Coordinated Utility RetroCommissioning Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Program Year 2019 (CY2019) (1/1/2019-12/31/2019)

Presented to
ComEd
Nicor Gas
Peoples Gas
North Shore Gas

FINAL

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Coordinated Utility RetroCommissioning Program Impact Evaluation Report

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Coordinated Utility RetroCommissioning Program Impact Evaluation Report

1. Introduction

This report presents the results of the impact evaluation of the Coordinated Utility CY2019 RetroCommissioning Program. It includes a summary of the energy and demand impacts for the total program broken out by relevant fuel type and program structure details. The appendix provides the impact analysis methodology and details of the Total Resource Cost inputs. CY2019 covers January 1, 2019 through December 31, 2019.

2. Program Description

The Coordinated Utility RetroCommissioning (RetroCommissioning) Program has been part of ComEd's Energy Efficiency Program since 2007. In 2010, ComEd began coordinating the program with gas utilities which also serve ComEd customers. ComEd manages and funds the program, and the gas utilities have the option to share the program costs and savings with ComEd on a project-by-project basis. The overlapping gas territories include Nicor Gas, Peoples Gas, and North Shore Gas. The RetroCommissioning Program is a natural fit for coordinated delivery with the gas utilities due to the intensive investigation and analysis of heating, ventilation, and air-conditioning (HVAC) systems. Individual measures often save both electricity and natural gas so that analyzing one energy source, while neglecting the other, would fail to document all energy benefits incented by the program. Nexant, Inc. is the implementation contractor (IC) for the RetroCommissioning Program, verifying, tracking and reporting savings for the coordinating utilities. Program-approved Energy Efficiency Service Providers (EESPs) recruit participants and work to complete projects.

The RetroCommissioning Program helps commercial and industrial (C&I) customers below 10 MW improve the performance and reduce energy consumption of their facilities through the systematic analysis of *existing* building systems. Beginning in CY2018, the program also serves public sector customers. Generally, the program pays for 100 percent of a detailed study, contingent upon a participant's commitment to spend a defined amount of their own money implementing a bundle of study recommendations having a simple payback of 18 months or less. The program consists of four tracks, with three targeted to medium to large commercial buildings: traditional RetroCommissioning (RCx), monitoring-based RetroCommissioning (MBCx), and RCxpress.

- **RCx** projects typically require more than one year and result in a single comprehensive deliverable.
- **MBCx** projects are based on a multi-year agreement between the building owner and the EESP. This comprehensive approach identifies, analyzes, implements, and verifies measures on a rolling basis with the EESP monitoring Building Automation System (BAS) data periodically using integrated program-installed software to document on-going savings. Measure savings are counted toward program goals in the calendar year they are submitted based on EESP monitoring since the prior submitted savings.
- **RCxpress** engagements generally last from eight to sixteen months and typically have a more limited scope than RCx.
- The **RCx Building Tune-Up** (Tune-up) track is more focused on the most common RCx measures in smaller commercial buildings and groceries and results in a briefer deliverable on a faster timeline.

The program reported 147 projects[1] in CY2019. In CY2019 the RetroCommissioning Program implemented measures with both electric and gas savings as shown in Table 2-1 and Table 2-2 and the

[1] A number of MBCx participants submitted multiple bundles at different times during the year. An MBCx participant counts as one project for CY2019.

following graphs. All participants are ComEd customers, but not all gas customers implemented gas savings. Additional program attributes are shown in Table 2-3 below.

Table 2-1. CY2019 Volumetric Findings Detail by Utility

Participation	Electric only	Nicor Gas	Peoples Gas	North Shore Gas	Total
Participants with service*	53	59	30	5	147
Participants with savings†	75	42	22	5	144
Electric Measures	201	145	113	25	484
Gas Measures	0	68	55	13	136
Total Measures‡	201	148	118	28	495
Number of Units/Projects	3.8	2.5	3.9	5.6	3.4

* As noted by the implementation contractor as having gas accounts. Electric only participants are those absent such notes.
† Gas company customer-participants without gas savings shifted to electric only.
‡Totals include many measures with both electric and gas savings. All projects with gas service and savings also have electric service and savings. Three projects have neither gas nor electric savings.
Source: ComEd tracking data and evaluation team analysis

Table 2-2. CY2019 Volumetric Findings Detail by Track*

Participation	MBCx	RCx	RCxpress	Tune-Up	Total
Participants	36	8	21	82	147
Participants with savings	35	8	21	80	144
Electric Measures	90	53	89	252	484
Gas Measures	16	21	25	74	136
Total Measures	92	57	89	257	495
Number of Units/Projects	2.6	7.1	4.2	3.1	3.4

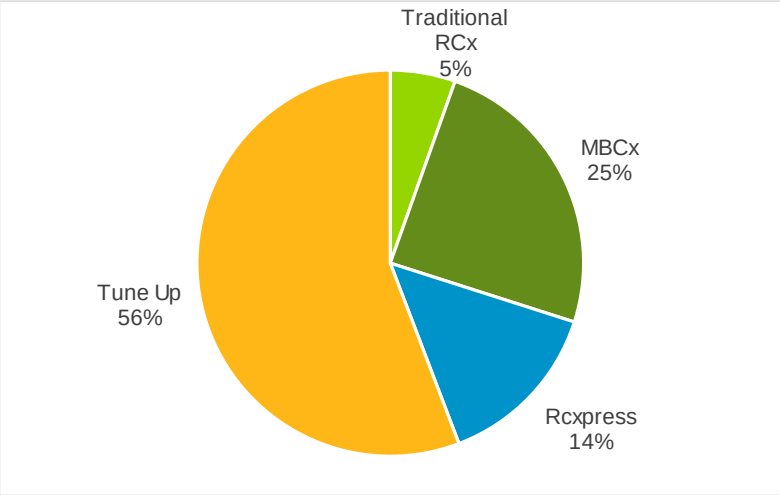
* Many measures have both electric and gas savings. Three projects have neither gas nor electric savings.
Source: ComEd tracking data and Guidehouse team analysis.

