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Impact and Process Evaluation of 2016 (PY9) Ameren Illinois Company Commercial & Industrial Retro-Commissioning Program

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1. Executive Summary

This report presents the results of Opinion Dynamics's evaluation of the Ameren Illinois Company (AIC) Commercial and Industrial (C&I) Retro-Commissioning Program in Program Year 9 (PY9). The Retro-Commissioning Program is one of three in AIC's C&I portfolio, which also includes the Custom and the Standard programs. PY9 ran from June 1, 2016 through May 31, 2017.

The Retro-Commissioning Program helps AIC business customers evaluate their existing mechanical equipment, energy management, industrial refrigeration, and industrial compressed air systems to identify no-cost and low-cost efficiency measures to optimize energy systems. Customers contract with preapproved Retro-Commissioning Service Providers (RSPs) to perform an energy survey, resulting in a written report detailing the savings opportunities. Following verified implementation of measures with a payback of less than 12 months, AIC pays an incentive that covers 70%–80% of the energy survey cost, based on the project type. A further implementation incentive is paid to the customer based on the energy saved, and a bonus is paid to the RSP based on timely measure implementation and energy saved.

For PY9, the program had a net electric savings target of 9,076 MWh and a net gas savings target of 275,039 therms. The program achieved 9,187 MWh in ex post net electric savings and 231,827 therms in ex post net gas savings, meeting its electric target but falling somewhat short of its gas target.

A secondary goal of the Retro-Commissioning Program is the identification of retrofit and capital improvement projects that can be channeled to the Standard and Custom incentive programs offered by AIC. AIC offers an additional bonus to customers who complete a Custom project within a year of having completed a retro-commissioning study.

The PY9 evaluation includes gross impact results, a limited process assessment, and prospective net-to-gross (NTG) research. Our quantitative impact research included engineering reviews of a census of PY9 retro-commissioning projects plus on-site inspection and verification of measures for a sample of projects.

The process evaluation involved reviewing program materials and program-tracking data, interviewing program managers, and a participant survey including high-level process questions.

Below we present the key findings of the PY9 evaluation.

Program Impacts

Table 1 summarizes reported and verified program participation. A total of 21 projects yielding savings were completed in the PY9 program, a small increase from a total of 19 in PY8. Two projects saved both electricity and gas at a given site—both at healthcare facilities. Two other projects were gas-only. All other projects completed in PY9 were industrial customers saving only electricity.

Beyond the 21 projects yielding savings, six customers took steps to begin participation in the program with initial assessments to determine retro-commissioning feasibility; AIC paid the RSP a small incentive, referred to as a "stipend," for this task. Since stipend costs occurred in PY9, they will be included in program cost-benefit analysis, although there are no savings associated with these sites in PY9. The customers may choose to implement study-recommended measures in future program years. Finally, the program began one compressed air project at a facility that later suffered tornado damage that rendered the compressed air system inoperable; the program did not claim savings for this project.

Table 1. PY9 Retro-Commissioning Program Participation Summary

Program Component	Unique Projects[a]	Ex Ante Gross Electric Savings		Ex Ante Gross Gas Savings	
		MWh	%	Therms	%
Compressed Air	16	7,992	74%	0	–
Industrial Refrigeration	1	1,184	11%	0	–
Large Facility	4	1,634	15%	252,564	100%
Healthcare	*4*	*1,634*	*15%*	*252,564*	*100%*
Commercial	*0*	*0*	–	*0*	–
Grocery	0	0	–	0	–
Total	**21**	**10,741**	**–**	**252,564**	**–**

[a] This project count reflects projects with associated savings. As discussed above, seven projects listed in the AIC database as paid have no associated savings and are not incorporated in this table.

The evaluation team performed an engineering desk review of all 21 projects as well as on-site visits for eight projects to obtain gross realization rates for the program savings. The evaluation team modified the program ex ante gross savings for several reasons, although ultimately the gross realization rates were relatively high (94% for MWh savings, 92% for MW savings, and 101% for therm savings).

The evaluation team applied net-to-gross ratios (NTGRs) approved by the Illinois Stakeholder Advisory Group (SAG) to the gross savings estimates to calculate program net impacts. Table 2 summarizes PY9 gross and net impacts.

Table 2. PY9 Retro-Commissioning Program Gross and Net Impacts

	Ex Ante Gross	Realization Rate	Ex Post Gross	NTGR	Ex Post Net
Energy Savings (MWh)					
Total MWh	10,740	0.94	10,096	0.91	9,187
Demand Savings (MW)					
Total MW	1.04	0.92	0.95	0.91	0.87
Energy Savings (Therms)					
Total Therms	252,564	1.01	254,755	0.91	231,827

Key Findings and Recommendations

Based on our research, the evaluation team makes the following impact recommendations for the program:

- **Improve documentation of baseline conditions.** This recommendation applies mostly to commercial and healthcare building retro-commissioning. Over the past several years documentation has improved, but several projects had gaps in baseline documentation. Calculation inputs should include notes for whether inputs are measured, based on design conditions, or assumed by the RSPs. Require more pre-implementation documentation of as-found conditions to confirm the baselines used in calculations, such as: screenshots of a week of operating data or a control schedule.

- **Use TRM or other standard defaults for assumed parameters.** Several projects include unreasonable assumptions for some operating parameters such as motor loading and efficiency. Encourage better

accuracy with measured values or design inputs. When this information is not available, use TRM-sourced defaults and lastly conservative program-level assumptions

- **Ensure demand savings reflect summer peak hour operation.** Several winter-saving measures claimed demand savings in error. Many optimizing control resets do not save during peak-load hours, but only make off-peak operation more efficient.

- **Continue to improve documentation of post-installation inspections.** Though inspection documentation is much improved from prior years, some gaps still exist. Document more measures with data or representational verification (photos, graphs, etc.). Clearly annotate which measures the verification is supposed to show. Some measures are hard to represent in this manner and some small measures may not merit large effort. A savings magnitude threshold (gross kWh or % of project savings) might be used to prioritize effort.

