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**BEFORE**

**THE PUBLIC UTILITIES COMMISSION OF OHIO**

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|---|---|---|
| In the Matter of the Annual Energy<br>Efficiency Portfolio Status Report of<br>Duke Energy Ohio, Inc. | )<br>)<br>) | Case No. 13-1129-EL-EEC |

# ANNUAL ENERGY EFFICIENCY STATUS REPORT

# OF DUKE ENERGY OHIO, INC.

# VOLUME 1 OF 3

**BEFORE**

**THE PUBLIC UTILITIES COMMISSION OF OHIO**

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| Duke Energy Ohio, Inc. | ) | |

# ANNUAL ENERGY EFFICIENCY STATUS REPORT OF DUKE ENERGY OHIO, INC.

## I. Introduction

Pursuant to Rule 4901:1-39-05, Ohio Administrative Code (OAC)., Duke Energy Ohio, Inc. (Duke Energy Ohio or Company) must file an annual status report by May fifteenth each year. The annual status report must contain a section on compliance which includes an update to the benchmark report, an assessment of program performance, and an independent program evaluator report. Following is Duke Energy Ohio's submission demonstrating its compliance with the State's energy mandates for 2012.

## II. Fourth Annual Energy Efficiency Portfolio Status Report

This portfolio status report represents the Company's fourth filing of a status report on the load impacts achieved through implementation of its energy efficiency and demand response programs pursuant to Rule 4901:1-39-05 (C), O.A.C. This report is composed of the following two sections: (1) Compliance Demonstration which provides information on load impact achievements relative to the baseline and (2) Program Performance Assessment which summarizes program activities and evaluation, measurement, and verification information.

**4901:1-39-05 (A) and (B) Initial Benchmark Report**

Pursuant to Rule 4901:1-39-05 (A), O.A.C., Duke Energy Ohio must file the following information in a benchmark report:

(1) The energy and demand baselines for kilowatt-hour sales and kilowatt demand for the reporting year; including a description of the method of calculating the baseline, with supporting data.

(2) The applicable statutory benchmarks for energy savings and electric utility peak-demand reduction.

In compliance with 4901:1-39-05(B), in preparing the baseline, Duke Energy Ohio is required to adjust the sales and/or demand baseline for normal weather as well as for changes in numbers of customers, sales, and peak demand to the extent such changes are outside its control.

This benchmark update report provides information on two areas. The first area involves the baseline for 2012, including a discussion of adjustments made to normalize for weather and to adjust for changes in numbers of customers, sales, and peak demand, where those changes are outside the control of Duke Energy Ohio. The second area involves an estimate of the statutory benchmarks for energy savings and electric utility peak-demand reduction.

In estimating the baseline for Duke Energy Ohio for the year 2012, the Company uses the three-year average of the actual level of total energy sold (sales plus losses) and peak demand, adjusted for differences from normal weather. Table 1 provides the historical level of total energy (kWh) for the years 2006 to 2011, the amount of the weather adjustment, and the weather normalized level of total energy.

Table 1 - Duke Energy Ohio Baseline and Benchmark for 2012

| Year | Total Energy (MWh) | Weather Normalization Adjustment (MWh) | Weather Normal Level of Total Energy (MWh) | Baseline: Three Year Average (MWh) | Benchmark Percentage | Benchmark Requirement (MWh) |
|---|---|---|---|---|---|---|
| 2006 | 22,402,660 | 262,896 | 22,665,556 | | | |
| 2007 | 23,510,777 | (763,963) | 22,746,814 | | | |
| 2008 | 22,321,489 | (72,401) | 22,249,088 | | | |
| 2009 | 20,405,122 | 320,494 | 20,725,616 | 22,553,819 | 0.3% | 67,661 |
| 2010 | 22,545,823 | (621,454) | 21,924,369 | 21,907,173 | 0.5% | 109,536 |
| 2011 | 20,238,172 | (207,407) | 20,030,765 | 21,633,024 | 0.7% | 151,431 |
| **2012** | | | | **20,893,583** | **0.8%** | **167,149** |