Table 2-3. Program Attributes – by Participation Track

Participation Track	Target Facility Size	Incentives	Customer Commitment
Retro-Commissioning (RCx)	>500,000 ft^2 >10 GWh	100% Study $60,000-$100,000 Customer implementation bonuses	$25,000 to implement recommendations
Monitoring Based (MBCx)	>150,000 ft^2 >3 GWh	Funded study, monitoring integration and savings incentives for grandfathered projects	12-month monitoring contract
RCxpress	150,000 - 500,000 ft^2 3-10 GWh	100% Study up to $59,999 Customer implementation bonuses	$5,000 -$10,000 to implement recommendations
RCx Building Tune-Up	<150,000 ft^2 0.5-3.0 GWh	100% of study up to $35,000 $0.04/kWh with caps	Coordination

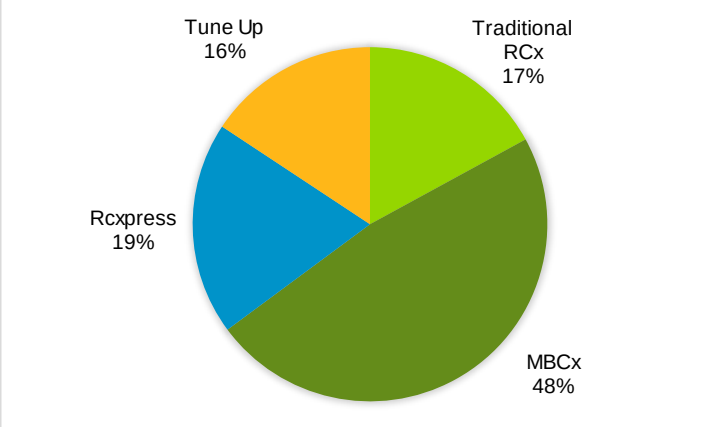
Source: ComEd

Figure 2-1. Distribution of Projects Completed by Track



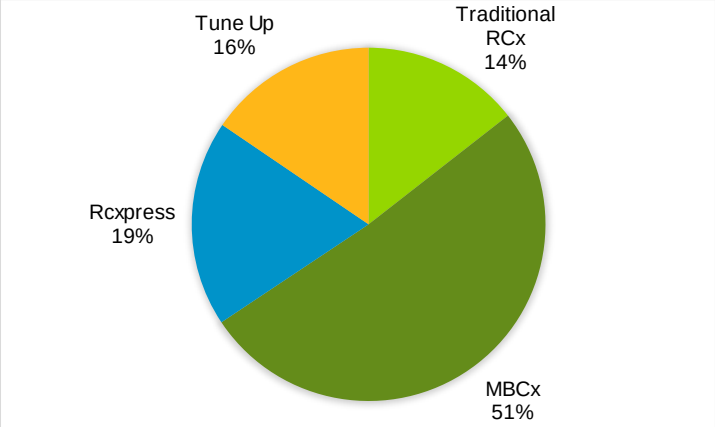
Source: ComEd tracking data and evaluation team analysis

Figure 2-2. Distribution of Electric kWh Saved (ex ante gross) by Track



Source: ComEd tracking data and evaluation team analysis

Figure 2-3. Distribution of Natural Gas Therms Saved (ex ante gross) by Track



Source: ComEd tracking data and evaluation team analysis

3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the RetroCommissioning Program achieved in CY2019. The gas savings are only those that ComEd may be able to claim, which excludes savings the gas utilities claim, either via joint or non-joint programs.[2]

Overall gas savings claimed by the gas utilities is shown in Table 3-2. Verified net electric savings are 31,348,785 kWh. Verified net gas savings converted to electric savings and may be claimed by ComEd are 1,079,644 kWh.

Overall, the gas companies claimed almost 93 percent of the gas savings realized through the program. ComEd may claim the remaining gas energy savings, converted to kWh (See Table 3-1 note).

[2] The evaluation will determine which gas savings will be counted toward goal while producing the portfolio-wide Summary Report.

Table 3-1. CY2019 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Non-Coincident Demand Savings (kW)	Summer Peak* Demand Savings (kW)
Electricity			
Ex Ante Gross Savings	35,441,530	NR	1,504.9
Program Gross Realization Rate	0.94	NA	1.19
Verified Gross Savings	33,349,771	NA	1,785.2
Program Net-to-Gross Ratio (NTG)	0.94	NA	0.94
Verified Net Savings	31,348,785	NA	1,678.1
Converted from Gas†			
Ex Ante Gross Savings	1,320,181	NA	NA
Program Gross Realization Rate	0.87	NA	NA
Verified Gross Savings	1,148,557	NA	NA
Program Net-to-Gross Ratio (NTG)	0.94	NA	NA
Verified Net Savings	1,079,644	NA	NA
Total Electric Plus Gas			
Ex Ante Gross Savings	36,761,711	NR	1,504.9
Program Gross Realization Rate	0.94	NA	1.19
Verified Gross Savings	34,498,328	NA	1,785.2
Program Net-to-Gross Ratio (NTG)‡	0.94	NA	0.94
Verified Net Savings	32,428,429	NA	1,678.1

NR = not reported (refers a piece of data that was not reported, i.e., non-coincident demand savings)
NA = not applicable (refers a piece of data cannot be produced or does not apply)
* The coincident summer peak period is defined as 1:00-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.
† Gas savings converted to kWh by multiplying therms * 29.31 (which is based on 100,000 Btu/therm and 3,412 Btu/kWh). The evaluation will determine which gas savings will be converted to kWh and counted toward ComEd's electric savings goal while producing the portfolio-wide Summary Report. According to Section 8-103B(b-25) of the Illinois Public Utilities Act, "In no event shall more than 10% of each year's applicable annual incremental goal as defined in paragraph (7) of subsection (g) of this Section be met through savings of fuels other than electricity."
‡ The combined NTG ratio in the 'Total Electric Plus Gas' section is not a deemed value, it is a weighted average effective NTG that falls out of the combined savings calculation in the CPAS spreadsheet for net electric savings (deemed NTG = 0.94) plus net gas-converted electric savings (deemed NTG = 0.94).
Source: ComEd tracking data and evaluation team analysis

Table 3-2. CY2019 Total Annual Incremental Therm Savings

Savings Category	Nicor Gas (Therms)	Peoples Gas (Therms)	North Shore Gas (Therms)
Natural Gas*			
Ex Ante Gross Savings	75,630	436,212	69,150
Program Gross Realization Rate	1.01	0.86	0.86
Verified Gross Savings	76,386	375,142	59,469
Program Net-to-Gross Ratio (NTG)	0.94	0.94	0.94
Verified Net Savings	71,803	352,634	55,901

* Natural gas savings with electric interactive effects removed. Ex ante gross savings is based on final project files provided by ComEd and the implementation contractor.
Source: ComEd, Nicor Gas, Peoples Gas, and North Shore Gas tracking data and evaluation team analysis.

4. Cumulative Persisting Annual Savings

Table 4-1 to Table 4-3 and Figure 4-1 show the total verified gross savings for the RetroCommissioning Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2019. The net electric CPAS across all measures installed in 2019 is 31,348,785 kWh (Table 4-1).

The program achieved 517,173 therms total net natural gas savings which includes 480,338 net therms cost-shared by the coordinated gas utilities[3] plus 36,835 net therms converted to kWh which may be claimed by ComEd as ComEd CPAS savings. The net CY2019 gas contribution to CPAS (converted to equivalent electricity) [4] is 1,079,644 kWh (Table 4-2). Adding the gas and electric contributions produces 32,428,429 net kWh of total CY2019 contribution to CPAS (Table 4-3). The "historic" rows in each table are the CPAS contribution back to CY2018. The "Program Total Electric CPAS" and the "Program Total Gas CPAS" are the sum of the CY2019 contribution and the historic contribution.

[3] The gas savings for Nicor Gas, Peoples, and North Shore Gas are not reported in ComEd CPAS tables. The evaluation team will determine which gas savings will be counted toward goal while producing the portfolio-wide Summary Report. According to Section-8-103B of Act 99-0906, "In no event shall more than 10% of each year's applicable annual incremental goal as defined in paragraph (7) of subsection (g) of this Section be met through savings of fuels other than electricity."

