appendix 2. Savings by Strata

The Data Centers Efficiency program sample includes 8 sites, across three strata as shown in Table 7-1. Most of the savings are due to three sites which make up the top two strata. These sites account for approximately 90% of the ex post energy savings and approximately 93% of the ex post demand savings. Each site’s savings can be broken down into various high efficiency data center measure, such as high efficiency chillers, HVAC controls, economizers, CRAH VFDs, installing new split systems and high efficiency UPS. All the sites measures are HVAC related with the exception being high efficiency UPS.

Table 7-1. PY9 Energy Savings by Strata

Sample 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	1	16,274,747	101%	16,369,760	0.64	10,476,646	15	N/A	N/A
2	2	19,129,513	109%	20,790,041	0.64	13,305,626	15	N/A	N/A
3	5	10,896,121	91%	9,952,032	0.64	6,369,300	15	N/A	N/A
	Total	46,300,381	102%	47,111,833	0.64	30,151,573	15	N/A	N/A

Source: ComEd tracking data and Navigant team analysis.
* 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.

[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

Table 7-2. PY9 Peak Demand Savings by Strata

Sample Strata	Sample Size	Ex-Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTGR*	Verified Net Demand Reduction (kW)
1	1	1,809	102%	1,851	0.64	1,185
2	2	2,626	72%	1,884	0.64	1,206
3	5	687	107%	736	0.64	471
	Total	5,123	87%	4,471	0.64	2,861

Source: ComEd tracking data and Navigant team analysis.
* 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.

8. Appendix 3. Impact Analysis Detail

The Data Centers Efficiency program sample includes 8 sites, across three strata as shown in Table 8-1. Most of the savings is due to projects 22867, 21935 and 22866; which account for approximately 90% of the ex post energy savings and approximately 93% of the ex post demand savings. These sites savings can be broken down into various high efficiency data center measure, such as high efficiency chillers, HVAC controls, economizers, CRAH VFDs, installing new split systems and high efficiency UPS. All the sites measures are HVAC related with the exception being high efficiency UPS.

Table 8-1. 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)
22867	1	16,274,747	101%	16,369,760	0.64	10,476,646
21935	2	9,856,716	100%	9,856,613	0.64	6,308,232
22866	2	9,272,797	118%	10,933,428	0.64	6,997,394
31522	3	2,433,757	98%	2,380,717	0.64	1,523,659
34888	3	915,905	104%	954,327	0.64	610,769
31484	3	613,250	100%	610,410	0.64	390,662
32783	3	421,691	27%	113,981	0.64	72,948
31664	3	374,209	77%	287,052	0.64	183,713
	Total	40,163,072	103%	41,506,288	0.64	26,564,024

Source: ComEd tracking data and Navigant team analysis.
* 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.

Table 8-2. PY9 Peak Demand Savings by Site

Sampled Application ID	Sample Strata	Ex-Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTGR*	Verified Net Demand Reduction (kW)
22867	1	1,809	102%	1,851	0.64	1,184.640
21935	2	1,383	67%	933	0.64	596.928
22866	2	1,244	76%	951	0.64	608.640
31522	3	151	108%	164	0.64	104.704
34888	3	105	0%	0	0.64	0.000
31484	3	70	100%	70	0.64	44.608
32783	3	45	35%	16	0.64	10.176
31664	3	43	82%	35	0.64	22.464
Total		4,849	83%	4,019	0.64	2,572.160

Source: ComEd tracking data and Navigant team analysis.
* 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.

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 8-1 summarizes the results for each project. Although the overall project realization rate is close to 100%, the evaluation team uncovered some issues in five of the eight projects. This could have resulted in large discrepancies in realization rates if they 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 #21935: 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. As noted above, the average annual PUE of 1.307 used in the ex ante calculation is much lower than the 1.354 PUE calculated for hours between 1 PM and 5 PM for the June through August period.
- Project #22866: The primary cause of the increase in energy savings and decrease in demand savings is that the ex post analysis used a multivariable regression analysis to estimate hourly PUE. Plotting PUE as a function of critical IT load kW shows a slight reduction in PUE as IT load increases. This is expected as the systems become more efficient when operating closer to design conditions. In addition, the ex post analysis considers the average PUE for June through August daytime WBT between the hours of 1 PM and 5 PM.
- Project #34888: The ex post demand savings was reduced to zero because all the claimed savings are expected to occur during unoccupied periods, which would typically fall outside of the PJM peak demand hours. Therefore, no peak demand savings were considered in the ex post calculations.
- Project #32783: The ex post savings are significantly lower than ex ante savings because of the treatment of savings from the previous phase. The savings at each phase should be trued up at the project level and not at individual measure level. The ex ante approach for this project was to consider only CRAH savings for the first phase and only UPS savings for the second phase. The ex post demand savings realization rate is higher than the energy realization rate because of a

cell-reference error in the ex ante calculation. The Phase 1 demand savings were inadvertently used instead of the Phase 2 demand savings.

- Project #31664: The ex post calculations assumed that all the CRAC units that ran pre-retrofit would be running post-retrofit. Unit 15 did not run during the post-retrofit verification period so the ex ante analysis essentially claimed savings for turning the unit off. There is no evidence that this would be due to installing the ECM plug fans in the unit. The energy and demand savings were also reduced by using a bin analysis on post-case fan speeds instead of using a simple average.

9. Appendix 4. Total Resource Cost Summary

Total Resource Cost (TRC) related data for the eight projects in the Data Centers Efficiency Program sample can be found in Table 9-1.

