2016 Evaluation of Mercantile Customer Program Evaluation Report

Prepared for the FirstEnergy Ohio Companies:

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1. Executive Summary

The Ohio operating companies, The Cleveland Electric Illuminating Company (“CEI”), Ohio Edison Company (“OE”), and The Toledo Edison Company (“TE”) (collectively “Companies”), continued the Mercantile Customer Program during 2016. This report presents the results of the impact and process evaluations of the Mercantile Customer Program activity occurring during 2016.

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, participating customers and contractors. Based on data provided by the Companies 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. Table 1-1 shows the sample size employed for this study.
- 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 these sites, energy efficient equipment was monitored in order to obtain accurate information on equipment operating characteristics. The 11 projects, for which on-site measurements and verification data were collected, account for approximately 51% of the expected kWh savings.

Table 1-1 Sample Sizes for Data Collection Efforts

Type of Data Collected	Sample Size
On-Site Measurement and Verification	11

Gross savings were estimated using proven techniques, including industry standard engineering calculations and verification of computer simulations developed to determine energy savings.

The realized energy savings of the 2016 Mercantile Customer Program from the three service territories are summarized in Table 1-2. For the entire program, the realized gross energy savings totaled 9,854,715 kWh. The gross realization rate for program kWh savings is 119%.

Table 1-2. Summary of kWh Savings for Mercantile Customer Program

Operating Company	Rate Code	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	CE-GP	1,718,783	2,765,111	161%
	CE-GS	2,712,233	3,103,423	114%
Total		**4,431,016**	**5,868,534**	**132%**
OE	OE-GS	3,828,330	3,986,181	104%
Total		**3,828,330**	**3,986,181**	**104%**
TE	N/A.	0	0	N/A.
Total		**0**	**0**	**N/A.**
Grand Total		**8,259,346**	**9,854,715**	**119%**

The realized gross peak kW reductions of the 2016 Mercantile Customer Program from the three service territories are summarized in Table 1-3. The achieved peak demand savings for the program are 2,251.96 kW. The gross realization rate for program peak kW savings is 1511%.

Table 1-3. Summary of Peak kW Savings for Mercantile Customer Program

Operating Company	Rate Code	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	CE-GP	11.00	331.57	3014%
	CE-GS	95.00	1,685.07	1774%
Total		**106.00**	**2,016.64**	**1902%**
OE	OE-GS	43.00	235.31	547%
Total		**43.00**	**235.31**	**317%**
TE	N/A.	0.00	0.00	N/A.
Total		**0.00**	**0.00**	**N/A.**
Grand Total		**149.00**	**2,251.96**	**1511%**

2. Introduction and Purpose of Study

This report presents the results of the impact and process evaluations of the Mercantile Customer Program for activity during the 2016 program year.

2.1 Overview of Evaluation Approach

The overall objective for the impact evaluation of the Mercantile Customer Program was to verify the gross energy savings and peak demand (kW) reduction resulting from participation in the program during the 2016 program year.

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

- Available documentation (e.g., audit reports, savings calculation work papers, etc.) was reviewed for a sample 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.
- 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 custom measures or relatively more complex measures, ADM estimated savings using IPMVP[1] Option C: Whole facility analysis methodology.

[1] International Performance, Measurement, and Verification Protocol. "Concepts and Options for Determining Energy and Water Savings", Volume 1. January 2012.

3. Description of Program

Since 2009, the Companies have implemented the Mercantile Customer Program in Ohio.

On July 17, 2013 the Public Utilities Commission of Ohio ordered that the Mercantile Pilot Program be permanently adopted, explaining that the Pilot for mercantile customers has fulfilled its goal of developing a simplified application filing and approval process.

To be eligible to participate in the Mercantile Customer Program, a customer had to be a "mercantile customer" as defined in R.C. § 4928.01 (A) (19). According to this definition, a mercantile customer is a commercial or industrial customer who meets either of two criteria:

- Consumes more than 700,000 kWh per year; or
- Is part of a national account involving multiple facilities in one or more states.

The Mercantile Customer Program is targeted at mercantile customers that have implemented projects in the last 3 calendar years that resulted in energy efficiency and/or peak demand reductions.

Under Rule 4901:1-39-05(F), Ohio Administrative Code (O.A.C.), a mercantile customer is allowed to file with the Public Utilities Commission of Ohio (PUCO), either individually or jointly with an electric utility, an application to commit the customer's existing demand reduction, demand response, and energy efficiency programs for integration with the electric utility's programs.

For the 2016 program year, mercantile customers who participated in the program received an exemption from the Demand Side Energy Efficiency (DSE2) Rider established by SB 221, for a specified period of time.