[4] The conversion factor from gas to electric is mandated by SAG rule as 1 therm = 100,000 Btu. 1 kWh = 3,412 Btu.
1 therm = 100,000/3412 = 29.31 kWh equivalent.

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

End Use Type	Research Category	EUL	CY2019 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	Verified Net kWh Savings 2018	2019	2020	2021	2022	2023	2024	2025	2026
RetroCommisioning	All	8.4	33,349,771	0.94	264,270,255		31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785
CY2019 Program Total Electric Contribution to CPAS			33,349,771		264,270,255		31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785	31,348,785
Historic Program Total Electric Contribution to CPAS‡						34,519,759	34,519,759	34,519,759	34,519,759	34,519,759	34,519,759	34,519,759	17,259,880	
Program Total Electric CPAS						34,519,759	65,868,544	65,868,544	65,868,544	65,868,544	65,868,544	65,868,544	48,608,664	31,348,785
CY2019 Program Incremental Expiring Electric Savings§								-	-	-	-	-	-	-
Historic Program Incremental Expiring Electric Savings‡§								-	-	-	-	-	17,259,880	17,259,880
Program Total Incremental Expiring Electric Savings§							-	-	-	-	-	-	17,259,880	17,259,880

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
RetroCommisioning	All	13,479,977	-	-	-	-							
CY2019 Program Total Electric Contribution to CPAS		13,479,977	-	-	-	-	-	-	-	-	-	-	-
Historic Program Total Electric Contribution to CPAS‡													
Program Total Electric CPAS		13,479,977	-	-	-	-	-	-	-	-	-	-	-
CY2019 Program Incremental Expiring Electric Savings§		17,868,807	13,479,977	-	-	-	-	-	-	-	-	-	-
Historic Program Incremental Expiring Electric Savings‡§		-	-	-	-	-	-	-	-	-	-	-	-
Program Total Incremental Expiring Electric Savings§		17,868,807	13,479,977	-	-	-	-	-	-	-	-	-	-

Note: The green highlighted cell shows program total first year electric savings. The gray cells are blank, indicating values irrelevant to the CY2019 contribution to CPAS.
* A deemed value. Source: is to be found on the SAG web site here: https://www.ilsag.info/ntg_2019.
† Lifetime savings are the sum of CPAS savings through the EUL.
‡ Historical savings go back to CY2018
§ Incremental expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n
|| EUL is the savings-weighted average of RCx Building Tune-up (EUL=7.5 years) and all other RCx tracks (EUL=8.6 years)
Source: Evaluation team analysis

Table 4-2. Cumulative Persisting Annual Savings (CPAS) – Gas – ComEd

End Use Type	Research Category	EUL#	CY2019 Verified Gross Savings (Therms)	NTG*	Lifetime Net Savings (Therms)†	Verified Net Therms Savings 2018	2019	2020	2021	2022	2023	2024	2025
RetroCommisioning	All	8.2	39,187	0.94	302,050		36,835	36,835	36,835	36,835	36,835	36,835	36,835
CY2019 Program Total Gas Contribution to CPAS (Therms)			39,187		302,050		36,835	36,835	36,835	36,835	36,835	36,835	36,835
CY2019 Program Total Gas Contribution to CPAS (kWh Equivalent)‡					9,703,896		1,079,644	1,079,644	1,079,644	1,079,644	1,079,644	1,079,644	1,079,644
Historic Program Total Gas Contribution to CPAS (kWh Equivalent)‡§						2,907,030	2,907,030	2,907,030	2,907,030	2,907,030	2,907,030	2,907,030	1,453,515
Program Total Gas CPAS (kWh Equivalent)‡						2,907,030	3,986,674	3,986,674	3,986,674	3,986,674	3,986,674	3,986,674	2,533,159
CY2019 Program Incremental Expiring Gas Savings (Therms)||								-	-	-	-	-	-
CY2019 Program Incremental Expiring Gas Savings (kWh Equivalent)‡||								-	-	-	-	-	-
Historic Program Incremental Expiring Gas Savings (kWh Equivalent)‡§||							-	-	-	-	-	-	1,453,515
Program Total Incremental Expiring Gas Savings (kWh Equivalent)‡||							-	-	-	-	-	-	1,453,515

End Use Type	Research Category	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
RetroCommisioning	All	36,835	7,367	-	-	-	-							
CY2019 Program Total Gas Contribution to CPAS (Therms)		36,835	7,367	-	-	-	-	-	-	-	-	-	-	-
CY2019 Program Total Gas Contribution to CPAS (kWh Equivalent)‡		1,079,644	215,929	-	-	-	-	-	-	-	-	-	-	-
Historic Program Total Gas Contribution to CPAS (kWh Equivalent)‡§														
Program Total Gas CPAS (kWh Equivalent)‡		1,079,644	215,929	-	-	-	-	-	-	-	-	-	-	-
CY2019 Program Incremental Expiring Gas Savings (Therms)||		-	29,468	7,367	-	-	-	-	-	-	-	-	-	-
CY2019 Program Incremental Expiring Gas Savings (kWh Equivalent)‡||		-	863,715	215,929	-	-	-	-	-	-	-	-	-	-
Historic Program Incremental Expiring Gas Savings (kWh Equivalent)‡§||		1,453,515	-	-	-	-	-	-	-	-	-	-	-	-
Program Total Incremental Expiring Gas Savings (kWh Equivalent)‡||		1,453,515	863,715	215,929	-	-	-	-	-	-	-	-	-	-

Note: The green highlighted cell shows program total first year gas savings in kWh equivalents. The gray cells are blank, indicating no values or do not contribute to calculating CPAS in CY2019.
* A deemed value. Source: is to be found on the SAG web site here: https://www.ilsag.info/ntg_2019.
† Lifetime savings are the sum of CPAS savings through the EUL.
‡ kWh equivalent savings are calculated by multiplying therm savings by 29.31.
§ Historic savings go back to CY2018.
|| Incremental expiring savings are equal to CPAS Yn-1 - CPAS Y_n.
EUL is the savings-weighted average of RCx Building Tune-up (EUL=7.5 years) and all other RCx tracks (EUL=8.6 years)
Source: Evaluation team analysis

Table 4-3. Cumulative Persisting Annual Savings (CPAS) – Total

End Use Type	Research Category	EUL	CY2019 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	Verified Net kWh Savings (Including Those Converted from Gas Savings) 2018	2019	2020	2021	2022	2023	2024	2025	2026
RetroCommisioning	All	8.4	34,498,328	0.94	273,123,336		32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429
CY2019 Program Total Contribution to CPAS			34,498,328		273,123,336		32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429	32,428,429
Historic Program Total Contribution to CPAS‡						37,426,789	37,426,789	37,426,789	37,426,789	37,426,789	37,426,789	37,426,789	18,713,395	
Program Total CPAS						37,426,789	69,855,218	69,855,218	69,855,218	69,855,218	69,855,218	69,855,218	51,141,823	32,428,429
CY2019 Program Incremental Expiring Savings§								-	-	-	-	-	-	-
Historic Program Incremental Expiring Savings‡§							-	-	-	-	-	-	18,713,395	18,713,395
Program Total Incremental Expiring Savings§							-	-	-	-	-	-	18,713,395	18,713,395

