Guidehouse

Combined Utility RetroCommissioning Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Program Year 2020 (CY2020) (1/1/2020-12/31/2020)

Prepared for:
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Peoples Gas
North Shore Gas

FINAL

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1. Introduction

This report presents results of the CY2020 impact evaluation of the Combined Utility RetroCommissioning (RetroCommissioning) Program. It summarizes the total energy and demand impacts for the program broken out by relevant fuel type, measure, and program structure details. The appendices provide the impact analysis methodology and details of the total resource cost (TRC) inputs. CY2020 covers January 1, 2020 through December 31, 2020.

2. Program Description

The C&I RetroCommissioning Program has been part of ComEd's Energy Efficiency Program since 2007. In 2010, ComEd began coordinating the program with gas utilities that 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 HVAC systems. Individual measures often save electricity and natural gas so analyzing one energy source while neglecting the other would fail to document all energy benefits incented by the program.

In CY2019 Virtual RetroCommissioning (VCx) was added to the RCx program portfolio. VCx is a data analytics approach to retrocommissioning that relies mostly on interval meter data to flag potential savings opportunities. VCx is sufficiently different in terms of recruitment, participation, and methods, that it is evaluated separately and not addressed in this report except for this mention.

Nexant, Inc. is the implementation contractor (IC) for the RetroCommissioning Program, and verifies, tracks and reports 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% 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 1 year and result in a single comprehensive deliverable.

- **MBCx** projects are supported by a multi-year agreement between the building owner and the EESP. This 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 ongoing 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 8 to 16 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.

Underscoring the overlapping processes for each track, ComEd is marketing traditional RCx, RCxpress, and tune-up as a unified track, RetroCommissioning Flex (RCx), beginning CY2021.

The program reported 132 projects[1] in CY2020. In CY2020, the RetroCommissioning Program implemented measures with both electric and gas savings as Table 2-1 and Table 2-2 show, as do the following figures. One project with both gas and electric savings reported gas savings in CY2020, but electric savings were verified in CY2019[2]. Table 2-3 shows additional program attributes.

Table 2-1. CY2020 Volumetric Findings Detail by Utility

Participation	Electric Only	Nicor Gas	Peoples Gas	North Shore Gas	Total
Participants with service*	53	42	27	10	132
Participants with savings†	72	36	18	6	132
Electric only measures	121	70	57	12	260
Gas only measures	0	14	4	1	19
Combination electric & gas	0	56	24	6	86
Total measures‡	121	140	85	19	365
Measures/project (service)	2.3	3.3	3.1	1.9	2.8

* As noted by the IC as having gas accounts. Electric Only projects are all projects that did not identify a gas company in the tracking system.

† Projects without gas savings are included in electric only, even when the participant was served by one of the gas companies.

‡ All projects with gas service and savings also have CY2020 electric service and savings, except one project where electric savings were verified in CY2019 (and counted now in historic CPAS) such that only the gas savings were verified in CY2020 (i.e., that project has gas-only savings in CY2020).

Source: ComEd tracking data and evaluation team analysis

[1] MBCx participants can submit multiple bundles at different times during the year. Each MBCx bundle is counted as a project. In CY2020, 38 unique MBCx participants submitted 55 MBCx projects.

[2] The CY2019 electric savings for this project is included only in the historic CPAS row in Table 4.1.

Table 2-2. CY2020 Volumetric Findings Detail by Track*

Participation	MBCx	RCx	RCxpress	Tune-Up	Total
Projects	55	7	22	48	132
Electric only measures	82	25	66	87	260
Gas only measures	10	0	3	6	19
Combination electric & gas	16	8	25	37	86
Total measures†	108	33	94	130	365
Measures/project	2.0	4.7	4.3	2.7	2.8

* Many measures have both electric and gas savings.

†Totals include many measures with both electric and gas savings, such that the total measures row is not the sum of the electric measures and gas measures totals. All projects with gas service and savings also have CY2020 electric service and savings, except one project where electric savings were verified in CY2019 (and counted now in historic CPAS) such that only the gas savings were verified in CY2020 (i.e., that project has gas-only savings in CY2020).

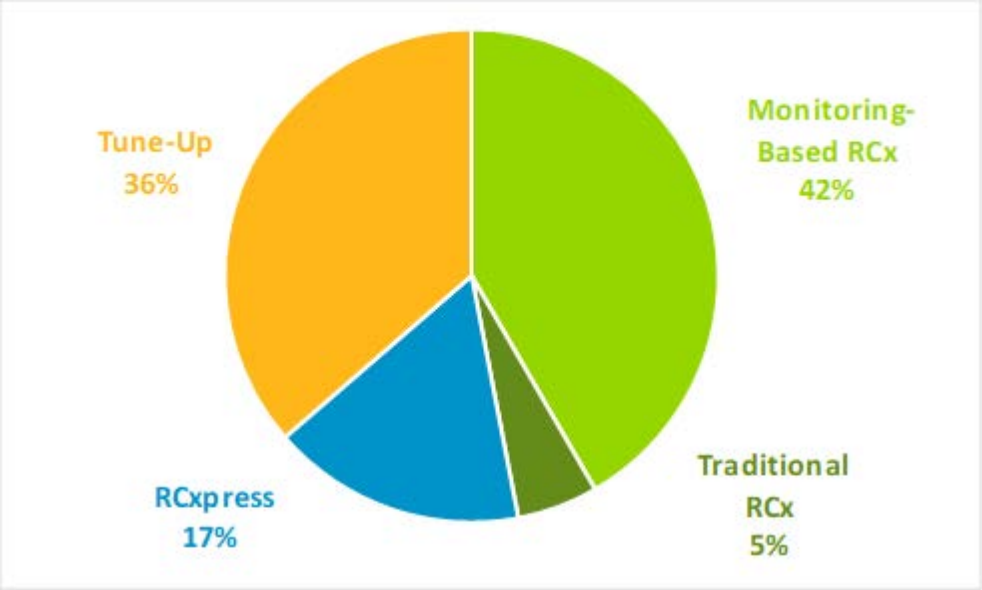
Source: ComEd tracking data and evaluation team analysis

Table 2-3. Program Attributes – by Participation Track

Participation Track	Target Facility Size	Incentives	Customer Commitment
RetroCommissioning (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

