NAVIGANT

Coordinated Utility Retro-Commissioning Program Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Plan Year 9 (EPY9) / Gas Plan Year 6 (GPY6) (6/1/2016-12/31/2017)

Presented to
Commonwealth Edison Company
Nicor Gas
Peoples Gas
North Shore Gas

FINAL

April 19, 2018

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Coordinated Utility RCx Program Impact Evaluation Report

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1. INTRODUCTION

This report presents the results of the impact evaluation of the EPY9/GPY6 Coordinated Utility Retro-Commissioning Program. It contains a summary of the energy and demand impacts for the total program broken out by relevant measure and program structure details. The appendix presents the impact analysis methodology and detailed results by program offering. EPY9/GPY6 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

The Northern Illinois Coordinated Utility Retro-Commissioning (Retro-Commissioning) Program has been operating each of the nine electric program years. Electric program year 9 (EPY9) also marked the sixth natural gas program year (GPY6) where the program was coordinated with the gas utilities where service areas overlap ComEd's service area. Retro-Commissioning was previously a jointly managed program, but is now coordinated between ComEd and gas utilities serving ComEd customers with ComEd managing the program and paying all management costs. The gas utilities have the option to purchase verified saved therms from the program, in effect sharing costs. The overlapping gas territories include Nicor Gas, Peoples Gas, and North Shore Gas. The Retro-Commissioning Program offering is a natural fit for coordinated delivery with the gas providers 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 savings.

The program helps commercial and industrial customers improve the performance and reduce energy consumption of their facilities through the systematic analysis of *existing* building systems. 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 five offerings, with three targeted to medium to large office buildings: traditional retro-commissioning (RCx), monitoring-based retro-commissioning (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 Retro-Commissioning Service Provider (RSP). This comprehensive approach identifies, analyzes, implements and verifies measures on a rolling basis with the RSP monitoring BAS data periodically to ensure on-going savings.
- RCxpress engagements last less than one year and typically have a more limited scope than RCx.

The RCx Building Tune-Up (Tune-up) and Grocery RCx offerings include direct implementation of common Retro-Commissioning measures by the customer and the RSP without prior detailed research and analysis.

- RCx Building Tune-up is more focused on the most common RCx measures in smaller commercial buildings and results in a briefer deliverable on a faster timeline.
- Grocery RCx focuses on the most common measures affecting refrigeration systems and equipment scheduling in full-service groceries and convenience stores.

The Grocery RCx offering is currently being merged into RCx Building Tune-up. Additional offering attributes are shown in Table 2-3, below..

The program had 124 projects, including 42 gas projects, in EPY9/GPY6 and implemented 423 measures as shown in Table 2-1 and Table 2-2 and the following graphs.

Table 2-1. EPY9/GPY6 Volumetric Findings Detail by Utility*

Participation	Electric Only	Nicor Gas	Peoples Gas	North Shore Gas	Total
Total Projects	82	15	25	2	124
Electric Measures	225	73	106	6	410
Gas Measures	0	36	55	2	93
Total Measures*	225	78	114	6	423
Measures/Project	2.7	5.2	4.6	3.0	3.4

*Project counts include six coordinated gas projects that did not report any gas savings in GPY6.
†Totals include some measures with both electric and gas savings.
Source: ComEd tracking data and Navigant team analysis.

Table 2-2. EPY9/GPY6 Volumetric Findings Detail by Offering

Participation	MBCx	RCx	RCxpress	Tune-Up	Grocery	Total
Total Projects	10	16	30	65	3	124
Electric Measures	29	69	128	179	5	410
Gas Measures	3	16	34	40	0	93
Total Measures*	30	70	136	182	5	423
Measures/Project	3.0	4.4	4.5	2.8	1.7	3.4

*Totals include some measures with both electric and gas savings.
Source: ComEd tracking data and Navigant team analysis.

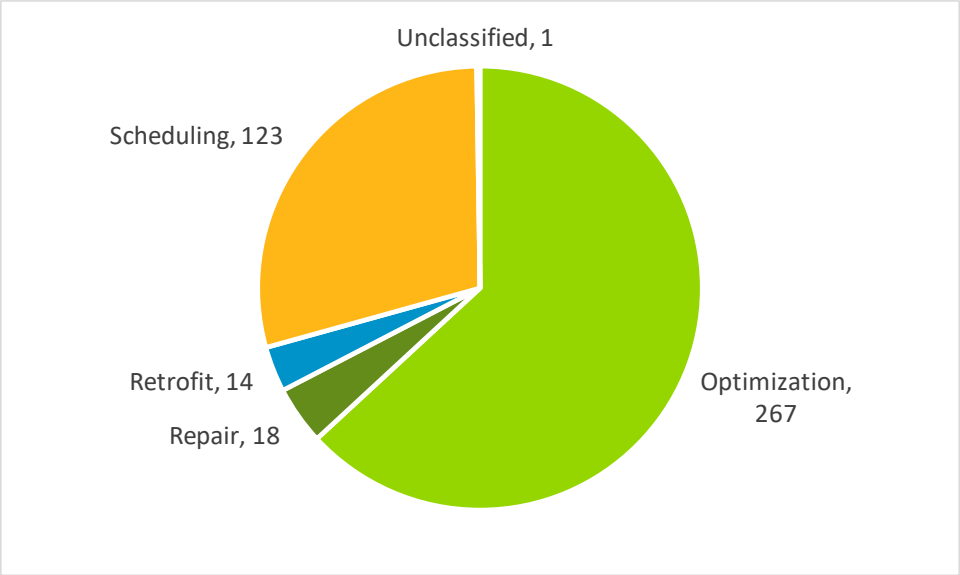
Table 2-3. Program Attributes – by Participation Offering

