Commercial and Industrial Energy Efficiency Incentive Programs Evaluation, Measurement, and Verification Report 2015 Participants

Prepared for the FirstEnergy Ohio Companies:

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1. Executive Summary

During 2014, the Ohio Operating companies, The Cleveland Electric Illuminating Company (CEI), Ohio Edison Company (OE), and The Toledo Edison Company (TE) (collectively "Companies"), continued to implement commercial and industrial programs. These programs (collectively "C/I Programs") include the following:

- Energy Efficient Equipment Program – Large (Large Equipment)
- Energy Efficient Equipment Program – Small (Small Equipment)
- Energy Efficient Buildings Program – Large (Large Buildings)
- Energy Efficient Buildings Program – Small (Small Buildings)
- Government Tariff Lighting Program (Government Lighting)

The C/I Programs were suspended in 2015 pursuant to the Companies filing and Commission approving an amended Plan for the 2015-2016 program years.[1] The suspension process supported commercial and industrial (C/I) customer program applications and pre-approval of projects through December of 2014 with project completions supporting 2014 program rebates during 2015 (2015 Participants).

The main features of the approach used for the evaluation are as follows:

- Data for the study were collected through review of program materials, on-site inspections, end-use metering, and interviews with the Companies' staff members, program implementation contractor staff members, and participating customers and contractors. Based on data provided by the Companies and their program implementation contractor, a sample design was developed for on-site data collection. Samples were drawn that provide savings estimates for each program providing energy savings estimation with ±10% statistical precision at the 90% confidence level.
- On-site visits were used to collect data for savings impact calculations, to verify measure installation, and to determine measure operating parameters. Facility staff were interviewed to determine the operating hours of installed systems and to locate any additional benefits or shortcomings with the installed systems. For many of the sites, energy efficient equipment was monitored in order to obtain accurate information on equipment operating characteristics. Since the subset of projects reported in 2014 and the subset of project reported in 2015 were all projects completed in the 2014 program year, sampled projects included in the already-filed 2014 M&V Report were used as part of the 2015 program evaluation for Large and Small Equipment Programs. Furthermore, program activity for Large Equipment had a large percentage of custom projects relative to 2014 program activity. In order to properly account for

[1] See *In the Matter of the Application for Approval of Energy Efficiency and Peak Demand Reduction Program Portfolio Plans for 2013-2015*, Case Nos. 12-2190-EL-POR *et al.,* November 20, 2014 Finding and Order.

higher savings associated with non-lighting projects, additional custom projects were added to the Large Equipment M&V sample to accurately represent the 2014 program year population. For Large Buildings, a census approach was taken to collect data for savings impact calculations, to verify measure installation, and to determine measure operating parameters. For Small Buildings, a two-fold evaluation approach was taken: a census approach to collect data for savings impact calculations, to verify measure installation, and to determine measure operating parameters for retro-commissioning projects, and use of the Ohio Technical Reference Manual (TRM) to calculate savings impacts for C/I Kits projects using program reported measure characteristics.

Gross savings were estimated using proven techniques, including industry standard engineering calculations and verification of computer simulations developed by program contractors to determine energy savings. The realized energy savings for each program are summarized in Table 1-1.

Table 1-1 Gross Savings by Program (2015 Participants)

Program	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
Large Equipment	110,058,593	96,987,290	88%	14,323.55	12,268.70	86%
Small Equipment	89,900,701	77,425,841	86%	12,616.28	11,271.20	89%
Large Buildings	16,368,216	16,294,788	100%	2,107.02	2,001.72	95%
Small Buildings	3,781,057	4,563,797	121%	74.69	59.45	80%
Total	**220,108,567**	**195,271,716**	**89%**	**29,121.54**	**25,601.07**	**88%**

The realized energy savings of the 2015 participants in the Large Equipment Program from the three service territories are summarized in Table 1-2. For the entire program, the realized gross energy savings totaled 96,987,290 kWh. The gross realization rate for the program is 88%.

Table 1-2 Summary of Annualized kWh Savings for Large Equipment (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	18,266,696	15,130,368	83%
OE	56,614,772	49,674,606	88%
TE	35,177,125	32,182,317	91%
Total Companies	**110,058,593**	**96,987,290**	**88%**

The realized gross peak kW reductions of the 2015 participants in the Large Equipment Program from the three service territories are summarized in Table 1-3. The achieved gross peak demand savings for the program are 12,268.70 kW. The gross realization rate for the program is 86%.

Table 1-3 Summary of Annualized Peak kW Savings for Large Equipment (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	2,478.13	2,235.36	90%
OE	7,849.32	6,018.26	77%
TE	3,996.11	4,015.07	100%
Total Companies	**14,323.55**	**12,268.70**	**86%**

The realized energy savings of the 2015 participants in the Small Equipment Program from the three service territories are summarized in Table 1-4. For the entire program, the realized gross energy savings totaled 77,425,841 kWh. The gross realization rate for the program is 86%.

Table 1-4 Summary of Annualized kWh Savings for Small Equipment (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	36,892,999	31,816,572	86%
OE	33,076,680	28,568,753	86%
TE	19,931,022	17,040,515	85%
Total Companies	**89,900,701**	**77,425,841**	**86%**

The realized gross peak kW reductions of the 2015 participants in the Small Equipment Program from the three service territories are summarized in Table 1-5. The achieved gross peak demand savings for the program are 11,271.20 kW. The gross realization rate for the program is 89%.

Table 1-5 Summary of Annualized Peak kW Savings for Small Equipment (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	5,297.93	4,761.94	90%
OE	4,914.40	4,403.57	90%
TE	2,403.95	2,105.69	88%
Total Companies	**12,616.28**	**11,271.20**	**89%**

The realized energy savings of the 2015 participants in the Large Buildings Program from the three service territories are summarized in Table 1-6. For the entire program, the realized gross energy savings totaled 16,294,788 kWh. The gross realization rate for the program is 100%.

Table 1-6 Summary of Annualized kWh Savings for Large Buildings (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
OE	5,306,036	5,250,421	99%

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
TE	11,062,180	11,044,367	100%
Total Companies	**16,368,216**	**16,294,788**	**100%**

The realized gross peak kW reductions of the 2015 participants in the Large Buildings Program from the three service territories are summarized in Table 1-7. The achieved gross peak demand savings for the program are 2,001.72 kW. The gross realization rate for the program is 95%.

Table 1-7 Summary of Annualized Peak kW Savings for Large Buildings (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post kWh Savings	Realization Rate
OE	653.00	583.72	89%
TE	1,454.02	1,418.00	98%
Total Companies	**2,107.02**	**2,001.72**	**95%**

The realized energy savings of the 2015 participants in the Small Buildings Program from the three service territories are summarized in Table 1-8. For the entire program, the realized gross energy savings totaled 4,563,797 kWh. The gross realization rate for the program is 121%.

Table 1-8 Summary of Annualized kWh Savings for Small Buildings (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	2,505,143	3,145,625	126%
OE	1,217,747	1,365,156	112%
TE	58,168	53,017	91%
Total Companies	**3,781,057**	**4,563,797**	**121%**

The realized gross peak kW reductions of the 2015 participants in the Small Buildings Program from the three service territories are summarized in Table 1-9. The achieved gross peak demand savings for the program are 59.45 kW. The gross realization rate for the program is 80%.

Table 1-9 Summary of Annualized Peak kW Savings for Small Buildings (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post kWh Savings	Realization Rate
CEI	10.57	10.69	101%
OE	51.77	36.68	71%
TE	12.35	12.08	98%
Total Companies	**74.69**	**59.45**	**80%**

2. Introduction and Purpose of Study

This report presents the results of the impact evaluations of the Large Equipment, Small Equipment, Large Buildings, and Small Buildings, (collectively "C/I Programs") for program activity from 2014 program rebates during 2015 (2015 Participants).

2.1 Overview of Evaluation Approach

The overall objective for the impact evaluation of the C/I Programs was to verify the gross energy savings and peak demand (kW) reduction resulting from participation in the program during 2015.

The approach for the impact evaluation had the following main features.

- Available documentation (e.g., audit reports, savings calculation work papers) was reviewed for a sample or a census of projects, with particular attention given to the calculation procedures and documentation for savings estimates.
- On-site data collection was conducted for a sample of projects to provide the information needed for estimating savings and demand reductions. Monitoring was also conducted at some sites to obtain more accurate information on the hours of operation for lighting and HVAC equipment.
- Gross savings were estimated using proven techniques:
  - Analysis of lighting savings was accomplished using ADM's custom-designed lighting evaluation model with system parameters (fixture wattage, operating characteristics, etc.) based on information on operating parameters collected on-site and, if appropriate, industry standards.
  - For HVAC measures, the original analyses used to calculate the expected savings were reviewed and the operating and structural parameters of the analysis were verified. For custom measures or relatively more complex measures, simulations with the DOE-2 energy analysis model were used to develop estimates of energy use and savings from the installed measures.

3. Description of Programs

3.1 Description of Large Equipment and Small Equipment Programs

Customers considered “large” based on the customer’s rate code are eligible to participate in the Large Equipment Program. Customers considered “small” based on the customer’s rate code are eligible to participate in the Small Equipment Program. Rate codes and corresponding customer sizes are presented in Table 3-1.

Table 3-1 Rate Code by Customer Size

Rate Code	*Customer Size*
GP	Large
GS	Small
GSU	Large
GT	Large

The primary objective of these programs is to increase the market share of high efficiency equipment among commercial and industrial customers. Qualifying existing small commercial, industrial, and municipal customers with buildings in the Companies’ service territories are eligible to participate in the program.

The energy efficiency measures (EEMs) that are implemented by the Large Equipment Program are organized into three categories: *HVAC measures*, *Lighting measures, and Custom Equipment measures*.

The HVAC, Lighting and Custom measures within Large Equipment are intended to encourage customers to retrofit or install more efficient equipment in an effort to reduce both energy consumption and demand.

The EEMs that are implemented by the Small Equipment Program are organized into five categories: *HVAC & Water Heating measures*, *Appliances measures*, *Food Service measures*, *Lighting measures, and Custom Equipment measures*.

The HVAC & Water, Appliance, Food Service, Lighting and Custom measures within Small Equipment are intended to encourage customers to retrofit or install more efficient equipment and applications in an effort to reduce both energy consumption and demand.