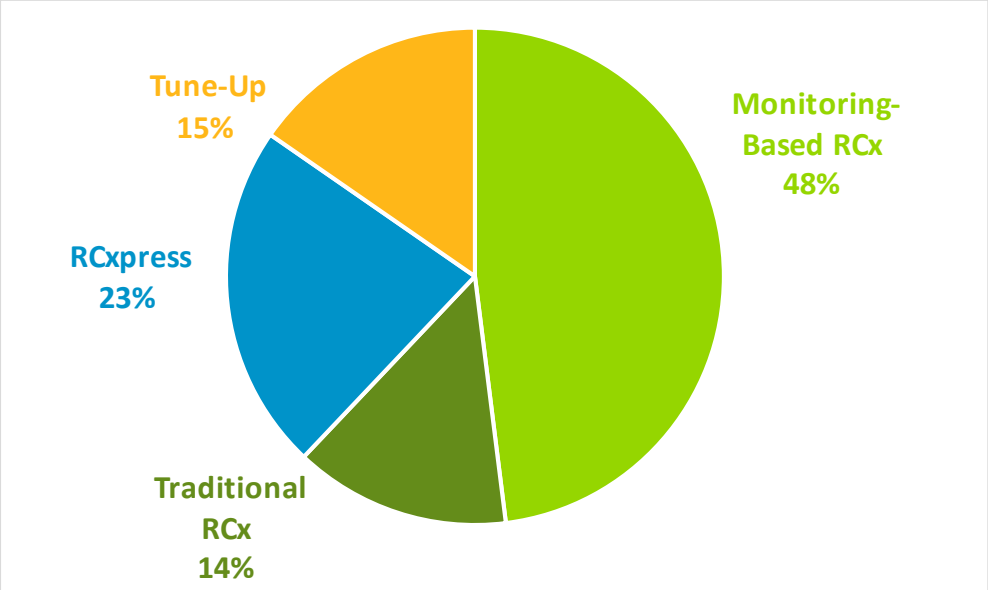
Source: ComEd

Figure 2-1. Distribution of Projects Completed by Track



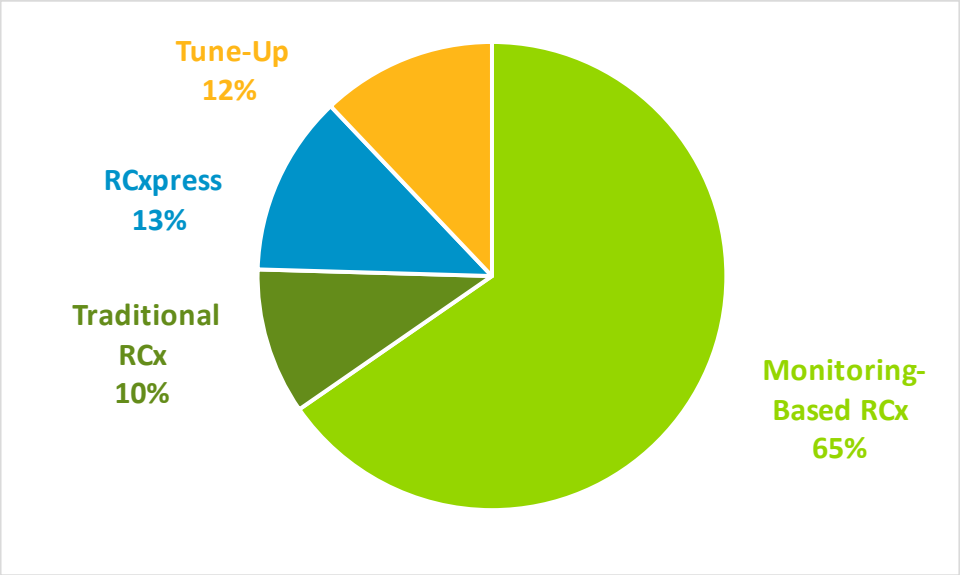
Source: ComEd tracking data and evaluation team analysis

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 CY2020. The gas savings in Table 3-1 are only those that ComEd may be able to claim, which excludes savings the gas utilities claim, either via joint or non-joint programs.[3]

Table 3-1 shows verified net electric savings are 26,840,963 kWh. Verified net gas savings converted to electric savings that may be claimed by ComEd are 3,291,555 kWh.

Table 3-2 shows overall gas savings claimed by the gas utilities. The gas companies claimed more than 87% of the gas savings realized through the program.

[3] Guidehouse will work with ComEd to determine whether the RetroCommissioning Program gas savings in this report will ultimately be counted toward the ComEd portfolio gas savings goal.

Table 3-1. CY2020 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Summer Peak* Demand Savings (kW)
Electricity		
Ex Ante Gross Savings	29,101,900	582
Program Gross Realization Rate	0.98	1.00
Verified Gross Savings	28,554,216	584
Program Net-to-Gross Ratio (NTG)‡	0.94	0.94
Verified Net Savings	26,840,963	549
Converted from Gas†		
Ex Ante Gross Savings	3,513,507	NA
Program Gross Realization Rate	1.00	NA
Verified Gross Savings	3,501,655	NA
Program Net-to-Gross Ratio (NTG)‡	0.94	NA
Verified Net Savings	3,291,555	NA
Total Electric Plus Gas		
Ex Ante Gross Savings	32,615,407	582
Program Gross Realization Rate	0.98	1.00
Verified Gross Savings	32,055,870	584
Program Net-to-Gross Ratio (NTG)‡	0.94	0.94
Verified Net Savings	30,132,518	549

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 p.m.-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.

† Gas savings converted to kilowatt-hours (kWh) by multiplying therms by 29.31 (which is based on 100,000 Btu/therm and 3,412 Btu/kWh). 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."[2]

‡ A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020

Source: ComEd tracking data and evaluation team analysis

Table 3-2. CY2020 Total Annual Incremental Therm Savings

Savings Category	Nicor Gas (Therms)	Peoples Gas (Therms)	North Shore Gas (Therms)
Natural Gas*			
Ex Ante Gross Savings	332,771	417,335	68,240
Program Gross Realization Rate	0.98	1.00	1.00
Verified Gross Savings	325,018	417,990	68,240
Program Net-to-Gross Ratio (NTG)	0.94	0.94	0.94
Verified Net Savings	305,517	392,911	64,146

* Natural gas savings with electric interactive effects removed. Ex ante gross savings are based on final project files provided by ComEd and the IC.