  - Frequently, the only verification for compressed air leak repairs is a hand-annotated list of leaks. If additional post-installation trend data are available for compressed air projects, they should be included in verification documentation.

  - Collect trend data from Building Automation Systems that demonstrate implementation.

  - Implement a stronger review regimen through the implementation contractor. Positively confirm operating hours, plant pressures, production pressures, and compressor part-load performance.

- **Continue to improve compressed air savings calculations.** Ensure use of marginal rather than average efficiency – especially for multi-compressor plants, avoid assuming year-round operation without any down-time, and accurately account for plant air pressure in savings estimates. Attention to these details will result in higher realization rates for the program.

- **Encourage implementation of more savings and measures in addition to leak repair.** For example, require implementation of bundled measures that meet a payback threshold — 12 months, for example — in order to receive the study subsidy incentive. All savings from PY9 sampled compressed air projects derive from leak repairs or pressure reduction. No other low-cost measures were implemented through the program. While the savings from leak repairs is significant and cost-effective, the RSPs should spend more effort investigating and encouraging implementation of other short-payback measures, including, for example, no-loss drains, elimination of inappropriate uses, storage, better staging of multiple compressors, and cycling driers. Compressed air retro-commissioning is more than leak repair.

2. Evaluation Approach

The assessment of Ameren Illinois Company's (AIC) Commercial and Industrial (C&I) Retro-Commissioning Program in Program Year 9 (PY9) consisted of an evaluation of program gross and net impacts and a limited program process assessment.

2.1 Research Objectives

The objective of the PY9 Retro-Commissioning Program evaluation is to provide estimates of gross and net electric and gas savings associated with the program. The PY9 impact evaluation answers the following questions:

1. What were the estimated gross energy and demand impacts from this program?
2. What were the estimated net energy and demand impacts from this program?
3. What were the levels of free-ridership and participant spillover among PY9 program participants (for prospective application in 2019)?

In addition, we provide limited insights into program processes and opportunities for improvement where possible. Key areas of inquiry for the process evaluation are as follows:

4. Effectiveness of Program Design and Implementation
    a. Did the program as implemented change compared to PY8? If so, how, why, and was this an advantageous change?
    b. What implementation challenges occurred in PY9, and how were they overcome?
    c. What areas could the program improve to create a more effective program for customers and help increase the energy and demand impacts?
5. Program Participation
    a. What were the characteristics of participating customers? How many projects were completed? By how many different customers? What type of projects?
    b. Did customer participation meet expectations? If not, how and why is it different from expectations? Are any changes in the mix of customers and projects desirable?

2.2 Evaluation Tasks

The PY9 assessment of the AIC Retro-Commissioning Program included both process and impact analyses. Table 3 summarizes the PY9 evaluation activities conducted for the Retro-Commissioning Program.

Table 3. PY9 Retro-Commissioning Program Evaluation Methods

Activity	PY9 Process	PY9 Impact	Forward Looking	Details
Program and Implementation Staff Interviews	✓			Explore changes made since PY8 and issues in PY9 implementation, and gather information about program marketing and implementation
Review of Program Materials and Data	✓	✓		Comprehensive review of program data to assess any changes in program processes or impacts and support evaluation planning, sampling, and reporting
Participant Survey	✓		✓	Conduct a limited assessment of participant experience with the program, as well as update NTGRs for application in 2019
Engineering Desk Reviews		✓		Assess engineering savings estimates and methods
On-Site Verification		✓		Verify implementation and key inputs to savings estimates and methods
Net Impact Analysis		✓		Estimate net impacts using SAG-approved NTGRs for PY9

The following activities informed the PY9 evaluation of the Retro-Commissioning Program.

2.2.1 Program and Implementation Staff Interviews

The evaluation team conducted an in-depth interview with the Retro-Commissioning program managers in early 2017 to understand the Retro-Commissioning Program's design and implementation and to discuss evaluation priorities.

2.2.2 Review of Program Materials and Data

The evaluation team reviewed all program materials and tracking data, including program marketing and implementation plans, customer and program ally communications, and extracts from program tracking databases. We received multiple extracts of the master AMPlify program database beginning in February 2017 to support initial activities, with a final database provided in October 2017.

2.2.3 Participant Interviews

The evaluation team conducted telephone interviews with customers who participated in the program in PY9. Participant interviews focused on attribution (i.e., NTGR), but included limited questions on program processes, including satisfaction with the program, barriers to participation, and areas for improvement. NTGR results for prospective application are presented in Appendix A.

The evaluation team attempted a census of all customers completing projects yielding energy savings in PY9 and completed 11 interviews.

Survey Dispositions and Response Rates

We fielded the participant survey from September 27 to November 10, 2017. Table 4 provides the final survey dispositions.

Table 4. Retro-Commissioning Participant Survey Dispositions

Disposition	Input[a]	Total
Complete interview	I	11
Eligible incomplete interview	N	0
Survey-ineligible customer	X1	0
Not eligible (disconnected phone)	X2	5
Customer with undetermined survey eligibility	U1	2
Undetermined if eligible customer	U2	3
Total Participants Dialed in Sample	**N/A**	**21**

[a] Inputs are for American Association for Public Opinion Research (AAPOR) response and cooperation rates detailed in Appendix A.

Table 5 provides the response rates (RRs) and cooperation rates (CRs). Appendix A provides information on the methodology used to calculate and RRs and CRs.

Table 5. Participant Survey Response and Cooperation Rates

AAPOR Rate	Percentage
RR3	73%
CR3	100%

2.2.4 Impact Analysis

Gross Impacts

The evaluation examined program impacts to estimate a realization rate of savings between ex ante and verified (ex post) gross savings in two steps. Given the number of completed projects in PY9 (21), the evaluation team first conducted engineering desk reviews for a census of program projects to revise program ex ante savings values.

The engineering desk reviews consisted of a thorough examination of all available project documentation, including project reports, communications, equipment submittals, and calculations, and any other project-specific data that were available to the evaluation team. We also spoke to some site contacts to confirm measures and their continued operation and performance.