Program Offering	Target Facility Size	Incentives	Customer Commitment
Retro-Commissioning (RCx)	>500,000 ft^2 >10 GWh	100% Study with caps	$25,000
Monitoring Based (MBCx)	>150,000 ft^2 >3 GWh	Monitoring integration and $0.07/kWh and $1/therm	18-month monitoring contract
RCxpress	150,000 – 450,000 ft^2	100% Study with caps	$5,000 or $10,000
RCx Building Tune-Up	<150,000 ft^2 0.5-3.0 GWh	$15,000 max study $0.03/kWh with caps	Coordination
Grocery RCx	Same as RCx Building Tune-Up		

Source: ComEd program fact sheets

Figure 2-1, Figure 2-2, and Figure 2-3 categorize implemented electric and gas measures by type: scheduling, system optimization, equipment repair, and equipment retrofit. Categorization by type may be useful for determining cumulative persistent annual savings (CPAS) as reporting metrics. As seen in Figure 2-1, most of the measures in the Retro-Commissioning Program are categorized as optimization.

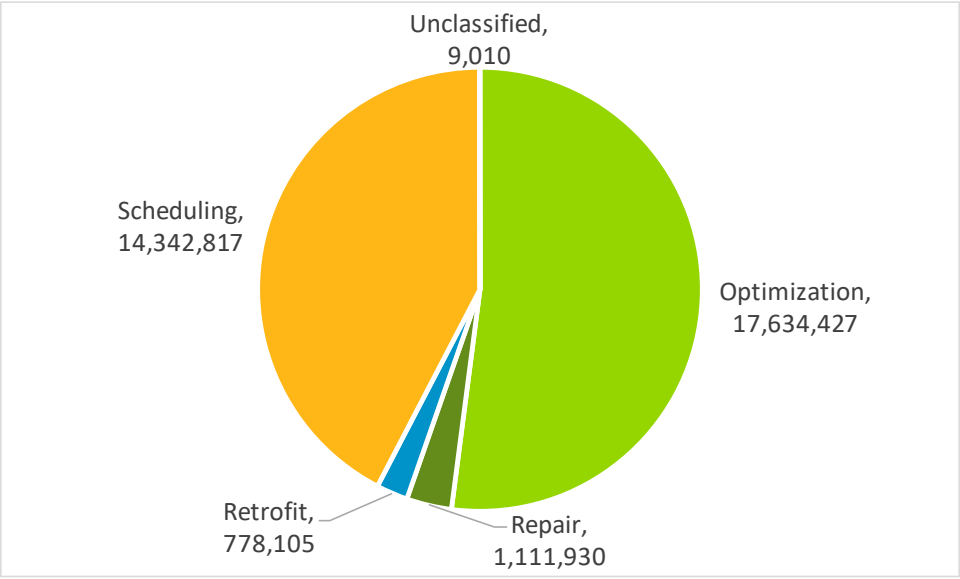
Figure 2-1. EPY9/GPY6 Number of Measures Installed by Type



Source: Program database

Figure 2-2 shows the breakdown of electric savings by measure type. Savings for optimization measures make up slightly more than half of the program's electric savings. Scheduling measures make up much of the remaining electric energy savings because the average measure savings are larger than the other measure types.

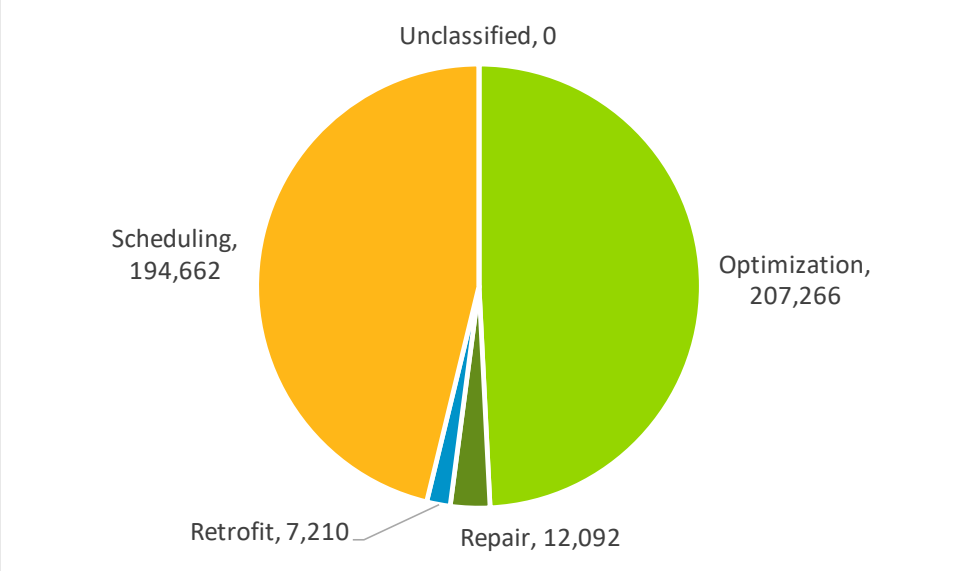
Figure 2-2. EPY9/GPY6 Electric Energy Savings in kWh Installed by Measure Type



Source: Program database

Figure 2-3 shows program gas savings by measure type. As with electric savings, scheduling and optimization together account for more than 90% of gas savings. Repair and retrofit measures make up only a small portion of energy savings in the program.