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 show total verified gross savings for the RetroCommissioning Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2020. Figure 4-1 shows the savings across the useful life of the measures. The net electric CPAS across all measures installed in CY2020 is 26,840,963 kWh (Table 4-1).

The program achieved 874,875 therms total net natural gas savings, which includes 762,573 net therms cost-shared by the coordinated gas utilities[4] plus 112,301 net therms converted to kWh that may be claimed by ComEd as ComEd CPAS savings. The CY2020 gas contribution to CPAS (converted to equivalent electricity) is 3,291,555 kWh net (Table 4-2). Adding the gas and electric contributions produces 30,132,518 kWh net of total CY2020 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 rows are the sum of the CY2020 contribution and the historic contribution.

[4] 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.”

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

End Use Type	Research Category	EUL‖	CY2020 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	Verified Net kWh Savings 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
RetroCommissioning	All	8.4	28,554,216	0.94	226,269,315			26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	11,541,614	
CY2020 Program Total Electric Contribution to CPAS			28,554,216		226,269,315			26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	26,840,963	11,541,614	
Historic Program Total Electric Contribution to CPAS‡						34,519,759	66,202,042	66,202,042	66,202,042	66,202,042	66,202,042	66,202,042	48,942,162	31,682,282	13,623,381	-	
Program Total Electric CPAS						34,519,759	66,202,042	93,043,004	93,043,004	93,043,004	93,043,004	93,043,004	75,783,125	58,523,245	40,464,344	11,541,614	
CY2020 Program Incremental Expiring Electric Savings§									-	-	-	-	-	-	-	15,299,349	11,541,614
Historic Program Incremental Expiring Electric Savings‡§								-	-	-	-	-	17,259,880	17,259,880	18,058,901	13,623,381	
Program Total Incremental Expiring Electric Savings§								-	-	-	-	-	17,259,880	17,259,880	18,058,901	28,922,730	11,541,614

Note: The green highlighted cell shows program total first year electric savings. The gray cells are blank, indicating values irrelevant to the CY2020 contribution to CPAS.

* A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

† 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#	CY2020 Verified Gross Savings (Therms)	NTG*	Lifetime Net Savings (Therms)†	Verified Net Therms Savings											
						2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
RetroCommissioning	All	8.6	119,470	0.94	965,792			112,301	112,301	112,301	112,301	112,301	112,301	112,301	112,301	67,381	
CY2020 Program Total Gas Contribution to CPAS (Therms)			119,470		965,792			112,301	112,301	112,301	112,301	112,301	112,301	112,301	112,301	67,381	
CY2020 Program Total Gas Contribution to CPAS (kWh Equivalent)‡						-	-	3,291,555	3,291,555	3,291,555	3,291,555	3,291,555	3,291,555	3,291,555	3,291,555	1,974,933	
Historic Program Total Gas Contribution to 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	1,079,644	215,929	-	
Program Total Gas CPAS (kWh Equivalent)‡						2,907,030	3,986,674	7,278,229	7,278,229	7,278,229	7,278,229	7,278,229	5,824,714	4,371,200	3,507,484	1,974,933	
CY2020 Program Incremental Expiring Gas Savings (Therms)‖									-	-	-	-	-	-	-	44,921	67,381
CY2020 Program Incremental Expiring Gas Savings (kWh Equivalent)‡‖									-	-	-	-	-	-	-	1,316,622	1,974,933
Historic Program Incremental Expiring Gas Savings (kWh Equivalent)‡§‖								-	-	-	-	-	1,453,515	1,453,515	863,715	215,929	
Program Total Incremental Expiring Gas Savings (kWh Equivalent)‡‖								-	-	-	-	-	1,453,515	1,453,515	863,715	1,532,551	1,974,933

Note: The green highlighted cell shows program total first year gas savings in kWh equivalents. The gray cells are blank, indicating no values or no contribution to calculating CPAS in CY2020.

* A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

† 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‖	CY2020 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	2027	2028	2029
RetroCommissioning	All	8.5	32,055,870	0.94	254,576,692			30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	13,516,547	-
CY2020 Program Total Contribution to CPAS			32,055,870		254,576,692			30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	30,132,518	13,516,547	-
Historic Program Total Contribution to CPAS‡						37,426,789	70,188,716	70,188,716	70,188,716	70,188,716	70,188,716	70,188,716	51,475,321	32,761,926	13,839,310	-	-
Program Total CPAS						37,426,789	70,188,716	100,321,234	100,321,234	100,321,234	100,321,234	100,321,234	81,607,839	62,894,444	43,971,828	13,516,547	-
CY2020 Program Incremental Expiring Savings§									-	-	-	-	-	-	-	16,615,971	13,516,547
Historic Program Incremental Expiring Savings‡§								-	-	-	-	-	18,713,395	18,713,395	18,922,616	13,839,310	-
Program Total Incremental Expiring Savings§								-	-	-	-	-	18,713,395	18,713,395	18,922,616	30,455,281	13,516,547

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 no contribution to calculating CPAS in CY2020.