To be eligible for an exemption, a customer was required to provide sufficient data to illustrate that the customer installed self-directed energy efficiency and/or demand reduction technologies that produced energy savings and/or peak demand savings.

Calculations for exemption from the DSE2 rider are made on a site-by-site basis, where a site is defined as a location with one or more facilities located on one or more parcels of land, provided that the parcels are contiguous (e.g., a plant, hospital complex, or university located on one or more contiguous parcels of land would qualify as a site). This is the Companies' definition and is not determined by Commission rules.

Although all accounts related to a given site were eligible for exemption, the exemption was applied only to those accounts identified by a customer on the Joint Application it files with the Company to the PUCO. Aggregate savings from projects on the site were compared to the aggregate baseline of all accounts included in the application to determine if the site met the eligibility requirement.

Several criteria were used to determine energy efficiency project incentive levels under the Mercantile Customer Program.

- Regardless of whether a customer replaces equipment before its end of life or upon equipment failure, efficiency savings were eligible for counting against the FE Ohio Company targets as measured against the as-found equipment. However, in the case of replacement on failure, for the purposes of calculating savings that are eligible for an incentive, the energy savings calculation must use the standard as the baseline, not the as-found condition.
- If a customer replaced equipment at end of life with standard equipment, projects were not eligible for an incentive; however, utilities may count the savings as compared to as-found towards compliance goals, and the customer is eligible for a Commitment Payment.[2]
- Behavioral modifications, or operational improvements could have qualified for incentives, but only if an investment was made on the customer's part and if the savings are measurable and verifiable. If there was no investment, the customer was not eligible for an incentive; however, utilities may count measureable and verifiable savings towards compliance goals, regardless of customer incentive level.
- Even though a customer may not receive an incentive for a behavioral modification or a replacement on failure to standard, they may receive instead a commitment payment so that utilities may commit those savings towards compliance.

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

The expected gross savings by utility are shown in Table 3-1. There were 32 dockets in the program which were expected to provide savings of 8,259,346 kWh. Figure 3-1 shows the program’s ex post kWh savings by date of implementation.

Table 3-1 Ex Ante Annual Energy Savings of the Mercantile Customer Program

Operating Company	Ex Ante kWh Savings
CEI	4,431,016
OE	3,828,330
TE	0
Total Companies	**8,259,346**

[2] The commitment payment is not an incentive but rather intended to offset the administrative costs of filing an applications. Case No. 10-834-EL-POR, September 15, 2010 Entry.

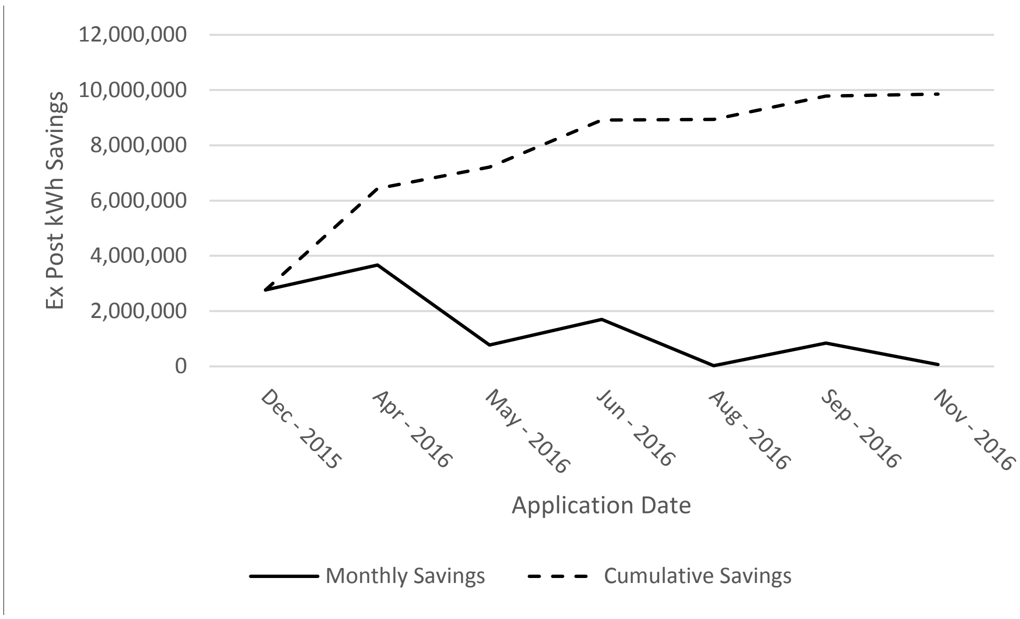

Figure 3-1. Mercantile Customer Program Realized Savings by Implementation Date

4. Methodology

ADM's evaluation of the 2016 Mercantile Customer Program consisted of both an impact evaluation and a process evaluation. The impact methodology is described in section 4.1 and the process evaluation is described in section 4.2 of this chapter.