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
RetroCommisioning	All	13,695,906	-	-	-	-	-	-	-	-	-	-	-
CY2019 Program Total Contribution to CPAS		13,695,906	-	-	-	-	-	-	-	-	-	-	-
Historic Program Total Contribution to CPAS‡			-	-	-	-	-	-	-	-	-	-	-
Program Total CPAS		13,695,906	-	-	-	-	-	-	-	-	-	-	-
CY2019 Program Incremental Expiring Savings§		18,732,522	13,695,906	-	-	-	-	-	-	-	-	-	-
Historic Program Incremental Expiring Savings‡§		-	-	-	-	-	-	-	-	-	-	-	-
Program Total Incremental Expiring Savings§		18,732,522	13,695,906	-	-	-	-	-	-	-	-	-	-

Note: The green highlighted cell shows program total first year electric savings (including direct electric savings and those converted from gas). The gray cells are blank, indicating no values or do not contribute to calculating CPAS in CY2019.

* A deemed value. Source: is to be found on the SAG web site here: https://www.ilsag.info/ntg_2019.

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

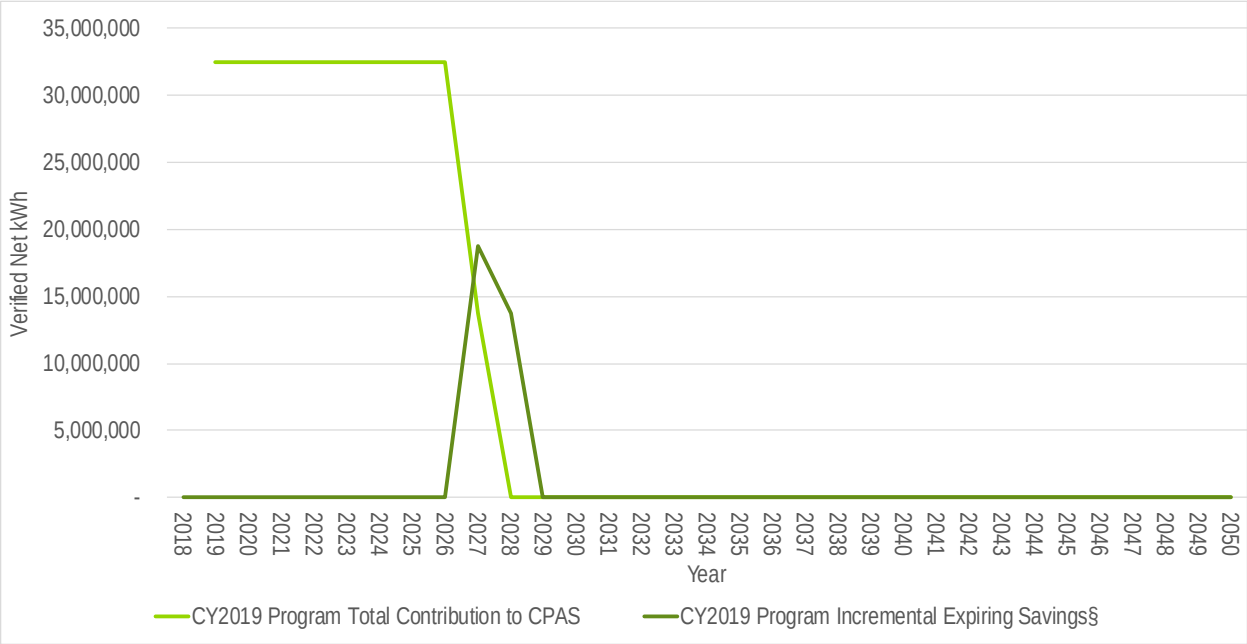
‡ Historic savings go back to CY2018.

§ Incremental expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n

|| EUL is the savings-weighted average of RCx Building Tune-up (EUL=7.5 years) and all other RCx tracks (EUL=8.6 years)

Source: Evaluation team analysis

Figure 4-1. Cumulative Persisting Annual Savings



* Expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n
Source: Evaluation team analysis

5. Program Savings by Measure

The evaluation team analyzed savings for the RetroCommissioning Program *in toto* instead of by measure or track. ComEd and the evaluators made this choice by consensus due to the years of consistent delivery and for evaluation budget reasons. Details of savings by project are provided in Appendix 2. Impact Analysis Detail.

6. Impact Analysis Findings and Recommendations

6.1 Impact Parameter Estimates

The program-level impact parameter estimates for the RetroCommissioning Program are shown below. There are not standard or TRM-based estimates for RCx measures. EESPs estimate energy and demand savings with custom algorithms, frequently using hourly weather data and time-series trend data. Evaluators reviewed each sampled project and implemented measures individually to validate the savings. Reviewed measure savings is rolled-up to realization rate impact parameter estimates for electric energy, electric demand, and natural gas energy savings.

EESPs determine ex ante savings with engineering relationships of energy, temperature and mass transfer on an hourly basis or summarized by outdoor temperature bins, usually supported by measured or monitored data. When data support the method, EESPs and evaluators determine savings by regressions of energy use versus outdoor temperature and other independent variables. When energy

efficiency measures have a climate component to usage, service providers and evaluators use standard weather data sets (TMY3)[5] for proximal locations to estimate weather-normalized savings.

The program only reports electric demand savings with respect to the summer peak. Some measures have demand savings tied to the time of day. Other measures have demand savings that are weather-dependent. For the latter, the program peak demand savings is based on the Weighted Temperature Humidity Index (WTHI) method[6], promulgated by the PJM Interconnection. For the ComEd service territory PJM has determined the WTHI zonal weather standard value is 81.6.

The lifetime energy and demand savings are the product of the verified savings and the effective useful life for each measure. The CY2019 savings parameters are shown in the following Table 6-1.