Customers submitted large and small equipment projects using the program’s online application process. Equipment projects are categorized into eight types and include, prescriptive and calculated lighting, HVAC and water heaters, appliances, food services, custom equipment, traffic signals, and data centers.

Expected energy savings were calculated using methodologies outlined in the Ohio Technical Reference Manual (TRM)[2], or using industry standard engineering calculations.

[2] Vermont Energy Investment Corporation (VEIC), *State of Ohio Energy Efficiency Technical Reference Manual,* Prepared for Public Utilities Commission of Ohio, August 6, 2010.

For the Large Equipment Program, the expected gross savings by measure type are shown in Table 3-2. There were 251 projects in the program which were expected to provide savings of 110,058,593 kWh.

Table 3-2 Ex Ante Annual Energy Savings of Large Equipment (2015 Participants)

Measure Type	Ex Ante kWh Savings			
	CEI	OE	TE	Total Companies
Custom Equipment	6,844,207	23,373,454	10,903,591	41,121,252
HVAC	594,725	412	0	595,136
Lighting	10,827,764	33,240,907	24,273,534	68,342,205
Total	**18,266,696**	**56,614,772**	**35,177,125**	**110,058,593**

For the Small Equipment Program, the expected gross savings by measure type are shown in Table 3-3. There were 1,139 projects in the program which were expected to provide savings of 89,900,701 kWh.

Table 3-3 Ex Ante Annual Energy Savings of Small Equipment (2015 Participants)

Measure Type	Ex Ante kWh Savings			
	CEI	OE	TE	Total
Appliances	7,696	16,752	1,376	25,824
Custom Equipment	3,678,967	2,647,768	2,151,433	8,478,169
Food Service	24,377	157,666	0	182,043
HVAC	64,662	50,147	25,134	139,943
Lighting	33,117,297	30,204,347	17,753,078	81,074,723
Total	**36,892,999**	**33,076,680**	**19,931,022**	**89,900,701**

Figure 3-1 shows the Large Equipment Program's ex post kWh savings by the date of application submission.

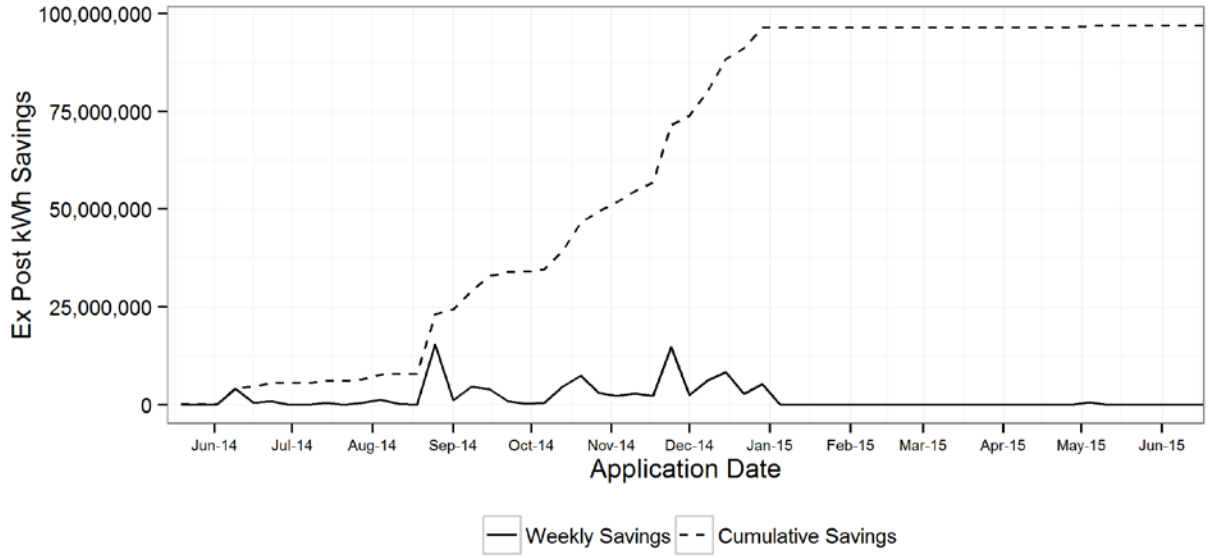

Figure 3-1 Large Equipment Cumulative Ex Post kWh Savings by Date of Application Submission (2015 Participants)

Figure 3-2 shows the Small Equipment Program's ex post kWh savings by the date of application submission.

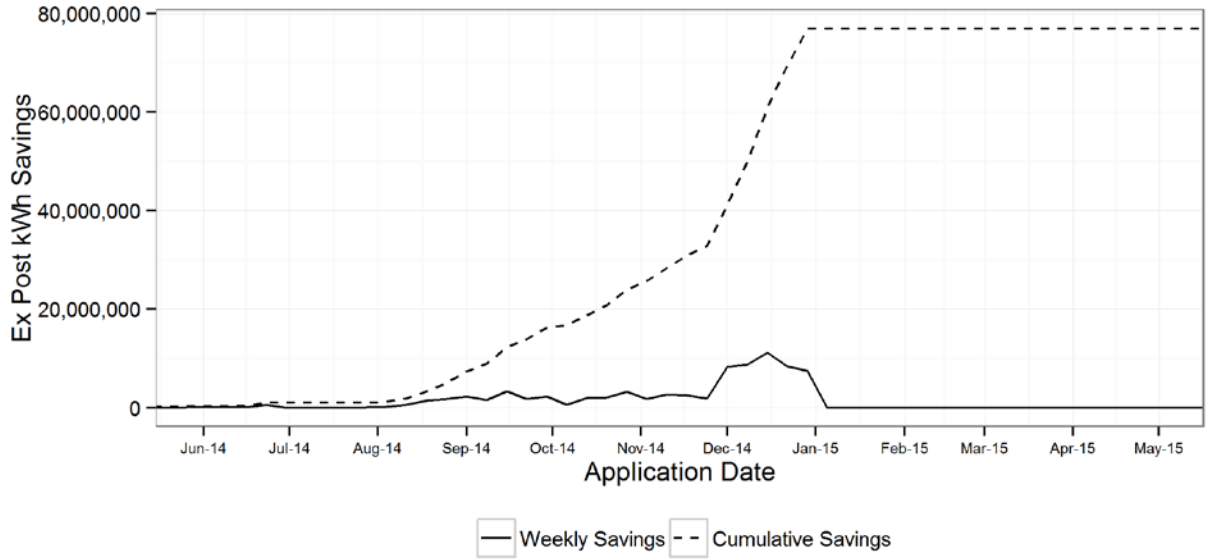

Figure 3-2 Small Equipment Cumulative Ex Post kWh Savings by Date of Application Submission (2015 Participants)

3.2 Description of the Large and Small Buildings Programs

Customers considered “large” based on the customer’s rate code are eligible to participate in the Large Equipment Program. Customers considered “small” based on the customer’s rate code are eligible to participate in the Small Equipment Program. Rate codes and corresponding customer size are presented above in Table 3-1.

The primary objective of these programs is to increase the energy efficiency of existing buildings used by commercial and industrial customers. Qualifying existing commercial, industrial, and municipal customers with buildings in the Companies’ service territories are eligible to participate in the program.

The EEMs that are implemented through the programs are organized into four categories: *New Construction measures*, *Audit measures*, *Custom Buildings measures*, and *Kit measures*.

The New Construction measure is intended to encourage customers to construct buildings to higher efficiency than required by applicable codes and standards. The Audit measure is intended to encourage customers to acquire a detailed third party energy efficiency audit for their building to assist them with identifying efficiency projects. The Custom Buildings measure is intended to encourage customers to install specialized building shell improvements that reduce energy consumption and power demand. The Kit measure is intended to educate customers on the benefits of simple EEMs and other opportunities to accelerate the adoption and increase the market share of high efficiency equipment in the small business sector, and to improve building energy performance in an effort to reduce both energy consumption and demand.

Expected energy savings were calculated using methodologies outlined in the Ohio TRM, or using industry standard engineering calculations.

For the Large Buildings Program, the expected gross savings by measure type are shown in Table 3-4. There were 7 projects in the program which were expected to provide savings of 16,368,216 kWh.

Table 3-4 Ex Ante Annual Energy Savings of Large Buildings (2015 Participants)

Measure Type	Ex Ante kWh Savings		
	OE	TE	Total Companies
Custom Equipment	3,426,607	0	3,426,607
Retro-Commissioning	1,879,429	11,062,180	12,941,609
Total	**5,306,036**	**11,062,180**	**16,368,216**

Figure 3-3 shows the Large Buildings Program's ex post kWh savings by the date of application submission.

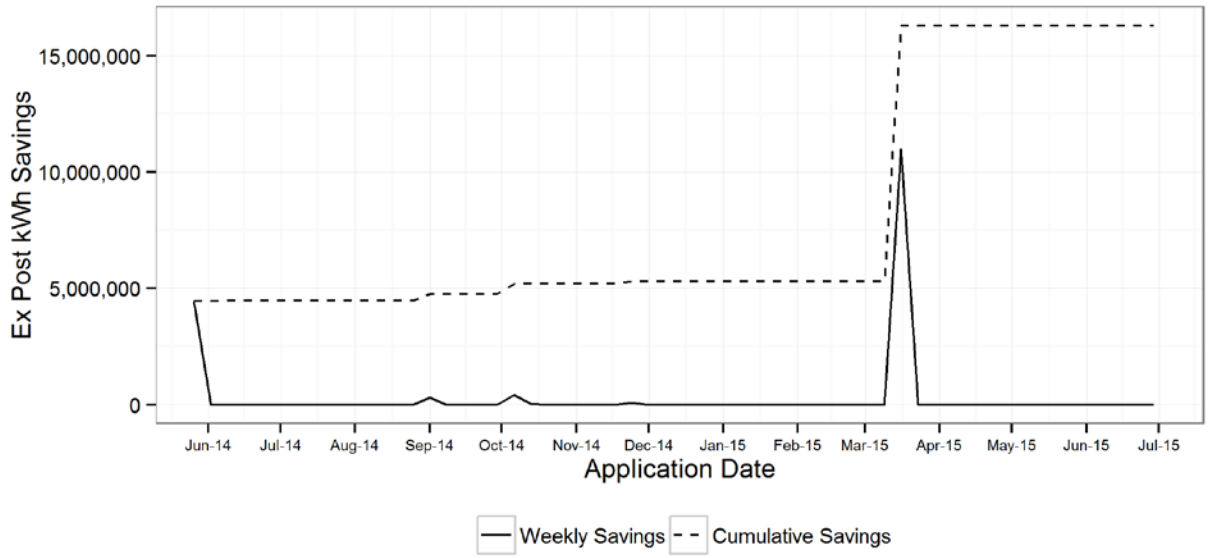

Figure 3-3 Large Buildings Cumulative Ex Post kWh Savings by Date of Application Submission (2015 Participants)

For the Small Buildings Program, the expected gross savings are shown in Table 3-5. There were 57 shipped kits and 14 projects in the program which were expected to provide savings of 3,781,057 kWh.