In addition, the evaluation team went on-site and inspected equipment and measure status for a randomly selected sample of eight projects[1] and collected supplemental data, as needed. On-site visits were made to three large facility sites, four industrial sites for compressed air, and one industrial site for refrigeration, representing samples of electric and gas savings achieved by the program in PY9. We selected the samples for electric and gas on-site verification as subsets of the program participants. Our sample was developed

[1] We drew a stratified random sample of projects, using project savings to stratify our sample to improve precision estimates.

targeting 10% relative precision at 90% confidence (90/10 precision) around gross savings. Table 6 provides detail on ex ante savings covered by our impact review by method.

Table 6. Impact Evaluation Savings Covered

Review Type	# of Projects	Ex Ante Gross Savings	
		MWh	Therms
Engineering review only	13	5,637	47,102
Engineering review and site visit	8	5,103	205,462
Total	**21**	**10,741**	**252,564**

We conducted a desk review of all savings but completed on-site verification at only a randomly selected sample of sites. To extrapolate these results to the population, we compared the savings determined through the desk reviews (at the project level) to the project-level savings determined for each project via the on-site verification to calculate savings-weighted realization rates (total site visit-determined gross savings divided by the total desk review-determined gross savings) by fuel type. These sample-based realization rates were then used to adjust savings for the population of PY9 Retro-Commissioning Program projects, for which savings had already been previously adjusted via desk review.

Net Impact Analysis Approach

The ex ante NTGRs for the program are the SAG-approved values of 0.91 for electricity and 0.91 for natural gas. Following the NTGR framework, we apply these NTGRs to PY9 savings.

2.3 Sources and Mitigation of Error

Table 7 provides a summary of possible sources of error associated with data collection conducted for the Retro-Commissioning Program. We discuss each item in detail below.

Table 7. Possible Sources of Error

Research Task	Survey Error		Non-Survey Error
	Sampling Error	Non-Sampling Error	
Participant Survey	N/A	• Measurement error • Non-response and self-selection bias • Data processing error • Sample frame error	N/A
Engineering Desk Reviews	N/A	N/A	• Analysis error
Verification Site Visits (Electric)	Yes	• Measurement error	• Data processing errors • Analysis error
Verification Site Visits (Gas)	Yes	• Measurement error	• Data processing errors • Analysis error
Net Impact Calculations	N/A	N/A	• Analysis error

The evaluation team took a number of steps to mitigate against potential sources of error throughout the planning and implementation of the PY9 evaluation.

Survey Error

- Sampling Error
  - **Participant Survey:** The evaluation team attempted a census of all participating customers in PY9. Therefore, there is no sampling error around our survey results.
  - **Engineering Desk Reviews:** The evaluation team reviewed a census of projects as part of our engineering desk reviews. As such, there was no sampling error associated with the desk reviews.
  - **Verification Site Visits:** The evaluation team performed on-site verification for eight projects in PY9. The evaluation team designed the verification site visit sample to achieve 90/10 precision. We achieved a relative precision of 5% around electric savings and less than 1% around gas savings.
- Non-Sampling Error
  - **Measurement Error:** For the participant survey, the validity and reliability of survey data were addressed through multiple strategies. First, we relied on the evaluation team's experience to create questions that align with the idea or construct that they were intended to measure (i.e., face value validity). We reviewed the questions to ensure that we did not ask double-barreled questions (i.e., questions that ask about two subjects, but allow only one response) or loaded questions (i.e., questions that are slanted one way or another). We also checked the overall logical flow of the questions to avoid confusing respondents, which would decrease reliability.

    All survey instruments were reviewed by key members of the evaluation team and were provided to AIC and Illinois Commerce Commission (ICC) staff for review. To determine whether question wording was clear and unambiguous, we pretested each survey instrument and reviewed the pretest survey data. We also used the pretests to assess whether the length of the survey was reasonable and shortened the survey as needed.

    For the on-site survey, the team addressed measurement error by using trained, experienced engineers and technicians familiar with the equipment affected by the Retro-Commissioning Program to conduct all interviews and site visits and checking the quality and consistency of collected data.
  - **Non-Response and Self-Selection Bias:** We attempted to mitigate possible bias in our participant survey by contacting each prospective respondent in the sample multiple times at different times of the day, until we received a firm refusal. We also reached out via email and sent multiple reminder emails to each prospective respondent in our sample at different times of the day and week. To assess whether evidence of non-response bias existed, we compared survey respondents to the population based on business type, number of projects, and project savings. We found no evidence to suggest that non-respondents differed significantly from respondents.
  - **Data Processing Error:** The evaluation team addressed processing errors by using trained, experienced Opinion Dynamics consultants to check the quality and consistency of completed survey data.
  - **Sample Frame Error:** We addressed external validity (the ability to generalize any findings to the population of interest) through the development of the sample frames that included all eligible members of the population.

Non-Survey Error

- **Analysis Error**
  - **Gross Impact Calculations:** We applied engineering models and calculations to the participant data in the project files to calculate gross impacts. To minimize data analysis error, a separate team member reviewed and verified calculation accuracy.
  - **Verification Site Visits:** To minimize data analysis error, a separate team member reviewed and verified the accuracy of the on-site calculations.
  - **Net Impact Calculations:** We applied deemed NTGRs to estimated gross impacts to derive the program's net impacts.

3. Detailed Findings

3.1 Process Findings

The evaluation team's process-related research focused mainly on characterizing PY9 program results, understanding the participant experience with the program, and assessing opportunities for improvement. Our results are based on in-depth interviews with program staff, a review of program data, and interviews with PY9 program participants.

3.1.1 Detailed Program Description and Participation Summary

The C&I Retro-Commissioning Program helps AIC business customers evaluate their existing mechanical equipment, energy management, and industrial compressed air systems to identify no-cost and low-cost efficiency measures to optimize existing energy-using systems.