Table 6-1. Savings Parameters

Gross Savings Input Parameters	Value	Units	Deemed * or Evaluated?	Source
Quantity Coordinated Utility	147	Projects	Evaluated	
Program Tracks	4		Evaluated	
NTG Electric	94	%	Deemed	SAG Consensus†
NTG Gas	94	%	Deemed	SAG Consensus†
Gross Savings (kWh) Sampled Measures	12,594,392	kWh	Evaluated	
Gross Savings (therms) Sampled Measures	244,572	therms	Evaluated	
Verified Realization Rate on Ex Ante Gross Savings (Electric)	94	%	Evaluated	
Verified Realization Rate on Ex Ante Gross Savings (Natural Gas)	87	%	Evaluated	
Effective Useful Life (EUL)‡	8.4	Years	Deemed	ComEd EUL Comm RCx and Behavior Memo 2019-09-17

* TRM is the State of Illinois Technical Reference Manual version 8.0 from http://www.ilsag.info/technical-reference-manual.html. The NTG values can be found on the SAG web site here: https://www.ilsag.info/ntg_2019.
† A deemed value. Sources: http://ilsagfiles.org/SAG_files/NTG/2019_NTG_Meetings/Corrected_NTG_Values/ComEd_NTG_History_and_CY2019_Recommendations_Faucet_Aerator_Showerhead_Correction_2019-04-12.xlsx, http://ilsagfiles.org/SAG_files/NTG/2019_NTG_Meetings/Corrected_NTG_Values/Nicor_Gas_NTG_History_and_2019_Recommendations_Aerator_Showerhead_Correction_2019-04-12.xlsx, http://ilsagfiles.org/SAG_files/NTG/2019_NTG_Meetings/Corrected_NTG_Values/PGL-NSG_NTG_History_and_2019_Recommendations_Faucet_Aerator_Showerhead_Correction_2019-04-12.xlsx
‡ EUL is the savings-weighted average of RCx Building Tune-up (EUL=7.5 years) and all other RCx tracks (EUL=8.6 years)

6.2 Other Impact Findings and Recommendations

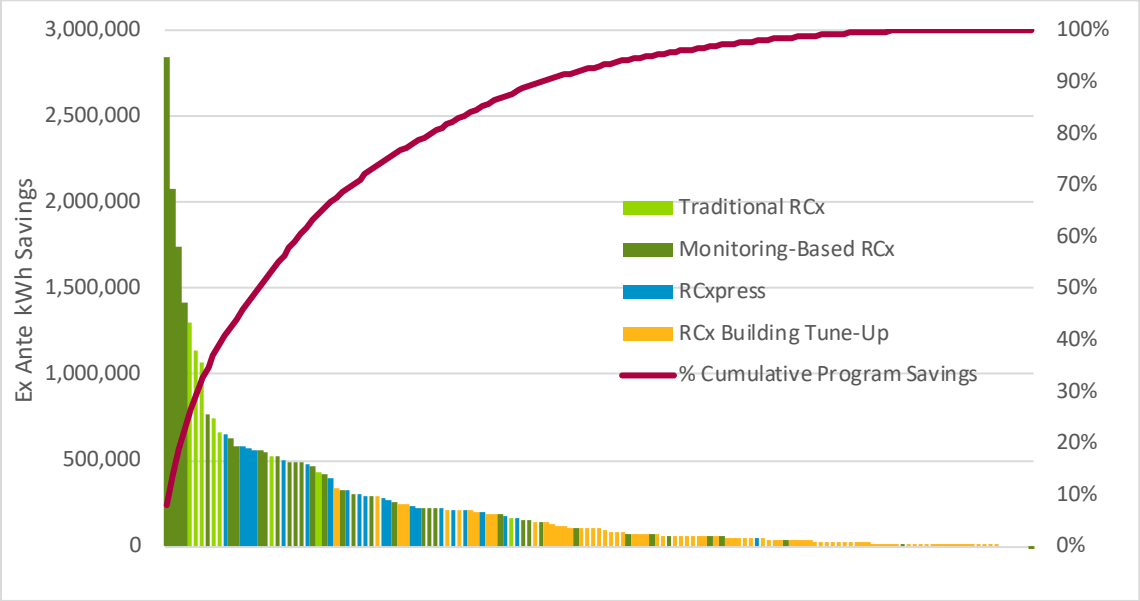
Guidehouse reviewed the overall program population from the program tracking data and performed a detailed analysis of a representative sample of projects.

Figure 6-1 shows the breakdown of electric savings in the RetroCommissioning Program by project and track. As expected, larger projects are generally in the MBCx and RCx programs, but some RCxpress

[5] Typical Meteorological Year, version 3, were produced by NREL's Electric and Systems Center under the Solar Resource Characterization Project, which is funded and monitored by the U.S. Department of Energy's Energy Efficiency and Renewable Energy Office. Source data for all 239 TMY3 locations draw on data from 1991 through 2005.
[6] See https://pjm.com/~/media/documents/manuals/m18b.ashx

projects are also quite large. For electricity, ex ante project savings ranged from over 2,800,000 kWh to 0 kWh, with the largest five projects making up slightly more than quarter of program savings and 39 projects comprising more than 75 percent of electric energy savings.

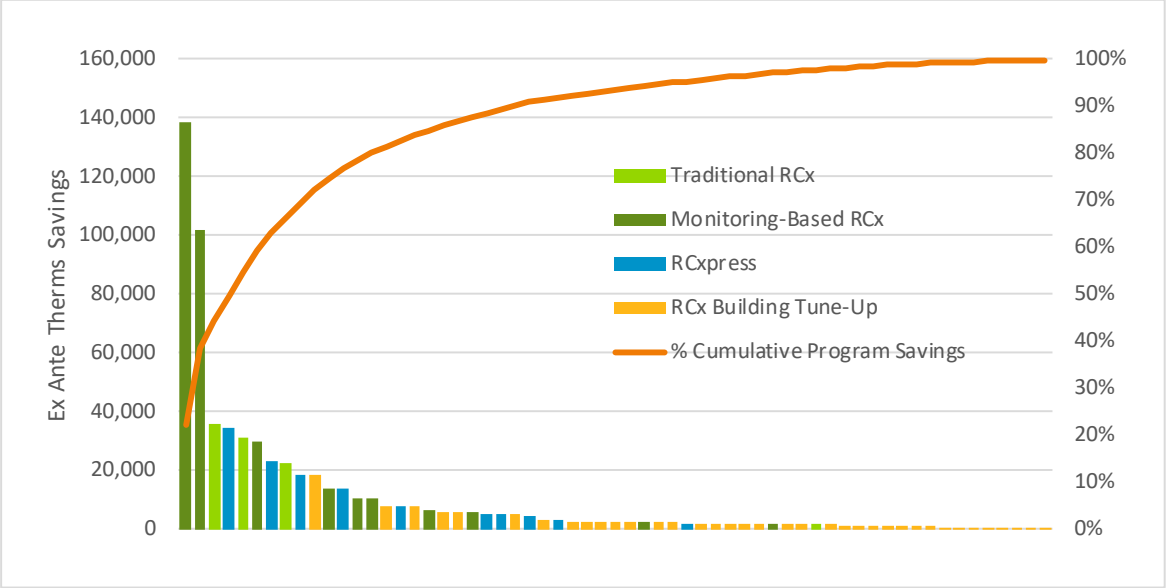
Figure 6-1. CY2019 Ex Ante Electric Energy Savings by Track and Project



Source: Evaluation team analysis

Figure 6-2 shows ex ante gas savings by project and track for the 69 projects with gas savings. As with electric savings, larger projects are generally in the RCx and MBCx tracks. For natural gas, ex ante savings per project ranged from 135,528 therms to -32 therms annually, with the largest four projects comprising more than half of program savings, and the eleven largest accounting for more than 75 percent of program savings.