Table 3-5 Ex Ante Annual Energy Savings of Small Buildings (2015 Participants)

Measure Type	Ex Ante kWh Savings			
	CEI	OE	TE	Total Companies
Retro-Commissioning	2,455,242	1,125,540	0	3,580,782
Kit A	39,990	90,887	58,168	189,045
Kit B	9,910	0	0	9,910
Kit C	0	1,320	0	1,320
Total	**2,505,143**	**1,217,747**	**58,168**	**3,781,057**

Figure 3-4 shows the Small Buildings Program's ex post kWh savings by the date of application submission.

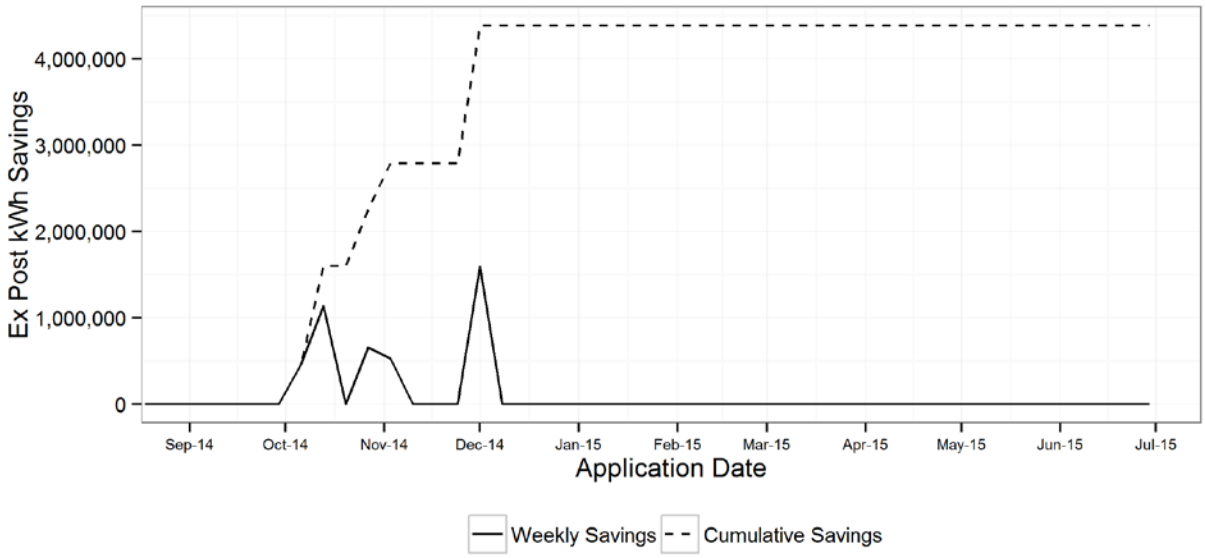

Figure 3-4 Small Buildings Cumulative Ex Post kWh Savings by Date of Application Submission (2015 Participants)

4. Methodology

ADM'S evaluation of the 2015 participants in the C/I Programs consisted of an impact evaluation. The impact evaluation methodology is described in section 4.1.

4.1 Impact Methodology

The methodology used to estimate gross savings is described in this section.

4.1.1 Sampling Plans – C/I Equipment Programs

For Large and Small Equipment Programs, inspection of data on kWh savings for individual projects provided by implementation contractors indicated that the distribution of savings was generally positively skewed, with a relatively small number of projects accounting for a high percentage of the estimated savings. Since the 2014 program year also included 2015 participants, sampled projects included in the already-filed 2014 M&V Report were used to develop realization rates with the appropriate statistical precision for the Large and Small Equipment programs. Furthermore, 2015 participants for Large Equipment had a large percentage of custom projects relative to 2014 program activity. In order to properly account for higher savings associated with non-lighting projects, additional custom projects were added to the Large Equipment M&V sample to accurately represent the population. Estimation of savings for each program is based on a ratio estimation procedure, which allows precision/confidence requirements to be met with a smaller sample size. ADM selected a sample with a sufficient number of projects to estimate the total achieved savings with 10% precision at 90% confidence. For both the Large and Small Equipment Program samples, the actual precisions are ±9.59% and ±9.91% respectively.

For the Large Buildings Program, estimation of savings for the program is based on a census of projects. Seven site visits were performed for the projects in the program.

For the Small Buildings Program, estimation of savings for the program is based on a census of the 14 retro-commissioning projects, and on the methodology outlined in the Ohio TRM for all Kits projects.

Sampling for the collection of program M&V data accounted for the M&V effort occurring in real time during program implementation. Completed projects accumulate over time as the program is implemented, and sample selection was thus spread over the entire program year. ADM used a near real-time process whereby a portion of the sample was selected periodically as projects in the program were completed. The timing of sample selection was contingent upon the timing of the completion of projects during the program year.

4.1.2 Review of Documentation

After the samples of projects were selected, the program implementation contractor provided project documentation for sampled projects. The first step in the evaluation effort

was to review this documentation and other program materials that were relevant to the evaluation effort.

For each project, the available documentation (e.g., audit reports, savings calculation work papers) for each rebated measure was reviewed, with particular attention given to the calculation procedures and documentation for savings estimates. Documentation that was reviewed for all projects selected for the sample included program forms, data bases, reports, billing system data, weather data, and any other potentially useful data. Each application was reviewed to determine whether the following types of information had been provided:

- Documentation for the equipment changed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Documentation for the new equipment installed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information
- Information about the savings calculation methodology, including (1) what methodology was used, (2) specifications of assumptions and sources for these specifications, and (3) correctness of calculations

If there was uncertainty regarding a project, or apparently incomplete project documentation, ADM staff contacted the implementation contractor to seek further information to ensure the development of an appropriate project-specific M&V plan.

4.1.3 On-Site Data Collection Procedures

On-site visits were used to collect data that were used in calculating savings impacts. The visits to the sites of the sampled projects were used to collect primary data on the facilities participating in the program.

When projects were selected for the M&V sample, ADM notified the Companies in two ways:

1) The Companies Customer Service Representatives (CSR) were provided with a list of all sites for which ADM attempted to schedule M&V activities and for which there was a CSR. This list included the company name, the respective CSR for the customer, the site address or other premise identification, as well as the respective contact information for the customer representative ADM intended to contact in order to schedule an appointment.
2) ADM provided the Companies Energy Efficiency and Demand Response EM&V staff with a list of projects for which ADM planned to schedule M&V activities. This notification also served as a request to the implementation contractor for any documentation relating to the projects. This list included the company name, the project ID, the site address or other premise identification, and the respective contact information for the customer representative ADM intended to contact in order to schedule an appointment.

For customers with CSRs, notification was typically provided at least two weeks prior to ADM contacting customers in order to schedule M&V visits. Upon CSR request, ADM coordinated its scheduling and M&V activities with the CSR.

During an on-site visit, the field staff accomplished three major tasks:

- First, they verified the implementation status of all measures for which customers received incentives. They verified that the energy efficiency measures were indeed installed, that they were installed correctly, and that they still functioned properly.
- Second, they collected the physical data needed to analyze the energy savings that have been realized from the installed improvements and measures. Data were collected using a form that was prepared specifically for the project in question after an in-house review of the project file.
- Third, they interviewed the contact personnel at a facility to obtain additional information on the installed system to complement the data collected from other sources.

At some sites, monitoring was conducted to gather more information on the operating hours of the installed measures. Monitoring was conducted at sites where it was judged that the monitored data would be useful for further refinement and higher accuracy of savings calculations. Monitoring was not considered necessary for sites where project documentation allowed for sufficiently detailed calculations.

4.1.4 Procedures for Estimating Savings from Measures

The method ADM employs to determine gross savings impacts depends on the types of measures being analyzed. Categories of measures include the following:

- Lighting
- HVAC
- Motors
- VFDs
- Compressed-Air
- Refrigeration
- Process Improvements
- Kits

ADM uses a specific set of methods to determine gross savings for projects that depend on the type of measure being analyzed. These typical methods are summarized in Table 4-1.

Table 4-1 Typical Methods to Determine Savings for Custom Measures

Type of Measure	*Method to Determine Savings*
Compressed Air Systems	Engineering analysis, with monitored data on load factor and schedule of operation
Lighting	Custom-designed lighting evaluation model, which uses data on wattages before and after installation of measures and hours-of-use data from field monitoring.
HVAC (including packaged units, chillers, cooling towers, controls/EMS)	eQUEST model using DOE-2 as its analytical engine for estimating HVAC loads and calibrated with site-level billing data to establish a benchmark.
Motors and VFDs	Measurements of power and run-time obtained through monitoring
Refrigeration	Simulations with EQuest engineering analysis model, with monitored data
Process Improvements	Engineering analysis, with monitored data on load factor and schedule of operation

The activities specified in Table 4-1 produced two estimates of gross savings for each sample project: an expected gross savings estimate (as reported in the project documentation and program tracking system) and the verified gross savings estimates developed through the M&V procedures employed by ADM. ADM developed estimates of program-level gross savings by applying a ratio estimation procedure in which achieved savings rates estimated for the sample projects were applied to the program-level expected savings. For programs with a census approach, verified gross savings were based on the census.

Energy savings realization rates[3] were calculated for each project for which on-site data collection and engineering analysis/building simulations are conducted. Sites with relatively high or low realization rates were further analyzed to determine the reasons for the discrepancy between expected and realized energy savings.

The following discussion describes the basic procedures used for estimating savings from various measure types.

Plan for Analyzing Savings from Lighting Measures: Lighting measures examined include retrofits of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. These types of measures reduce demand, while not affecting operating hours. Any proposed lighting control strategies are examined that might include the addition of energy conserving control technologies such as motion sensors or

[3] The savings realization rate for a project is calculated as the ratio of the achieved savings (ex post) for the project (as measured and verified through the M&V effort) to the expected savings (ex ante) (as determined through the project application procedure and recorded in the tracking system for the program).

daylighting controls. These measures typically involve a reduction in hours of operation and/or lower current passing through the fixtures.