Figure 2-3. EPY9/GPY6 Gas Energy Savings in Therms Installed by Measure Type



Source: Program database

3. Program Savings

Table 3-1 summarizes the incremental energy and demand savings the Retro-Commissioning Program achieved in EPY9/GPY6. Overall, Navigant found the evaluated program savings to be higher than the reported ex ante values. This was more notable in demand and gas savings, in part due to under-reporting of demand and gas results in the Tune-Up offering. However, the Tune-Up offering has more recently been making efforts to report all types of savings. Utility-specific results for natural gas savings are presented in Section 5 and Section 6.

Table 3-1. EPY9/GPY6 Total Annual Incremental Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)	Gas Savings (Therms)
Ex Ante Gross Savings	33,876,288	1,683	1,683	421,230
Program Gross Realization Rate	1.04	1.38	1.38	1.08
Verified Gross Savings	35,156,156	2,318	2,318	454,223
Program Net-to-Gross Ratio (NTGR)	0.95	0.95	0.95	1.02
Verified Net Savings	33,398,349	2,202	2,202	463,307

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The Retro-Commissioning Program is evaluated by offering instead of by measure. Details of savings by offering are provided in Appendix 1, Program Savings by Offering.

5. Impact Analysis Findings and Recommendations

5.1 Impact Parameter Estimates

There are few program-level impact parameter estimates for the Retro-Commissioning Program. All analysis is rolled-up to realization rate impact parameter estimates for electric energy, electric demand, and natural gas energy savings. Service providers estimate energy and demand savings with custom algorithms, frequently using hourly weather data and time-series trend data. As such, the Navigant team conducted research to validate the savings individually for all measures in the evaluation sample.

The lifetime energy and demand savings are estimated by multiplying the verified savings by the effective useful life for each measure. The Navigant team conducted research to validate the parameters that were not specified in the TRM.

Table 5-1. Verified Gross Savings Parameters

Gross Savings Input Parameters	Value	Deemed* or Evaluated?
Quantity	124	Evaluated
Offerings	5	Evaluated
Gross Savings (kWh), Sampled Measures	19,552,601	Evaluated
Gross Savings (Therms), Sampled All Measures	292,750	Evaluated
Verified Realization Rate on Ex-Ante Gross Savings (Electric)	1.04	Evaluated
Verified Realization Rate on Ex-Ante Gross Savings (Gas)	1.08	Evaluated

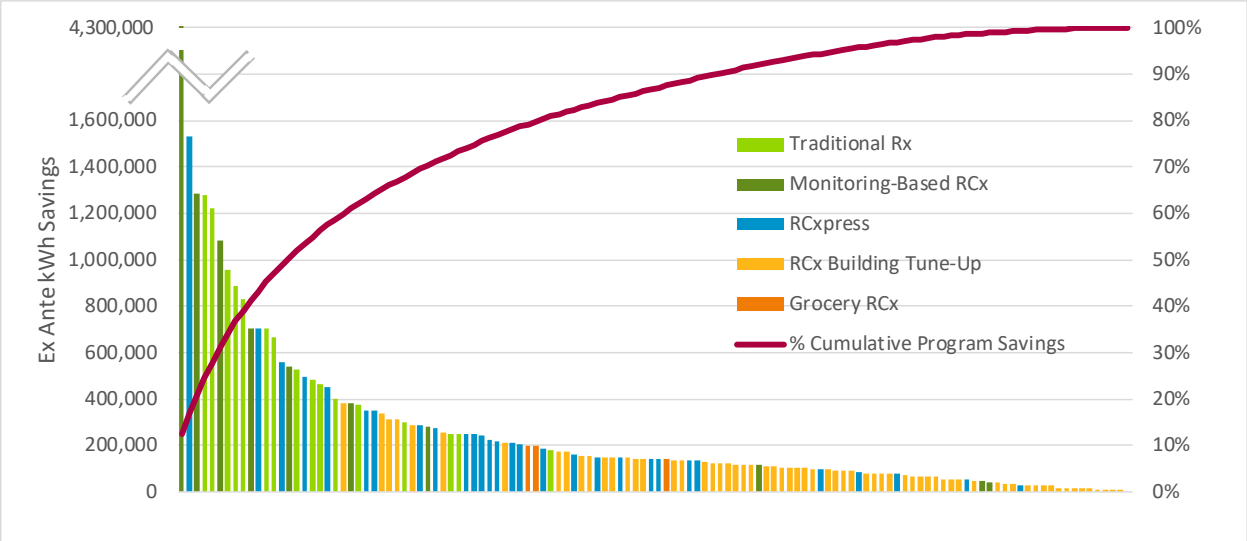
* State of Illinois Technical Reference Manual version 5.0 from http://www.ilsag.info/technical-reference-manual.html.
Source: ComEd tracking data and Navigant team analysis

5.2 Other Impact Findings and Recommendations

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

Figure 5-1 shows the breakdown of electric savings in the program by project and offering. One project had more than twice the savings of any others and made up over 12% of program savings. As expected, larger projects are generally in the MBCx and RCx offerings, but some RCxpress projects are also quite large. For electricity, project savings ranged from over 4,200,000 kWh to 3,000 kWh, ex ante, with the largest 15 projects making up slightly over half of program savings.