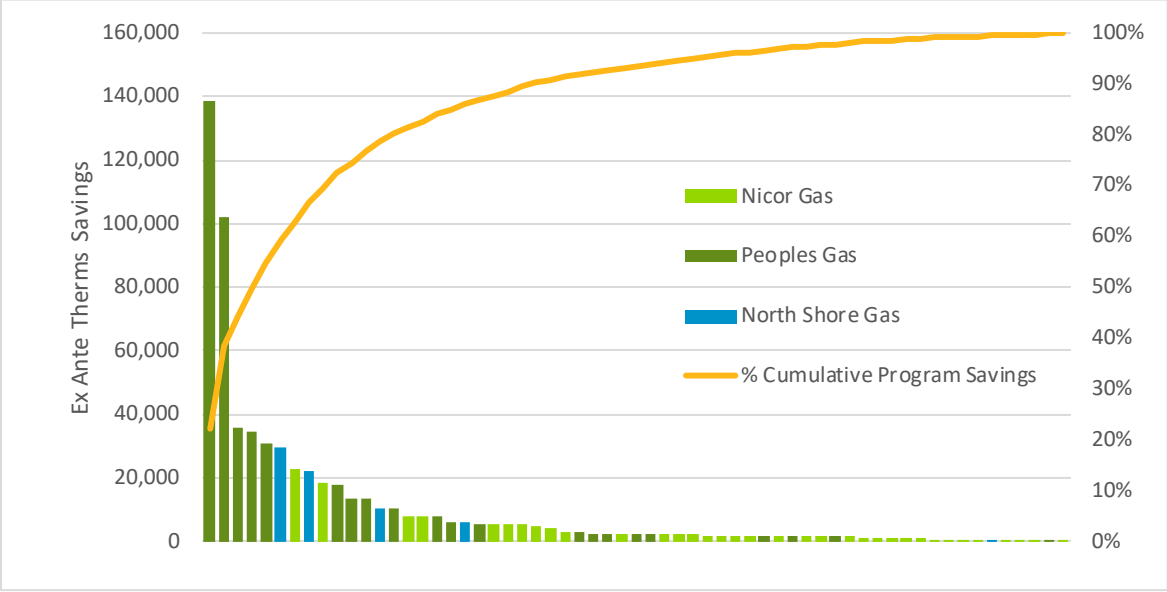
Figure 6-2. CY2019 Gas Energy Savings by Track and Project



Source: Evaluation team analysis

Figure 6-3 shows ex ante gas savings by utility. Most savings are from Peoples Gas customers, with only five participants in the North Shore Gas territory.

Figure 6-3. CY2019 Gas Energy Savings by Utility and Project



Source: Evaluation team analysis

The total program verified gross savings are in Table 6-2. The table presents savings at the utility-level for projects generating savings. Realization rates are the results of evaluating and verifying 40 projects, made up of more than 170 measures.

Table 6-2. Verified Gross Savings Realization Rates*

Savings Category	ComEd kWh	ComEd kW	Nicor Gas therms	Peoples Gas therms	North Shore Gas therms
Ex Ante Project Counts	144	73	30	22	5
Ex Ante Gross Savings	35,441,530	1,505	75,630	436,212	69,150
Verified Gross Realization Rate	0.94	1.19	1.01	0.86	0.86
Verified Gross Savings	33,349,771	1,785	76,386	375,142	59,469

* Electric energy in kWh, electric demand in kW, gas in therms
Source: ComEd tracking data and evaluation team analysis

There are several reasons why realization rates are other than 1.0, including:

- On-site verification determined measures were implemented differently than reported. This can include modified schedules or set points. Changes in schedules or set points were mostly due to operator adjustments to maintain occupant comfort.

- Some measures saved energy on the base-building systems by pushing air-conditioning loads onto tenant-operated equipment, thus saving little or no energy in aggregate.

- Some projects continued to implement additional recommended measures or finish implementing measures after projects were verified and closed by the service provider and implementation contractor.

- Some measures did not include demand savings even when warranted and others claimed demand savings not found during verification. Demand calculations also used a variety of conditions that did not conform to the weighted temperature-humidity index (WTHI) method for summer demand savings for weather dependent measures in the ComEd service territory.

- Occasional calculation or engineering errors also affected realization rates. Several types of calculation errors were encountered this year:
    - Weather datasets were not consistently applied. Some projects used different weather data for different measures at the same site.
    - Discrepancies in set points or hours of operation between reported conditions and those used in calculations resulted in numerous, but generally small, changes in savings.
    - A few calculations included mis-typed hard-coded values.
    - Other engineering or spreadsheet calculation errors.

The evaluation team developed several recommendations based on findings from the CY2019 evaluation.

Finding 1. For several projects the measure Discharge Air Temperature (DAT) Reset is not being implemented properly. The intent of the measure is to mix more return air into the mixed air plenum to raise the temperature of the discharge air, thus conserving the heat of the building during the winter heating season. Trend data, however, show the building controls are not mixing more return air (evidenced by unchanged mixed air temperatures) and the air-handler heating coils are simply heating the air to achieve higher DAT. This does not change the heating load of the building, but simply moves the loads from the terminal boxes to the air handlers.

Recommendation 1. Guidehouse recommends more scrutiny in quality control for the DAT Reset measures.

Finding 2. Some calculations use revenue meter data, downloaded through the Building Energy Analyzer (BEA) portal, as the basis of savings. This type of analysis is preferred when measures can be isolated and identified that way. The BEA data are often filtered and collapsed by the EESP engineer while calculating the savings, and the full BEA data set is not preserved intact. Furthermore, older data are dropped from the BEA portal so they cannot be reconstructed during the evaluation. Evaluation engineers need to work with the complete datasets to ensure accurate savings estimates and methods.

Recommendation 2. We recommend that full BEA data sets, used for savings estimates, are archived with the project documentation to be available for evaluation.

Finding 3. Some projects use different weather stations for different measures.

Recommendation 3. While there is some discretion involved in choosing weather stations for locations between two possible stations, a single project at one location should use a consistent weather station across all measures.

Finding 4. Demand savings for one measure was included in the ex ante estimates even though it was abandoned. This was one error among almost 500 implemented measures.

Recommendation 4. Perform cross-checks between project and measure implementation summary databases.

Finding 5. EESPs are incorporating regression equations in their analyses more often, but sometimes the regression results are accepted without careful consideration, when they might demonstrate nonsense relationships (decreasing loads as outdoor temperatures become more extreme) or oversimplified (using a single second order polynomial to describe multiple operating modes.)

Recommendation 5. Ensure that regression results have a basis in engineering. Use piece-wise linear regressions to model different operating modes. Ensure Pearson correlation coefficients R and R^2 are sufficiently high. Do not extrapolate non-linear regressions beyond measured data.

Recommendation 6. If regression methods fail to produce results that model well, do not use them.

Finding 6. Nicor Gas, Peoples Gas, and North Shore Gas program tracking data reported total therm savings that did not match the final project files provided by ComEd and the implementation contractor used for impact evaluation.

Recommendation 7. Guidehouse recommends the gas utilities coordinate with ComEd after the program year closes to reconcile project-level therm savings prior to closing tracking data on January 30.

