



ComEd Non-Residential New Construction Small Buildings Offering IPA Program Impact Evaluation Report

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

Presented to
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FINAL

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1. INTRODUCTION

This report presents the results of the PY9 impact evaluation of ComEd’s New Construction – Small Buildings Offering (NC-SBO) IPA Program which began in PY8. It presents a summary of the energy and demand impacts for the total program. The appendix presents the impact analysis methodology and lists project-specific impact analysis findings and results. PY9 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

The Weidt Group (TWG) implemented the NC-SBO Program, a new construction energy efficiency IPA program for non-residential buildings from 5,000 to 20,000 square feet (SF) and multifamily buildings from 5,000 to 100,000 SF. The NC-SBO Program was centered on a tool developed by TWG called Net Energy Optimizer (NEO). The NEO tool can run simulations quickly, provide economic analysis of an efficiency measure bundle and display up to three different efficiency bundle options, which allows for real-time iterations with a participant design team.

Unlike traditional energy modeling where a participant may contract with a professional modeler outside of a utility’s program, TWG conducted the energy modeling for this program. TWG collected information from the participant’s design team to build a model within a few weeks. TWG then met with the participant’s design team again and presented a NEO baseline simulation as well as several enhanced efficiency options. Once the participant selected an efficiency bundle, TWG sent them a Bundle Requirements Document which outlined the agreed measures, documentation required and the incentive. Upon completion of the project, TWG verified the measures so that the incentive could be paid to the participant.

The program had eleven participants in PY9. Each project determined savings via comprehensive building energy modeling which was reported as a single, whole-building measure. The number of participants and projects was the same since there were no multi-project participants in PY9. Table 2-1 provides the volumetric findings.

Table 2-1. PY9 Volumetric Findings Detail

Participation	Count of Projects/Participants
Participants	11
Total Measures	11
Number of Units/Projects	1

Source: ComEd tracking data and Navigant team analysis.

3. PROGRAM SAVINGS

Table 3-1 summarizes the incremental energy and demand savings the NC-SBO 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	1,339,540	233	247
Program Gross Realization Rate	83%	76%	51%
Verified Gross Savings	1,112,042	177	126
Program Net-to-Gross Ratio (NTGR)	0.77	0.77	0.77
Verified Net Savings	856,272	136	97

Source:

Source: ComEd tracking data and Navigant team analysis.

4. PROGRAM SAVINGS BY MEASURE

The NC-SBO Program did not track savings by measure since every project was a single whole building measure. Program savings were estimated through participant-specific whole building energy analyses, discussed further in Section 5. However, the buildings had energy savings strategies which collectively form the basis of the whole building measure. When discussing energy savings strategies in this report, they will be referred to as measures.

5. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

5.1 Impact Parameter Estimates

The evaluation team calculated verified gross savings for energy, demand, and coincident peak demand¹ resulting from the PY9 NC-SBO Program by using participant-specific whole-building energy models developed for baseline and as-built design scenarios. For each participant, the baseline and as-built design energy models estimated the annual whole building energy consumption based on architectural, building envelope, HVAC, lighting, and other building parameters. The baseline energy model for a project estimated the counterfactual annual energy consumption the building would have been expected to consume if it was built to meet the energy performance baseline standards. The estimated first year savings was the difference in annual electric consumption between the two models. The energy performance baseline was the Illinois Energy Conservation Code for Commercial Buildings, which referenced and incorporated the applicable International Energy Conservation Code (IECC). This reference specifically allowed for use of ASHRAE Standard 90.1 as an alternate compliance method. The program assumed the appropriate baseline based on the date that the project applied to the program. Projects that applied prior to May 31, 2016 used the IECC 2012, and those that applied after June 1, 2016 used IECC 2015.

Program-level lifetime was determined by a Seventhwave study, which was a weighted average of effective useful life (EUL) for energy efficiency measures installed as part of ComEd's Business New Construction (BNC) program. Both the BNC and the NC-SBO Programs utilized this study and determined an EUL of 17.4 years. The lifetime energy and demand savings were estimated by multiplying the verified savings by the effective useful life for each project.

Table 5-1 presents the parameters that were used in the verified gross and net savings calculations and indicates which were calculated through evaluation activities and which were deemed.

¹ Utility and PJM Summer Peak demand are both defined as 1-5PM, non-holiday weekdays, June through August.

Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Source	Deemed or Evaluated?
Baseline Lighting Model Inputs	ASHRAE 90.1	Evaluated
Baseline HVAC Model Inputs	ASHRAE 90.1	Evaluated
Baseline Envelope Model Inputs	ASHRAE 90.1	Evaluated
Efficient Lighting Model Inputs	Building Design Documents	Evaluated
Efficient HVAC Model Inputs	Building Design Documents	Evaluated
Efficient Envelope Model Inputs	Building Design Documents	Evaluated
Refrigeration Measures	Illinois TRM*	Evaluated
Verified Realization Rate on Ex Ante Gross Savings	NEO Building Simulation Models	Evaluated
Net to Gross Ratio	SAG agreement†	Deemed

* State of Illinois Technical Reference Manual version 5.0 from <http://www.ilsag.info/technical-reference-manual.html>.

† PY9 deemed NTG ratios are available on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>

Source: Navigant team analysis

5.2 Other Impact Findings and Recommendations

Most sampled projects required some level of energy adjustment, while all sampled projects required a peak demand reduction adjustment. The final realization rate was 82 percent for energy and 51 percent for peak demand reduction.

There are two primary reasons for the lower energy realization rate. Several projects had adjustments to the HVAC fan power reduction measure and one large project overstated refrigeration savings associated with reducing heat provided to refrigeration doors. The lower peak demand reduction realization rate was primarily due to the ex ante peak demand reduction not calculating savings during the summer peak period. The second largest project in terms of ex ante demand savings had a project-level realization rate of three percent. Most of the ex ante savings from this project was due to exterior lights which had zero savings during the peak period. Further details are given in Appendix 2. Impact Analysis Detail.

Navigant provides the following key program findings and recommendations based on our evaluation of program impacts. These recommendations from the evaluation team are specific to decreasing variability between the ex ante and ex post calculations and streamlining the impact verification.

Finding 1. Forty percent of the sampled projects had savings from HVAC Fan Reduction adjusted downwards due to excessive ex ante savings calculations. Fan savings for packaged/unitary equipment were calculated during unoccupied hours, while Appendix G does not allow unoccupied fan savings for packaged/unitary equipment.

Recommendation 1. Reconfigure the NEO tool to not calculate HVAC fan savings for packaged/unitary HVAC equipment during unoccupied hours.

Recommendation 2. Reexamine the HVAC fan power reduction calculation, especially for smaller buildings. Cross check the output by performing custom engineering calculations of the fan power savings.

Finding 2. Refrigeration savings from low energy doors and anti-sweat heater controls were too high. The savings also exceeded Illinois TRM baseline energy values.

Recommendation 3. Reexamine the low energy doors and anti-sweat heater controls calculations. Cross check the output by performing TRM calculations and ensure results are similar between NEO and the TRM.

Finding 3. One sampled project was a three-story multifamily building, which required a baseline relative to residential code. Residential code required 75 percent of the lighting fixtures to be high-efficiency. Since most of the lights were incandescent and did not qualify as high-efficiency, all lighting savings were removed from the project. Savings were calculated for lighting even though the lighting systems did not meet residential code.

Recommendation 4. For multifamily buildings three-stories or less, ensure residential code is met for all measures before applying ex ante savings.

Finding 4. Reported peak demand reduction did not match the NEO tool average demand reduction during the summer peak period of 1PM to 5PM on non-holiday weekdays, June through August.

Recommendation 5. Calculate the peak demand reduction by determining the energy saved during the peak period and divide by the hours in the peak period to determine the average peak demand reduction.

Finding 5. One sampled project reported significant peak demand reduction for exterior lighting when this measure should not have had any savings during the peak period.

Recommendation 6. Install quality checks on major savings measures to ensure substantial calculation errors do not occur. Consider both a peer review and a senior engineer review for larger items.

6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

6.1 Engineering Methodology

The impact analysis for the projects completed in PY9 included the following steps:

1. Adjusting the baseline NEO model for compliance with Illinois Energy Code.
2. Adjusting the model inputs in the executable files to match the as-built conditions identified in our review of the New Construction Program's project files and then rerunning the model.
3. Quantifying impacts by comparing two simulations representing the projected design scenario and the baseline scenario.
4. Checking the accuracy of the NEO simulation by comparing to industry standard engineering calculations. Where the NEO simulation produced erroneous results, further custom analysis is conducted.