| Year | Peak Demand (MW) | Weather Normalization Adjustment (MW) | Weather Normal Level of Peak Demand (MW) | Baseline: Three Year Average (MW) | Cumulative Benchmark Percentage | Cumulative Benchmark Requirement (MW) | Incremental Benchmark Percentage | Incremental Benchmark Requirement (MW) |
|---|---|---|---|---|---|---|---|---|
| 2006 | 4,520 | 71 | 4,591 | | | | | |
| 2007 | 4,607 | (279) | 4,328 | | | | | |
| 2008 | 4,125 | 337 | 4,462 | | | | | |
| 2009 | 4,002 | 476 | 4,478 | 4,460 | 1.00% | 44.6 | 1.00% | 44.6 |
| 2010 | 4,114 | 330 | 4,444 | 4,423 | 1.75% | 77.4 | 0.75% | 33.2 |
| 2011 | 4,398 | (28) | 4,370 | 4,461 | 2.50% | 111.5 | 0.75% | 33.5 |
| **2012** | | | | **4,431** | **3.25%** | **144.0** | **0.75%** | **33.2** |

The Company employs the following process to normalize kWh and kW for differences in the weather: Using econometric equations for each customer class, from the load forecast process discussed in the Long-Term Forecast Report filing, the adjustment process for kWh is performed as follows:

Let: KWH(N) = f(W(N))g(E)

KWH(A) = f(W(A))g(E)

Where: KWH(N) = electric sales - normalized

W(N) = weather variables - normal

E = economic variables

KWH(A) = electric sales - actual

W(A) = weather variables – actual

Then: KWH(N) = KWH(A) * f(W(N))g(E)/f(W(A))g(E)

= KWH(A) * f(W(N))/f(W(A))

With this process, weather-normalized sales are computed by scaling actual monthly sales for each class by a factor from the econometric equation that accounts for the impact of deviations from monthly normal weather. Similarly, using an econometric equation for peak, the adjustment process for kW is performed as follows:

Let: KW(N) = f(W(N))g(E)

KW(A) = f(W(A))g(E)

Where: KW(N) = electric peak demand - normalized

W(N) = weather variables - normal

E = economic variable

KW(A) = electric peak demand - actual

W(A) = weather variables - actual

Then: KW(N) = KW(A) * f(W(N))g(E)/f(W(A))g(E)

= KW(A) * f(W(N))/f(W(A))

With this process, weather-normalized peak demand is computed by scaling actual peak demand by a factor from the econometric equation that accounts for the impact of deviations from normal weather.

Once total energy and peak demand have been adjusted for normal weather, the computation of the baseline for 2012 is simply the average of the load values for the three years 2009 to 2011. The baseline values for energy and demand are provided above in Table 1.

**4901:1-39-05(C)(1)(a)-(c) Portfolio Status Report and Compliance Demonstration**

In accordance with 4901:1-39-05(C)(1)(a), with the establishment of the baseline energy and peak demand, the level of the statutory benchmark is computed by applying the appropriate incremental percentage of achievement, as established in S.B. 221, to the baseline. The computation of the benchmark achievement level for 2012 is provided above on Table 1. The baseline for energy is 167,149 MWH and the baseline for peak loads is 33.2 MW.

Duke Energy Ohio respectfully submits that this information is responsive to all of the baseline and benchmark calculations as set forth in Rule 4901:1-39-05(A), O.A.C., and requests that the Commission approve these baseline and benchmark calculations as submitted.

In response to 4901:1-39-05(C)(1)(b), which requires a comparison of the applicable benchmark of actual energy savings and peak-demand reductions achieved, as a result of the Company's 2012 efforts to promote customer participation in its energy efficiency and demand response programs, the Company has achieved incremental energy and demand impacts in 2012 as summarized below in Table 2. Details of impacts for each program are provided in Appendix A.

**Table 2: Incremental Energy Efficiency and Demand Response Program Impact Summary**

| | Participants/Measures | MWH | MW |
|---|---|---|---|
| Demand Response Programs | | | |
| Power Manager | | | (4.7) |
| PowerShare | | | 1.3 |
| PowerShare Generators | | | (31.4) |
| Large Transmission Customer | | | 67.5 |
| **Total Demand Response Programs** | | **0.0** | **32.7** |
| | | | |
| Energy Efficiency Programs | | | |
| Residential Programs (1) | 1,756,306 | 135,795 | 27.2 |
| Non-Residential Programs | 576,979 | 126,642 | 22.9 |
| **Total EE Programs** | **2,333,285** | **262,437** | **50.1** |
| | | | |
| Prior Bank per SB-221 | | 490,308 | 165.3 |
| Adjustments to Prior Years (2) | | (60) | 6.9 |
| **Total Load Impacts** | | **752,685** | **255** |

(1) Residential Programs includes Low Income Weatherization 2009-2012 participation and impacts not previously filed.