Over time, deferred maintenance and changing operating directives and practices can lead to inefficient operation of building systems. Retro-commissioning is a process that examines current operations relative to the needs of equipment owners and those served by the equipment and determines opportunities for increasing equipment efficiency through maintenance, system tune-ups, scheduling, and optimization of operations. Most of the identified measures require little, if any, capital funds to implement. Secondary objectives of the program include:

- Channeling participation into other AIC programs to implement cost-effective equipment replacements and retrofits
  - AIC offers an additional bonus to customers who complete a Custom project within a year of having completed a retro-commissioning study
- Developing a network of RSPs that will continue to operate in the AIC service territory

Major market barriers to these energy efficiency opportunities are lack of awareness and the cost of the detailed engineering studies. Furthermore, even with a quality study in-hand, customer apathy can inhibit implementation of recommendations despite being no-cost. To overcome these barriers, the program subsidizes RSP studies and publicizes the benefits of retro-commissioning to foster a market for the services, with utility-certified RSPs providing the marketing outreach. AIC incentives pay for 70%–80% of the study cost.

In PY9, the Retro-Commissioning Program had four subcomponents:

- **Compressed Air Retro-Commissioning.** The Compressed Air offering provides incentives to defray the cost of a retro-commissioning study of compressed air equipment, leading to the implementation of low-cost/no-cost energy efficiency measures for existing compressed air systems. Typical measures include leak repair, installation of zero-loss drains, and installation or tune-up of compressed air system controls.
- **Industrial Refrigeration Retro-Commissioning.** The Industrial Refrigeration offering provides incentives to defray the cost of a retro-commissioning study of industrial refrigeration equipment, leading to the implementation of low-cost/no-cost energy efficiency measures for existing industrial refrigeration systems. Typical measures include lowering condensing pressure, raising suction pressure, evaporator fan control, evaporator defrost settings, and compressor sequencing.

- **Large Facilities Retro-Commissioning.** The Large Facilities offering targets two separate types of facilities: healthcare facilities and large commercial facilities (primarily offices). Healthcare facilities represent a major opportunity for energy savings in AIC territory and historically have driven this offering. Typical measures include energy management system (EMS) settings adjustments to optimize the operation of HVAC systems.

- **Grocery Store Retro-Commissioning.** Beginning in PY7, the Retro-Commissioning Program began to offer retro-commissioning to grocery stores under a separate offering. This offering is similar to the Large Facilities offering with relaxed facility size requirements and an increased focus on refrigeration systems. To date, this offering has not had any activity.

Large Facilities retro-commissioning projects go through a screening phase that examines the feasibility of retro-commissioning at the facility. Sites with good savings potential are eligible to apply to the program after AIC reviews the project. RSPs commit resources to this deliverable, which may or may not result in a viable retro-commissioning project. To defray the financial risk to the RSP and to encourage the RSPs to market the program more aggressively, AIC pays a screening stipend of 10% of the retro-commissioning study cost to the RSP for complex projects. This stipend does not require a commitment to implement a project and does not necessarily mean that energy savings will be achieved in future years.

Program incentives vary by type of project, as shown in Table 8 below.

Table 8. Summary of Retro-Commissioning Program Incentives

Project Type	Survey Incentive	Customer Implementation Incentive	Incentive Requirements
Compressed Air	80% of survey cost	• 2¢/kWh saved	• Payback period of 0–1 year • Measure must be complete before program incentive is paid
Industrial Refrigeration	70% of survey cost	• 2¢/kWh saved	• Payback period of 0–1 year • Measure must be complete before program incentive is paid
Large Facilities	70% of survey cost 10% of survey cost as "stipend" to RSP for complex projects	• 2¢/kWh • 40¢/therm	• Payback period of 0–1 year • Measure must be complete before program incentive is paid • Measures do not need to be complete for stipend to be paid
Grocery Store	50-70% of survey cost	• 2¢/kWh • 40¢/therm	• Payback period of 0–1 year • Measure must be complete before program incentive is paid

In PY9, projects were completed in the Compressed Air, Industrial Refrigeration, and Large Facilities categories. No projects were completed under the Grocery Store offering. All four Large Facilities projects in PY9 were healthcare projects.

Table 9 displays the contributions of each component to the Retro-Commissioning Program's overall PY9 ex ante gross savings.

Table 9. Summary of PY9 Retro-Commissioning Program Components

Program Component	Projects[a]	Ex Ante Gross Savings			
		MWh	%	Therms	%
Compressed Air	16	7,922	74%	0	–
Industrial Refrigeration	1	1,184	11%	0	–
Large Facility	4	1,634	15%	252,564	100%
Healthcare	*4*	*1,634*	*15%*	*252,564*	*100%*
Commercial	*0*	*0*	–	*0*	–
Grocery	0	0	–	0	–
Total	**21**	**10,741**	**–**	**252,564**	**–**

[a] The project count reflects all projects with savings in PY9, which does not include projects that only received a stipend.

In PY9, the total number of projects completed increased slightly from PY8, but remained below peak program performance in PYs 4–6. Table 10 shows historic program participation.

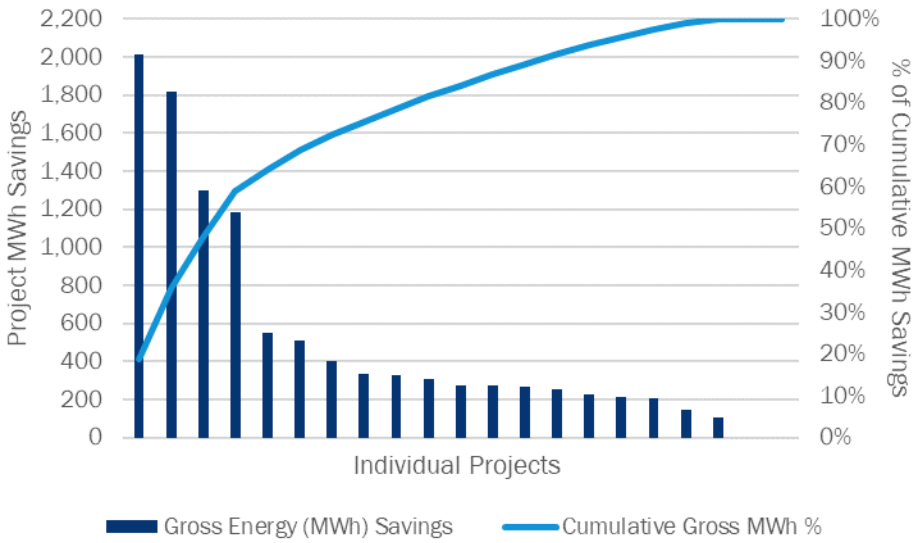
Table 10. Summary of Past Program Participation