The baseline scenario in the model is dictated by the appropriate Illinois Energy Conservation Code for Commercial Buildings (this is to be distinguished from the IECC, the International Energy Conservation Code). A project's savings model is based on a baseline scenario which incorporates the building codes that were in effect at the time of the project's application. Although the applicable energy codes may change by the time a project obtains a building permit, the program's approach of using the application date to determine the applicable building code is reasonable and justified.

TWG allowed for "Evaluation Level" access to their proprietary NEO tool which was used for all building models. Evaluation adjustments were made in the NEO tool itself where possible. When either limitations of the NEO tool or the Evaluation Level access was insufficient, the evaluation team adjusted the model results with targeted custom engineering calculations. Verified energy savings were determined by

running the adjusted models and subtracting the as-built energy consumption from the baseline energy consumption.

The evaluation team calculated demand reduction by running the NEO tool and analyzing the output of both the baseline and the as-built models. The difference in hourly outputs between the two models represent the hourly savings of the project. Project demand reduction is found by locating the hour within a typical climatic year in which the maximum savings occurred. Coincident peak demand is determined by summing the energy savings occurring in the peak period and dividing that sum by the number of hours in the peak period.

Verified net energy and demand savings were calculated by multiplying the verified gross savings estimates by a net-to-gross ratio (NTGR). In PY9, the NTGR values used to calculate the net verified savings were based on past evaluation research and approved by the Stakeholder Advisory Group (SAG)².

6.2 Overview of Data Collection Activities

The evaluation team selected a stratified random sample for the NC-SBO Program to support the engineering desk reviews. The evaluation team designed the sample to provide 90 percent confidence with a 10 percent precision for evaluated savings values. We divided the sample frame of all projects into two strata based on their electrical savings and randomly selected ten projects across these strata to compose our sample. We then developed case weights to extrapolate the results to similar projects, ensuring that the engineering results are representative of the population of PY9 participants. Table 6-1 summarizes the sampling approach.

Table 6-1. Sampling Approach for PY9 Projects

Stratum	Boundaries (MWh)	Projects in Population	Projects in Sample	Stratum kWh Weight
Large	>250	2	2	52%
Small	0 – 250	9	8	48%
Total		11	10	100%

Source: ComEd tracking data and Navigant team analysis

The evaluation achieved the target 90/10 confidence and precision level for energy and peak demand savings. On energy the precision is 9.5 percent at 90 percent confidence. For peak demand reduction the precision is 8.0 percent at 90 percent confidence.

7. APPENDIX 2. IMPACT ANALYSIS DETAIL

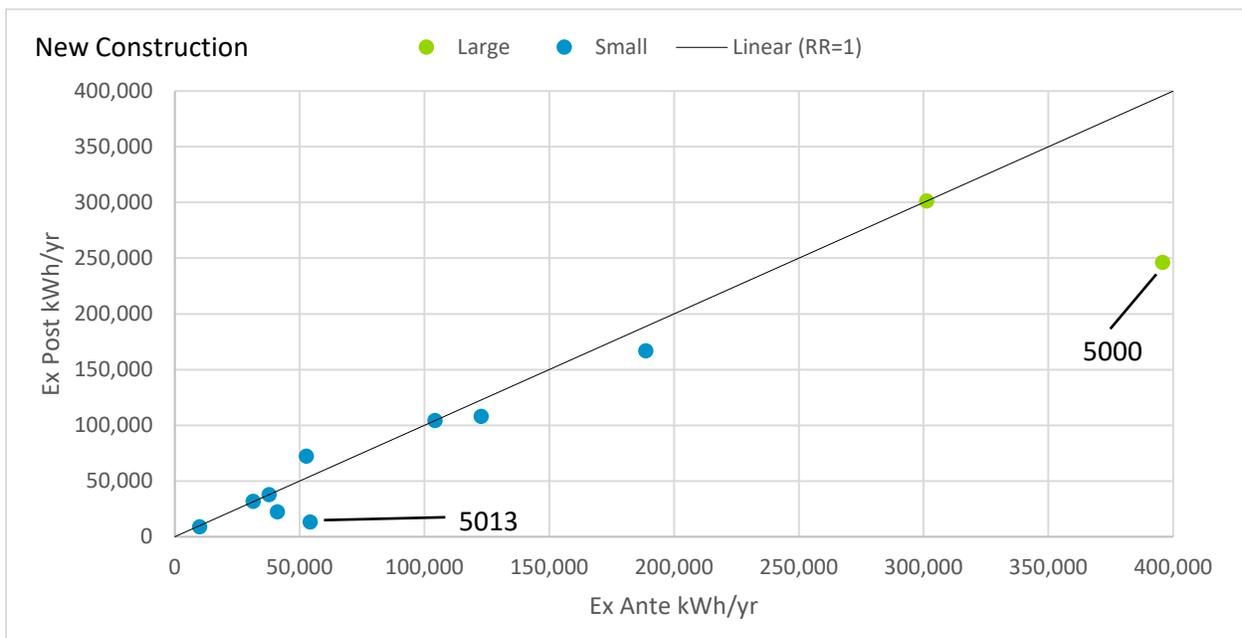
Data analysis reveals certain factors are driving the realization rate between claimed savings and verified savings. This section will begin by discussing in detail the major factors that influence the program-level energy and demand realization rates and will conclude by briefly covering all sampled projects and what factors influence the project-level realization rates. Realization rates below 100 percent indicate that energy savings are adjusted downwards while realization rates above 100 percent indicate energy savings are adjusted upwards.