(2) Bank figures as originally filed were 490,308 MWH and 165.3 MW. MWH changes were due to Smart $aver Custom and MW changes due to PowerShare.

Table 3 provides a comparison of the impacts relative to the benchmarks previously mentioned. This indicates that the Company has complied with the S.B. 221 statutory benchmarks for the year 2012.

| Table 3: Comparison of Achieved Impacts to the 2012 Benchmark | | | |
|---|---|---|---|
| | 2012 Benchmark | Achievement | Variance Over/(Under) |
| MWH | 167,149 | 752,685 | 585,536 |
| MW | 33.2 | 255 | 221.8 |

In addition, since the Company's efforts exceeded the requirement, there is a residual amount of load impacts that carry forward to support achievement of the 2013 benchmarks.

In compliance with 4901:1-39-05(C)(1)(c), an affidavit indicating that the reported performance complies with the statutory benchmarks is provided in Appendix B.

**4901:1-39-05(C)(2) Program Performance Assessment**

As part of Duke Energy Ohio's Electric Security Plan (ESP) filing in 2008, the Company proposed a set of energy efficiency and demand response programs. These were subsequently approved on December 17, 2008 and reaffirmed (except for the Prepaid Meter Program) in the Commission's Order in Case No. 09-1999-EL-POR. Implementation of the new Save-A-Watt programs began January 2009. On July 20, 2011, Duke Energy Ohio filed for a new recovery mechanism to replace Save-A-Watt due to expire on December 31, 2011. Case No. 11-4393-EL-RDR included the recovery mechanism of shared savings, as well as, three new programs. The recovery mechanism and programs were approved on August 15, 2012. In compliance with the Commission's Order, after reviewing the market potential study conducted for it by Forefront Economics Inc, Duke Energy Ohio filed its three-year portfolio plan for 2014-2016 with the Commision on April 15, 2013. Program descriptions and key activities for its current portfolio are provided below.

**4901:1-39-05 (C)(2)(a)(i) Program Descriptions and Key Activities**

**Residential Programs**

*Smart $aver® Residential Program*

The Smart $aver® Residential program offers a variety of programs and measures that allow customers to take action and reduce energy consumption. The program is available to residential customers served by Duke Energy Ohio.

*Compact Fluorescent Lamps (CFL) Program*

The CFL Program is designed to increase the energy efficiency of residential customers by offering customers CFLs to install in high-use fixtures within their homes. The CFLs are offered through an on-demand ordering platform, enabling eligible customers to request CFLs and have them shipped directly to their homes. Eligibility is based on past campaign participation (i.e. coupons, Business Reply Cards (BRCs) and other Duke Energy Ohio programs distributing CFLs). Bulbs are available in 3, 6, 8, 12 and 15 pack kits that have a mixture of 13 and 20 watt bulbs. The maximum number of bulbs available for each customer is 15, but customers may choose to order less.

Customers have the flexibility to order and track their shipment through three separate channels:

1) Telephone:

   Customers may call a toll-free number to access the Interactive Voice Response (IVR) system which provides prompts to facilitate the ordering process. Both English and Spanish-speaking customers may easily validate their account, determine their eligibility and place their CFL order over the phone.

2) Duke Energy Web Site:

Customers can go online to complete the ordering process. Eligibility rules and frequently asked questions are also available.

3) Online Services (OLS):

Customers who participate in the Online Services program are encouraged to order their CFLs through the Duke Energy Ohio web site if they are eligible.

The benefits of providing these three distinct channels include:

- Improved customer experience
- Advanced inventory management
- Simplified program coordination
- Enhanced reporting
- Increased program participation
- Reduced program costs

Customers continue to utilize the simple ordering process and the convenience of bulbs being shipped directly to their home. Over 114,600 orders were placed in 2012; resulting in over 1,470,000 bulbs distributed. Over 44 percent of the orders were placed by calling the toll free phone number, 25 percent of the orders were placed on the Duke Energy Ohio web site and 31 percent on the OLS platform.