Program Year	Projects[a]	Ex Ante Gross Savings	
		MWh	Therms
PY1	1	2,045	0
PY2	17	10,640	0
PY3	21	29,819	0
PY4	25	19,273	412,666
PY5	35	29,257	577,834
PY6	26	12,091	248,851
PY7	16	10,175	226,171
PY8	19	12,193	514,070
PY9	21	10,741	252,564

[a] This project count reflects projects with associated savings. A number of projects listed in the AIC database as paid have no associated savings — the vast majority of which are "stipend" projects.

PY9 project data show that, as in past years, program savings are heavily reliant on very few projects. Figure 1 shows that four projects make up nearly 60% of program electric savings, and eight projects comprise more than 75% of program electric savings. Gas savings are similarly dependent on a small number of projects. Only four projects completed in PY9 had associated gas savings, all of which were Large Facilities projects.

Figure 1. Annual Project and Cumulative Program Ex Ante Electric Savings



The evaluation team noted in PY8 that five stipends were paid: four for healthcare studies and a fifth for a commercial study. Three of these stipends from PY8 led to completed projects in PY9; all healthcare projects. In PY9, six stipends were paid, all for healthcare studies.

Table 11 summarizes PY9 RSP participation, which remained relatively unchanged from PY7. Seven RSPs were active in the program in PY9, with one RSP completing solely stipend-only projects. One RSP completed all four Large Facilities projects under the program in PY9. Two of the remaining four were responsible for 13 of the 16 Compressed Air projects yielding savings in PY9.

Table 11. Summary of PY9 RSP Participation

RSP	Completed Compressed Air Projects	Completed Industrial Refrigeration Projects	Completed Large Facilities Projects	Completed Stipend-Only Projects
RSP-A	9	0	0	0
RSP-B	0	0	4	4
RSP-C	4	0	0	0
RSP-D	2	0	0	0
RSP-E	2[a]	0	0	0
RSP-F	0	0	0	2
RSP-G	0	1	0	0
Total	**17**	**1**	**4**	**6**

[a] This RSP completed only one project yielding savings in PY9; as mentioned above, this RSP began one compressed air project at a facility that later suffered tornado damage that rendered the compressed air system inoperable; the program did not claim savings for this project.

In addition to Retro-Commissioning Program's primary goal of achieving electric energy and gas savings in PY9, we have verified that the program is channeling participation into the C&I Custom program, a secondary goal for the program. Eight C&I Custom projects were completed in PY9 and received a bonus incentive for having been completed within a year of a retro-commissioning study at the same site. These eight projects totaled 9,231 MWh in ex ante gross electric energy savings and 79,900 therms in ex ante gross gas savings, claimed through the Custom Program.

3.1.2 Program Design and Implementation

Implementation Changes

Based on interviews with program staff, PY9 implementation of the Retro-Commissioning Program remained relatively consistent with prior years.

3.1.3 Participant Survey

Participant Satisfaction

In general, participants reported a very high level of satisfaction with the Retro-Commissioning Program. Participants were asked to rank their overall satisfaction with the program on a 0-10 scale.[2]

The mean satisfaction score among participants we interviewed was 9.0. All but one participant we spoke with was very satisfied[3] with the program overall. The one exception was a participant who believes that the program application should be streamlined.

Barriers to Participation

We asked participants we spoke with to tell us what they perceive as key barriers to completing retro-commissioning projects. Participants mentioned a range of barriers, all of which are typical for this type of program. Four participants indicated that lack of time to focus on this type of project is a significant barrier. In addition, two participants mentioned lack of awareness of retro-commissioning, and two participants mentioned internal production demands as the reason for not completing projects.

Recommendations for Program Improvement

We also asked participants to provide any suggestions they might have for program improvement. Four participants mentioned improving program communications to better educate potential participants about the program's offerings to ensure that they are aware of all available incentives. Two participants suggested streamlining the program application.

3.2 Impact Assessment

The following sections provide gross and net impacts for PY9, as well as gross realization rates. The impact analysis looked at program impact tracking from application acceptance through project savings verification.

[2] Where 0 means "extremely dissatisfied" and 10 means "extremely satisfied."

[3] A rating of 7 or greater on the aforementioned scale.

Ex ante impacts and project documentation were tracked in the AMPlify database, which included the data needed to track project milestones and impacts.

3.2.1 Gross Impacts

The evaluation team analyzed the project retro-commissioning and post-inspection reports and re-estimated savings with data in the documentation and our own best estimates. As shown by the relatively high realization rates, in most cases our re-estimations confirmed reported savings with the available data. In some cases, the evaluation team estimated ex post project savings that differed from the ex ante estimates. Reasons for significant adjustments include:

- Compressed Air
  - The evaluation team identified and corrected analysis errors in the ex ante savings estimates (e.g., mistaken application of a parameter).
  - RSPs typically calculate air leakage rates with a set plant pressure assumption. In some cases, plant pressure is different than the savings assumption. In these cases, we revised savings estimates to use actual plant pressure, which can change baseline air leakage rates (and the associated savings).
  - RSPs still occasionally estimate savings based on average compressor performance (CFM/kW) as observed during the retro-commissioning inspection, rather than equipment performance at part-load or at marginal reductions in compressed air flow. Using the average performance metric often overestimates savings. Savings are not proportional to reduced airflow for many compressed air systems,[4] so reducing airflow due to leak repair does not save the equivalent proportion of energy.
- Large Facilities
  - The evaluation team identified and updated unreasonable assumptions in savings calculations (e.g., motor loading and efficiency).
  - On-site inspection revealed that some settings have changed from those proposed for ex ante estimates. Occasional changes such as these are expected as building and plant operators try to maintain adequate service for occupants and production processes. These changes varied, but included changes in set points and schedules in multiple cases.