Table 9-1. TRC Table. Total Resource Cost Savings Summary

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)
22867	Data Center	Each	1	15	16,274,747	1,809	16,369,760	1,851
21935	Data Center	Each	1	15	9,856,716	1,383	9,856,613	933
22866	Data Center	Each	1	15	9,272,797	1,244	10,933,428	951
31522	Economization	Each	1	15	2,433,757	3	2,380,717	164
34888	LAN Closet Renovation	Each	1	15	915,905	105	954,327	-
31484	New Data Center	Each	1	15	613,250	70	610,410	70
32783	New Data Center	Each	1	15	421,691	45	113,981	16
31664	EC Fan Retrofit	Each	1	10	374,209	43	287,052	35

APPENDIX B. ComEd Data Centers PY8 and PY9 NTG Memo 2018-09-17

230 Horizon Drive,
Suite 101-B
Verona, WI 53593

Memorandum

To: Erin Daughton, ComEd

CC: Milos Stefanovic, ComEd
Jennifer Morris, ICC Staff

From: Jennifer Fagan, Itron
Jeff Erickson, Randy Gunn, Rob Neumann, Laura Agapay-Read, Navigant

Date: September 17, 2018

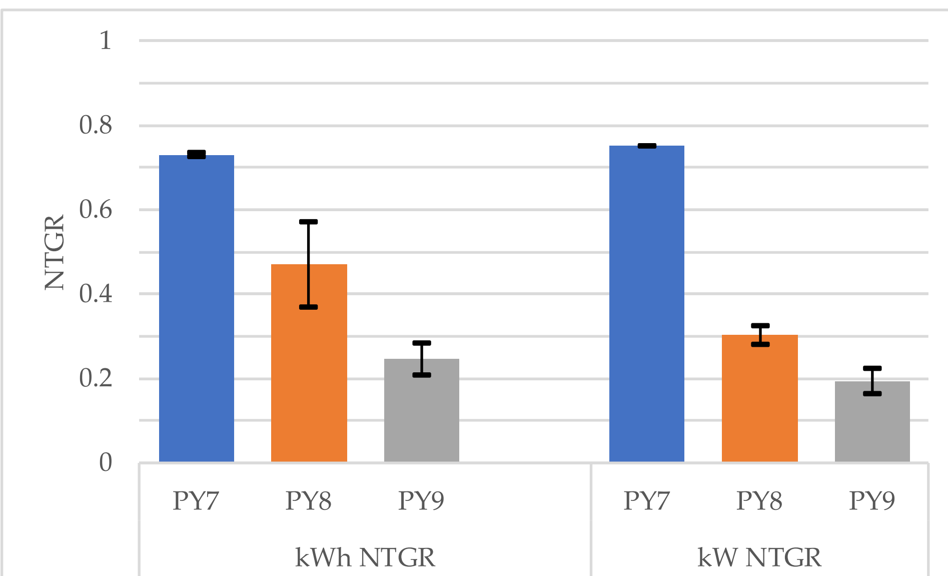
Re: Net-to-Gross Research Results from the PY8 and PY9 ComEd Data Centers Efficiency Program

SUMMARY OF FINDINGS

This memo presents the findings of the PY6 and PY9 net-to-gross ratios (NTGR) study of the ComEd Data Centers Program.

The Evaluation Research findings energy and demand-weighted NTGRs for PY7, PY8, and PY9, are presented below in
Figure 1**Error! Reference source not found.**. The overall trend in the NTGRs has been sharply downward.

Figure 1. Evaluated NTGR by Program Year with 90% Confidence Interval



The EM&V team also calculated a combined PY8 and PY9 NTGR. The team developed this value using savings weighted NTGRs from PY8 and PY9 and computing a weighted average value. The combined PY8/9 value of 0.31 is much lower than the PY7 NTGR of 0.68.

Finally, given the dramatic difference found between co-location and non-co-location NTGRs, the EM&V team calculated separate combined PY8/9 values for these segments. The combined PY8/9 NTGR for co-locations is 0.25, while the PY8/9 NTGR for non-co-locations is 0.71. The evaluation team also found significant NTGR variation within the co-location segment for new construction vs. retrofit projects, with new construction project NTGRs much lower than retrofit project NTGRs. The combined PY8/9 new construction project NTGR is 0.20, while the retrofit project NTGR value is 0.72. *The EM&V team recommends that the combined PY8/9 values for co-location* new construction projects of 0.20, for co-location retrofit projects *of 0.72, and for non-co-locations of 0.71 be used to compute program-verified savings for CY2019 projects going forward.*

INTRODUCTION

This memorandum presents the evaluation's PY8 and PY9 net-to-gross ratio (NTGR) estimates for ComEd's Data Centers Efficiency program. The evaluation team completed NTG interviews with participants for both PY8 and PY9. The analysis of the PY8 data was postponed until the conclusion of the PY9 evaluation. Thus, this memo reports findings for PY8, PY9 and pooled PY8/PY9 NTGR results.

EVALUATION RESEARCH NET IMPACT FINDINGS

NTG Algorithm Specifications

The PY8 and PY9 NTGR calculations were based on the NTG algorithms specified in the Illinois TRM version 6.0. Approval to use version 6.0 was provided by the Illinois Stakeholder Advisory Group and Illinois Commerce Commission staff via an email seeking permission dated April 2, 2018 and their lack of objections by April 16, 2018, which was interpreted as consensus. The NTG protocols in version 6.0 were developed by the Illinois Net-to-Gross Working Group in their deliberations during the summer and fall of 2017.

The protocols provide two options for combining the three scores. These two options use different specifications to account for the impact of the program on project timing (referred to as "deferred free ridership"). Evaluators are to calculate free ridership using both options and to select one option for purposes of calculating the annual incremental energy savings for comparing to the legislated goal.

The evaluation team's preferred algorithm specification **is Core Free Ridership Algorithm 1**, shown graphically below (Figure 2). The majority of NTG findings discussed below are based on this version. The second option, Core Free Ridership Algorithm 2 (Figure 3) has also been analyzed, and those findings will be presented as a sensitivity case later in this memo. The rationale for selecting Algorithm 1 over Algorithm 2 is that Algorithm 1 provides for equal weighting of each of the three scores, which represent different ways of determining program influence. In contrast, Algorithm 2 applies a 50% weight to the program's effect on the timing of the project, which we believe is too high. Such a high weighting essentially discounts the effect of the other factors affecting program influence, which in our view is inappropriate.