² PY9 deemed NTG ratios are available on the IL SAG website here: <http://ilsag.info/net-to-gross-framework.html>.

7.1 Energy Realization Rate

Figure 7-1 is a graphical representation of the ex ante versus ex post energy savings for the sampled projects. They are grouped by sample strata, with large strata projects represented in blue and small strata projects represented in gray. The diagonal line represents the goal of a realization rate of 100 percent. Points above and to the left of the RR=100 percent line represent buildings with energy realization rates above 100 percent, while the points below and to the right are buildings with realization rates less than 100 percent. The most significant outliers are labeled with their respective project numbers.

Figure 7-1. Ex Ante vs. Ex Post Energy Savings



Source: Navigant analysis

Project 5013 is an example of a systemic impact issue the evaluation team identified, that the NEO tool is in many projects estimating excessive savings from HVAC Fan Power Reduction that is not consistent with established fan power reduction findings. Project 5013 was almost entirely, 96 percent of project kWh savings, HVAC fan savings from a dual speed roof top unit (RTU). The key feature of the RTU was the dual speed capability. The evaluation team found the reported savings to be significantly higher than the baseline energy consumption per ASHRAE 90.1 – Appendix G. Navigant reduced the fan energy savings by 79 percent from the ex ante savings by using a custom calculation with Appendix G as the baseline and engineering approximations for the as-built case.

The verification team does not have the ability to dissect the actual calculations that the NEO tool conducts for fan energy, but by analyzing the NEO model in a DOE2 environment³ it appears NEO is calculating fan savings for both occupied and unoccupied conditions. Appendix G section G3.1.2.5 Fan System Operation, states that, “Supply and return fans shall operate continuously whenever spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours. If the supply fan is modeled as cycling and fan energy is included in the energy-efficiency rating of the equipment, fan energy shall not be modeled explicitly.” In other words, for packaged HVAC equipment such as RTU units

³ NEO is built on a DOE2 platform. With the evaluator access that was provided to Navigant, the evaluation team could analyze building models in a DOE2 environment.

where efficiency ratings include efficiency, the models should not be reflecting any fan savings during unoccupied hours.

Project 5000 is a grocery store with 64 percent of the ex ante energy savings from refrigeration measures and 18 percent of the savings from HVAC fan power reduction. Like project 5013, the HVAC fan power savings are overstated in the ex ante model and Navigant reduced fan power savings by 37 percent. However, the major project level adjustment is due to the refrigeration measures which consisted of LED case/door lighting with occupancy sensors, electrically commutated fan motors, anti-sweat heater controls, and low energy doors.