Analyzing the savings from such lighting measures requires data for retrofitted fixtures on (1) wattages before and after retrofit and (2) hours of operation before and after the retrofit. Fixture wattages are taken from a table of standard wattages, with corrections made for non-operating fixtures. Hours of operation are determined from metered data collected after measure installation for a sample of fixtures.

To determine baseline and post-retrofit demand values for the lighting efficiency measures, ADM uses in-house data on standard wattages of lighting fixtures and ballasts to determine demand values for lighting fixtures. These data provide information on wattages for common lamp and ballast combinations.

As noted, ADM collects data with which to determine average operating hours for retrofitted fixtures by using Time-of-Use (TOU) data loggers to monitor a sample of "last points of control" for unique usage areas in the sites where lighting efficiency measures have been installed. Usage areas are defined to be those areas within a facility that are expected to have comparable average operating hours. For industrial customers, expected usage areas include fabrication areas, clean rooms, office space, hallways/stairways, and storage areas. Typical usage areas are designated in the forms used for data collection.

ADM uses per-fixture baseline demand, retrofit demand, and appropriate post-retrofit operating hours to calculate peak demand savings and annual energy savings for sampled fixtures of each usage type.

The on-off profile and the fixture wattages are used to calculate post-retrofit kWh usage. Fixture peak demand is calculated by dividing the total kWh usage calculated peak period of the day by the number of hours in the peak period.

Peak Period Demand Savings are calculated as the difference between peak period baseline demand and post-installation peak period demand of the affected lighting equipment.

The baseline and post-installation peak period demands are calculated by dividing the total kWh usage during the Peak Period by the number of hours in the peak period.

ADM calculates annual energy savings for each sampled fixture per the following formula:

$$Annual\ Energy\ Savings = kWh_{Before} - kWh_{After}$$

The values for insertion in this formula are determined through the following steps:

1) Results from the monitoring data are used to calculate the average operating hours of the metered lights for every unique building type/usage area. The monitoring data are extrapolated to develop the annual operating profile of the lighting.

2) These average operating hours are then applied to the baseline and post-installation average demand for each usage area to calculate the energy usage and peak period demand for each usage area.

3) The annual baseline energy usage is calculated as the sum of the annual baseline kWh for all of the usage areas. The post-retrofit energy usage is calculated similarly. The energy savings are calculated as the difference between baseline and post-installation energy usage.

4) Savings from lighting measures in conditioned spaces are factored by the region-specific, building type-specific heating cooling interaction factors in order to calculate total savings attributable to lighting measures, inclusive of impacts on HVAC operation. These factors were calculated using DEER prototypical models and Typical Meteorological Year 3 (TMY3) weather data.

Plan for Analyzing Savings from HVAC Measures: Savings estimates for HVAC measures installed at a facility are derived by using the energy use estimates developed through DOE-2 simulations and engineering calculations. The HVAC simulations also allow calculation of the primary and secondary effects of lighting measures on energy usage. Each simulation produces estimates of HVAC energy and demand usage to be expected under different assumptions about equipment and/or construction conditions. There may be cases in which DOE-2 simulation is inappropriate because data are not available to properly calibrate a simulation model, and engineering analysis provides more accurate M&V results.

For the analysis of HVAC measures, the data collected through on-site visits and monitoring are utilized. Using these data, ADM prepares estimates of the energy savings for the energy efficient equipment and measures installed in each of the participant facilities. ADM Engineering staff develop independent estimates of the savings through engineering calculations or through simulations with energy analysis models. By using energy simulations for the analysis, the energy use associated with the end use affected by the measure(s) being analyzed can be quantified. With these quantities in hand, it is a simple matter to determine what the energy use would have been without the measure(s).

Before making the analytical runs for each site with sampled project HVAC measures, engineering staff prepared a model calibration run. This is a base case simulation to ensure that the energy use estimates from the simulations have been reconciled against actual data on the building's energy use. This run is based on the information collected in an on-site visit pertaining to types of equipment, their efficiencies and capacities, and their operating profiles. Current operating schedules are used for this simulation, as are local (TMY) weather data covering the study period. The model calibration run is made using actual weather data for a time period corresponding to the available billing data for the site.

The goal of the model calibration effort is to have the results of the DOE-2 simulation come within approximately 10% of the patterns and magnitude of the energy use observed in the billing data history. In some cases, it may not be possible to achieve this calibration goal because of idiosyncrasies of particular facilities (e.g., multiple buildings, discontinuous occupancy patterns, etc.).

Once the analysis model has been calibrated for a particular facility, ADM performs three steps in calculating estimates of energy savings for HVAC measures installed or to be installed at the facility.

- First, an analysis of energy use at a facility under the assumption that the energy efficiency measures are not installed is performed. If the measure involves replacement of equipment on failure, the required minimum efficiencies given by the appropriate energy efficiency standard would be used. This methodology holds true for all programs/measures being considered.
- Second, energy use at the facility with all conditions the same but with the energy efficiency measures now installed is analyzed.
- Third, the results of the analyses from the preceding steps are compared to determine the energy savings attributable to the energy efficiency measure.

Plan for Analyzing Savings from Motors: Estimates of the energy savings from use of high efficiency motors on HVAC and non-HVAC applications are derived through an "after-only" analysis. With this method, energy use is measured only for the high efficiency motor and only after it has been installed. The data thus collected are then used in estimating what energy use would have been for the motor application *if the high efficiency motor had not been installed.* In effect, the after-only analysis is a reversal of the usual design calculation used to estimate the savings that would result from installing a high efficiency motor. That is, at the design stage, the question addressed is how would energy use change for an application if a high efficiency motor is installed, whereas the after-only analysis addresses what the level of energy use would have been had the high efficiency motor not been installed.

For the “after only” analysis, it is not possible to use a comparison of direct measurements to determine savings, since measured data are collected only for the high efficiency motor. However, savings attributable to installation of the high efficiency motor can be estimated using information on the efficiencies of the high efficiency motor and on the motor it replaced. In particular, demand and energy savings can be calculated as follows:

$$\text{Demand Savings} = kW_{peak} \times (1/Eff_{old} - 1/Eff_{new})$$

where kW_{peak} = Volts x $Amps_{peak}$ x Power Factor, and $Amps_{peak}$ is the interval with the maximum recorded Amps during the monitoring period

$$\text{Energy Savings} = kW_{ave} \times (1/Eff_{old} - 1/Eff_{new}) \times \text{Hours of use}$$

where kW_{ave} = Volts x $Amps_{ave}$ x Power Factor and $Amps_{ave}$ is the average measured Amps for the duration of the monitored period.

Annual Energy Savings = kW_{ave} x ($1/Eff_{old}$ -$1/Eff_{new}$) x (days of operation per year/ days metered) x Annual Adjustment Factor

where kW_{ave} = Volts x $Amps_{ave}$ x Power Factor for the monitoring period
$Amps_{ave}$ = the average measured Amps for the duration of the monitored period, and use factor is determined from interviews with site personnel.

Annual Adjustment Factor is 1 if the monitoring period is typical for the yearly operation, less than 1 if the monitoring period is expected to be higher use than typical for the rest of the year, and more than 1 if the monitoring period is expected to be lower than typical for the rest of the year.[4]

The information on motor efficiencies needed for the calculation of savings is obtained from different sources.

Data on the efficiencies of high efficiency motors installed under the program should be available from program records.

Care must be taken using nameplate efficiency ratings of replaced motors, unless the company maintains good documentation of their equipment. If a motor has been rewound it may not operate as originally rated. However, if the efficiencies of the old motors are not directly available, the efficiency values can be imputed by using published data on average efficiency values for motors of given horsepower. If the motor replacement is for normal replacement, the baseline efficiency is established as the efficiency of a new, standard efficiency motor. However, in cases of early replacement, the efficiency of the old motor is used for the length of the remaining life. [5]

Because most motors monitored run only under full load conditions, some adjustments must be made from the “industry averages” of full load efficiencies. Motor efficiency curves of typical real motors that have the same full load efficiencies are used for determining part load efficiencies.

Like motor efficiency, the power factor varies with motor loading. Motor power factor curves of typical real motors that have the same full load power factor are used for determining part load power factor.

Another factor to consider in demand and energy savings comparisons of motor change out programs is the rotor slip. Full load RPM ratings of motors vary. For centrifugal loads such as fans and pumps, the power supplied is dependent on the speed of the driven equipment. The power is theoretically proportional to the cube of the speed, but in practice acts more like the square of the speed. In general high efficiency motors have slightly higher full load RPM ratings (lower slip) than standard motors. Where nameplate

[4] Current year weather data were compared with the *Typical Meteorological Year* from the National Oceanic & Atmospheric Administration (NOAA).

[5] Assumptions regarding measure expected useful life were taken from the most recent Database for Energy Efficiency Resources (DEER). See http://www.deeresources.com/.

ratings of full load RPM are available for replaced motors, a de-rating factor can be applied.[6]

The data needed to carry out these plans for determining savings are collected from several sources.

- The first source of data is the information from each project's documentation. This information is expected to include aggregate energy used at a site, disaggregated energy usage data for certain targeted processes (if available), before (actual) and after (projected) data on production and other key performance indicators, and final reports (which include process improvement recommendations, analyses, conclusions, performance targets, etc.).
- The second source of data is the energy use data that the Companies collect for these customers.
- The third source is information collected through on-site inspections of the facilities. ADM staff collects the data during on-site visits using a form that is comprehensive in addressing a facility's characteristics, its modes and schedules of operation, and its electrical and mechanical systems. The form also addresses various energy efficiency measures, including high efficiency lighting (both lamps and ballasts), lighting occupancy sensors, lighting dimmers and controls, air conditioning, high efficiency motors, etc.
- As a fourth source of data, selected end-use equipment are monitored to develop information on operating schedules and power draws.

Plan for Analyzing Savings from VFDs: A variable-frequency drive (VFD) is an electronic device that controls the speed of a motor by varying the magnitude of the voltage, current, or frequency of the electric power supplied to the motor. The factors that make a motor load a suitable application for a VFD are (1) variable speed requirements and (2) high annual operating hours. The interplay of these two factors can be summarized by information on the motor's duty cycle, which essentially shows the percentage of time during the year that the motor operates at different speeds. The duty cycle should show good variability in speed requirements, with the motor operating at reduced speed a high percentage of the time.