Figure 2. Core Free Ridership Algorithm 1

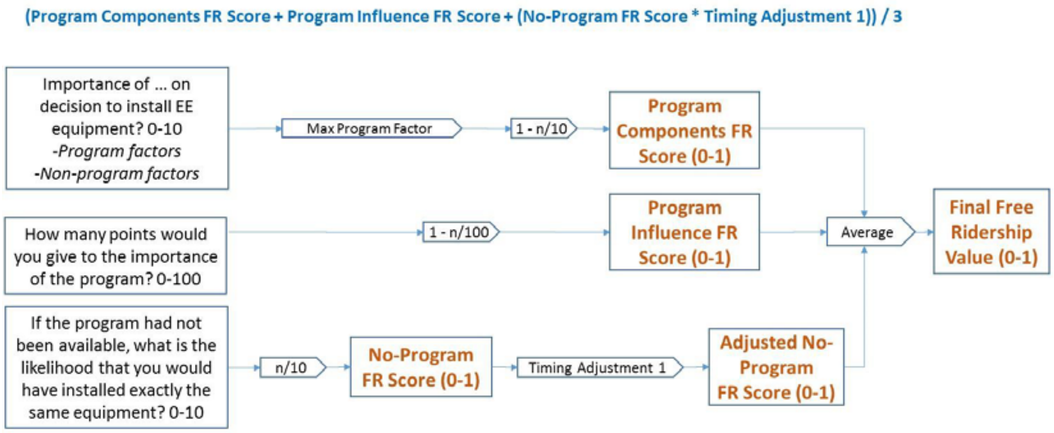
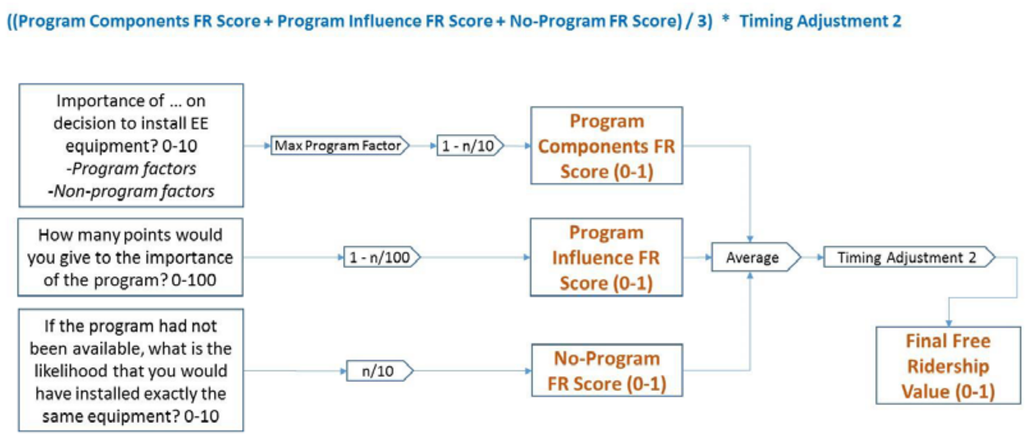


Figure 3: Core Free Ridership Algorithm 2



NTGR Calculation

The calculation of both the free ridership rate and each project's net-to-gross ratio (NTGR) is a multi-step process. Responses from the telephone survey are used directly to calculate a timing and selection score, a program influence score and a no-program score for each project (as outlined in Table 0-1 below for both versions of the NTGR algorithm). These three scores can take values of 0 to 10 where a lower score indicates a higher level of free-ridership. The calculation then averages those three scores and incorporates spillover findings to come up with a project-level net-to-gross ratio.

Table 0-1. Net-to-Gross Scoring Algorithms for the PY8 and PY9 Data Centers Program[1]

Scoring Element	Algorithm 1 Calculation	Algorithm 2 Calculation
Timing and Selection Score. The maximum self-reported score (on a 0 to 10 scale of importance) for the following program elements: A. Availability of the program incentive B. Technical assistance from utility or program staff C. Recommendation from utility or program staff D. Information from utility or program marketing materials E. Endorsement or recommendation by utility account rep F. Recommendation from vendor or Technical Service Provider[2].	Maximum of A, B, C, D, E, and F	Maximum of A, B, C, D, E, and F
Program Influence score. From a Total of 10 points, the self-reported number of points assigned to the importance of the Program in their decision to implement the <PROJECT> (as versus other non-program factors.	Points awarded to the program. Reduce by half if decision made BEFORE learning about rebate eligibility	Points awarded to the program. Reduce by half if decision made BEFORE learning about rebate eligibility
No-Program score. If the Program had not been available, the self-reported likelihood (on a 0 to 10 scale, where 0 is "Not at all likely" and 10 is "Extremely likely") that they would have installed exactly the same PROJECT.	Linear adjustment to self-reported No Program Likelihood Score and 10 (maximum score based on deferred installation 48 months or more later).	Self-reported No Program Likelihood.Score.
Timing Adjustment. Timing credit provided for deferred installation absent the Program. Linear adjustment with gradually increasing credit value for each year of deferral of 25% for one year,50% for two years, 75% for three years and 100% for four years or more.	Incorporated into No Program score.	Applied to the average of the Timing and Selection, Program Influence and No-Program scores
Project-level Free-ridership (ranges from 0.00 to 1.00)	1 minus Sum of scores (Timing and Selection, Program Influence, No-Program)/30	1 minus the average of the Timing and Selection, Program Influence and No-Program scores, adjusted for Timing
PY8 and PY9 Project level Net-to-Gross Ratio (ranges from 0.00 to 1.00)	1 minus Project level Free-ridership	1 minus Project level Free-ridership

[1] Based on the NTG algorithm specifications in TRM v.6.0 Attachment A (Illinois Statewide Net-to-Gross Methodologies)
[2] Only applicable for sites that indicated a vendor influence score greater than maximum of the other program element scores or those sites that had a study performed by a Technical Service Provider.

NTG Sample Design and Completed Surveys

During both PY8 and PY9, the NTG sample design consisted of 8 sample points that corresponded to and completely overlapped with the gross impact M&V sample of 8 projects in each year. In both years, telephone surveys were completed for all 8 sample points, across two waves of sample. Therefore, the findings for each year are based on a total of 8 completed interviews to support the calculation of the net-to-gross ratio calculation.

Table 2 and Table 3 below summarize the number of completed telephone surveys in each year, and the percent of ex-ante kWh claims represented. The surveys completed represent 48 percent and 87 percent of ex-ante kWh claims in PY8 and PY9, respectively.