Finding 7. Through the evaluation review process, it became clear that not all involved parties were able to access the most recent project-level tracking data, and discrepancies existed between the tracking data used by program implementers and some of the individual utilities. Therefore, individual gas utilities sometimes tracked different per-project savings compared to the tracking data provided to the evaluation team and/or different project numbers were used to refer to the same project making cross-references difficult when comparing project lists across utilities.

Recommendation 8. The program implementer, ComEd, Nicor Gas, Peoples Gas, and North Shore Gas should work to ensure the most recent and accurate project-level data is available and provide to all relevant parties.

Finding 8. Actual measure installation dates are seldom included in the project documentation and evaluators must resort to inferring dates from invoices and report dates. When evaluation

tries to estimate savings from time-series data, such as BEA meter data, it is necessary to have accurate dates in order to assign data to pre-implementation and post-implementation periods

Recommendation 9. Include explicit dates for implementation start and finish dates for each measure, especially if time-series data are used to generate estimates.

7. Appendix 1. Impact Analysis Methodology

The impact evaluation consists of a review of a representative sample of projects: both an engineering desk-review and on-site verification for a subset of projects. Evaluators review gross program impacts with a project-by-project and measure-by-measure approach. Savings calculation reviews ensure the savings estimates are accurately modeled, use consistent inputs and include reasonable assumptions, as required. In some cases, evaluators acquired additional trend data or interval meter data to verify savings with both more data and data concurrent with expected savings, e.g. winter data for night set-back measures. In most cases, the impact evaluation involves analysis of time-series trend and measured data, both pre- and post- implementation.

For a nested sample of projects (selected from projects sampled for engineering review), Guidehouse performed on-site inspections to determine whether implemented measures were still operating as described in project documentation (set points, affected equipment, hours of operation, etc.). Where we found differences, our research findings estimate reflect those new inputs.

Due to the number of projects and the compressed schedule between program year-end and reporting, Guidehouse began project reviews in waves, roughly quarterly starting after 2019Q1, including a mid-quarter sample between the third and fourth quarter. Results from the impact evaluation were rolled up by sampling strata and extrapolated to the participant population to determine gross researched impacts. [7] Deemed net-to-gross (NTG) ratios were applied to verified gross results to arrive at net researched impacts.

8. Appendix 2. Impact Analysis Detail

Program impacts are tracked by the IC through the several phases of the program with the IC giving feedback to Energy Efficiency Service Providers (EESPs) and requiring changes at each phase. Thus, the evaluator's task is to check a sample of measures verified by the EESPs and IC and ensure that measures are indeed complete, and savings are accurately estimated.

For all 40 projects in the sample, Guidehouse reviewed measure implementation plans, assumptions and calculations in detail. In general, Guidehouse found the calculations accurately constructed, based on clearly measured data rather than rules-of-thumb, and reasonably transparent in spreadsheet form. In some instances, we found calculation errors due to spreadsheet equation errors, erroneous inputs, omissions of relevant impacts and inconsistencies in assumptions from measure-to-measure on the same system, but most of these errors resulted in only minor changes to overall savings. Some of the

[7] Guidehouse notes that the relative precision of the electric realization rate was slightly outside the targeted 10% for electric savings. The reason was due to an outlier MBCx project with a low realization rate combined with the fact 37% of program electric savings was not available for sampling until January 2020, most of which was MBCx savings. The late addition of substantial savings in the MBCx track means that those savings were not verifiable within the 2019 reporting timeframe, however, were claimed within the 2019 program. The outlier project was thus amplified by the addition of substantial unverifiable savings in the MBCx track that over-weighted that track at the last minute compared with the 2019 sampling approach up to December 31, 2019.

spreadsheets contained hard-coded input values but these were generally based on external trend data files and standard TMY3[8] data that we could inspect.

Savings estimation approaches among EESPs were mostly consistent. Most calculation spreadsheets were comprehensive, though some were excessively complex and others overly simple. Despite the range of approaches in CY2019, there were very few lapses in engineering methods. When faced with the need to make engineering assumptions, EESPs are often more conservative than the program guidelines. Where there was no further justification for overly conservative estimates, the evaluation team restored guideline defaults or supplemented estimated savings with secondary effects of the measures as could be determined with available data.

In cases where Guidehouse-verified inputs were inconsistent with EESP reported data, such as set points or operational hours, Guidehouse re-estimated savings with available data, additional data requested from the participant or EESP or program guideline inputs. Research findings gross realization rates are the result of analysis of individual measures for each project in the impact sample.

Table 8-1 details the realization rates of all sampled projects.

[8] TMY3 is the most recent version of the Typical Meteorological Year weather data sets.

Table 8-1. Project Level Realization Rates

Nexant project number	Track	Gas utility	RR.kWh	RR.kW	RR.gas	Notes
17-003	RCx	Electric Only	1.00			
18-033	RCxpress	Electric Only	1.30	1.12	na	Extrapolation of fan speed using a polynomial curve fit creates error at extrema.
18-034	RCxpress	Electric Only	0.75	0.51	na	Verified savings determined with analysis of interval meter data. Overall savings achieved is less than estimated.
18-036	RCxpress	Electric Only	1.13	1.71	na	Inappropriate extrapolation of polynomial curve fit.
18-405	TU	Nicor Gas	1.00	na	1.00	No changes. Measure was a setback, two manual thermostats switched to a 7 day programmable for a single unit. The initial study had five measures 9,900 kWh, 4,300 therms. Measures included economizer, condenser. Building A and Building D. Public sector project came in from 2018 for 360 projects.
18-489	TU	Nicor Gas	1.00	1.00	1.00	
18-568	TU	Nicor Gas	0.84	na	na	Economizer on four units. Hours of use changes, horsepower CFM change.
18-588	TU	Electric Only	1.55	na	na	The service provider applied a single safety factor across multiple sites. Multiple sites were submitted under one project number. The service provider used workarounds on an approved calculator instead of doing a custom calculation for the measure--the calculators should be updated to include new functionality if needed by the program.
18-604	TU	Electric Only	1.95	na	na	The service provider applied a single safety factor across multiple sites. Multiple sites were submitted under one project number. The service provider used workarounds on an approved calculator instead of doing a custom calculation for the measure--the calculators should be updated to include new functionality if needed by the program.
16-105	MBCx	Electric Only	1.10	2.28	0.99	Changed weather station, minor changes to schedule
17-006	Rcxpress	Nicor Gas	1.01	1.00	1.00	
17-013	RCx	Electric Only	0.90	0.16		Primary reason for the discrepancy is ECM6 units not on DDC could not be implemented
17-016	Rcxpress	Nicor Gas	0.99		1.00	
17-017	RCx	Electric Only	0.52			Interval data findings were substantially lower than ex ante assumed savings due to how the heating schedule ramped down with the actual control system found installed ex post.
17-112	MBCx	Peoples Gas	0.86		1.04	
17-114	MBCx	Electric Only	0.41	na	na	Measure implemented as described, but verification relied on limited data set at mild temperatures and extrapolated. Correlations were made between power and concurrent temperature, when setback is actually dependent on the cumulative temperatures while the system is setback. The ex ante analysis also neglects higher morning warm-up power due to lower set-backs.
18-047	RCx	North Shore Gas	0.86	0.98	0.92	Primary reason for discrepancy is AHU scheduling measures could not be implemented between 60F and 70F resulting in substantial loss of savings for 100% OA units.
18-488	TU	Nicor Gas	0.95		1.00	Server room setback measures save less than ex ante approach will typically calculate
18-492	TU	Peoples Gas	1.07	na	na	Updated with correct data for this project.
18-518	TU	Peoples Gas	1.00	0.94	0.24	Updated with gas billing data analysis.
17-107	MBCx	Electric Only	1.15	0.71		Corrected pump equations and changed chiller efficiency to ASHRAE 90.1-1999 IPLV =6.1. Reduced winter savings due to influence of new data at cold temperatures. Also reduced high temperature savings due to data showing loads still active above 85F. Changed calculation for Hz and extrapolated at constant kW for after-hours operation.
17-108	MBCx	Electric Only	1.00	1.00	na	
18-001	Rcxpress	Electric Only	1.00	0.93		