* A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

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

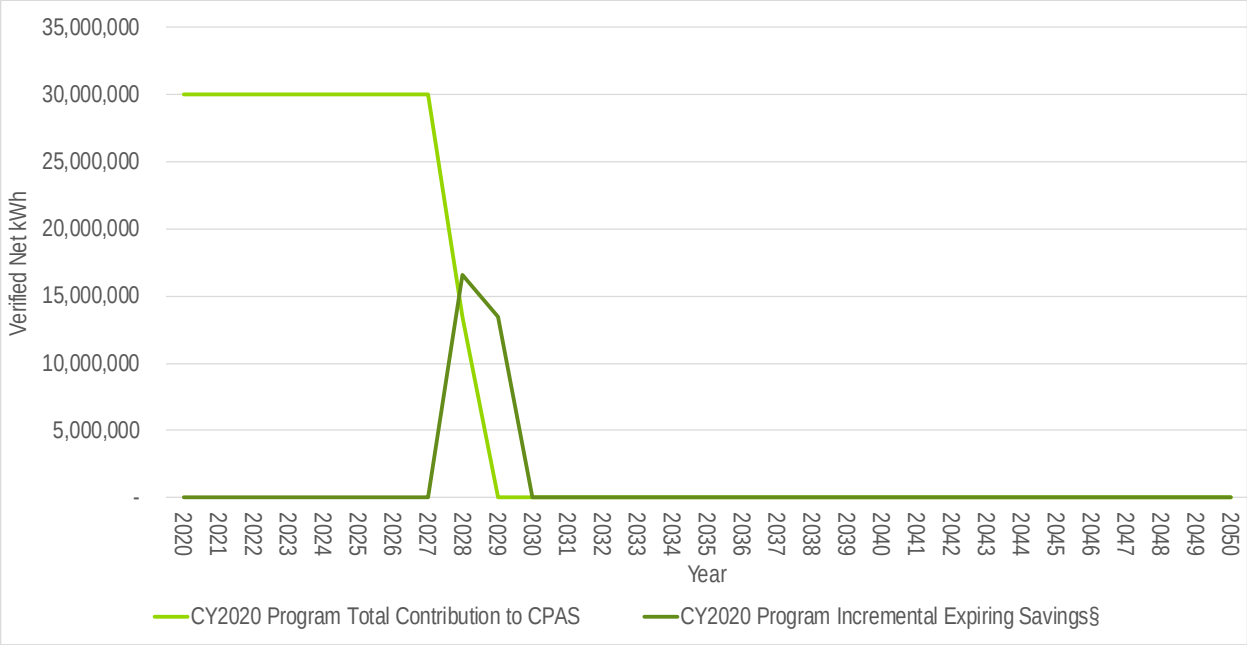
‡ Historic savings go back to CY2018.

§ 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 + Expiring Savings Y_{n-1}.

Source: Evaluation team analysis

5. Program Savings by Measure

The evaluation team analyzed savings for the RetroCommissioning Program as a whole instead of by measure or track. ComEd and the evaluation team made this choice by consensus due to the years of consistent delivery. Appendix B details the savings by project.

6. Impact Analysis Findings and Recommendations

6.1 Impact Parameter Estimates

Table 6-1 shows the program-level impact parameter estimates for the RetroCommissioning Program. There are no standard or Illinois Statewide Technical Reference Manual (TRM) v8.0-based estimates for RCx measures.

The lifetime energy and demand savings are the product of the verified savings and the effective useful life. Table 6-1 shows the CY2020 savings parameters.

Table 6-1. Savings Parameters

Gross Savings Input Parameters	Value	Units	Deemed * or Evaluated?	Source
NTG Electric	0.94		Deemed	Illinois SAG Consensus†
NTG Gas	0.94		Deemed	Illinois SAG Consensus†
Effective Useful Life (EUL) Tune-Up‡	7.5	Years	Deemed	ComEd EUL Comm RCx and Behavior Memo 2019-09-17
Effective Useful Life (EUL) RCx, MBCx, RCxpress‡	8.6	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 net-to-gross (NTG) values can be found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

† A deemed value. For ComEd converted therms, the electric NTG is used. Sources: https://ilsag.s3.amazonaws.com/ComEd_NTG_History_and_CY2020_Recs_Final_2019-10-01.xlsx, https://ilsag.s3.amazonaws.com/Nicor_Gas_NTG_History_and_2020_Values_2019-10-01_Final.xlsx, https://ilsag.s3.amazonaws.com/PGL-NSG_NTG_History_and_2020_Values_2019-10-01_Final.xlsx.

‡ EUL is the savings-weighted average of deemed values: Building Tune-up (EUL=7.5 years) and all other RCx tracks (EUL=8.6 years).

Source: Evaluation team analysis

6.2 Other Impact Findings and Recommendations

CY2020 realization rates for savings are higher than historic realization rates, in most cases. Gas realization rates are about 1.0 except for Nicor Gas (.0.98). The electric energy, kWh, realization rate is about 0.98 and the electric demand, kW realization rate is 1.0. The higher rates in CY2020 can be partly attributed to the lack of onsite verification, due to Covid-19 restrictions, which often identifies measures that have been modified from their reported operation.

The evaluation team has developed several recommendations based on findings from the CY2020 evaluation listed below. These findings explain primary drivers of variance from a 1.0 realization rate and suggest ways to improve program ex ante savings estimates, reducing evaluation risk. Effects on project realization rates can be identified in Table B-1. Table B-1 provides project level detail with realization rates across RCx measures which reflects the varied aspects of RCx projects.

6.2.1 General Findings

Finding 1. Actual implementation of measures was not always as-reported. Phone interviews with operating engineers determined modified schedules and setpoints. These changes were mostly due to operator adjustments to maintain occupant comfort. In other cases, projects continued to implement additional recommended measures or finish implementing measures after projects were verified and closed by the service provider and IC. These differences could move the realization rate higher or lower.

Finding 2. Infrequent calculation errors can increase or decrease realization rates. Most identified errors are accidental and not systemic. The CY2020 program included almost 400 measures with custom calculations and inputs, and the vast majority were found to be accurate. Several types of calculation errors were encountered this year:

- Double-counted savings for complex and complementary measures.
- Estimated variables outside of trended ranges distort savings estimates
- Mis-applied fan affinity law for power estimates, such as mis-application of program guidance for affinity law exponents (both too high and too low), and faulty application of affinity laws when both pressure and volume change.
- Different weather stations used for measures at the same project and location rather than a consistent dataset for a project's measures

Projects in Table B-1 with the largest impacts on program realization rate are, broadly speaking, of two types: (1) those which lack sufficient detail to support the baseline equipment connected load and operation, and (2) those for which the calculation spreadsheets are too general to permit accurate calculations (e.g., bin size does not match the granularity of the setpoint adjustment resulting in incorrect hours of use attributed to measures; scheduling spreadsheet does not allow easy adjustments for summer schedules in schools).

> **Recommendation 1.** The IC can reduce program evaluation risk by continuing to provide more scrutiny in quality control of the EESP measure calculations, and help EESPs improve calculation spreadsheets and develop best practices. For example, extrapolate trended data with more adjacent data, i.e. estimate parameters at 80ºF with data from 65 -75ºF and not 10-75ºF

6.2.2 Methodology Findings

Finding 3. EESPs incorporated regression equations in their analyses more often than in CY2019, but sometimes the regression results were accepted without careful consideration when they demonstrated nonsense relationships (decreasing loads as outdoor temperatures become more extreme) or were oversimplified (using a single second order polynomial to describe multiple operating modes). This causes the realization rate to fluctuate up and down and impacts accuracy and integrity of results.