Table 2: Profile of the PY8 Participant Survey Net-to-Gross Sample by Strata

	Program Population Summary			NTG Interviews Completed		
Sampling Strata	Number of Records (N)	Ex Ante kWh Impact Claimed	kWh Weights by Strata	N	kWh	% of Population Ex Ante kWh
1	2	6,369,445	0.34	2	6,369,445	100%
2	9	6,432,226	0.35	3	1,935,237	30%
3	18	5,816,088	0.31	3	674,837	12%
TOTAL PY8 DC	**29**	**18,617,759**	**-**	**8**	**8,979,519**	**48%**

Table 3. Profile of the PY9 Participant Survey Net-to-Gross Sample by Strata

	Program Population Summary			NTG Interviews Completed		
Sampling Strata	Number of Records (N)	Ex Ante kWh Impact Claimed	kWh Weights by Strata	N	kWh	% of Population Ex Ante kWh
1	1	16,274,747	0.35	1	16,274,747	100%
2	2	19,129,513	0.41	2	19,129,513	100%
3	16	10,896,121	0.24	5	4,758,812	44%
TOTAL PY9 DC	**19**	**46,300,381**	**-**	**8**	**40,163,072**	**87%**

Weighted NTG Results Based on Core Free Ridership Algorithm 1 (Preferred specification)

Weighted results are presented in this section for each sampling size stratum, and for the program overall. To produce an estimate of the net-to-gross ratio (NTGR), the individual NTGRs for each of the projects in the sample were weighted by the size of the ex-ante savings estimates (savings) associated with the project, and the proportion of the total sampling domain savings represented by each sampling stratum. NTGR results are weighted by ex-ante kWh.

PY8 NTG Results

Table 4 shows the PY8 project-specific and stratum level NTGRs. The overall program energy NTGR for PY8 is 0.47, which represents a significant drop from the PY7 result of 0.68. By strata, the mean energy NTGR values are 0.32 for stratum 1 (large-sized projects), 0.41 for stratum 2 (medium-sized projects), and 0.70 for stratum 3 (small sized projects) which indicates the free-ridership level for the largest sized projects in strata 1 and 2 is much higher than the free-ridership of the smaller project sizes in stratum 3. The low NTG values for strata 1 and 2 projects are a key factor for the decline in PY8 NTG results.

Table 4. PY8 NTGR Results for the Data Centers Sample

Project ID*	Sampling Stratum	Project Specific NTGR	Sample-Based Verified kWh NTGR	Sample-Based Verified kW NTGR
PY8 – 01**	1	0.40	0.32	0.17
PY8 – 02**	1	0.05		
PY8 – 03**	2	0.83	0.41	0.02
PY8 – 04**	2	0.00		
PY8 – 05**	2	0.60		
PY8 – 06**	3	0.67	0.70	0.70
PY8 – 07**	3	0.67		
PY8 – 08**	3	0.83		
Total	**N/A**	**NA**	**0.47**	**0.30**

* Actual Project IDs are not provided to protect customer confidentiality
**Overlaps with gross impact sample

By stratum, highlights include the following:

- For the two stratum 1 projects evaluated, the NTGRs were 0.05 and 0.40, respectively, indicating weak program influence. Both projects were for co-location data centers, which are already driven by market forces to drive their operating costs per-unit (also referred to as Power Utilization Effectiveness or PUE) down as low as possible. One decisionmaker explained that they like to deliver an already energy efficient product to prospective clients. With co-location facilities, a lot of the leases include the electric bill, and energy efficient features of the building, which makes them more attractive to clients. Related, they like to earn LEED certification. Both projects appreciated the rebate and it helped the payback, but they were going to do what they did anyway.
- For stratum 2 projects, NTGRs ranged from 0.00 to 0.83, indicating wide variation in project circumstances. One of the three stratum 2 projects (with an NTGR of 0.00) was a co-location new construction project with sufficient motivation already to pursue building an energy efficient facility. Because it was new construction, many decisions on equipment had already been made beforehand. The second project, with an NTGR of 0.60, involved an HVAC retrofit project with an air side economizer to boost energy efficiency and provide redundancy. The program incentive played an important role in moving the project within the company's acceptable payback cutoff point. The third project (with an NTGR of 0.83) involved merging two data centers and installing energy

efficient cooling equipment with a much smaller footprint. This new equipment was much more expensive than conventional equipment, and the program rebate was important to help offset some of that added cost.

- NTGRs for stratum 3 projects ranged from 0.67 to 0.83, indicating moderate free ridership. For two of the projects, the technical assessment study conducted by the program was critical to their equipment choices and decisionmaking. The program incentive, which was also analyzed in the technical studies, was what made the economics work for the project. For the third project, the company's management didn't accept the proposed technology (hot aisle containment) and didn't want to make a change until ComEd's program was brought in. The combination of the program incentive plus the technical study was what changed their mind.

The evaluation team used a ratio estimation technique to estimate the program-level NTGR, based on the steps outlined in the California Evaluation Framework. The evaluation team used the standard error to estimate the error bound around the estimate of the verified evaluation NTGR. The program level kWh and kW NTGR, along with confidence intervals and precision estimates, is shown in Table 5 (kWh impacts) and in Table 6 (kW impacts).

Information regarding participant spillover was also collected, but ultimately did not support a finding of any spillover. Therefore, no spillover was included in the calculation of NTGR for PY8.

Table 5. kWh NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.32	0.32	0.32
2	70%	0.12	0.41	0.70
3	7%	0.65	0.70	0.75
TOTAL PY8 DC	**22%**	**0.37**	**0.47**	**0.57**

Table 6. kW NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.17	0.17	0.17
2	216%	0.00	0.02	0.05
3	7%	0.65	0.70	0.75
TOTAL PY8 DC	**7%**	**0.28**	**0.30**	**0.32**

PY9 NTG Results

The PY9 project-specific and stratum level NTGRs are reported below in **Error! Not a valid bookmark self-reference.**. The program-level PY9 mean energy NTGR averaged 0.25. In general, PY9 mean energy NTGR values are much lower than the PY8 value of 0.47 and significantly lower than the PY7 value of 0.68. Energy NTGR values for the three sampling strata are 0.05 for stratum 1 (large sized projects), 0.23 for stratum 2 (medium sized projects), and 0.57 for stratum 3 (small sized projects). As in PY8, this indicates that the free-ridership level for the largest sized projects (stratums 1 and 2) is much higher than the free-ridership of the small project sizes.