Potential energy savings from the use of VFDs are usually most significant with variable-torque loads, which have been estimated to account for 50% to 60% of total motor energy use in the non-residential sectors. Energy saving VFDs may be found on fans, centrifugal pumps, centrifugal blowers, and other centrifugal loads, most usually where the duty cycle of the process provided a wide range of speeds of operation.

[6]As an example, take the case where a new motor has a full load RPM rating of 1770 and the old motor had a full load RPM rating of 1760. The derating factor would be:

Derating factor = $(RPM_{old})^2 / (RPM_{new})^2 = 1760^2 / 1770^2 = 0.989$

ADM's approach to determining savings from installation of VFDs involves (1) making one-time measurements of voltage, current, and power factor of the VFD/motor and (2) conducting continuous measurements of amperage over a period of time in order to obtain the data needed to develop VFD load profiles and calculate demand and energy savings. VFDs are generally used in applications where motor loading changes when the motor speed changes. Consequently the true power drawn by a VFD is recorded in order to develop VFD load shapes. One-time measurements of power are made for different percent speed settings. Power and percent speed or frequency (depending on VFD display options) are recorded for as wide a range of speeds as the customer allows the process to be controlled; field staff attempt to obtain readings from 40 to 100% speed in 10 to 15% increments.

Plan for Analyzing Savings from Compressed Air Measures: Measures to improve the efficiency of a compressed air system include the reduction of air leaks, resizing of compressors, installing more efficient compressors, improved controls, or a complete system redesign. Savings from such measures are evaluated through engineering analysis of compressor performance curves, supported by data collected through short-term metering.

ADM field staff obtains nameplate information for the pre-retrofit equipment either from the project file or during the on-site survey. Performance curve data are obtained from manufacturers. Engineering staff then conducts an engineering analysis of the performance characteristics of the pre-retrofit equipment. During the on-site survey, field staff inspects the as-built system equipment, take pressure and load readings, and interview the system operator to identify seasonal variations in load. Potential interactions with other compressors are assessed and it is verified that the rebated compressor is being operated as intended.

When appropriate, short-term measurements are performed to reduce the uncertainty in defining the load on the as-built system. These measurements may be taken either with a multi-channel logger, which can record true power for several compressors, with current loggers, which can provide average amperage values, or with motor loggers to record operating hours. The appropriate metering equipment is selected by taking into account variability in load and the cost of conducting the monitoring.

Plan for Analyzing Savings from Refrigeration and Process Improvements: Analysis of savings from refrigeration and process improvements is inherently project-specific. Because of the specificity of processes, analyzing the processes through simulations is generally not feasible. Rather, reliance is made on engineering analysis of the process affected by the improvements. Major factors in ADM's engineering analysis of process savings are operating schedules and load factors. Information on these factors is developed through short-term monitoring of the affected equipment, be it pumps, heaters, compressors, etc. The monitoring is done after the process change, and the data gathered on operating hours and load factors are used in the engineering analysis to define "before" conditions for the analysis of savings.

Plan for Analyzing Savings from CFL Kit Measures: For this measure, energy savings impacts come from shipped kits containing compact fluorescent light bulbs, smart strip plug outlets, and LED night lights that are mailed directly to participants' facilities. The baseline lighting connected load was determined in accordance with methodology outlined in the Ohio TRM. Energy savings for smart strip plug outlets were determined in accordance with the methodology outlined in the Ohio TRM, while energy savings for LED night lights were determined in accordance with the methodology outlined in the Pennsylvania TRM. The three parameters that are determined from tracking data are the hours of operation, heating cooling interaction factors, and coincidence factors. Hours of operation used in the analysis are determined using Ohio TRM deemed values and building type-specific information found in the program tracking data. Heating cooling interaction factors and coincidence factors are region-specific and building type-specific and were calculated using DEER prototypical models and TMY3 weather data. The ISR is based on methodology outlined in the Ohio TRM; furthermore, the ISR is adjusted to include CFLs anticipated to be installed in the future.

5. Detailed Evaluation Findings

This chapter reports ADM's impact evaluation findings for the Large Equipment, Small Equipment, Large Buildings, Small Buildings, and Government Lighting Programs for 2015 participants.

5.1 Impact Evaluation Findings

This section provides the results of gross savings for the Large Equipment, Small Equipment, Large Buildings, and Small Buildings for 2015 participants. Table 5-1 summarizes the gross savings for each program.

Table 5-1 Gross Savings by Program (2015 Participants)

Program	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
Large Equipment	110,058,593	96,987,290	88%	14,323.55	12,268.70	86%
Small Equipment	89,900,701	77,425,841	86%	12,616.28	11,271.20	89%
Large Buildings	16,368,216	16,294,788	100%	2,107.02	2,001.72	95%
Small Buildings	3,781,057	4,563,797	121%	74.69	59.45	80%
Total	**220,108,567**	**195,271,716**	**89%**	**29,121.54**	**25,601.07**	**88%**

5.1.1 Gross Savings

To estimate gross kWh savings and peak kW reductions for Large Equipment, data were collected and analyzed for a sample of 10 incentive projects. To estimate gross kWh savings and peak kW reductions for Small Equipment, data were collected and analyzed for a sample of 4 incentive projects. To estimate gross kWh savings and peak kW reductions for Large Buildings, data were collected and analyzed for a census of seven projects. The methodology outlined in the Ohio TRM was used to estimate gross kWh savings and peak kW reductions for Small Buildings with baselines adjusted as applicable based on provisions of Ohio Senate Bill 310 legislation. Also, for a sub-set of retro-commissioning projects in the Small Buildings Program, data were collected and analyzed for a census of 14 projects.

The data were analyzed using the methods described in section 4.1 to estimate project energy savings and peak kW reductions and to determine realization rates for the programs. The results of that analysis are reported in this section.

5.1.2 Realized Gross kWh Savings

The gross kWh savings for 2015 participants of the Large Equipment Program are summarized by sampling stratum in Table 5-2. Overall, the achieved gross savings of 96,987,290 kWh were equal to 88% of the expected savings.

The gross kWh savings for 2015 participants of the Small Equipment Program are summarized by sampling stratum in Table 5-3. Overall, the achieved gross savings of 77,425,841 kWh were equal to 86% of the expected savings.

The gross kWh savings for 2015 participants of the Large Buildings Program are summarized by census in Table 5-4. Overall, the achieved gross savings of 16,294,788 were equal to 100 % of the expected savings.

The gross kWh savings for 2015 participants of the Small Buildings Program are summarized by Kit Type in Table 5-5. Overall, the achieved gross savings of 4,563,797 kWh were equal to 121% of the expected savings.

Table 5-2 Expected and Gross Realized kWh Savings for Large Equipment by Sample Stratum (2015 Participants)

Stratum	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
5	39,136,695	38,787,965	99%
4	20,666,380	17,528,122	85%
3	21,767,877	15,591,689	72%
2	16,611,130	14,535,745	88%
1	11,876,511	10,543,769	89%
Total	**110,058,593**	**96,987,290**	**88%**

Table 5-3 Expected and Gross Realized kWh Savings for Small Equipment by Sample Stratum (2015 Participants)

Stratum	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
5	19,847,555	18,438,301	93%
4	27,602,271	25,294,937	92%
3	22,028,223	19,283,361	88%
2	16,284,492	10,601,175	65%
1	4,138,161	3,808,066	92%
Total	**89,900,701**	**77,425,841**	**86%**

Table 5-4 Expected and Gross Realized kWh Savings for Large Buildings (2015 Participants)

Stratum	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
Census	16,368,216	16,294,788	100%
Total	**16,368,216**	**16,294,788**	**100%**

Table 5-5 Expected and Gross Realized kWh Savings for Small Buildings by Kit Type (2015 Participants)

Measure Type	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
Retro-Commissioning	3,580,782	4,384,219	122%
Kit A	189,045	169,980	90%
Kit B	9,910	8,496	86%
Kit C	1,320	1,103	84%

Measure Type	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
Total	**3,781,057**	**4,563,797**	**121%**

Table 5-6 shows the expected and realized energy savings by project for the Large Equipment Program. Table 5-7 shows the expected and realized energy savings by project for the Small Equipment Program. Table 5-8 shows the expected and realized energy savings by project for the Large Buildings Program. Table 5-9 shows the expected and realized energy savings by project for the retro-commissioning sub-set of the Small Buildings Program.

Table 5-6 Expected and Gross Realized kWh Savings for Large Equipment by Project (2015 Participants)

Project ID	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
FOSIPS1530569689	11,098,702	10,906,545	98%
FOSQPS1530153644	4,992,201	5,114,242	102%
FOSIPS1530161380	4,794,047	4,727,845	99%
FOSQPS1530439510	1,211,029	384,323	32%
FOSQPS1530504957	989,973	609,548	62%
FOSQPS1530254592	950,186	623,646	66%
FOSQPS1530672678	272,813	276,196	101%
FOSQPS1530719805	271,752	216,648	80%
FOSQPS1530265962	199,851	153,726	77%
FOSQPS1530297861	129,029	122,810	95%
Non-Sample Projects	**85,149,010**	**73,851,761**	**87%**
Total	**110,058,593**	**96,987,290**	**88%**

Table 5-7 Expected and Gross Realized kWh Savings for Small Equipment by Project (2015 Participants)

Project ID	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
FOSIPS1530705016	1,026,229	1,112,108	108%
FOSIPS1530559854	6,613	5,904	89%
FOSIPS1530659630	3,897	2,486	64%
FOSLPS1530631141	498	515	103%
Non-Sample Projects	**88,863,464**	**76,304,828**	**86%**
Total	**89,900,701**	**77,425,841**	**86%**

Table 5-8 Expected and Gross Realized kWh Savings for Large Buildings by Project (2015 Participants)

Project ID	Expected kWh Savings	Realized Gross kWh Savings	Project Gross Realization Rate
FORCPS1530943700	10,992,664	10,992,664	100%

Project ID	Expected kWh Savings	Realized Gross kWh Savings	Project Gross Realization Rate
FOSQPS1529840231	3,426,607	4,449,050	130%
FOSQPS1530361868	1,055,877	422,816	40%
FOSQPS1530242015	713,403	294,180	41%
FORCPS1530569733	110,149	84,375	77%
FORCPS1530376635	58,507	40,694	70%
FORCPS1529888673	11,009	11,009	100%
Non-Sample Projects	**0**	**0**	**0%**
Total	**16,368,216**	**16,294,788**	**100%**

Table 5-9 Expected and Gross Realized kWh Savings for Small Buildings by Project (2015 Participants)

Project ID	Expected kWh Savings	Realized Gross kWh Savings	Project Gross Realization Rate
FORCPS1530374399	464,846	604,100	130%
FORCPS1530428498	405,561	119,019	29%
FORCPS1530374389	305,596	223,610	73%
FORCPS1530590435	305,112	495,447	162%
FORCPS1530439491	282,145	130,342	46%
FORCPS1530359781	281,899	464,111	165%
FORCPS1530428474	279,468	192,507	69%
FORCPS1530439468	273,394	398,755	146%
FORCPS1530590449	257,458	214,174	83%
FORCPS1530590441	172,076	289,859	168%
FORCPS1530380152	148,056	310,494	210%
FORCPS1530647137	142,852	464,565	325%
FORCPS1530590443	132,769	132,489	100%
FORCPS1530420399	129,550	344,747	266%
Non-Sample Projects	**200,275**	**179,578**	**90%**
Total	**3,781,057**	**4,563,797**	**121%**

Gross realized kWh savings for 2015 participants of the Large Equipment Program are shown by building type in Table 5-10. Among discrete building types, manufacturing facilities account for the largest percentage of incentive gross energy, 74%.