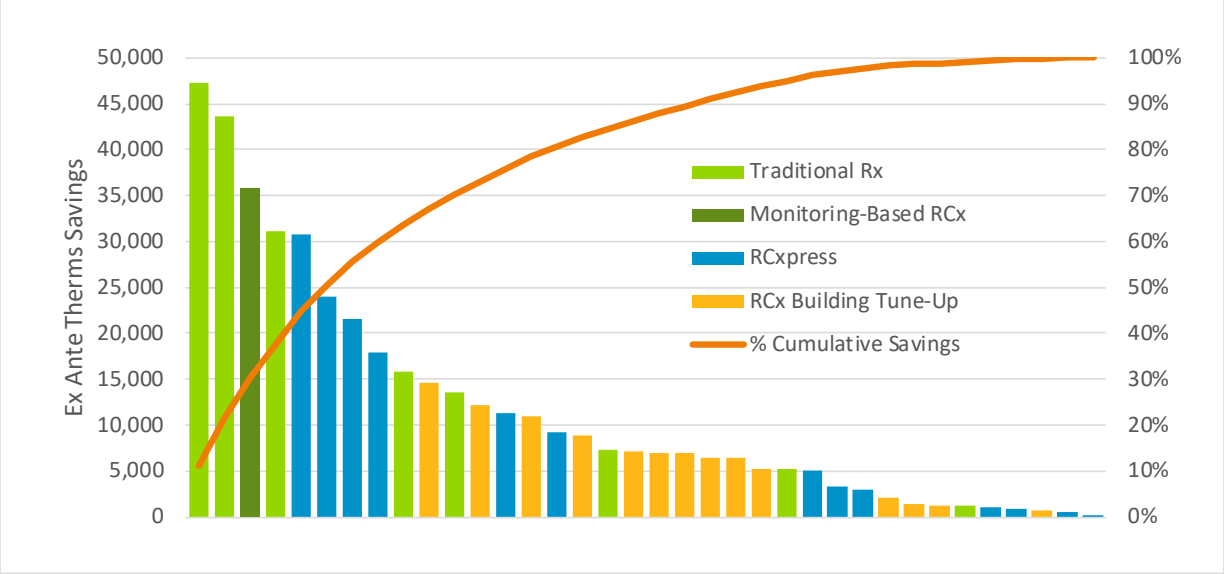
Figure 5-1. EPY9/GPY6 Ex Ante Electric Energy Savings by Project



Source: ComEd tracking data and Navigant team analysis

Figure 5-2 shows ex ante gas savings by project. As with electric savings, larger projects are generally in the RCx and MBCx offerings. For natural gas, implemented savings ranged from over 47,000 therms to 237 therms annually, with the largest project comprising slightly over a tenth of program savings, and the six largest accounting for over half of program savings.

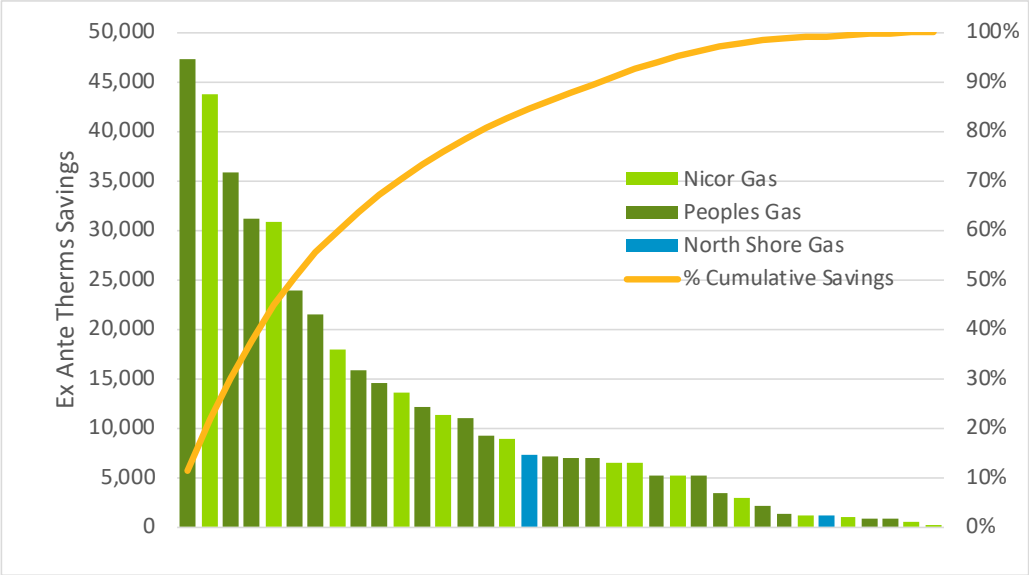
Figure 5-2. EPY9/GPY6 Gas Energy Savings by Offering



Source: ComEd tracking data

Figure 5-3 shows ex ante gas savings by utility. Most savings are from Nicor Gas and Peoples Gas customers, with only two participants in the North Shore Gas territory.

Figure 5-3. EPY9/GPY6 Gas Energy Savings by Utility



Source: ComEd tracking data and Navigant team analysis

The total program verified gross savings are in Table 5-3. The table presents savings at the customer-level. Realization rates are the results of analyzing 39 projects, made up of 156 measures.