Table 8-1. Project Level Realization Rates (continued)

Nexant project numb	Track	Gas utility	RR.kWh	RR.kW	RR.gas	Notes
18-011	RCx	Peoples Gas	1.35	0.74	0.49	Several changes required to correct calculations - one unit removed and decommissioned - observed settings and control different from claimed on several fans - only sensible cooling savings claimed - return fan demand savings neglected in all units - un-occupied period fan savings not included for many hours in error. - 20% duty cycle un-occupied calculated wrong - gas savings duty cycle should depend on OAT - design CFM wrong for one unit - min OA damper position at 100% open used rather than unit OA ratio including fixed minimum and modulating damper arrays.
18-023	Rcxpress	Electric Only	1.00	1.00		Changed humidity data to O'Hare TMY3 averages by bin
18-038	Rcxpress	Electric Only	1.01	1.01		Used O'Hare weather data
18-490	TU	Nicor Gas	1.00	1.00		
18-582	TU	Nicor Gas	1.00		1.00	
18-599	TU	Nicor Gas	1.00	1.00	na	Baseline static pressure values were changed to better reflect the baseline conditions from the reports.
18-629	TU	North Shore Gas	0.76	1.00	1.00	The primary reason for the realization rate was Navigant found the space was conditioned and therefore had stable temperature and relative humidity resulting in lower savings for the anti-sweat door heater controls, whereas the ex ante calculations assumed the space was not conditioned with a broader range of temperature and relative humidity resulting higher ex ante savings for the anti-sweat door heater controls.
18-004	RCx	Peoples Gas	1.19	1.00	-	There were many measures installed here (many that overlapped) but these are the two where we made adjustments. ECM 5- lower minimum OA on the damper ECM 7- Repair OA Damper One of the measures (ECM 7) had a negative impact on energy usage based on ex ante field measurements and provided engineering calculations. Instead of claiming this energy savings the EESP instead took the savings from ECM 5 and applied 50/50% to both ECM's. We felt that ignoring this negative interactive effect was incorrect and included the savings for every ECM.
18-003	RCx	Peoples Gas	0.82	1.06	0.86	Did not change mixed air temperature so DAT measure savings were not there; other observations updated to match verification settings; some spreadsheet calculation errors.
18-043	Rcxpress	Nicor Gas	1.00	1.00	1.00	no issues noted in the calculator, billing data shows similar savings.
17-019	Rcxpress	Peoples Gas	1.00	1.00	1.00	Finalized based on new ERV fan speed information from Nexant.
18-002	Rcxpress	Peoples Gas	0.82	0.89	0.46	Zeroed savings for Tower A due to exhaust fans in hand/bypass. Changing the MAU DAT control just causes lower corridor temps or pushes loads to living units which are also on the boiler and chiller.
17-113	MBCx	Peoples Gas	1.09	0.93	1.04	Various small changes, include motor efficiency factor, changed 0% OA minimum to 20%.
18-008	Rcxpress	Nicor Gas	1.14	na	1.04	Removed safety factors
18-044	Rcxpress	Nicor Gas	1.00	1.00	1.00	
18-417	TU	Nicor Gas	0.97		1.00	The Server Closet measure was the driver of the lower realization rate for this project. The references in the ex ante calculations pertain to data center savings, not to data closets in a school. Important differences that may reduce the source of savings for a school compared to a data center include free cooling in data centers, and humidity setpoints in data centers, that are not relevant for a middle school data closet.
18-581	TU	Nicor Gas	1.00	1.01	1.02	Changes are due to rounding of scheduled hours and a more reasonable assumption for heat wheel efficacy

Source: Evaluation team analysis

9. Appendix 3. Total Resource Cost Detail

Table 9-1 shows the Total Resource Cost (TRC) cost-effectiveness analysis inputs available at the time of finalizing this impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to the evaluation team later.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Verified Gross Electric Energy Savings (kWh)	Verified Gross Peak Demand Reduction (kW)	Verified Gross Gas Savings (Therms)	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG (kWh)	NTG (kW)	NTG (Therms)	Verified Net Electric Energy Savings (kWh)	Verified Net Peak Demand Reduction (kW)	Verified Net Gas Savings (Therms)	Net Heating Penalty (kWh)	Net Heating Penalty (Therms)
RetroCommissioning	All	Project	147	8.4	No	33,349,771	1,785.22	39,187	0	0	0.94	0.94	0.94	31,348,785	1,678.10	36,835	0	0
	Total			8.4		33,349,771	1,785	39,187	0	0	NA	NA	NA	31,348,785	1,678	36,835	0	0

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.
† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.
Source: ComEd tracking data and evaluation team analysis

Table 9-2. Total Resource Cost Savings Summary for Nicor Gas

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Ex Ante Gross Savings (Therms)	Verified Gross Savings (Therms)	NTG (Therms)	Verified Net Savings (Therms)
RetroCommisioning	All	Projects	30	8.4	No	75,630	76,386	0.94	71,803
				8.4		75,630	76,386	0.94	71,803

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.
† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.
Source: Guidehouse analysis of tracking data.

Table 9-3. Total Resource Cost Savings Summary for Peoples Gas

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Ex Ante Gross Savings (Therms)	Verified Gross Savings (Therms)	NTG (Therms)	Verified Net Savings (Therms)
RetroCommisioning	All	Projects	22	8.4	No	436,212	375,142	0.94	352,634
				8.4		436,212	375,142	0.94	352,634

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.
† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.
Source: Guidehouse analysis of tracking data.

Table 9-4. Total Resource Cost Savings Summary for North Shore Gas

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Ex Ante Gross Savings (Therms)	Verified Gross Savings (Therms)	NTG (Therms)	Verified Net Savings (Therms)
RetroCommisioning	All	Projects	5	8.4	No	69,150	59,469	0.94	55,901
				8.4		69,150	59,469	0.94	55,901

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.
† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.
Source: Guidehouse analysis of tracking data.