Table 12 shows the ex ante and ex post gross energy impacts of the program, as well as the realization rates. The ex post impacts are based on our engineering desk reviews of all PY9 projects and on-site visits at a sample of projects. We found high realization rates through both efforts. Desk reviews found realization rates of 98% for electric energy, 97% for electric demand, and 101% for gas energy. Our site visits (starting from savings already adjusted via desk reviews) found realization rates of 96% for electric energy, 95% for electric demand, and 100% for gas energy.

[4] Constant speed rotary machines consume about 70% of rated power when delivering no compressed air. Constant speed centrifugal machines blow off excess compressed air when delivering less than 70%–80% of design airflow.

Table 12. PY9 Retro-Commissioning Program Gross Impacts

Savings Category	Ex Ante Gross	Realization Rate	Ex Post Gross
Energy Savings (MWh)	10,741	0.94	10,096
Demand Savings (MW)	1.04	0.92	0.95
Gas Savings (Therms)	252,564	1.01	254,755

Overall, the impact evaluation adjusted the program ex ante gross savings for several reasons. Among most reviewed projects, verification adjustments represented isolated cases of miscalculated savings and not systematic problems. Electronic versions of calculations ensure transparency to verify savings estimates.

3.2.2 Net Impacts

The ex ante NTGRs for the program are the SAG-approved values of 0.91 for electricity and 0.91 for natural gas. Following the NTGR framework, we apply these NTGRs to PY9 savings. Table 13 provides the PY9 net impacts for the Retro-Commissioning Program.

Table 13. PY9 Net Program Impacts

Savings Category	Ex Post Gross	NTGR	Ex Post Net
Energy Savings (MWh)	10,096	91%	9,187
Demand Savings (MW)	0.95	91%	0.87
Gas Savings (Therms)	254,755	91%	231,827

4. Conclusions and Recommendations

While realization rates in PY9 are relatively high, some opportunities to increase savings calculation accuracy still exist.

- Compressed air savings calculations still include error types that have been flagged for several evaluation cycles: inappropriate use of average compressor efficiency rather than marginal efficiency, assumptions of year-round operation without any downtime, and failure to accurately account for plant air pressure in savings estimates.
- The implementation contractor continued to perform post-installation inspections in PY9. Documentation for these visits has improved greatly since they began in PY4, but still has gaps, especially for HVAC retro-commissioning projects. Photographic, data, or graphical confirmation was included for less than half of the measures. Several measures still lacked positive confirmation or the implementation contractor did not adequately annotate provided confirmation to describe the measures verified by the images.

Based on our research, the evaluation team makes the following impact recommendations for the program. Though there have been marked improvements, many of these opportunities are carryover recommendations from prior years to better document and organize the baseline and post-implementation conditions and estimation methods.

- **Review underlying RSP assumptions.** One RSP completing healthcare projects uses a standardized project spreadsheet that makes a variety of assumptions for key inputs to calculations, if they are not measured. In some cases, these assumptions are erroneous or poorly sourced and should be reviewed. We recommend that the implementer provide suggestions for these key assumptions to RSPs to increase accuracy of savings estimates. In particular, we identify two assumptions in need of review:
  - **Motor loading.** This RSP assumes default motor loading of 85%. The evaluation team would always prefer motor loading to be measured. However, if not measured, the RSP should assume a more conservative value in its calculations (e.g., the IL-TRM's default load factor of 65% for VFDs in HVAC applications).
  - **Motor efficiency.** This RSP assumes motor efficiency of 85%; the evaluation team notes that for larger motors, this is likely an underestimate.
- **Encourage implementation of more savings and measures in addition to leak repair.** For example, require implementation of bundled measures that meet a payback threshold—12 months, for example—in order to receive the study subsidy incentive. Nearly all savings from PY9 compressed air projects derive from leak repairs. While the savings from leak repairs is significant and cost-effective, the RSPs should spend more effort investigating and encouraging implementation of other short-payback measures, including, for example, no-loss drains, elimination of inappropriate uses, storage, better staging of multiple compressors, and cycling driers.

Our limited assessment of program processes in PY9 indicated no major issues with the program as compared to prior years.

Appendix A. NTGR Results

In PY9, the evaluation team conducted research with Retro-Commissioning program participants toward the goal of establishing a net-to-gross-ratio (NTGR) for application in 2019. Consistent with prior program years, the NTGRs developed for individual PY9 program participants are based on self-reported information from their respective CATI survey. To develop NTGRs, the participant survey results were used to develop estimates of free-ridership (FR) and participant spillover (PSO), and we used estimates of non-participant spillover (NPSO) from our Business Program-wide PY7 survey.

Key Findings

Table 14 presents the results of our PY9 NTG analysis. Due to the small number of completed interviews (11) and, in particular, the small number that focused on projects achieving gas savings (2) we chose to calculate a single NTGR[5]—weighting by total energy savings (Btu).

Table 14. PY9 Retro-Commissioning NTGR Research Results

FR	PSO	NPSO[a]	NTGR (1-FR+PSO+NPSO)
0.11	0.00	0.00	0.89

[a] From PY7 research.

NTGR Background

Net impact evaluation is generally described in terms of determining program attribution. Program attribution accounts for the portion of gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. The program-induced savings, indicated as a NTGR, is made up of FR and spillover (SO) and is calculated as (1 – FR + SO). FR is the portion of the program-achieved verified gross savings that would have been realized absent the program and its interventions. SO is generally classified into participant and NPSO. PSO occurs when participants take additional energy-saving actions that are influenced by the program interventions but did not receive program support. NPSO is the reduction in energy consumption and/or demand by customers who did not participate in the program yet were influenced by it.

The formula to calculate the NTGR is:

$$NTGR = 1 - FR + PSO + NPSO$$

The Illinois evaluation teams have worked with the ICC and the Illinois SAG to create a standard Illinois Statewide Net-to-Gross approach for use in Illinois energy efficiency evaluation, measurement, and verification work. Per the NTG Methods attachment to the Illinois TRM,[6] all NTG data collection and analysis activities for program types covered by the attachment that began after June 1, 2016 must conform to the statewide NTG methods. This evaluation conforms with these requirements.