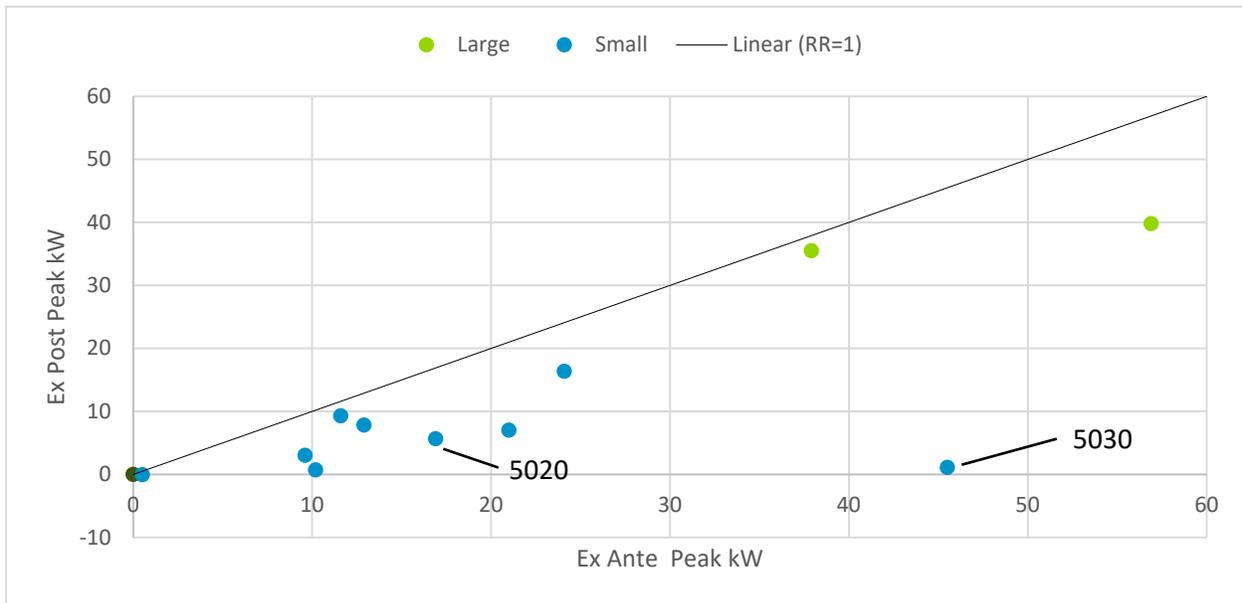
The evaluation team was unable to determine exactly how the NEO tool is analyzing the refrigeration measures, so the team analyzed the measures relative to established engineering calculations given by the Illinois Technical Reference Manual (TRM) or other regional TRMs. The evaluation team found both the LED lighting with occupancy sensors and the electrically commutated fan motor ex ante savings to be within an acceptable range and no adjustments were made. When analyzing the low energy doors and the anti-sweat heater controls, which both attempt to reduce heat provided to a refrigeration glass door, the evaluation team found the ex ante savings to be well beyond established savings calculations.

The savings from anti-sweat heater controls are given by the Illinois TRM, and ex ante savings for this measure is so excessive it exceeds the baseline energy consumption given in the TRM. Low energy doors are not a measure covered by the IL TRM, so the evaluation team used the Minnesota TRM V2.2 to estimate savings. These TRMs provided a reasonable energy savings for these two measures and resulted in reducing the combined ex ante savings for the two measures by 63 percent.

7.2 Peak Demand Realization Rate

Like the energy savings analysis, the discussion of peak demand reduction is begun by analyzing Figure 7-2, which is a graphical representation of the project-level ex ante versus ex post peak demand reduction findings. The diagonal line represents the goal of a realization rate of 100 percent. Points above and to the left of the RR=100 percent line represent projects with peak demand realization rates above 100 percent, while the points below and to the right are projects with realization rates less than 100 percent.

Figure 7-2. Ex Ante vs. Ex Post Peak Demand Reduction



Source: Navigant analysis

The overriding adjustment made to the ex ante peak demand calculation applied to every sampled project. The NEO baseline and as-built models report hourly energy consumption for an entire year. The hourly difference between the two models represents the hourly savings. Peak demand reduction should be calculated using the energy saved in kWh during the peak period divided by the hours in the peak period. The reported peak demand reduction in the tracking data does not correspond to this definition of peak demand reduction. In most cases this resulted in a downward adjustment of the ex ante demand savings⁴. One significant example is project 5020 which has an energy realization rate of 101 percent. The only adjustment to the demand calculation is due to calculating savings during the proper peak hours which results in a demand realization rate of 34 percent.

Project 5030 is a car dealership with 82 percent of the ex ante peak demand reduction coming from the exterior lighting power density. No peak savings should be attributed to them since these exterior lights need to be controlled off during the daylight hours per energy code. The ex post demand savings due to this measure was set to zero. Additionally, the remainder of the demand reduction measures in this project were not calculated during the peak period and were appropriately adjusted.