4.1 Impact Evaluation Methodology

The methodology used for estimating gross savings is described in this section.

4.1.1 Sampling Plan

Data used to estimate the gross savings achieved through the Mercantile Customer Program were collected for samples of projects completed during the 2016 program year. Data provided by the Companies program staff showed that during 2016, there were 32 dockets associated with the program, which were expected to provide savings of 8,259,346 kWh annually.

Inspection of the data on kWh savings for individual projects, provided by the Company program staff, 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. 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 the sample, the actual precision is ±7.54%.

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.

Table 4-1 presents the number of projects and expected energy savings of the sampled projects by stratum.

Table 4-1 Population Statistics Used for Sample Design for Mercantile Customer Program.

	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Stratum 5	Totals
Strata boundaries (kWh)	< 92,037	92,038 – 220,186	220,187 – 288,533	288,534 – 809,284	809,285 – 1,718,783	
Number of projects	9	9	3	10	1	32
Total kWh savings	484,228	1,436,802	720,114	3,899,419	1,718,783	8,259,346
Average kWh Savings	53,803	159,645	240,038	389,942	1,718,783	258,105
Standard deviation of kWh savings	25,787	36,118	11,853	90,206	N/A.	303,769
Coefficient of variation	0.48	0.23	0.05	0.23	N/A.	1.1769222
Final design sample	2	2	1	5	1	11

As shown in Table 4-2, the sample projects account for approximately 51% of the expected kWh savings.

Table 4-2.Expected kWh Savings for Sampled Projects by Stratum

Stratum	Ex Ante kWh Savings (Population)	Ex Ante kWh Savings (Sample)	Percent of Ex Ante Peak kWh Savings in Sample
5	1,718,783	1,718,783	100%
4	3,899,419	1,925,272	49%
3	720,114	248,417	34%
2	1,436,802	279,181	19%
1	484,228	72,957	15%
Total	**8,259,346**	**4,244,610**	**51%**

As shown in Table 4-3, the sample projects account for approximately 24% of the expected peak kW savings.

Table 4-3 Expected Peak Demand kW Savings for Sampled Projects by Stratum

Stratum	Ex Ante Peak kW Savings (Population)	Ex Ante Peak kW Savings (Sample)	Percent of Ex Ante Peak kW Savings in Sample
5	11.00	11.00	100%
4	34.00	5.00	15%
3	0.00	0.00	N/A.
2	29.00	11.00	38%
1	75.00	9.00	12%
Total	**149.00**	**36.00**	**24%**

4.1.2 Review of Documentation

After the sample of projects was selected, the Companies' program staff provided documentation pertaining to the 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, etc.) 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 Company program staff 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 completed to collect data that were used in calculating savings impacts. The visits to the sites of the sampled projects collected 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) Customer Service Representatives (CSR), which were assigned to sites, were provided with a list of all sites for which ADM attempted to schedule M&V activities. This list includes 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 for any documentation relating to the projects. This list included the company name, the PUCO docket, 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.

Typically, for customers with CSRs, notification was 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 the on-site visits, the ADM 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 Installed through the Mercantile Customer Program

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

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 4-4.

Table 4-4 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 produced two estimates of gross savings for each sample project: an expected gross savings estimate (as provided by the customer) 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.

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

[3]The savings realization rate for a project is calculated as the ratio of the achieved savings for the project (ex post) (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).

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. Peak fixture demand is calculated by dividing the total fixture kWh usage during the Companies’ peak period 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, per the following formula:

$$\text{Peak Demand Savings} = kW_{\text{Before}} - KW_{\text{After}}$$

The baseline and post-installation average 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:

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

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

1) Results from the monitored sample are used to calculate the average operating hours of the metered lights in each costing period for every unique building type/usage area.
2) These average operating hours are then applied to the baseline and post-installation average demand for each usage area to calculate the respective energy usage and peak period demand for each usage area.

3) The annual baseline energy usage is the sum of the baseline kWh consumption in 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 region-specific and building type-specific heating cooling interaction factors, allowing for the calculation of total savings attributable to lighting measures, inclusive of impacts on HVAC operation.

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. 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. 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 prepare 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.
- 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 an 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:

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

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.