Table 5-2. Verified Gross Savings Realization*

Savings Category	ComEd	ComEd Demand	Nicor Gas	Peoples Gas	North Shore Gas
Ex Ante Project Counts	124	55	14	20	2
Ex Ante Gross Savings*	33,876,288	1,683	150,269	262,506	8,455
Verified Gross Realization Rate	1.04	1.38	1.13	1.05	1.00
Verified Gross Savings*	35,156,156	2,318	170,246	275,521	8,455

*Electric energy in kWh, electric demand in kW, gas in therms
Source: ComEd tracking data and Navigant 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 projects continued to implement additional recommended measures or finish implementing measures after they were verified and closed by the service provider and implementation contractor.
- Some projects generated gas savings that the program did not track accurately.
- 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 PJM WTHI[1] method of using savings at 81.6 °F outdoor air temperature.
- Occasional calculation or engineering errors also affected realization rates. Several types of calculation errors were encountered this year:

[1] Weighted temperature-humidity index. Each PJM-member utility is assigned a temperature representative of the average conditions in the utility service territory for PJM summer demand hours.

  - Saving analysis sometimes used poorly-chosen data sets for verifying savings. In one significant case, the post-installation data set predated complete installation of the measure, resulting in low ex ante savings.
  - Reducing simultaneous heating and cooling measures did not always quantify the cooling savings.
  - Floating head and suction savings were overly optimistic given the design and condition of refrigeration equipment included in the Grocery RCx projects.
  - Weather datasets were not consistently applied. Some projects used different weather data for different measures. One project used a Detroit weather dataset.
  - 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 apparent typos, including copying cells without locking references.
- Other engineering or calculation errors affected verified savings, but these instances were not systematic.

5.2.1 Findings and Recommendations

Though the process for estimating savings has evolved and become more consistent since the program was launched in PY1, there is still room for improvement, as detailed in the following list of findings and recommendations.

Finding 1: Two projects reported savings using "post-implementation" meter data that included partial implementation periods, resulting in an under-estimate of savings.
Recommendation 1: Ensure that ex ante estimates use post-installation data collected after the measures are fully implemented.

Finding 2: Some projects use different weather datasets for different measures at the same location, including one that used all three Chicago area weather stations for measures at the same location. One evaluated project used Detroit weather data. A project in Rockford used O'Hare airport data when there is a Rockford weather station.
Recommendation 2: Give explicit recommendations for preferred weather datasets. Include weather dataset selection in QC steps for ex ante savings. Add the Rockford weather station to the program calculators.

Finding 3: Several MBCx projects relied on stand-alone data loggers for ex ante verification. A core precept of the MBCx offering is controls integration and monitoring that facilitates reliable and less-intrusive investigation and verification. Use of data loggers to verify savings seems contrary to the program.
Recommendation 3: The program should require verification use facility Building Automation Systems (BAS) trend data or interval meter data to non-intrusively identify opportunities and verify savings.

Finding 4: Some descriptions of measure verification do not clarify whether a measure is physically observed or whether the verification is only from the BAS screen.
Recommendation 4: Where physical adjustments are integral to the measure implementation, e.g. damper adjustment for minimum outdoor air, require physical verification and unambiguous description in the report.

Finding 5: For one project in the sample, the distinction between the Retro-Commissioning and Custom Program became blurred. Typically, retro-commissioning measures do not include large equipment costs. This measure retrofitted four fans with new variable speed drives (VSDs) at a cost exceeding $150,000. Retrofits of this nature are usually processed through the Custom or Standard-Offer Program. Depending on the project, the participant

incentives might be very different, program goal achievement might be distorted, and RSP service scopes might become biased.

Recommendation 5: Establish clear rules for situations where a measure might be implemented through different energy efficiency programs. Ensure that incentives to participants and fees to service providers do not distort the focus of the Retro-Commissioning Program.

6. Appendix 1: Program Savings by Offering

The Retro-Commissioning Program implements multiple measures that affect different building systems and end uses in each project. The program analyzes all identified measures but reports savings at the project level. Each project has enrolled in the program through one of the offerings described in Table 5-2, above. Electric savings by program offering are summarized in Table 6-1 and Table 6-2, and natural gas savings by utility in Table 6-3. Though RCx Building Tune-up (Tune-Up) has the highest participant volume, the traditional retro-commissioning (RCx) and monitoring-based (MBCx) offerings have the greatest savings, due to the larger facility sizes and greater equipment control capabilities among these participants.

Technical measure life is the technical life of the existing control system by which the measure has been implemented. Since most measures are implemented via existing Building Automation Systems (BAS), the evaluation considers the technical life is about 50% of a new BAS. At this juncture, the evaluation is using a 9-year technical measure life for retro-commissioning measures. Measure persistence is currently being researched, and would be applied during the life of a measure to reflect the rate that implemented optimization or scheduling measures might change over time.

Overall, the program had an electric energy savings realization rate of slightly over unity. Grocery RCx had the lowest realization rate of the offerings, largely because one of the three projects had reversed the implemented setpoint changes, greatly reducing savings. Table 6-1 shows electric energy savings by RCx offering.

Table 6-1. EPY9 Electric Energy Savings by Offering

Offering	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTGR *	Verified Net Savings (kWh)	Technical Measure Life	Persistence	Effective Useful Life (EUL)†
MBCx	8,721,825	1.06	9,248,519	0.95	8,786,093	9	TBD	TBD
RCx	9,778,667	1.06	10,369,182	0.95	9,850,722	9	TBD	TBD
RCxpress	8,128,479	1.06	8,619,342	0.95	8,188,375	9	TBD	TBD
Tune-Up	6,929,611	0.96	6,671,114	0.95	6,337,558	9	TBD	TBD
Grocery	317,706	0.78	248,000	0.95	235,600	9	TBD	TBD
All	33,876,288	1.04	35,156,156	0.95	33,398,349	9	TBD	TBD

Source: ComEd tracking data and Navigant team analysis.

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.

† EUL is a combination of technical measure life and persistence.