[5] Given the small number of interviews, a single NTGR that can be applied to both electric and gas savings seemed preferable to calculating separate NTGRs for each fuel type (an electric-only NTGR would have been based on 9 interviews and a gas-only NTGR would have been based on just 2 interviews).

[6] Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0. Volume 4: Cross-Cutting Measures and Attachments. Dated: February 11, 2016. Effective: June 1, 2016.

Free-Ridership

Methodology

Free-riders are program participants who would have implemented the incented energy-efficient measure(s) even without the program. FR estimates are based on a series of questions that explore the influence of the program on the energy-efficient installations as well as likely actions had the program not been available.

For all Retro-Commissioning Program projects included in the participant survey, we implemented four specifications of the FR algorithm, following the IL-TRM's Study-Based Free-Ridership protocol. Each specification of the algorithm consists of three scores: (1) influence of program components score, (2) overall program influence score, and (3) no-program score (counterfactual), as well as a timing adjustment (in some cases). Each sub-score serves as a separate estimator of FR and can take on a value of 0 to 1, where a higher score means a higher level of FR. The overall FR for a project is the average of the three scores. The FR score for each project thus ranges from 0 (no FR) to 1 (100% FR).

The three scores included in the algorithm, their variations, and the timing adjustment are described below.

Free-Ridership Scores

1. **Influence of Program Components (PC)**. This score is based on a series of 12 questions that ask respondents to rate the importance of program and non-program components in their decision to complete retro-commissioning improvements, using a scale of 0 to 10 (where 0 is "Not at all important" and 10 is "Very important"). Components considered are summarized in Table 15 below.

Table 15. Program and Non-Program Components Considered

Component	Type
The subsidized retro-commissioning study	Program factors (PF)
Recommendations made by an RSP	
Information from the program	
A recommendation from an AIC representative	
Technical assistance from an RSP	
Standard practice in business or industry	Non-program factors (NPF)
Age or condition of existing equipment	
Corporate policy or guidelines	
Previous experience with retro-commissioning	Either program or non-program factors, depending on follow-up questions
Expected energy savings	
Financial criteria, such as payback or return on investment	
Other factors	

We estimate the PC score in two different ways, referred to as "Program Components FR Score A" and "Program Components FR Score B." Program Components FR Score A is based on ratings for program factors only. The FR score is calculated as:

Equation 1. Program Components FR Score A

$$PCS_A = 1 - \left(\frac{PF_{max}}{10}\right)$$

Greater importance of the PC means a lower level of FR. In this approach, if a respondent rated the subsidized retro-commissioning study 10 out of 10, the recommendation of an RSP 8 out of 10, and the information from the program 8 out of 10, the final Program Components FR Score A would be 0.

Program Components FR Score B is based on ratings for both program and non-program factors. The FR score is calculated as:

Equation 2. Program Components FR Score B

$$PCS_B = 1 - \left(\frac{PF_{max}}{PF_{max} + NPF_{max}}\right)$$

Greater importance of the PC relative to the importance of non-program components means lower level of FR. In this approach, if a respondent rated both the program rebate and corporate policy as a 10 out of 10, the final Program Components FR Score B would be a 0.5.

2. **Program Influence (PI)**. This score is based on a survey question asking the respondent to rate the importance of the program compared to the importance of other factors in their decision to complete improvements. To do so, respondents were asked to divide 100 points between the program and other, non-program factors. This score is estimated as:

   Program Influence FR Score = 1 – (Points Given to Program / 100)

   More points allocated to the program means lower level of FR. For example, if a respondent gave the program 70 points out of 100, the Program Influence FR score would be 0.30.

3. **No-Program Score (NP).** This score is based on the likelihood that the exact same energy efficient improvements would have been made without the program. The IL-TRM provides two options for calculating this score. Both options are computed on the measure-level and then rolled up to the project-level using measure-level savings weights to accurately represent the importance of each measure completed.

   NP Score – Option 1

   Option 1 follows the IL-TRM's Core Non-Residential FR approach and uses responses to a counter-factual likelihood question combined with a timing adjustment. Respondents are asked to answer the likelihood they would have completed a given retro-commissioning improvement if the program had not been available, using a scale of 0 to 10 (where 0 is "Not at all likely" and 10 is "Very likely"). This answer is then used to calculate a NP score, presented below:

   NP Score = Likelihood to Complete Same Improvements / 10

   A greater likelihood of participating without the program means higher level of FR. For example, if the participant provides a likelihood rating of 7 to complete the same improvements in the absence of the program, their NP FR score would be a 0.70.

   This score is then combined with a timing adjustment (discussed next) as follows:

$$NP\ Score_{Adjusted} = (Likelihood\ to\ Install\ Same\ Equipment / 10) * Timing\ Adjustment$$

Program Timing Adjustment

The program timing adjustment is based on two questions: (1) if the installation would have been done at the same time without the program; and (2) if the installation would have been done later, how much later. Later implementation without the program means lower level of FR. This adjustment is calculated on a 0 to 1 scale. A timing adjustment of 1 means that there is no evidence the program changed the timeframe in which the project would have been implemented, while a lower value of the timing adjustment means that the program caused the project to be implemented sooner. The timing adjustment provides the program with some credit for accelerating the project by reducing the level of FR. Table 16 provides detail on how participant responses correspond to various timing adjustments.