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

where kW_{ave} = Volts x $Amps_{ave}$ x Power Factor for the monitoring period, $Amps_{ave}$ is 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. Based on rules established under the Commission's Mercantile Pilot Program, Docket No. 10-834-EL-EEC, utilities may count equipment of failure to as-found conditions.

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 ratings of full load RPM are available for replaced motors, a derating factor can be applied.[5]

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, scrap, and other key performance indicators, and

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

[5] 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:

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

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.

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 as 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 conduct 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 Whole Facility Energy and Water Process Improvements: In cases where a measure's impact may be "visible in the bills", ADM investigates using an IPMVP[6] Option C: Whole Facility analysis methodology. The general format used is a monthly pre/post-implementation billing data regression, which compares site-specific weather data and/or other impactful variables (e.g. production data) against monthly billing data to determine how energy consumption of the facility varies with these variables and the implemented measure. In order to perform the billing regression, several pieces of information are usually ascertained:

- Details about the electric metering arrangement at a facility, to determine which meter(s) are impacted by the measure, and other loads involved.

[6] International Performance, Measurement, and Verification Protocol. "Concepts and Options for Determining Energy and Water Savings", Volume 1. January 2012.

- Time period affected by measure implementation.
- Whether or not any other energy projects or changes to facility operation affecting energy usage were implemented in or around the timeframe of the rebated measure. If so, adjustments may be made, or in some cases, the regression is not feasible.

4.2 Process Evaluation Methodology

A process evaluation of the Mercantile Program was not completed for 2016 because of limited program participation. Under the requirements of SB 310, customers no longer needed to commit savings to the Mercantile Customer program for a temporary exemption from the Demand Side Energy Efficiency (DSE2) Rider. Additionally, the program suspended the provision of cash incentives. These changes lead to a large reduction in program activity.

5. Detailed Evaluation Findings

This chapter reports ADM's impact evaluation findings for the 2016 Mercantile Customer Program.

5.1 Impact Evaluation Findings

This section provides the results of gross savings for the Mercantile Customer Program during the 2016 Program year.

5.1.1 Realized Gross kWh Savings

The gross kWh savings of the 2016 Mercantile Customer Program are summarized by sampling stratum in Table 5-1. Overall, the achieved gross savings of 9,854,715 kWh were equal to 119% of the expected savings. Table 5-2 shows the expected and realized energy savings by project. Table 5-3 provides a description of realization rate causes for dockets with less-than-expected energy savings.

Table 5-1.Expected and Gross Realized kWh Savings for Mercantile Customer Program by Sample Stratum

Stratum	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
5	1,718,783	2,765,111	161%
4	3,899,419	3,497,949	90%
3	720,114	632,115	88%
2	1,436,802	2,419,354	168%
1	484,228	540,186	112%
Total	**8,259,346**	**9,854,715**	**119%**

Table 5-2.Expected and Gross Realized kWh Savings for the Mercantile Customer Program

PUCO Docket ID	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
16-0285	1,718,783	2,765,111	161%
16-0077	14,030	16,842	120%
16-0084	92,801	139,734	151%
16-0085	58,927	64,546	110%
16-0094	248,417	218,060	88%
16-0096	365,692	561,252	153%
16-0098	465,279	449,904	97%
16-0100	186,380	330,364	177%
16-0103	320,937	278,644	87%
16-0107	303,458	416,401	137%
16-0104	469,906	20,852	4%

PUCO Docket ID	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
Non-Sample Dockets	**4,014,736**	**4,593,005**	**114%**
Total	**8,259,346**	**9,854,715**	**119%**

5.1.2 Realized Gross Peak kW Savings

The realized gross peak kW reductions of the 2016 Mercantile Customer Program are shown in Table 5-3. The achieved gross peak demand savings for the program are 2,251.96 kW which is equal to 1511% of expected savings.

Table 5-3. Expected and Gross Realized Peak kW Savings for the Mercantile Customer Program

Stratum	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
5	11.00	331.57	3014%
4	34.00	1,597.12	4697%
3	0.00	29.65	N/A.
2	29.00	166.54	574%
1	75.00	127.08	169%
Total	**149.00**	**2,251.96**	1511%

5.1.3 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.

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.

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.