Demand savings exceeded the ex ante values for the MBCx, RCx, and RCxpress offerings, largely due to omission of some measure-level demand savings. Table 6-2 shows electric PY9 peak demand savings by offering.

Table 6-2. EPY9 Peak Demand Savings by Offering

Enduse Type	Ex-Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTGR*	Verified Net Demand Reduction (kW)
MBCx	475	1.52	720	0.95	684
RCx	460	1.52	699	0.95	664
RCxpress	306	1.52	465	0.95	442
Tune-Up	441	0.98	435	0.95	413
Grocery	0	NA	0	0.95	0
All	1,683	1.38	2,318	0.95	2,202

Source: ComEd tracking data and Navigant team analysis

Gas energy savings were above the ex ante values, in part due to under reporting in the Tune-Up offering. Table 6-3 shows natural gas GPY6 therm savings by utility.

Table 6-3. GPY6 Natural Gas Therms by Utility

Utility	Ex Ante Gross Savings (Therms)	Verified Gross Realization Rate	Verified Gross Savings (Therms)	NTGR *	Verified Net Savings (Therms)	Technical Measure Life	Persistence	Effective Useful Life (EUL)†
Nicor Gas	150,269	1.13	170,246	1.02	173,651	9	TBD	TBD
Peoples Gas	262,506	1.05	275,521	1.02	281,032	9	TBD	TBD
North Shore Gas	8,455	1.00	8,455	1.02	8,624	9	TBD	TBD
All	421,230	1.08	454,223	1.02	463,307	9	TBD	TBD

* A deemed value. Source: PG-NSG_GPY6_NTG_Values_2016-02-29_Final.xlsx and Nicor_Gas_GPY6_NTG_Values_2016-02-29_Final.xlsx, which are to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.

Source: ComEd tracking data and Navigant team analysis

7. Appendix 2: Impact Analysis Methodology

This evaluation of the Retro-Commissioning Program reviews the ninth year ComEd has offered the program and the sixth year of its coordinated offering with the gas utilities. In general, the Electric Program Year 9 (EPY9) / Gas Program Year 6 (GPY6) impact evaluation paralleled prior impact evaluations for the program.

7.1 Methodology Overview

The impact evaluation consists of a review of a representative sample of projects: both an engineering desk-review and on-site verification for a sub-set 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 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), Navigant performed on-site inspections of projects 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 savings estimates reflect those new inputs.

Due to the number of projects and the compressed schedule between program year-end and reporting, Navigant began project reviews in waves. We constructed an impact sample in early May 2017 based on projects complete to-date and expected to be completed prior to year-end. ComEd and Nexant provided project files in waves as they were completed: end of July 2017, end of October, mid-December and January 2018.

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

7.2 Sampling Methodology

The sample draw for EPY9/GPY6 gross impact evaluation was done in two waves roughly proportional to the populations they represented. The first wave of sampling was conducted on projects with a planned completion during EPY9/GPY6 based on the Nexant Operations Report in May 2016, when the program had completed almost half of the EPY9/GPY6 participation target. The second and final wave of sampled projects adjusted the first wave sample based on projects completed as of the final EPY9/GPY6 Operations Report. The Table 7-1 is the population of projects completed in the EPY9/GPY6 program.

Table 7-1. Sampling Population of PY9/GPY6 RCx Projects

Offering	ComEd	Nicor Gas	Peoples Gas	North Shore Gas
Monitoring-based (MBCx)	10	0	1	0
Traditional Retro-commissioning (RCx)	16	3	3	2
RCxpress	30	7	6	0
RCx Building Tune-Up (Tune-Up)	65	4	10	0
Total	121	14	20	2

Source: ComEd tracking data and Navigant team analysis.

The sample design considered the RCx, RCxpress, and MBCx projects as one component, and the Tune-Up projects as a separate component. Strata were defined by project size (separately for RCx, RCxpress, MBCx, and Tune-Up projects) based on ex ante gross energy savings boundaries that placed about one-third of program-level savings into each stratum. Sampling involved a combination of random and targeted sampling approaches to select a majority of the ComEd program large savers and a balanced number of projects in the medium and small savers strata, while capturing the gas utility projects along with electric savings. Sampling was targeted to provide a 90/10 level confidence and relative precision for gross impact realization rate results for the ComEd and gas utility overall programs. However, 90/10 could not be achieved for the gas projects, as the adjustments between the projected completion as of May 2017 and the final completed projects reduced the ex ante gas savings of the sample and the available replacement options.

Table 7-2 below provides the ComEd sample selection by program path and stratification. Overall the sample represented 30 percent of the project count and 57 percent (19,234,895 kWh) of the population ex ante savings of 33,558,582 kWh. A total of 36 projects were selected from the population of 121 completes (excluding Grocery projects), including 19 RCx, RCxpress, MBCx projects, and 17 Tune-Up projects.

Table 7-2. Profile of the ComEd EPY9 Gross Savings Verification Sample by Path Strata

		Population Summary		Sample Summary		
Population Group	Sampling Strata	Number of Projects (N)*	Ex Ante kWh	Number of Projects (n)	Ex Ante kWh	Sampled % of Population
RCx+RCxpr+MBCx Waves 1&2	1	5	9,559,372	5	9,559,372	100%
	2	11	8,166,138	6	5,004,156	61%
	3	40	8,903,461	8	2,113,959	24%
Subtotal		56	26,628,971	19	16,677,487	63%
Tune-Up Waves 1&2	1	10	2,602,588	5	1,324,516	51%
	2	16	2,122,111	5	697,817	33%
	3	39	2,204,912	7	535,075	24%
Subtotal		65	6,929,611	17	2,557,408	37%
Program Total		121	33,558,582	36	19,234,895	57%

* A total of 124 projects were completed in PY9. Population used for sampling excludes three grocery projects and savings.
Source: ComEd tracking data and Navigant team analysis.