7.3 Project Level Realization Rate

Table 7-1 below shows the project level results of the engineering desk review. Ex ante savings, ex post savings, and the resulting realization rate are presented for each of the 10 projects included in the sample. Where applicable, the table includes a narrative describing the reasons for any discrepancies between ex ante and ex post savings.

⁴ All sampled projects have a peak demand realization rate < 100%. A few projects saw an increase in realization rate due to correctly applying only the peak hours, but those projects had other factors reducing the realization rate for all hours of the year.

Table 7-1. Researched Gross Savings for Sampled Projects

Project ID	Ex Ante		Ex Post		Realization Rate		Description
	Energy Savings (kWh/yr)	Peak Demand Reduction (kW)	Energy Savings (kWh/yr)	Peak Demand Reduction (kW)	Energy Savings RR	Peak Demand Savings RR	
5000	395,798	56.9	246,080	39.8	62%	70%	The energy savings for this project were adjusted primarily due to the refrigeration low energy doors and anti-sweat heater controls. The HVAC fan power reduction calculation was adjusted downward. Additionally, the ex ante peak demand reduction was calculated using an incorrect peak period.
5002	301,198	37.9	301,198	35.5	100%	94%	The ex ante peak demand reduction was not calculated using the correct peak period.
5003	37,707	11.6	37,707	9.3	100%	80%	The ex ante peak demand reduction was not calculated using the correct peak period.
5004	52,657	12.9	72,275	7.8	137%	61%	The savings from glazing were underestimated in the NEO model, but there was also a slight reduction in savings for direct expansion (DX) cooling efficiency. The evaluation team adjusted savings per the verified window and air conditioning performance factors. The ex ante peak demand reduction was calculated using an incorrect peak period.
5010	9,903	0.5	8,895	-0.1	90%	-11%	This project is a 3-story multifamily building, which makes the baseline relative to residential code. Residential code requires 75% of the lighting fixtures to be high-efficacy. Since most of the lights are incandescent and don't qualify as high-efficacy, all lighting savings were removed from the project. The NEO tool shows as-built peak demand is slightly higher than the baseline peak demand, which is why the demand reduction was adjusted to a negative number. The ex ante peak demand reduction was calculated using an incorrect peak period.
5013	54,239	10.2	13,034	0.7	24%	7%	96% of the ex ante savings were from HVAC fan power reduction which overstated the savings from a dual speed RTU. The evaluation team

Project ID	Ex Ante		Ex Post		Realization Rate		Description
	Energy Savings (kWh/yr)	Peak Demand Reduction (kW)	Energy Savings (kWh/yr)	Peak Demand Reduction (kW)	Energy Savings RR	Peak Demand Savings RR	
							recalculated using standard engineering practices and following ASHRAE 90.1, Appendix G. The ex ante peak demand reduction was calculated using an incorrect peak period.
5019	41,027	9.6	22,216	3.1	54%	32%	60% of the ex ante project savings were from HVAC fan power reduction which overstated the savings from a dual speed residential style furnace with ECM motors and DX cooling. The evaluation team recalculated using standard engineering practices and following ASHRAE 90.1, Appendix G. The ex ante peak demand reduction was calculated using an incorrect peak period.
5020	31,397	16.9	31,657	5.7	101%	34%	The ex post savings from glazing were slightly increased due to actual installed window specifications. The ex ante peak demand reduction was calculated using an incorrect peak period.
5025	104,268	24.1	104,268	16.4	100%	68%	The ex ante peak demand reduction was calculated using an incorrect peak period.
5030	188,655	45.5	166,872	1.1	88%	3%	The reduction in energy savings was due to the HVAC fan power calculation being overstated in the ex ante calculation. 82% of the ex ante demand reduction was due to a lighting power density reduction in exterior lighting. The ex post calculation removed all lighting demand reduction from the peak period. The ex ante peak demand reduction was calculated using an incorrect peak period.

Source: Navigant Analysis

8. APPENDIX 3. TOTAL RESOURCE COST DETAIL

Table 8-1 shows the Total Resource Cost (TRC) variable table, only includes cost-effectiveness analysis inputs available at the time of finalizing the PY9 NC-SBO Program impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to evaluation later. EUL information in this table is subject to change and is not final.

Table 8-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Whole Building	Whole Building	Project	11	17.4	1,339,540	247	1,112,042	126

Source: ComEd tracking data and Navigant team analysis