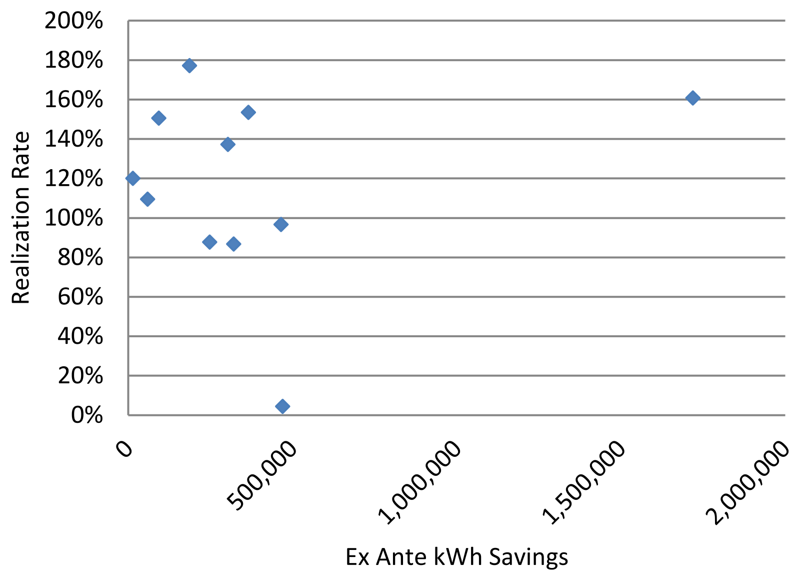

Figure 5-1. Sample Project Realization Rate versus Expected kWh Savings for the Mercantile Customer Program

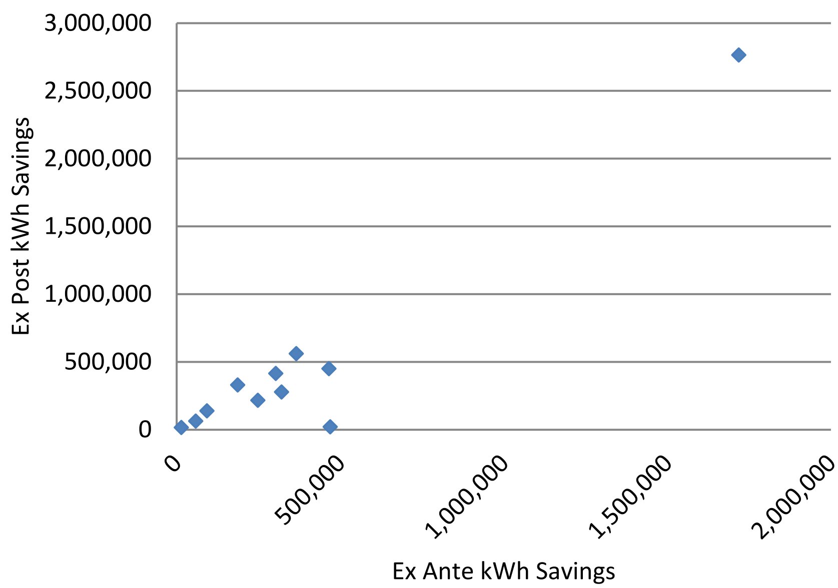

Figure 5-2 Sample Project Ex Post kWh Savings versus Ex Ante kWh Savings for the Mercantile Customer Program

6. Summary

Table 6-1 summarizes the gross savings for each program. The Mercantile Program achieved an overall realization rate of 119%.

Table 6-1. Summary of kWh Savings for Mercantile Customer Program

Operating Company	Rate Code	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	CE-GP	1,718,783	2,765,111	161%
	CE-GS	2,712,233	3,103,423	114%
Total		**4,431,016**	**5,868,534**	**132%**
OE	OE-GS	3,828,330	3,986,181	104%
Total		**3,828,330**	**3,986,181**	**104%**
TE		0	0	N/A.
Total		**0**	**0**	**N/A.**
Grand Total		**8,259,346**	**9,854,715**	**119%**

Appendix A: Required Savings Tables

This appendix contains annualized gross kWh savings, peak demand reductions, and lifetime savings for the Mercantile Customer Program.

Table A-1. Summary of kWh Savings for Mercantile Customer Program

Operating Company	Ex Ante kWh Savings	Ex Post kWh Savings	Realization Rate
CEI	4,431,016	5,868,534	132%
OE	3,828,330	3,986,181	104%
TE	0	0	N/A.
Total Companies	**8,259,346**	**9,854,715**	**119%**

Table A-2. Summary of Peak kW Savings for Mercantile Customer Program

Operating Company	Ex Ante Peak kW Savings	Ex Post Peak kW Savings	Realization Rate
CEI	106.00	2,016.64	1902%
OE	43.00	235.31	317%
TE	0.00	0.00	N/A.
Total Companies	**149.00**	**2,251.96**	**1511%**

Table A-3 Summary of Lifetime kWh Savings for Mercantile Customer Program

Operating Company	Lifetime Ex Post kWh Savings
CEI	88,028,016
OE	59,792,710
TE	0
Total Companies	**147,820,726**