> **Recommendation2.** 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. Do not use regressions if the dependent variable is not modeled well.

Finding 4. Actual measure installation dates were seldom included in the project documentation and the evaluation team resorted to inferring dates from invoices and report dates. When the evaluation team tried to estimate savings from time-series data, such as BEA meter data, they needed accurate dates to assign data to pre-implementation and post-implementation periods. This made it difficult to assess final savings and impacted the realization rate to be lower.

> **Recommendation 3.** Include explicit dates for implementation start and finish dates for each measure, especially if trend data are used to generate estimates.

Finding 5. Some calculations used 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; however, the EESP engineer often filtered and collapsed the BEA data when they calculated the savings, and the full BEA dataset was not preserved intact. Furthermore, older data were dropped from the BEA portal and cannot be reconstructed during the evaluation. When evaluators try to supplement the analysis with more

data, we cannot determine whether the baseline is accurate and the ex post savings are almost always different from the ex ante. This may lower the realization rate upon final savings analysis due the data insufficiency.

> **Recommendation 4.** Archive full BEA datasets, used for ex ante savings estimates, with the project documentation for use by the evaluation team.

Finding 6. While better than previous years, Nicor Gas, Peoples Gas, and North Shore Gas program tracking data reported total therm savings that did not initially match the final project files provided by ComEd and the IC used for impact evaluation. This tends to make final savings analysis difficult to assess efficiently within the required reporting timeline, requiring substantial re-work after the initial report draft.

> **Recommendation 5.** Gas utilities should continue to improve coordination with ComEd during the implementation year and after the program year closes to reconcile project-level therm savings and claims prior to closing tracking data on January 30 to reduce the cost of the evaluation and help maintain the required reporting timeline.

Finding 7. The evaluation team found that ex ante demand calculations were not performed consistently, and used a variety of conditions that did not conform to the WTHI method for summer demand savings for weather dependent measures in the ComEd service territory.

> **Recommendation 6.** The IC should include quality control checks on all measure savings estimates that might have demand savings. Although many RCx measures do not result in demand savings, and the RCx program does not bid into the PJM capacity market, and the average demand savings for RCx projects is relatively small (~11 kW average ex ante in CY2020), the program would avoid evaluation risk and improve ex ante demand savings estimates, thereby accurately capturing all program impacts, by calculating demand savings in a consistent manner.

6.2.3 Engineering Findings

Finding 8: The EESP used building-level utility meter data to support ice melt system savings without sufficient supporting documentation. This impacts the realization rate and has a negative effect on accuracy of program results. The apparent savings in the meter data was much higher than expected for an ice melt system of this size, and it was not clear whether the building-level savings may include other activities besides the ice melt system measure. Other measures were recommended in the investigation report though ultimately not claimed by the program, which raised the question of whether the participant ended up implementing other undocumented measures. The evaluation team adjusted savings downward in this case.

> **Recommendation7.** Use building-level data only when the results can be cross-checked. Equipment level trending or datalogging, photographs, manufacturer's equipment specifications including connected electric load and a detailed description of baseline system operating hours, are generally needed to support ex ante savings claims:
>
> - Avoid building-level analysis for measures with an unpredictable, infrequent schedule, such as an ice melt control system.
>
> - Avoid building-level analysis when expected ex ante savings are less than 10% of the baseline usage. This is especially true if there is a high degree of uncertainty in

the expected savings. In this case, resources such as the ASHRAE Handbook can be used to quickly size the expected usage of an ice melt system in Chicago.

- Institute reasonableness checks on estimates that use building-level data as many factors (not just the described measure) can affect energy use shown in this high-level data. Use connected loads and expected hours of use to corroborate the apparent savings in the building-level meter data analysis. Investigate and explain any unexpected findings before claiming savings.

- Document equipment details, such as equipment connected electric load, control sequences, and baseline hours, even if building-level utility meter data will be used to support savings. A high degree of uncertainty in the baseline calls for more, not less, direct documentation of the baseline end-use equipment loads and operating hours.[5]

- Reference manufacturer's data from online research if onsite documentation is not available.

Finding 9. Several EESP's overstated heating savings for measures that reduce minimum outside air limits to save energy. In summer cooling mode reduced ventilation limits will save energy, but in the winter mixed air controls will frequently prevent the ventilation rate to approach the new minimum, thus there is limited or no heating savings. This is finding is an example of a primary driver of variance from a 1.0 realization rate – implementing this change can improve program ex ante savings estimates and reduce evaluation risk.

> **Recommendation 8.** Scrutinize ventilation heating savings for measures like demand-controlled ventilation or reduced minimum ventilation that affect ventilation rates unequally across the range of operation to improve accuracy of estimates.

[5] For this project, the participant reported that the system was 'out of control' in the baseline.

Appendix A. Impact Analysis Methodology

A.1 Ex ante estimates

EESPs estimated energy and demand savings with custom algorithms, frequently using hourly weather data and time-series trend data applied in engineering relationships of energy, temperature, and mass transfer on an hourly basis. Alternatively, when data supported the method, EESPs determined savings by regressions of energy use versus outdoor temperature and other independent variables. When energy efficiency measures had a climate component to usage, service providers used standard weather datasets (typical meteorological year [TMY3])[6] 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 time of day. Other measures have demand savings that are weather-dependent. For the ComEd service territory, PJM determined the weighted temperature-humidity index (WTHI) zonal weather standard value is 81.6.

A.2 Evaluation methods

The impact evaluation consists of a review of a representative sample of projects. Under more normal circumstances, the evaluation team would conduct both an engineering desk review and onsite verification for a subset of sampled projects. Due to COVID-19 virus protocols, the evaluation team were unable to conduct planned onsite visits. Instead we supplemented desk reviews with more phone interviews with building operators and reviewed some BAS via remote connection or teleconferencing.