Gross realized kWh savings for the 2015 participants of the Small Equipment Program are shown by building type in Table 5-11. Among discrete building types, Other space type facilities account for the largest percentage of incentive gross energy, 29%.

Gross realized kWh savings for 2015 participants of the Large Buildings Program are shown by building type in Table 5-12. Among discrete building types, manufacturing facilities account for the largest percentage of incentive gross energy, 95%.

Gross realized kWh savings for 2015 participants of the Small Buildings Program are shown by building type in Table 5-13. Among discrete building types, grocery facilities account for the largest percentage of incentive gross energy, 96%.

Table 5-10 Realized Gross kWh Savings by Facility Type for Large Equipment (2015 Participants)

Facility Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Manufacturing	10,826,875	41,442,753	26,599,405	78,869,033	9,525,243	37,733,026	24,620,123	71,878,393	74%	91%
Education	200,453	5,196,044	4,491,867	9,888,363	178,227	4,404,362	3,970,136	8,552,725	9%	86%
Other	1,393,061	2,951,047	3,069,854	7,413,962	1,217,774	2,122,998	2,700,542	6,041,314	6%	81%
Warehouse	1,684,418	1,080,427	264,722	3,029,567	1,228,160	862,770	231,379	2,322,309	2%	77%
Office	2,858,313	890,667	29,173	3,778,153	1,833,604	687,978	25,938	2,547,520	3%	67%
Hospital	1,303,576	3,096,072	239,593	4,639,241	1,147,359	2,493,403	209,560	3,850,323	4%	83%
Grocery	0	1,856,083	22,800	1,878,883	0	1,279,663	20,272	1,299,935	1%	69%
Retail	0	101,680	0	101,680	0	90,406	0	90,406	0%	89%
Lodging	0	0	169,633	169,633	0	0	150,824	150,824	0%	89%
Multi-Family Common Areas	0	0	290,078	290,078	0	0	253,541	253,541	0%	87%
Medical	0	0	0	0	0	0	0	0	0%	0%
Total	**18,266,696**	**56,614,772**	**35,177,125**	**110,058,593**	**15,130,368**	**49,674,606**	**32,182,317**	**96,987,290**	**100%**	**88%**

Table 5-11 Realized Gross kWh Savings by Facility Type for Small Equipment (2015 Participants)

Facility Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Other	8,659,412	12,344,415	5,027,928	26,031,755	7,265,125	10,690,517	4,445,082	22,400,723	29%	86%
Manufacturing	15,131,044	4,903,447	1,312,414	21,346,905	13,499,411	4,388,554	1,114,725	19,002,690	25%	89%
Retail	4,736,016	3,504,562	4,487,265	12,727,843	3,848,146	2,889,204	3,481,043	10,218,393	13%	80%
Grocery	969,409	2,913,481	2,125,736	6,008,626	849,011	2,466,147	2,083,440	5,398,598	7%	90%
Warehouse	2,398,070	1,813,630	2,235,498	6,447,199	2,098,741	1,579,454	1,913,300	5,591,496	7%	87%
Office	1,234,550	3,212,459	240,354	4,687,363	985,526	2,790,143	169,501	3,945,170	5%	84%
Education	411,543	518,584	886,488	1,816,615	344,321	432,424	677,119	1,453,864	2%	80%
Multi-Family Common Areas	2,144,391	43,578	2,453,937	4,641,906	1,898,948	28,369	2,224,352	4,151,669	5%	89%
Food Service	263,414	1,366,255	374,739	2,004,409	184,183	1,155,300	290,951	1,630,434	2%	81%
Lodging	536,519	726,444	640,828	1,903,791	468,581	561,073	542,146	1,571,800	2%	83%
Hospital	401,702	1,729,824	131,302	2,262,828	368,201	1,587,569	85,477	2,041,247	3%	90%
Medical	6,928	0	14,534	21,462	6,377	0	13,379	19,756	0%	92%

Facility Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Total	**36,892,999**	**33,076,680**	**19,931,022**	**89,900,701**	**31,816,572**	**28,568,753**	**17,040,515**	**77,425,841**	**100%**	**86%**

Table 5-12 Realized Gross kWh Savings by Facility Type for Large Buildings (2015 Participants)

Facility Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Manufacturing	0	3,426,607	10,992,664	14,419,271	0	4,449,050	10,992,664	15,441,714	95%	107%
Hospital	0	1,055,877	0	1,055,877	0	422,816	0	422,816	3%	40%
Education	0	713,403	11,009	724,412	0	294,180	11,009	305,189	2%	42%
Other	0	110,149	58,507	168,656	0	84,375	40,694	125,069	1%	74%
Total	**0**	**5,306,036**	**11,062,180**	**16,368,216**	**0**	**5,250,421**	**11,044,367**	**16,294,788**	**100%**	**100%**

Table 5-13 Realized Gross kWh Savings by Facility Type for Small Buildings (2015 Participants)

Facility Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Lodging	7,271	34,039	29,084	70,394	6,396	30,011	25,690	62,097	1%	88%
Office	30,404	50,897	14,542	95,842	26,515	44,302	12,699	83,517	2%	87%
Other	2,478	0	0	2,478	2,246	0	0	2,246	0%	91%
Retail	0	3,635	0	3,635	0	3,823	0	3,823	0%	105%
Warehouse	2,478	0	0	2,478	1,983	0	0	1,983	0%	80%
Grocery	2,455,242	1,125,540	0	3,580,782	3,101,273	1,282,946	0	4,384,219	96%	122%
Education	0	0	3,635	3,635	0	0	2,034	2,034	0%	56%
Manufacturing	0	0	10,906	10,906	0	0	12,592	12,592	0%	115%
Food Service	3,635	3,635	0	7,271	4,020	4,074	0	8,094	0%	111%
Garage	3,635	0	0	3,635	3,191	0	0	3,191	0%	88%
Total	**2,505,143**	**1,217,747**	**58,168**	**3,781,057**	**3,145,625**	**1,365,156**	**53,017**	**4,563,797**	**100%**	**121%**

5.1.3 Realized Gross Peak kW Savings

The realized gross peak kW reductions for 2015 participants of the Large Equipment Program are shown in Table 5-14. The achieved gross peak demand savings for the program are 12,268.70 kW.

The realized gross peak kW reductions for 2015 participants of the Small Equipment Program are shown in Table 5-15. The achieved gross peak demand savings for the program are 11,271.20 kW.

The realized gross peak kW reductions for 2015 participants of the Large Buildings Program are shown in Table 5-16. The achieved gross peak demand savings for the program are 2,001.72 kW.

The realized gross peak kW reductions for 2015 participants of the Small Buildings Program are shown in Table 5-17. The achieved gross peak demand savings for the program are 59.45 kW.

Table 5-14 Expected and Gross Realized Peak kW Savings for Large Equipment (2015 Participants)

Stratum	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
5	5,517.20	4,085.08	74%
4	2,236.14	2,597.42	116%
3	2,719.21	2,068.47	76%
2	2,680.14	2,162.34	81%
1	1,170.87	1,355.40	116%
Total	**14,323.55**	**12,268.70**	**86%**

Table 5-15 Expected and Gross Realized Peak kW Savings for Small Equipment (2015 Participants)

Stratum	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
5	2,498.41	2,557.63	102%
4	3,651.04	3,794.67	104%
3	3,139.84	2,420.72	77%
2	2,735.27	2,020.74	74%
1	591.72	477.44	81%
Total	**12,616.28**	**11,271.20**	**89%**

Table 5-16 Expected and Gross Realized Peak kW Savings for Large Buildings (2015 Participants)

Stratum	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
Census	2,107.02	2,001.72	95%
Total	**2,107.02**	**2,001.72**	**95%**

Table 5-17 Expected and Gross Realized Peak kW Savings for Small Buildings (2015 Participants)

Stratum	Ex Ante Peak kW Savings	Ex Post kWh Savings	Realization Rate
Retro-Commissioning	32.20	17.00	53%
Kit A	40.14	40.20	100%
Kit B	2.08	2.03	98%
Kit C	0.27	0.22	82%

Stratum	Ex Ante Peak kW Savings	Ex Post kWh Savings	Realization Rate
Total	**74.69**	**59.45**	**80%**

5.1.4 Discussion of Gross Savings Analysis

The project realization rates were reviewed to assess whether there were factors that were causing systematic differences in the realization rates. An analysis was conducted to determine whether realization rates for projects differed systematically by expected kWh savings for Large Equipment and Small Equipment Programs.

For Large Equipment, sample project realization rates and expected kWh savings are plotted in Figure 5-1. There is not a strong association between realization rates and expected kWh savings. Figure 5-2 plots the project realized energy savings against the expected energy savings for each sample point.

For Small Equipment, sample project realization rates and expected kWh savings are plotted in Figure 5-3. There is not a strong association between realization rates and expected kWh savings. Figure 5-4 plots the project realized energy savings against the expected energy savings for each sample point.