Table 7. PY9 NTGR Results for the Data Centers Sample

Project ID*	Sampling Stratum	Project Specific NTGR	Sample-Based Verified kWh NTGR	Sample-Based Verified kW NTGR
PY9 – 01**	1	0.05	0.05	0.05
PY9 – 02**	2	0.40	0.23	0.23
PY9 – 03**	2	0.05		
PY9 – 04**	3	0.77	0.57	0.42
PY9 – 05**	3	0.71		
PY9 – 06**	3	0.77		
PY9 – 07**	3	0.50		
PY9 – 08**	3	0.00		
Total	**N/A**	**NA**	**0.25**	**0.19**

* Actual Project IDs are not provided to protect customer confidentiality
**Overlaps with gross impact sample

Stratum-level highlights include the following:

- The three projects in stratum 1 and 2 had NTGRs of 0.05, 0.05 and 0.40. All three are co-location data centers, which are already driven by market forces to drive their operating costs per-unit down as low as possible. This is clearly reflected in the very low NTGRs, indicating low or no program influence on decisions.
- Across the smallest projects, stratum 3, NTGRs ranged from 0.00 to 0.77, and averaged 0.57, indicating a medium level of free ridership. It is interesting to note the wide range of results across the 5 projects evaluated. Three projects' NTGRs were clustered around medium-high values (0.71 to 0.77, three projects), another had a mid-range value of 0.50, and one had an extremely low value of 0.00.
    - For the 3 projects with the highest NTGRs, the program rebate was a key influence which helped to accelerate equipment retrofit decisions. Absent the program, the projects would not have been pursued for several years.
    - For the mid-range NTGR project (0.50), key decision factors included the program incentive and technical assistance which were considered critical to making the project viable.
    - The project with the lowest NTGR value (0.00) had already made their decision before they learned about the availability of an incentive through the program. They would have installed the same equipment at the same time absent the program.

The program level kWh and kW NTGR, along with confidence intervals and precision estimates, are shown in Table 8 (kWh impacts) and in Table 9Table 6 (kW impacts).

Information regarding participant spillover was also collected, but ultimately did not support a finding of any spillover. Therefore, a quantification of spillover was not included in the calculation of NTGR for PY9.

Table 8. PY9 kWh NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.05	0.05	0.05
2	0%	0.23	0.23	0.23
3	28%	0.41	0.57	0.73
TOTAL PY9 DC	**15%**	**0.21**	**0.25**	**0.28**

Table 9. PY9 kW NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.05	0.05	0.05
2	0%	0.23	0.23	0.23
3	53%	0.20	0.42	0.64
TOTAL PY9 DC	**15%**	**0.16**	**0.19**	**0.22**

Combined PY8 and PY9 Results

The PY8 and PY9 project-specific NTGRs are plotted in Figure 4 and Figure 5, respectively. Each plot point in the figure represents a sampled project. The plot points are grouped by strata, where stratum 1 is large sized projects, stratum 2 is medium sized projects, and stratum 3 is small sized projects. The green and blue horizontal lines denote the strata-level energy and demand weighted NTGRs, respectively. Note that in PY9, strata 1 and 2 were combined for the demand weighted NTGR, as there was only a single stratum 1 project with demand savings.

Figure 4: PY8 Sample NTGR by Stratum

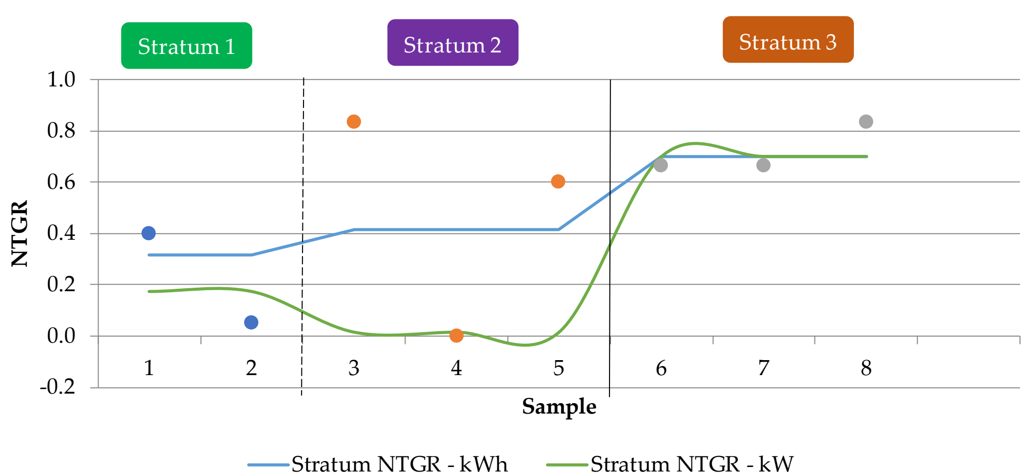
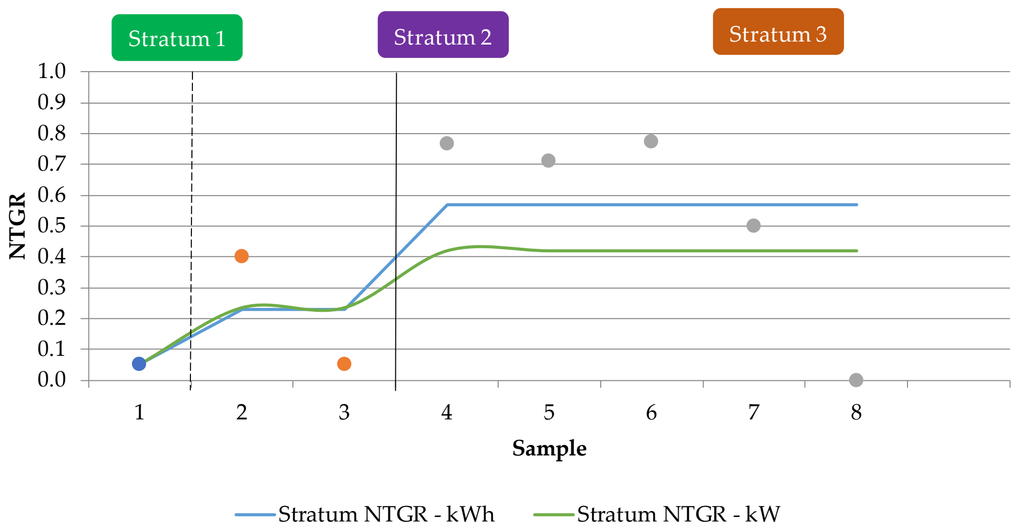