Table 16. Timing Adjustments

Participant Survey Response	Timing Adjustment
In absence of program, would have completed project…	
within 6 months	1.0
seven months to one year later	0.93
more than one year up to two years	0.71
more than two years up to three years	0.43
more than three years up to four years	0.14
more than four years later	0.14

NP Score – Option 2

Option 2 utilizes more detailed-measure level questions to assign the NP score at the measure level. The rules presented below are followed in order to assign the NP score.

a. If the respondent indicates that they conduct regular maintenance on the equipment treated through the program, and that the regular maintenance always includes the improvements made through the program, then the NP FR Score = 1.

b. If the respondent indicates that they were unaware of the performance issue corrected by the improvement made, that they would have been very unlikely to conduct a retro-commissioning study on their own, and that there is not regular maintenance conducted on the treated equipment that always includes the improvement made through the program, then the NP FR Score = 0.

c. If the respondent indicates that they were unaware of the performance issue corrected by the improvement made, that they were very unfamiliar with the recommended improvement, and that there is not regular maintenance conducted on the treated equipment that always includes the improvement made through the program, then the NP FR Score = 0.

d. For all other combinations of responses, NP Score – Option 1 is used to calculate FR.

Determining Overall Free-Ridership

As mentioned above, we implemented four specifications of the FR algorithm, following the IL-TRM's Study-Based Free-Ridership protocol. Each specification of the algorithm consists of a combination of the three scores mentioned above, and the overall FR score for a project is the average of the three scores. However, the different specifications of the algorithm combine the multiple versions of the scores presented above (e.g., PC FR Score A and B) in different ways.

This evaluation implemented and analyzed the following four specifications of the FR algorithm.

- **Approach 1A:** (PC FR Score A + PI Score + NP Score – Option 1) / 3
- **Approach 1B:** (PC FR Score B + PI Score + NP Score – Option 1) / 3
- **Approach 2A:** (PC FR Score A + PI Score + NP Score – Option 2) / 3
- **Approach 2B:** (PC FR Score B + PI Score + NP Score – Option 2) / 3

Results

Table 17 presents our results by approach. Because we conducted a census attempt of all PY9 participants, there is no sampling error around our results.

Table 17. FR Results by Approach

Approach	FR Score	α
Approach 1A	0.11	0.33
Approach 1B	0.25	0.37
Approach 2A	0.17	0.18
Approach 2B	0.31	0.26

The evaluator is tasked with determining which specification of the algorithm is most appropriate for application. We used Cronbach's alpha (α in the table above) as a tool to help us evaluate the different algorithm specifications for the Instant Incentives offering. As each of the three scores incorporated into the final FR estimate serves as a separate estimate of FR, we used Cronbach's alpha to examine the internal consistency of the three scores for each specification, working from the basis that a higher degree of internal consistency is desirable for the algorithm. A general rule of thumb is that a Cronbach's alpha of 0.7 or higher indicates an acceptable level of internal consistency.

As can be seen, the Cronbach's alphas for all approaches are relatively poor. To supplement our decision-making around which algorithm to use, we also examined and compared FR results across algorithms. When we examine the scores inside each algorithm specification (both in this study and in others using the same protocol), we find that the Program Components FR Score B is generally close to 0.5, regardless of other responses provided. As such, we feel that an algorithm incorporating this score is not a reasonable choice for use, since it reduces the correlation among the two components in the NTGR algorithm, thus reducing the reliability of the resulting NTGR. Therefore, we eliminated Approaches 1B and 2B from consideration for final application.

Of the remaining two specifications of the algorithm, we find that the alpha for Approach 2A is especially poor, and as such, we select Approach 1A for our recommended NTGR.

Participant Spillover

Methodology

Participant spillover (PSO) refers to the installation of energy efficient measures or completion of energy-efficient improvements by program participants that were influenced by the program but did not receive an incentive. An example of PSO is a customer who completes improvements in one facility and, as a result of the positive experience, installs additional equipment or completes improvements at another facility but does not request an incentive (outside SO). In addition, the participant may install additional equipment or complete improvements, without an incentive, at the same facility because of the program (inside SO).

We examined both inside and outside SO in projects using participant responses to the phone survey. Per the IL-TRM, we used a threshold approach to determine whether unincented measures or improvements made by program participants could be considered SO. The threshold condition for SO is based on responses to the following two survey questions:

- On a scale of 0-10, where 0 means "no influence" and 10 means "greatly influenced," how much did your experience with the AIC Retro-Commissioning program influence your decision to install high efficiency equipment or change maintenance practices on your own beyond those recommended in the retro-commissioning project?
- If you had NOT participated in the AIC Retro-Commissioning program, how likely is it that you would still have installed this additional energy efficient equipment or changed your maintenance practices? Please use a 0 to 10 scale, where 0 means you "definitely WOULD NOT have implemented this equipment or changed maintenance practices" and 10 means you "definitely WOULD have implemented this equipment or changed maintenance practices".

The response to the first question cited above is "Measure Attribution Score 1," and the response to the second question cited above is "Measure Attribution Score 2." Spillover is considered to be attributable to the program if the "Spillover Score" is greater than 7.0. The "Spillover Score" is defined as follows:

$$\text{Spillover Score} = (\text{Measure Attribution Score 1} + (10 - \text{Measure Attribution Score 2}))/2$$

Results

We found no program-attributable spillover through our research in PY9.

Appendix B. Survey Response Rate Methodology

The survey response rate is the number of completed interviews divided by the total number of potentially eligible respondents. We calculated RR3 using the standards and formulas set forth by the AAPOR.[7] The formulas used to calculate RR3 are presented below. The definitions of the letters used in the formulas are shown in the survey disposition tables in the Retro-Commissioning participant survey section of this report.

Equation 3. Formula for RR3

$$RR3 = \frac{I}{\left(I + N + e1(U1 + e2 * U2)\right)}$$

Where:

$$e1 = \frac{(I + N)}{(I + N + X1)}$$

$$e2 = \frac{(I + N + X1 + U1)}{(I + N + X1 + U1 + X2)}$$

We also calculated a cooperation rate, which is the number of completed interviews divided by the total number of eligible sample units. We used AAPOR Cooperation Rate 3 (COOP3) for the web surveys used in this evaluation, which is calculated as:

Equation 4. AAPOR Cooperation Rate 3

$$COOP3 = \frac{I}{((I + P) + R)}$$

[7] *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, AAPOR, 2011. http://www.aapor.org/AM/Template.cfm?Section=Standard_Definitions2&Template=/CM/ContentDisplay.cfm&ContentID=3156.

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