Table 7-3 provides the breakdown of the sample selection for the gas programs. Neither of the two North Shore Gas projects were selected.

Table 7-3. Profile of the Gas GPY6 Gross Savings Verification Sample by Strata

		Population Summary		Sample Summary		
Population Group	Sampling Strata	Number of Projects (N)	Ex Ante Therms	Number of Projects (n)	Ex Ante Therms	Sampled % of Population
Nicor Gas Waves 1&2	1	1	43,699	1	43,699	100%
	2	2	48,666	2	48,666	100%
	3	11	57,904	3	25,207	44%
Nicor Total		14	150,269	6	117,572	78%
Peoples Gas Waves 1&2	1	2	83,156	2	83,156	100%
	2	4	92,408	3	61,268	66%
	3	14	86,942	3	30,754	35%
Peoples Gas Total		20	262,506	8	175,178	67%

Source: ComEd tracking data and Navigant team analysis.

For each sampled project, Navigant reviewed all measures. All measure savings for a project were rolled-up into project-level realization rates. Navigant subsequently rolled-up project-level results by stratum - weighted on savings - for strata-level realization rates. These rates were then applied to the population of projects in each stratum to determine research findings gross realization rates for the program.

In addition to the stratified random sampling discussed here, evaluators reviewed three grocery projects which were census sampled.

8. Appendix 3. Impact Analysis Detail

Program impacts are tracked through the several phases of the program with the implementation contractor (IC) giving feedback and requiring changes along the way. Thus, the evaluator's task is to check a sample of measures verified by the Retro-Commissioning Service Providers (RSPs) and IC and ensure that measures are indeed complete and savings are accurately estimated.

The evaluators conclude that the investigation, reports, verification reports, supporting data, and calculations provided sufficient confirmation that the measures were installed as described. Navigant identified 16 projects, comprising 11,000 MWh and 250,000 therms, within the impact sample for on-site verification.[2] Evaluators visited all 16 of these sites between August 2017and January 2018 and verified implementation and observed actual operation of measures. In most cases, measure implementation persists. In some cases, the facility had modified set points and schedules due to facility requirements, including adjustments to refrigeration systems at a grocery site. In a couple cases, evaluators learned that the participating site was continuing to make recommended improvements after the project was formally verified and closed.

The evaluation team reviewed 58% of electric energy savings and 71% of gas savings. Table 8-1 details the evaluation by offering.

Table 8-1. Savings Evaluated by Offering

	MBCx	RCx	RCxpress	RCx Building Tune-Up	Grocery	Total
Total Number of Projects	10	16	30	65	3	124
Evaluated Projects	4	10	5	17	3	39
Population kWh Ex Ante Savings	8,721,825	9,778,667	8,128,479	6,929,611	317,706	33,876,288
Sample kWh Ex Ante Savings	7,317,693	6,729,723	2,630,071	2,557,408	317,706	19,552,601
Evaluated Percent of kWh	84%	69%	32%	37%	100%	58%
Population Therms Ex Ante Savings	35,877	165,124	128,729	91,500	0	421,230
Sample Therms Ex Ante Savings	35,877	125,529	103,236	28,108	0	292,750
Evaluated Percent of Therms	100%	76%	80%	31%	NA	69%

Source: ComEd tracking data and Navigant team analysis

8.1 Evaluation Research Gross Impact Findings

For all 39 sites in the sample, Navigant reviewed measure implementation plans, assumptions and calculations in detail. In general, Navigant 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 spreadsheets contained hard-coded input values but these were generally based on trend data files and standard TMY3[3] data.

[2] On-site verification projects were selected based on project savings size, measure type and facility type. Large projects were selected because of their impact on program goals. Diverse facility types were selected to capture a range of operating strategies and participant requirements (for example year-round cooling for equipment intensive sites or 24-hour operation for hospitals).

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

Savings estimation approaches among RSPs were mostly consistent. Most calculation spreadsheets were comprehensive, though some were excessively complex and others overly simple. Despite the range of approaches in EPY9/GPY6, there were very few lapses in engineering methods. When faced with the need to make engineering assumptions, RSPs are often more conservative than the program guidelines. Where there was no further justification for overly conservative estimates, the evaluation team restored guideline defaults and/or supplemented estimated savings with secondary effects of the measures as could be determined with available data.

Navigant cautions that Grocery RCx projects may be at risk of low realization rates due to the inability of systems to reach the aggressive set points used by the program. Retrofitting valves to allow floating head set points and compressor staging would ensure significantly higher savings for the program. One project reverted to old setpoints due to equipment limitations during this program year.

In cases where inputs were inconsistent with reported data, such as set points or operational hours, Navigant re-estimated savings with available data, additional data requested from the participant or RSP and/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 8-2 details the realization rates by sampled project. Realization rates for energy varying by more than 10 percent from 1.0 are due to reasons noted. The wide variation in demand realization rates is caused by inconsistent ex ante calculation methodologies and is not discussed in detail in the table.