The overall strategy of the program is to reach residential customers who have not adopted CFL bulbs. Duke Energy Ohio will continue to educate customers on the benefits of CFLs while addressing barriers for consumers who have not participated in the program. Additionally, the ease of program participation will also be highlighted to encourage use of the on-demand ordering platform.

Direct mail marketing has generated a significant percentage of orders in Ohio. Direct mail campaigns target Prizm segments of Ohio customers with a high propensity to participate in the program. Marketing pieces and personalized letters include the customer account number for easy ordering through the IVR or Web platform.

Duke Energy Ohio will continue to market the CFL program through various channels including Email, Bill Messages, Bill Envelopes, Social Media, Direct Mail, Printed Collateral, Earned Media[1], and other Duke Energy Program collaboration efforts. Response of each channel is tracked and monitored.

*CFL Program Potential Changes*

Innovative marketing campaigns and tactics will be utilized to improve awareness for hard to reach and late adopter[2] customers.

Duke Energy Ohio is expanding its lighting offer to include specialty bulbs such as indoor recessed lights, candelabras, three-way bulbs and dimmable bulbs. The web based e-commerce store will provide discounted specialty lights and ship directly to the home. Building on the insights and lessons learned from the current CFL promotion, Duke Energy Ohio will determine best practices and go to market options to inform customers of the specialty bulb offer.

<u>Property Manager Program</u>

The Property Manager Program is an extension of the CFL program and allows Duke Energy Ohio to target multi-family apartment complexes. Eligible units are those Duke Energy Ohio served apartments on a residential rate. Honeywell manages the program and partners with Ohio property managers to enroll multi-family properties.

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[1] Earned media refers to favorable publicity gained through promotional efforts other than advertising.

[2] Customers who are slow to start using or buying a new product, technology, or idea.

The program helps property managers upgrade lighting with energy efficiency 13 watt CFLs, reducing maintenance costs while improving tenant satisfaction by lowering energy bills. Each apartment may qualify for up to 12 bulbs per unit depending on the size.

Once enrolled, the property manager identifies the number of permanent lighting fixtures available. Duke Energy Ohio provides the CFLs but the property manager pays for all shipping costs.

The CFLs are installed in permanent fixtures during routine maintenance visits. The property manager provides tracking for the number of bulbs installed. Honeywell validates this information and provides a report for each individual unit on the property.

A Property Manager CFL promotional and landing page were developed for managers to self-serve and learn more about the program. A contract, installation worksheet and CFL frequently asked question sheet are available for download. Marketing material including information on CFL savings and safety sheets are available in English and Spanish to further support the program.

Honeywell markets the program to Ohio Property Managers through various channels including tradeshows, email, and Apartment Association events. Duke Energy Ohio will continue to support the Property Manager program by updating and maintaining program information on the Web site.

*Property Manager Program Potential Changes*

To minimize overages, Honeywell will begin subtracting twenty percent of the bulbs ordered by Property Managers. Honeywell will also begin marketing the program through additional channels to increase participation and educate apartment associations about the program. Marketing strategy will include phone solicitation, apartment association functions/networking, onsite meetings and presentations, email blasts and trade shows.

*Residential HVAC Program*

Duke Energy Ohio served homeowners currently residing in or building a single family residence, condominium, duplex or mobile home are eligible for this program. Installation of a high efficiency heat pump or air conditioner will result in a $300 incentive. GoodCents administers the program and establishes relationships with home builders and HVAC contractors who interface directly with residential customers. These trade allies adhere to program requirements and submit the incentive application. Once the application is processed, GoodCents disburses the incentive funds. For replacement of an existing system, a Duke Energy Ohio customer receives $200 and the HVAC contractor receives the remaining $100. For new home construction, the home builder receives the full $300 incentive but has the option to pass the incentive on to the customer. Additionally, the installation of attic insulation and completion of air sealing will result in a $250 incentive, installation of duct insulation will result in a $75 incentive, and completion of duct sealing will result in a $100 incentive. All incentives are paid directly to customers upon approval of a completed application. GoodCents disburses the incentive funds to the appropriate party upon application approval. GoodCents also handles calls from trade allies and customers about the program.