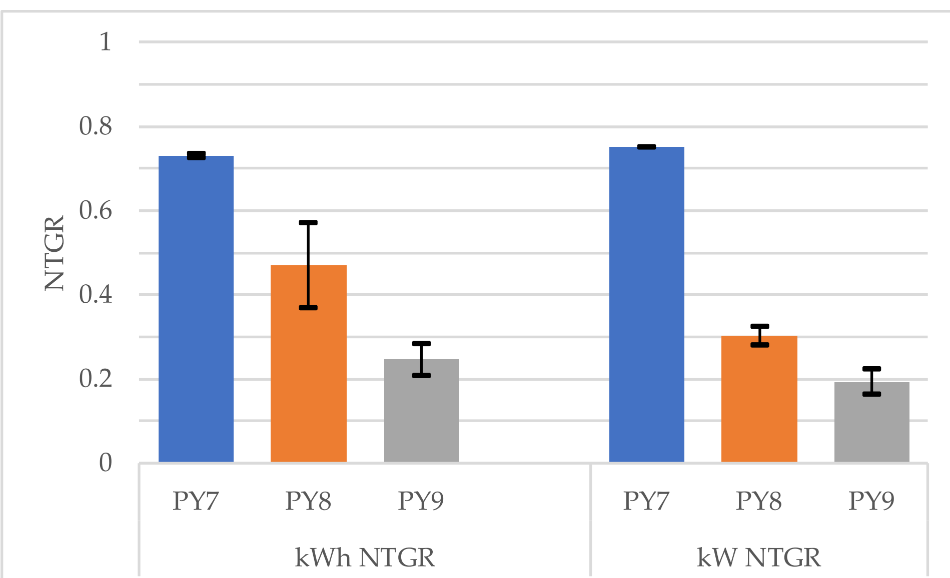
Figure 5: PY9 Sample NTGR by Stratum



The evaluation research findings energy and demand-weighted NTGR by program year, for PY7, PY8, and PY9, are presented below in

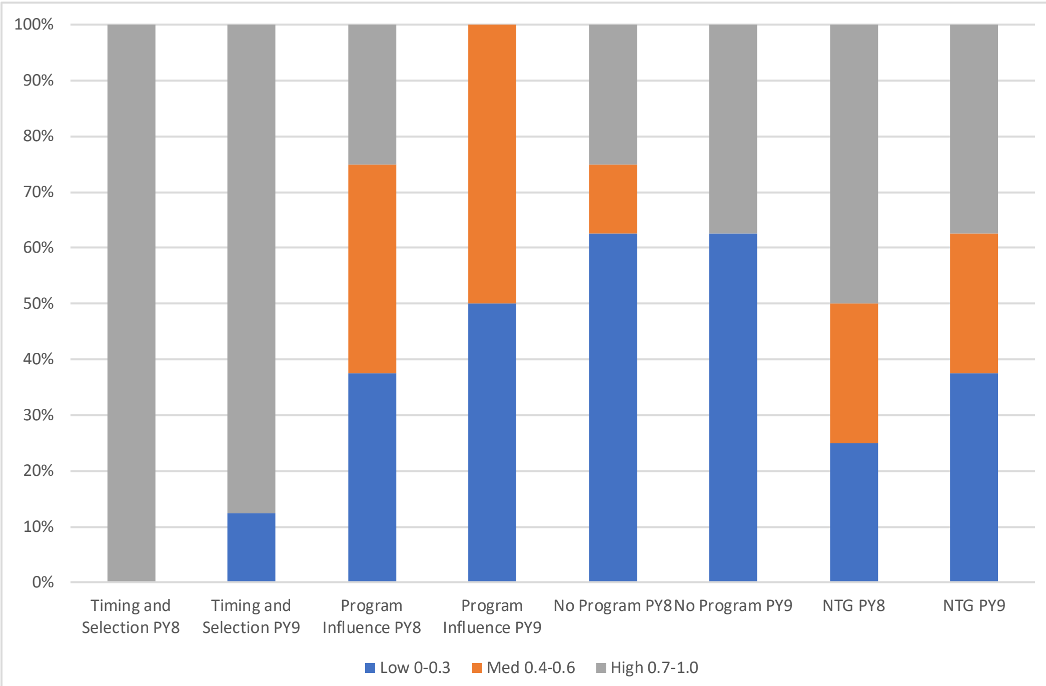
Figure 0-6. The overall trend in the kWh NTGR for Data Center projects has been sharply downward.

Figure 0-6. Evaluated NTGR by Program Year with 90% Confidence Intervals



A breakdown of NTGR by the three component scores is shown in Figure 0-7. The timing and selection score reflects the importance of various program and program-related elements in the customer's decision and timing of the decision in selecting specific program measures. The program influence score reflects the relative degree of influence the program had on the customer's decision to install the specified measures as versus non-program factors. The no-program score captures the likelihood of various actions the customer might have taken now and in the future if the program had not been available.

Figure 0-7. NTGR Level by Component Scores



A scan of the PY8 vs. PY9 bars provides additional insight into a key causal factor for the drop in the NTGR value between PY8 and PY9. For all but the last score, the concentration of High values is moderately to significantly higher in PY8 than PY9. As a result, for the overall NTGR, the share of High scores in PY8 exceeds that in PY9 by a wide margin.

Stratum-level causal factors leading to these results were discussed previously. In general, PY9 projects were characterized by program-related factors that were either unimportant or not applicable to the final decisions to do the project.

1.1.1.1 Combined PY8 and PY9 NTGR

The evaluation team calculated a combined PY8 and PY9 NTGR. This value was determined using savings weighted NTGRs from PY8 and PY9 and computing a weighted average value. The combined PY8/9 value of 0.31 is much lower than the PY7 NTGR of 0.68.