Table 8-2. Project Level Realization Rates

Project	Realization Rates			
	kWh	kW	Therms	Notes on ex ante estimates
14-109	99%	NA	NA	
14-110	85%	NA	NA	Simultaneous heating and cooling measure only estimated heating savings. EM&V added cooling and analyzed additional interval data. Minor calculation errors in discharge air temperature and outdoor air damper measures
15-005	72%	NA	376%	Changes made based on on-site observations and some errors in the calculations. Estimated fan BHP exceeded nameplate HP in some cases.
15-009	147%	NA	104%	Motor loading double counted in kW calculations, resulting in undercount of fan power savings.
15-017	160%	156%	NA	Simultaneous heating and cooling measure only estimated heating savings. EM&V added cooling and analyzed additional interval data
15-022	98%	103%	317%	Changed district steam eff from 100% to 80% efficiency; fixed errors that did not carry setback hours through all calculations.
15-023	105%	NA	NA	Minor correction to hours for one AHU, chiller size, and outside air minimum.
15-029	97%	7%	100%	
15-035	86%	93%	NA	Changes made based on on-site observations.
15-108	101%	97%	100%	
15-110	90%	100%	NA	
15-456	95%	NA	NA	
15-550	97%	95%	NA	
15-557	204%	NA	NA	
15-558	68%	97%	NA	
15-561	113%	NA	NA	Ex ante BIN hours were less than 8760. Using Midway TMY3 data gave increased cooling and decreased heating hours.

Project	Realization Rates			Notes on ex ante estimates
	kWh	kW	Therms	
15-562	76%	NA	NA	Inputs to standard calculators were wrong or were determined to have changed based on on-site inspection. Over-ventilation measure was zeroed out because EM&V determined that 30-50% outside air is appropriate for concurrent outdoor air temperatures.
15-563	36%	70%	NA	Inputs to standard calculators were wrong or were determined to have changed based on on-site inspection.
15-569	80%	NA	NA	Implementer calculated post period usage based on November data, but notes that mid-November to December has abnormal hours. Recalculated post period usage based on 10 months from January-October in 2017.
15-570	60%	NA	NA	Implementer calculated post period usage based on November data, but notes that mid-November to December has abnormal hours. Recalculated post period usage based on 10 months from January-October in 2017.
16-004	83%	NA	100%	Reduction in hours of operation on ECM5.
16-007	104%	117%	101%	Standard Nexant calculator set to Detroit for weather. Changed to Waukegan.
16-010	299%	100%	NA	Minor changes based on on-site observations. Analysis of additional interval data for night-time heating reduction.
16-017	98%	NA	NA	Minor adjustments to setpoints for cooling water temperature and static pressure setpoints based on screenshots and data in ex ante investigation and verification reports.
16-031	98%	40%	96%	
16-034	99%	33%	102%	Minor changes, but mixes TMY3 data for Rockford and O'Hare. VFD spot measurements of power do not agree with speed trends.
16-035	59%	74%	52%	On-site EM&V determined that night-set-back was not occurring any longer. Chiller sizes incorrect in standard calculator and custom estimate for condenser water reset over-estimated savings versus manufacturer documentation (1.25%/°F vs 0.5%/°F). Other small calculation discrepancies
16-039	90%	88%	93%	
16-400	97%	89%	NA	
16-403	112%	100%	NA	Changed weather station from O'Hare to Waukegan, removed Saturday hours, reduced baseline DAT to match report, matched start time in ECM2 to ECM1.
16-413	120%	NA	25%	ECMs 2&5 calculated independent of ex ante calculator, which was very convoluted.
16-416	100%	NA	78%	Conversion from steam to gas energy issues.
17-410	110%	NA	NA	
17-424	95%	NA	NA	
17-428	102%	100%	NA	
17-482	97%	111%	100%	
Grocery 1	81%	NA	NA	Restrict savings to expected temperature ranges for savings. More post-install data used.
Grocery 2	53%	NA	NA	Measure mostly reversed according to the report. Restrict savings to expected range. New EM&V data.
Grocery 3	100%	NA	NA	Restrict savings to expected temperature ranges for savings. More post-install data used.

Source: Evaluation research

8.2 Evaluation Research Net Impact Findings

After gross program impacts have been assessed, net program impacts are derived by applying the deemed net-to-gross ratio (NTGR) that quantifies the percentage of the gross program impacts that can be reliably attributed to the program. Currently, deemed NTGRs for electric savings is 0.95 for all electric program offerings and 1.02 for all gas savings.

The EM&V team is conducting free ridership and spillover research among participants in all program offerings in EPY9/GPY6. Results of this research may be considered for deeming in CY2019 and beyond.

9. APPENDIX 4. TRC DETAIL

The following data is for the calculation of the Total Resource Cost test benefit/cost ratios.

Table 9-1 TRC Test Inputs*

Projects	Units	Quantity	Measure Life	Ex Ante kWh	Ex Ante kW	Ex Ante Therms	Verified Gross kWh Savings	Verified Gross kW Savings	Verified Gross Therms Savings
ComEd	Project	124	9	33,876,288	1,683	NA	35,156,156	2,318	NA
Nicor Gas	Project	14	9	NA	NA	150,269	NA	NA	170,246
Peoples Gas	Project	20	9	NA	NA	262,506	NA	NA	275,521
North Shore Gas	Project	2	9	NA	NA	8,455	NA	NA	8,455
All	Project	124*	9	33,876,288	1,683	421,230	35,156,156	2,318	454,223

* The Total Resource Cost (TRC) variable table only includes cost-effectiveness analysis inputs available at the time of finalizing this PY9 impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to evaluation at a later date. Further, detail in this table (e.g., EULs) other than final PY9 savings and program data are subject to change and are not final.