The evaluation team reviewed each sampled project and implemented measures individually to validate the savings, usually using the same methods of the EESP described above. Savings calculation reviews ensured the savings estimates were accurately modeled, used consistent inputs, and included reasonable assumptions, as required. In some cases, the evaluation team acquired additional trend data or interval meter data to verify savings with more data and data concurrent with expected savings, e.g., winter data for night set-back measures. In most cases, the impact evaluation involved analysis of time-series trend and measured data, both pre- and post-implementation. In all cases, the evaluation team normalized savings estimates to TMY data to minimize the effects of atypical weather variation.

In general, the evaluation team found the calculations accurately constructed, based on measured data rather than rules-of-thumb, and reasonably transparent in spreadsheet form. In rare 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.

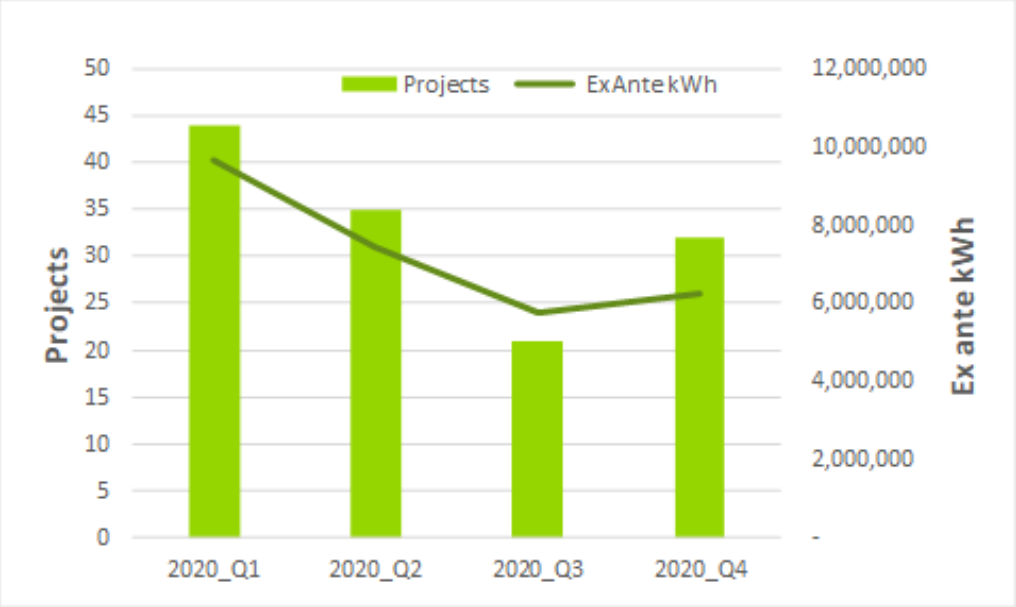
In cases where the evaluation team's verified inputs were inconsistent with EESP reported data, such as setpoints or operational hours, we re-estimated savings with available data, additional data requested from the participant or EESP, or program guideline inputs.

[6] 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.

Reviewed measure and project savings were rolled-up according to the sampling protocol to realization rate impact parameter estimates for electric energy, electric demand, and natural gas energy savings.

Due to the number of projects and the compressed schedule between program year-end and reporting, the evaluation team reviewed projects in waves, roughly quarterly starting with the first quarter of 2020, including a mid-quarter sample between the third and fourth quarter. Figure A-1 shows the distribution of IC project completions by quarter.

Figure A-1. Ex Ante Project Counts and Savings by Quarter



Source: ComEd tracking data and evaluation team analysis

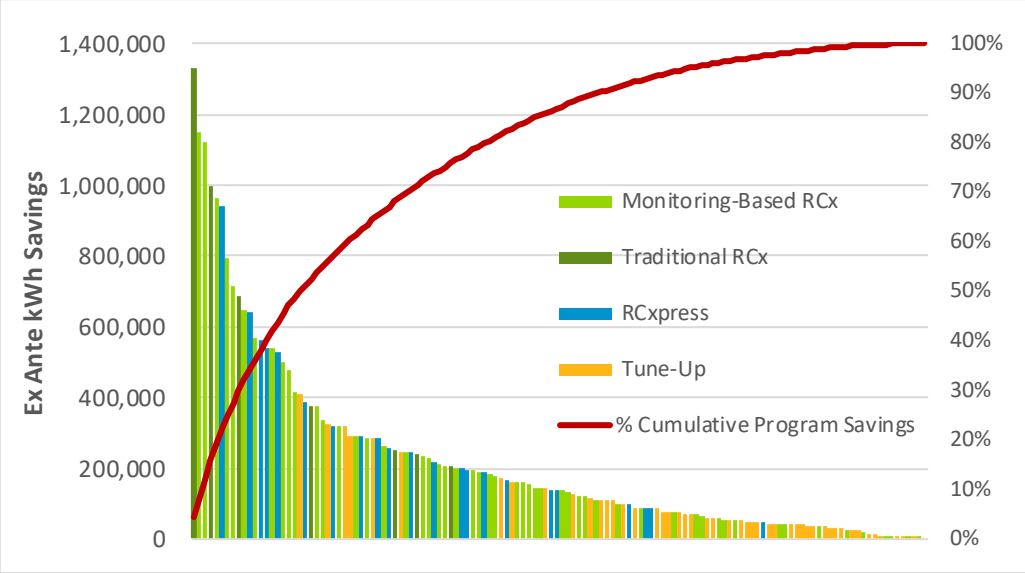
In CY2020, the evaluation team reviewed 48 projects (36% of the total), 201 measures (53% of the total), 12,816 MWh (44% of claimed) and almost 500,000 therms (53% of claimed).

Results from the impact evaluation were rolled up by sampling strata and extrapolated to the participant population to determine gross researched impacts. Deemed NTG ratios were applied to verified gross results to arrive at net researched impacts.

Appendix B. Impact Analysis Detail

Figure B-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 Traditional RCx tracks, but some RCxpress projects are also large. For electricity, ex ante project savings ranged from over 1,333,000 kWh to 0 kWh, with the largest seven projects making up slightly more than one-quarter of program savings and 46 projects (one-third of the total) covering more than 75% of electric energy savings.