Table 10. Combined PY8 and PY9 MWh NTG Ratio

Year	N	kWh	Weight	NTGR	NTG SE
PY8	29	18,617,759	29%	0.47	8%
PY9	19	46,300,381	71%	0.25	3%
DC PY8/PY9	**48**	**64,918,140**	**100%**	**0.31**	**4%**

Finally, given the dramatic difference found between co-location and non- co-location NTGRs, separate combined PY8/9 values were also calculated for these segments. The combined PY8/9 NTGR for co-locations is 0.25, while the PY8/9 NTGR for non-co-locations is 0.71. The evaluation team also found significant NTGR variation within the co-location segment for new construction vs. retrofit projects, with new construction project NTGRs much lower than retrofit project NTGRs. The combined PY8/9 new construction project NTGR is 0.20, while the retrofit project NTGR value is 0.72. *The EM&V team recommends that the combined PY8/9 values for co-location* new construction projects of 0.20, for co-location retrofit projects *of 0.72 , and for non-co-locations of 0.71 be used to compute program-verified savings for CY2019 projects.* This recommendation is consistent with the planned research spelled out in our PY8 and PY9 evaluation plans.

Sensitivity Case - Weighted NTG Results Based on Core Free Ridership Algorithm 2

The evaluation team also performed a sensitivity analysis based on Core Free Ridership Algorithm 2. This algorithm varies from Algorithm 1 with respect to how it treats the effect of timing in the calculation of the NTGR. Algorithm 1 adjusts for Timing within the No-Program score, then averages the 3 scores. Algorithm 2 determines the No-Program Score without a Timing adjustment, averages the 3 scores, then applies a Timing adjustment factor to the 3-score average, based on the formula below:

> **Timing Adjustment Factor (Free Ridership Score)** as equal to:
> 1 - ((Number of Months Expedited - 6)/42)*((10 - Likelihood of Implementing within One Year)/10)

NTG Algorithm 2 –PY8 Weighted NTG Results

The PY8 program level NTGR for version 2 of the algorithm, along with precision estimates, is shown below in Table 11. The overall program NTGR for PY8 is 0.50, which is slightly higher than the Algorithm 1 value of 0.47. This reveals that there is only a slight timing effect on the NTGR for these projects – half of the projects are new facilities and would need to be built at the same time regardless of any program effect.

Table 11. Algorithm 2 PY8 MWh NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.32	0.32	0.32
2	72%	0.13	0.47	0.80
3	13%	0.64	0.73	0.83
DC PY8 Alg 2	**24%**	**0.38**	**0.50**	**0.62**

NTG Algorithm 2 –PY9 Weighted NTG Results

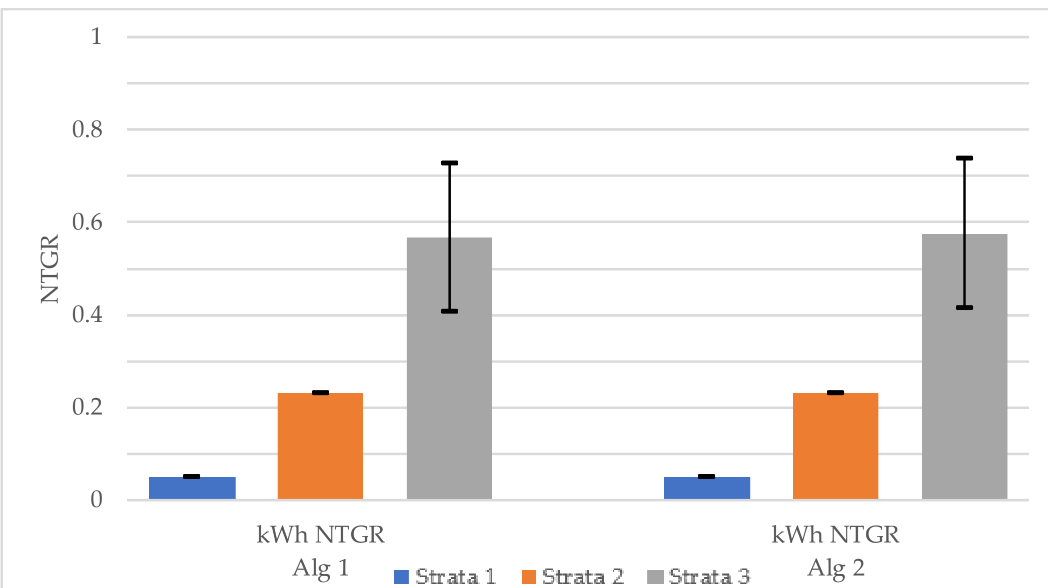
For this second version of the NTG algorithm, the PY9 program level NTGR, along with precision estimates, is shown below in Table 12. The program-level PY9 mean energy NTGR average of 0.25 is identical to the NTG Algorithm 1 value. This reveals that there is virtually no effect of timing on the NTGR for these projects – again, new construction projects (co-location data centers) account for the majority of projects and they would need to be built at the same time regardless of any program effect.

Table 12. Algorithm 2 PY9 kWh NTG Ratio and Relative Precision at 90% Confidence Level

Sampling Strata	Relative Precision ± %	Low	Mean	High
1	0%	0.05	0.05	0.05
2	0%	0.23	0.23	0.23
3	28%	0.41	0.58	0.74
DC PY9 – Alg 2	**15%**	**0.21**	**0.25**	**0.29**

Figure 8 below compares the PY9 evaluated NTGRs for Algorithms 1 and 2 for each sampling stratum. For PY9, when compared to Algorithm 1, the mean energy NTGR values are unchanged for stratum 1 and stratum 2 (large and medium-sized projects), and 0.58 vs. 0.57 for stratum 3 (small sized projects. The slight improvement in stratum 3 projects is not enough to affect the overall NTGR result. Note the very wide confidence bands around the stratum 3 results in both cases.