For Large Buildings, sample project realization rates and expected kWh savings are plotted in Figure 5-5. There is not a strong association between realization rates and expected kWh savings. Figure 5-6 plots the project realized energy savings against the expected energy savings for each sample point.

For Small Buildings, sample project realization rates and expected kWh savings are plotted in Figure 5-7. There is a moderate association between realization rates and expected kWh savings; projects with large expected energy savings had a lower realization rate. Figure 5-8 plots the project realized energy savings against the expected energy savings for each sample point.

Case-by-case examination showed that project-specific factors were more likely to cause realized kWh savings to differ from expected savings. Project-specific factors include type of measure implemented, building type, facility operating schedule, and other parameters that may affect energy efficiency measure savings.

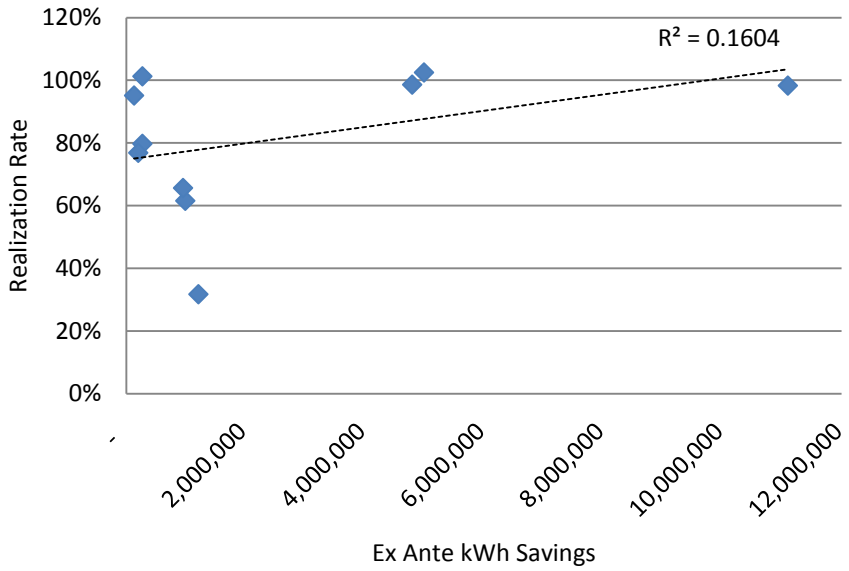

Figure 5-1 Sample Project Realization Rate versus Expected kWh Savings for Large Equipment (2015 Participants)

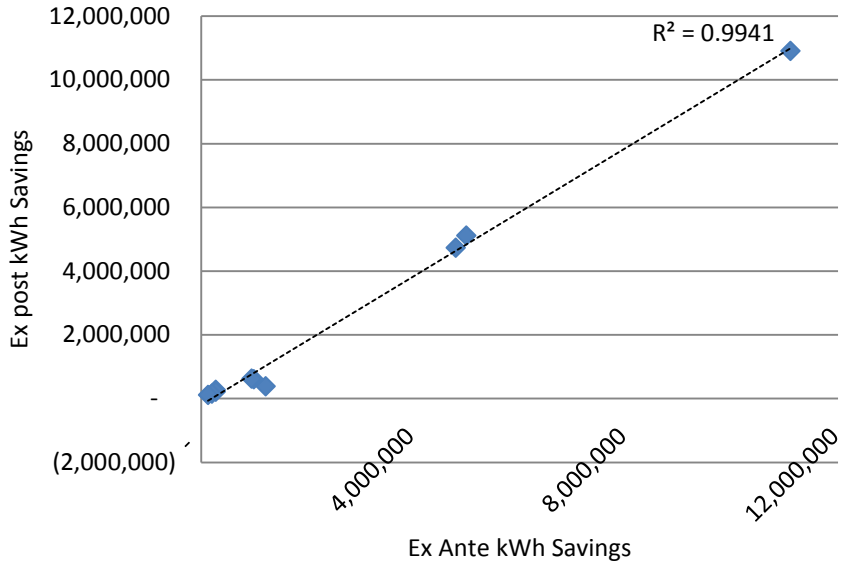

Figure 5-2 Sample Project Realized kWh Savings versus Expected kWh Savings for Large Equipment (2015 Participants)

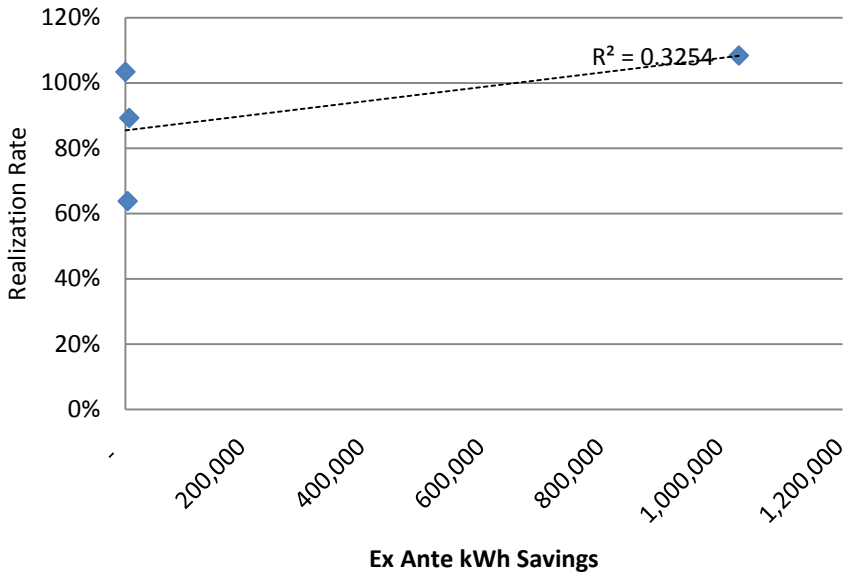

Figure 5-3 Sample Project Realization Rate versus Expected kWh Savings for Small Equipment (2015 Participants)

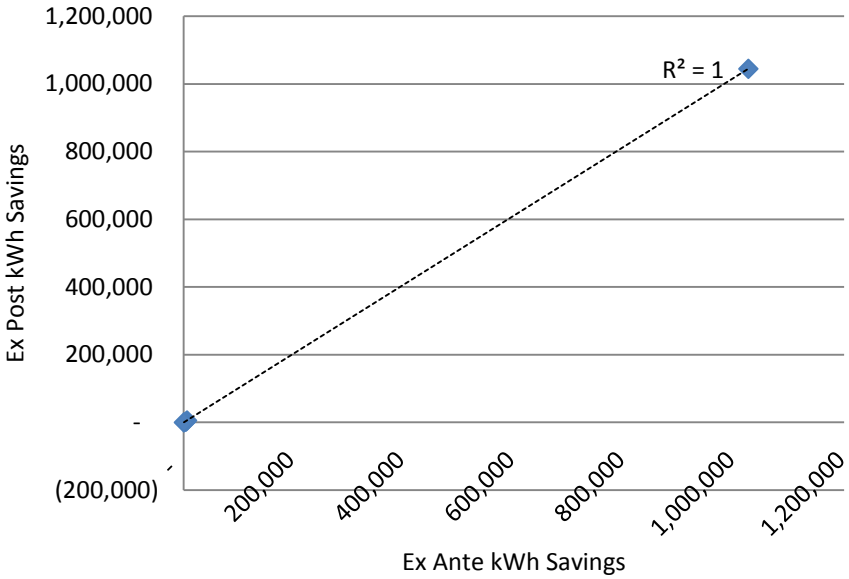

Figure 5-4 Sample Project Realized kWh Savings versus Expected kWh Savings for Large Buildings (2015 Participants)

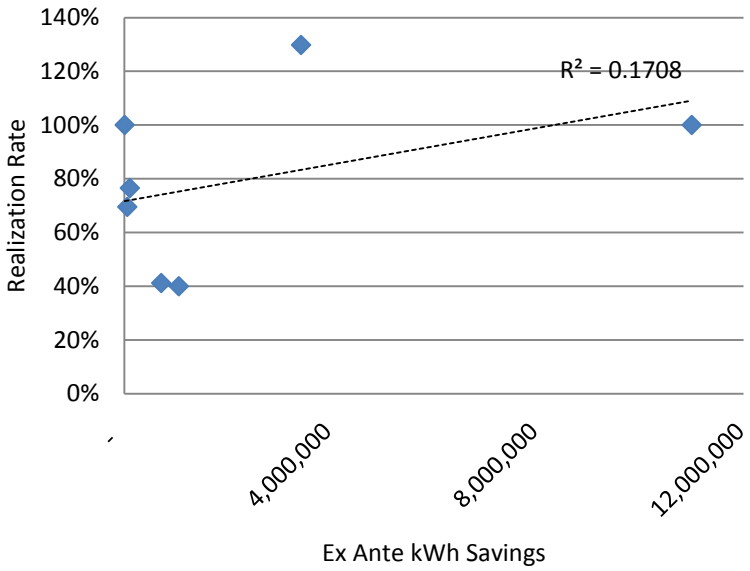

Figure 5-5 Sample Project Realized kWh Savings versus Expected kWh Savings for Large Buildings (2015 Participants)

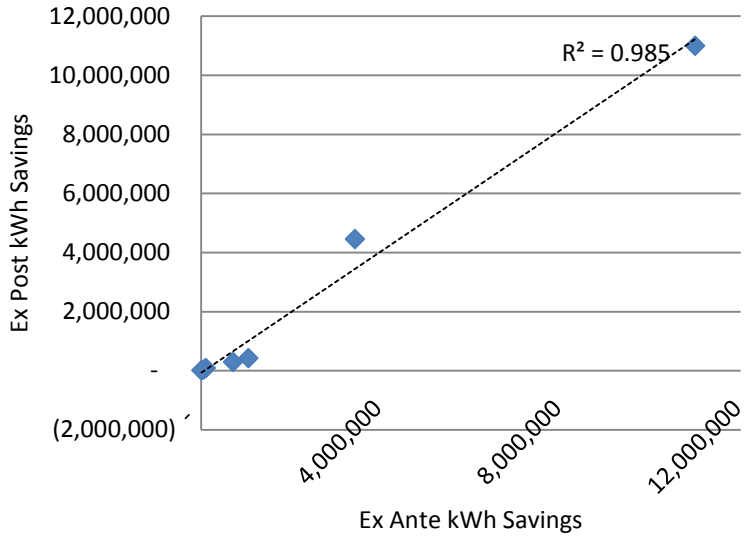

Figure 5-6 Sample Project Realized kWh Savings versus Expected kWh Savings for Census Sub-Set of Small Buildings (2015 Participants)