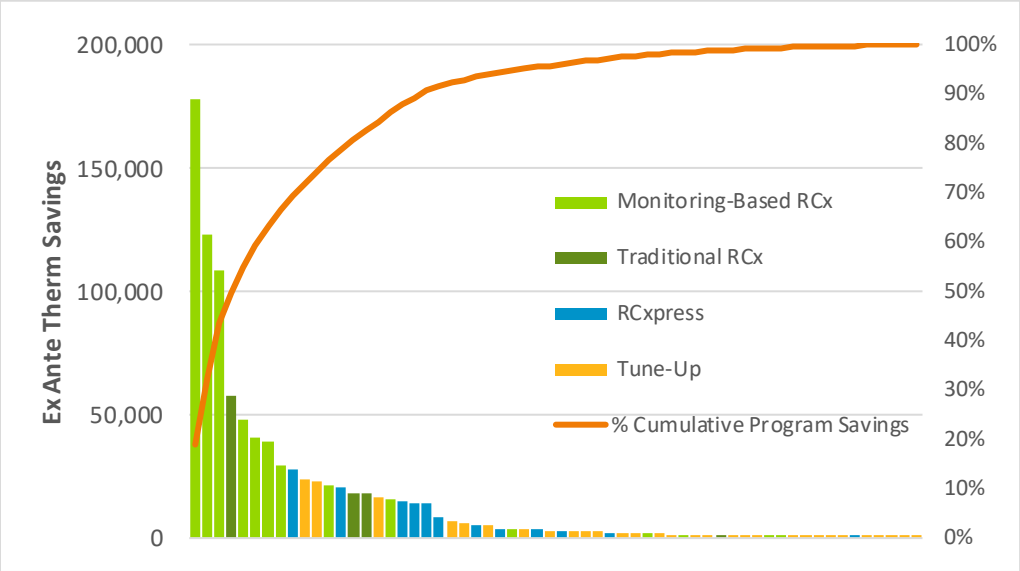
Figure B-1. CY2020 Ex Ante Electric Energy Savings by Track and Project



Source: Evaluation team analysis

Figure B-2 shows ex ante gas savings by project and track for the 60 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 178,100 therms to 4 therms annually, with the largest four projects making up one-half of program savings, and the 12 largest accounting for more than 75% of program savings.

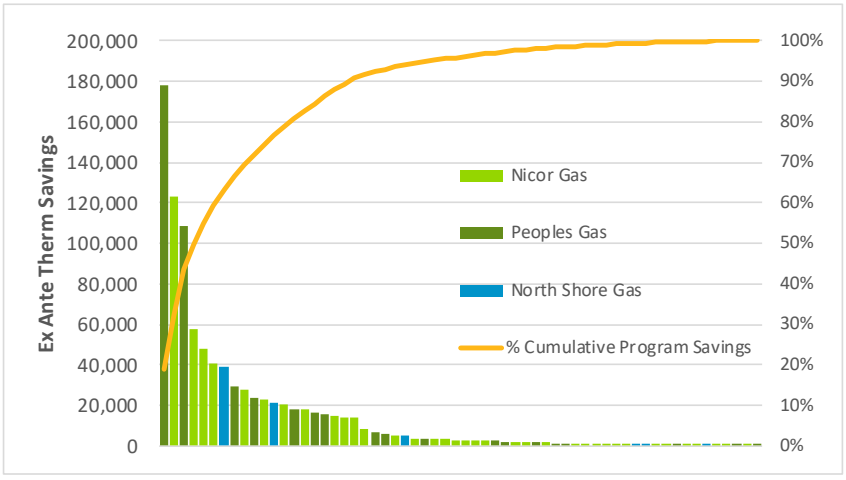
Figure B-2. CY2020 Gas Energy Savings by Track and Project



Source: Evaluation team analysis

Figure B-3 shows ex ante gas savings by utility. Nicor Gas and Peoples Gas customers had similar total savings though Nicor Gas had twice as many projects. There are five participants with six projects in the North Shore Gas territory.

Figure B-3. CY2020 Gas Energy Savings by Utility and Project



Source: Evaluation team analysis

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

Table B-1. Project Level Realization Rates

Nexant Project #	Track	Gas Utility	RR.kWh	RR.kW	RR.Therms	Notes
14-109	MBCx	Electric Only	1.00	1.00	na	
14-110-B8	MBCx	Electric Only	1.00	na	na	
15-108-B9	MBCx	Peoples Gas	1.01	na	1.01	
16-104-B2	MBCx	North Shore Gas	0.74	na	1.00	The bin method used to estimate savings from economizing included both affect and unaffected hours, thus obscuring savings. Evaluation adjusted the bins to align with set-points and changed settings to isolate measure effects.
16-104-B3	MBCx	North Shore Gas	0.98	0.95	na	
16-104-B4	MBCx	North Shore Gas	1.00	1.00	1.00	
17-112	MBCx	Peoples Gas	1.00	na	1.00	
17-121	MBCx	Electric Only	1.00	na	na	
18-107-B3	MBCx	Nicor Gas	0.97	0.89	1.04	Different and distant weather stations were used for ex ante estimates. Evaluation used a single station located near the project site.
18-110	MBCx	Electric Only	1.00	na	1.00	
18-115	MBCx	Electric Only	1.00	na	na	
18-118	MBCx	Electric Only	1.00	na	na	
18-122-B4	MBCx	Nicor Gas	na	na	0.87	The ex ante estimates are based on trend data, which cover a limited range of operation. Extrapolations of operating parameters span multiple modes of operation (heating, economizing and cooling) and assume like operation for all equipment, distorting the extrapolations. Evaluators limited the trending to more proximal data. Ex post savings includes estimated savings for summer reheat reduction.
18-129	MBCx	Electric Only	1.00	na	na	
19-0030-B3	MBCx	Peoples Gas	1.00	1.00	na	
19-0030-B6	MBCx	Peoples Gas	0.96	na	0.98	A measure to schedule AHU operation inconsistently applied assumptions about after-hours operation. Trend data extrapolations were based on multiple modes of system operation, thus distorting the extrapolated data.
19-0094-B1	MBCx	North Shore Gas	1.00	1.00	1.00	
18-006	RCx	Nicor Gas	1.00	1.00	1.00	
18-048	RCx	Electric Only	0.93	na	na	Evaluation analyzed additional winter-season interval data to augment the 35 days of data used in the ex ante estimate. The effective hours of some measures overlap and some hours of savings were double-counted.
18-049	RCx	Electric Only	1.00	na	na	
18-010	Rcxpress	Nicor Gas	1.00	1.00	1.06	Two complementary measures were implemented simultaneously and both demonstrate function by reduced fan speed. The EESP used speed trends to justify two separate savings estimates for the measures, when the savings of both measures are included in a single calculation, thus savings for one measure had been double-counted.
18-018	RCxpress	Electric Only	0.85	1.11	na	One measure reduced static pressure in hybrid constant/variable volume air systems resulting in reduced fan speed. The EESP determined savings with the volume vs. power relationship with an exponent of 3.0 rather than the program-stipulated 2.5. Even with a revised exponent, this is an incorrect application of the affinity laws as both pressure and volume are changing with these systems.
18-026	RCxpress	Nicor Gas	1.08	na	1.02	
18-027	RCxpress	Electric Only	1.00	na	na	