Figure 8. Comparison of PY9 Evaluated NTGRs by NTG Algorithm and Stratum



Procedures to Reduce Free Ridership

One way to assess the rate of free ridership likely on a given project is to critically examine the key reasons behind the project **before** the incentive is approved. For example:

- Has the project already been included in the capital or operating budget? Has the equipment already been ordered or installed?
- Is the measure one that the company or other comparable companies in the same industry/segment routinely installs as a standard practice? Is the measure installed in other locations, without co-funding by incentives? Is the measure potentially Industry Standard Practice?
- Is the project being done, in part, to comply with regulatory mandates (such as environmental regulations)?
- Are the project economics already compelling without incentives? Is the rebate large enough to make a difference in whether or not the project is implemented?
- Is the company in a market segment that is ahead of the curve on energy efficiency technology installations? Is it part of a national chain that already has a corporate policy to install the proposed technology?
- Does the proposed measure have substantial non-energy benefits? Is it largely being considered for non-energy reasons (such as improved quality or increased production)?
- Is the project payback quite short even without the incentive?

By conducting a brief interview regarding these issues before the incentive is approved, ComEd can better assess the likely degree of free ridership and may be able to then decide if the project should be excluded or substantially re-scoped to a higher efficiency level. In particular, co-location new construction projects, and other data center projects suspected of high free ridership would be prime candidates for this screening interview.

Spillover

Spillover effects were examined in this evaluation and their magnitude was found to be zero, since none of the participants interviewed in either PY8 or PY9 had installed additional program-qualifying measures outside of any of ComEd's programs. Therefore, spillover was zero for the PY8 and PY9 NTGR.

Cronbach's Alpha Results

Cronbach's Alpha is a measure of internal consistency or reliability. It is used to assess how closely related a set of items are as a group. In this memo, Cronbach's Alpha is used to assess how closely related the items going into the NTG score are to each other. In general, the higher the measured Cronbach's Alpha value, the more consistent and reliable are the results. However, given the small number of items (i.e., the 3 scores) being considered in this application of Cronbach's Alpha, a high alpha value is not expected. Realistically, Alpha values ranging from 0.4 to 0.6 are considered an acceptable measure of reliability for this analysis given the small number of items being analyzed.

We used the Standardized Cronbach's Alpha calculation as specified below:

$$\alpha = \frac{N \cdot \bar{r}}{1 + (N - 1) \cdot \bar{r}}$$

Where:

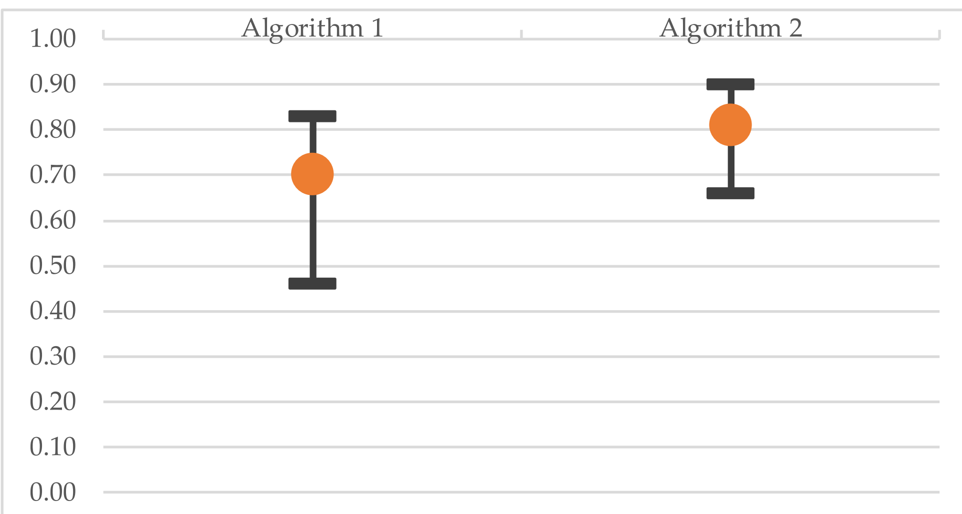
N = the number of items
$\bar{r}$ = the average correlation

We calculated the Cronbach Alpha for both program years combined, for each of the algorithm variations discussed previously.

Figure 9 and **Error! Reference source not found.** below present the Cronbach's Alpha and the 90% confidence intervals for the two NTGR algorithm variations for the PY8 and PY9 Data Centers Program, respectively. Overall Cronbach's Alphas range from 0.46 to0.90.

Note that the confidence intervals around Alpha are expected to be quite large due to the small sample sizes. For Algorithm 1, the Alpha value is slightly lower and the confidence bands are wider than for Algorithm 2, although both Algorithm specifications yield wide confidence intervals. Most likely this is due to the small sample size and somewhat diverse project-level NTGR results.

Figure 9: PY8/9 Data Centers Program Cronbach's Alpha and 90% Confidence Intervals for the Two Algorithm Variations (N=16)



APPENDIX: DATA CENTERS PROGRAM NTG HISTORY

	Data Centers
EPY7	**Data Centers NTG: 0.48** **Free-Ridership 0.52** **Participants Spillover: Negligible** **Nonparticipants Spillover: Negligible** **See EPY7 Custom Program**
EPY8	**Recommendation (based upon PY6 research):** **Data Center NTG kWh: 0.61** **Data Center NTG kW: 0.57** **Data Center Free Ridership kWh: 0.39** **Data Center Free Ridership kW:0.43** **Data Center Spillover: Negligible** NTGR results were based on self-reported data from surveys of a census of PY6 projects. For PY6, the net program impacts were quantified solely on the estimated level of Free-Ridership. Information regarding participant spillover was also collected, but ultimately did not support a finding of any spillover – spillover was very small.
EPY9	**Data Center NTG: 0.68** **Data Center Free Ridership: 0.36** **Data Center Spillover: Negligible** **NTG Research Source:** Free-Ridership: PY7 Participant and vendor self-report data Spillover: PY7 Participant and vendor self-report data
EPY10	**Data Center NTG kWh and kW: 0.68** **Data Center Free Ridership kWh and kW: 0.32** **Data Center Spillover: Negligible** **NTG Research Source:** Free-Ridership: PY7 Participant and vendor self-report data Spillover: PY7 Participant and vendor self-report data The evaluation team performed telephone surveys in PY8, but the analysis will be performed and combined with PY9 findings.

Source:
http://ilsagfiles.org/SAG_files/NTG/2017_NTG_Meetings/Final/ComEd_NTG_History_and_PY10_Recommendations_2017-03-01.pdf