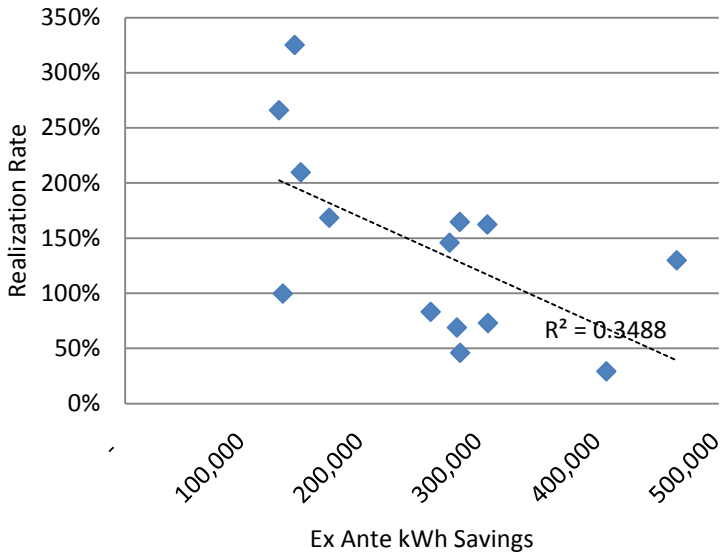

Figure 5-7 Sample Project Realized kWh Savings versus Expected kWh Savings for Census Sub-Set of Small Buildings (2015 Participants)

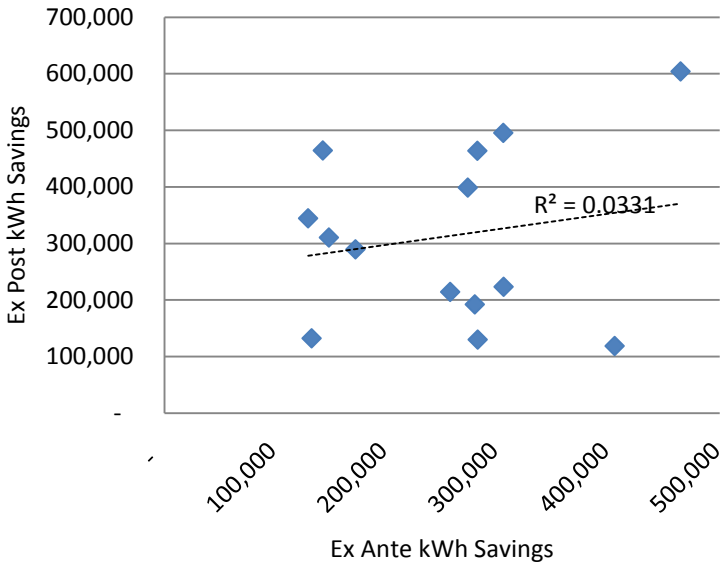

Figure 5-8 Sample Project Realized kWh Savings versus Expected kWh Savings for Small Equipment

The gross savings by measure type and company for the Large Equipment Program are summarized in Table 5-18. Non-standard lighting accounts for most (62%) of the ex post kWh savings.

The gross savings by measure type and company for the Small Equipment Program are summarized in Table 5-19. Non-standard lighting accounts for most (90%) of the ex post kWh savings.

The gross savings by measure type and company for the Large Buildings Program are summarized in Table 5-20. Retro-commissioning accounts for most (73%) of the ex post kWh savings.

Table 5-18 Realized kWh Savings by Measure Type and Company for Large Equipment (2015 Participants)

Measure Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Custom Equipment	6,844,207	23,373,454	10,903,591	41,121,252	5,292,662	20,904,882	10,043,174	36,240,718	37%	88%
HVAC	594,725	412	0	595,136	521,232	366	0	521,598	1%	88%
Lighting	10,827,764	33,240,907	24,273,534	68,342,205	9,316,474	28,769,357	22,139,143	60,224,974	62%	88%
Total	**18,266,696**	**56,614,772**	**35,177,125**	**110,058,593**	**15,130,368**	**49,674,606**	**32,182,317**	**96,987,290**	**100%**	**88%**

Table 5-19 Realized kWh Savings by Measure Type and Company Small Equipment (2015 Participants)

Measure Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Appliances	7,696	16,752	1,376	25,824	7,084	15,421	1,267	23,772	0%	92%
Custom Equipment	3,678,967	2,647,768	2,151,433	8,478,169	3,297,605	2,390,627	1,898,527	7,586,760	10%	89%
Food Service	24,377	157,666	0	182,043	22,440	131,364	0	153,804	0%	84%
HVAC	64,662	50,147	25,134	139,943	50,990	38,244	23,137	112,371	0%	80%
Lighting	33,117,297	30,204,347	17,753,078	81,074,723	28,438,453	25,993,097	15,117,585	69,549,134	90%	86%
Total	**36,892,999**	**33,076,680**	**19,931,022**	**89,900,701**	**31,816,572**	**28,568,753**	**17,040,515**	**77,425,841**	**100%**	**86%**

Table 5-20 Realized kWh Savings by Measure Type and Company Large Buildings (2015 Participants)

Measure Type	Ex Ante kWh Savings				Ex Post kWh Savings				Percent of Total Ex Post kWh Savings	Realization Rate
	CEI	OE	TE	Total Companies	CEI	OE	TE	Total Companies		
Custom Equipment	0	3,426,607	0	3,426,607	0	4,449,050	0	4,449,050	27%	130%
Retro-commissioning	0	1,879,429	11,062,180	12,941,609	0	801,371	11,044,367	11,845,738	73%	92%
Total	**0**	**5,306,036**	**11,062,180**	**16,368,216**	**0**	**5,250,421**	**11,044,367**	**16,294,788**	**100%**	**100%**

6. Summary and Conclusions

Table 6-1 summarizes the gross savings for each program. The C/I Programs achieved an overall realization rate of 88%. Prior to suspension, the program continued to run effectively to process remaining 2015 participants.

Table 6-1 Gross Savings by Program (2015 Participants)

Program	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
Large Equipment	110,058,593	96,987,290	88%	14,323.55	12,268.70	86%
Small Equipment	89,900,701	77,425,841	86%	12,616.28	11,271.20	89%
Large Buildings	16,368,216	16,294,788	100%	2,107.02	2,001.72	95%
Small Buildings	3,781,057	4,563,797	121%	74.69	59.45	80%
Total	**220,108,567**	**195,271,716**	**89%**	**29,121.54**	**25,601.07**	**88%**

Appendix A: Required Savings Tables

This appendix contains gross kWh savings, and peak demand savings for Large Equipment, Small Equipment, Large Buildings, and Small Buildings.

Table A-1 Gross Savings by Program (2015 Participants)

Program	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
Large Equipment	110,058,593	96,987,290	88%	14,323.55	12,268.70	86%
Small Equipment	89,900,701	77,425,841	86%	12,616.28	11,271.20	89%
Large Buildings	16,368,216	16,294,788	100%	2,107.02	2,001.72	95%
Small Buildings	3,781,057	4,563,797	121%	74.69	59.45	80%
Total	**220,108,567**	**195,271,716**	**89%**	**29,121.54**	**25,601.07**	**88%**

Table A-2 Summary of kWh Savings for Large Equipment (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	18,266,696	15,130,368	83%
OE	56,614,772	49,674,606	88%
TE	35,177,125	32,182,317	91%
Total Companies	**110,058,593**	**96,987,290**	**88%**

Table A-3 Summary of Peak kW Savings for Large Equipment (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	2,478.13	2,235.36	90%
OE	7,849.32	6,018.26	77%
TE	3,996.11	4,015.07	100%
Total Companies	**14,323.55**	**12,268.70**	**86%**

Table A-4 Summary of Lifetime kWh Savings for Large Equipment (2015 Participants)

Operating Company	Lifetime Ex Post kWh Savings
CEI	226,955,513
OE	745,119,088
TE	482,734,750
Total Companies	**1,454,809,350**

Table A-5 Summary of kWh Savings for Small Equipment (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	36,892,999	31,816,572	86%
OE	33,076,680	28,568,753	86%
TE	19,931,022	17,040,515	85%

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
Total Companies	**89,900,701**	**77,425,841**	**86%**

Table A-6 Summary of Peak kW Savings for Small Equipment (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	5,297.93	4,761.94	90%
OE	4,914.40	4,403.57	90%
TE	2,403.95	2,105.69	88%
Total Companies	**12,616.28**	**11,271.20**	**89%**

Table A-7 Summary of Lifetime kWh Savings for Small Equipment (2015 Participants)

Operating Company	Lifetime Ex Post kWh Savings
CEI	477,248,586
OE	428,531,295
TE	255,607,731
Total Companies	**1,161,387,611**

Table A-8 Summary of kWh Savings for Large Buildings (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
OE	5,306,036	5,250,421	99%
TE	11,062,180	11,044,367	100%
Total Companies	**16,368,216**	**16,294,788**	**100%**

Table A-9 Summary of Peak kW Savings for Large Buildings (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
OE	653.00	583.72	89%
TE	1,454.02	1,418.00	98%
Total Companies	**2,107.02**	**2,001.72**	**95%**

Table A-10 Summary of Lifetime kWh Savings for Large Buildings (2015 Participants)

Operating Company	Lifetime Ex Post kWh Savings
OE	26,252,105
TE	55,221,835
Total Companies	**81,473,940**

Table A-11 Summary of kWh Savings for Small Buildings (2015 Participants)

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	2,505,143	3,145,625	126%
OE	1,217,747	1,365,156	112%
TE	58,168	53,017	91%
Total Companies	**3,781,057**	**4,563,797**	**121%**

Table A-12 Summary of Peak kW Savings for Small Buildings (2015 Participants)

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	10.57	10.69	101%
OE	51.77	36.68	71%
TE	12.35	12.08	98%
Total Companies	**74.69**	**59.45**	**80%**

Table A-13 Summary of Lifetime kWh Savings for Small Buildings (2015 Participants)

Operating Company	Lifetime Ex Post kWh Savings
CEI	12,435,892
OE	5,922,761
TE	186,137
Total Companies	**18,544,790**