Table B-2. Project Level Realization Rates (continued)

Nexant Project #	Track	Gas Utility	RR.kWh	RR.kW	RR.Therms	Notes
18-042	RCxpress	Nicor Gas	1.03	1.00	1.15	Multiple operating parameters (hours of operation, HP, CFM) were not entered correctly into some calculations. Data center set-back savings removed for the winter months when the excess heat is beneficial to the surround spaces, thus no net savings in the winter.
18-051	RCxpress	North Shore Gas	0.94	na	1.00	Evaluation corrected the mechanical cooling-enable temperature setpoint and estimated cooling loads with the water-side economizer rather than the compressors.
18-053	RCxpress	Nicor Gas	1.04	1.00	1.00	Economizer high-limit was changed in calculations to match actual operation.
18-057	RCxpress	Peoples Gas	1.00	1.00	na	
19-0010	Rcxpress	Peoples Gas	0.96	0.77	na	Several parameters entered into calculations contradicted observations in the report and screen-shots of controls. One part of one measure was double-counted in another measure. Set-points for the same AHU were not consistent across complementary measures.
19-0011	RCxpress	Nicor Gas	0.99	0.69	0.99	
19-0027	RCxpress	Electric Only	0.96	na	na	The savings estimate included modified operation to 4 airhandlers, where the measure was not implemented.
19-0047	RCxpress	Electric Only	1.00	na	na	
19-0053	RCxpress	Peoples Gas	1.00	na	1.00	
19-0056	RCxpress	Electric Only	1.17	1.00	na	
18-442	TU	Nicor Gas	1.00	1.00	1.00	
18-447	TU	Electric Only	0.72	na	na	One measure claimed savings that is not supported by trend data, design criteria or manufacturer's data.
18-462	TU	Nicor Gas	1.00	na	1.00	
18-463	TU	Nicor Gas	0.85	na	0.85	The key measure is scheduling airhandlers. BEA data demonstrate that the schedule is not exactly as estimated and there are substantial building warm-up loads following prolonged off hours that are not included in the ex ante estimates.
18-467	TU	Electric Only	1.00	na	na	
18-623	TU	Nicor Gas	1.02	na	0.98	
18-625	TU	Nicor Gas	0.91	na	1.10	The savings estimate assumes that the school was fully occupied during baseline summers. Facility staff report and BEA data show the building is at least partially shutdown during the baseline, thus reducing savings.
18-638	TU	Nicor Gas	0.90	na	1.01	The savings estimate assumes that the school was fully occupied during baseline summers. Facility staff report and BEA data show the building is at least partially shutdown during the baseline, thus reducing savings.
19-0086	TU	Nicor Gas	0.98	2.13	na	Small demand savings value evaluated somewhat larger
19-0135	TU	Nicor Gas	0.97	na	na	Static pressure in the calculations do not match the verification report. Alternative inputs were confirmed by phone interview.
19-0136	TU	Electric Only	0.98	1.00	na	
19-0144	TU	Nicor Gas	0.87	0.77	1.00	Phone interview with operating engineer determined that several operating parameters (actual hours of operation, minimum fan speeds and static pressure) are different than input into ex ante calculations.
19-0161	TU	Electric Only	1.07	na	na	
19-0162	TU	Electric Only	1.00	na	na	

Appendix C. Total Resource Cost Detail

Table C-1 shows the 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 C-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Gross Electric Energy Savings (kWh)	Gross Peak Demand Reduction (kW)	Gross Gas Savings (Therms)	Gross Secondary Savings due to Water Reduction (kWh)	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG (kWh)	NTG (kW)	NTG (Therms)	Net Electric Energy Savings (kWh)	Net Peak Demand Reduction (kW)	Net Gas Savings (Therms)	Net Secondary Savings due to Water Reduction (kWh)	Net Heating Penalty (kWh)	Net Heating Penalty‡ (Therms)
RetroCommissioning	All	Project	131	8.5	No	28,554,216	584.0	119,470	0	0	0	0.94	0.94	0.94	26,840,963	548.97	112,301	0	0	0
	Total			8.5		28,554,216	584	119,470	0	0	0	NA	NA	NA	26,840,963	549	112,301	0	0	0

Note: To avoid double counting, the verified gross kWh and net kWh used in the TRC analysis excluded secondary energy savings from water reduction measures.

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of the 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.

‡ Gas heating penalties represent the program therms heating penalties. The therms penalties are not required to be applied to the program savings.

Source: Evaluation team analysis of tracking data

Table C-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‡	Verified Net Savings (Therms)
RetroCommissioning	All	Project	30	8.4	No	332,771	325,018	0.94	305,517
						332,771	325,018		305,517

* The total of the EUL column is the weighted average measure life (WAML) and is calculated as the sum product of the 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.

‡ A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020

Source: Evaluation team analysis of tracking data

Table C-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‡	Verified Net Savings (Therms)
RetroCommissioning	All	Project	18	8.5	No	417,335	417,990	0.94	392,911
						417,335	417,990		392,911

* The total of the EUL column is the weighted average measure life (WAML) and is calculated as the sum product of the 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.

‡ A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020

Source: Evaluation team analysis of tracking data

Table C-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‡	Verified Net Savings (Therms)
RetroCommissioning	All	Each	6	8.5	No	68,240	68,240	0.94	64,146
						68,240	68,240		64,146

* The total of the EUL column is the weighted average measure life (WAML) and is calculated as the sum product of the 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.

‡ A deemed value. Source: is found on the Illinois SAG website: https://www.ilsag.info/ntg_2020

Source: Evaluation team analysis of tracking data