The HVAC Program successfully transitioned program administrators from Wisconsin Energy Conservation Corporation (WECC) to GoodCents during the first quarter of 2012 and launched the insulation and sealing measures into the market during the fourth quarter. Over 4,000 participants received an incentive for a completed measure during 2012.

Duke Energy Ohio and GoodCents have formed strong relationships with trade allies across Ohio and continue to develop relationships with trades serving the new measures. These partnerships help application fulfillment and prompt payment of incentives as well as maintain top-of-mind awareness of the program and its benefits.

*Residential HVAC Program Potential Changes*

Electronic submission of the incentive application is under development at this time as well as an online platform that will allow trade allies to check customer eligibility and confirm incentive status for their customers.

*Residential Energy Assessments Program*

The Residential Energy Assessments program includes Home Energy House Call (HEHC).

HEHC targets residential customers that own a single family home with at least four months of billing history. HEHC is a free in-home assessment designed to help customers reduce energy usage and save money. An energy specialist completes a 60 to 90 minute walk through assessment of the home and analyzes energy usage to identify energy saving opportunities. The Building Performance Institute (BPI) certified energy specialist discusses behavioral and equipment modifications that can save energy and money with the customer. A customized report is provided to the customer that identifies actions the customer can take to increase their home efficiency. Example recommendations might include the following:

- Turning off vampire load equipment when not in use
- Turning off lights when not in the room
- Using CFLs in light fixtures
- Using a programmable thermostat to better manage heating and cooling usage

- Replacing older equipment
- Adding insulation and sealing the home

Customers receive an Energy Efficiency Starter Kit with a variety of measures that can be directly installed by the energy specialist. The kit includes measures like CFLs, low flow shower head, low flow faucet aerators, outlet/switch gaskets, weather stripping and energy saving tips booklet.

Duke Energy Ohio partners with several key vendors in support of the HEHC program: WECC, ProtoType, CustomerLink and AM Conservation. WECC administers the assessment component of the program. Additional key vendors include ProtoType for mailing services, CustomerLink for customer care support and scheduling (call center and back office), and AM Conservation for fulfillment of the Energy Efficiency Starter Kits.

*HEHC Program Potential Changes:*

Some program enhancements to increase program impacts and raise participation satisfaction levels being considered include:

- Evaluating other measures for the Energy Efficiency Start Kit. Current analysis is taking place to determine market opportunities.
- Removing the geographic limitation and begin to mass promote utilizing our delivery channels and possibly adding new channels through Duke Energy's online services home page. Expected implementation is early 2013.
- Creating a separate customer wait list for those willing to accept last minute appointments.
- Redesigning the program to better suit market needs and adoption rates.

*Energy Efficiency Education Program for Schools*

The Energy Efficiency Education Program for Schools Program is an energy conservation program available in Ohio. The Energy Efficiency Education Program is available to K-12 students enrolled in public and private schools and who reside in households served by Duke Energy Ohio.

The Program provides principals and teachers with an innovative curriculum that educates students about energy, electricity, ways energy is wasted and how to use our resources wisely. Education materials focus on concepts such as energy, renewable fuels, and energy efficiency through classroom and take home assignments, enhanced with a live 25 minute theatrical production performed by two professional actors.

School principals are the main point of contact and will schedule the performance at their convenience for the entire school. Once the principal has confirmed the performance date and time, two weeks prior to the performance, all materials are delivered to the principal's attention for distribution. Materials include school posters, teacher guides, classroom and family activity books.

Students are encouraged to complete a home energy survey with their family (found in their activity book), so they can receive an Energy Efficiency Starter Kit. The kit contains specific energy efficiency measures to reduce home energy consumption.

The current program is developed to educate kindergarten through eighth grade students. Duke Energy Ohio partners with a third party vendor, The National Theatre for Children to administer the program.

*Energy Efficiency Education Program Potential Changes:*

The National Theatre for Children has been the program administrator since October 2011. NTC is working closely with Duke Energy to enhance the program by

- Partnering with Duke Energy Account/District Managers to leverage existing relationships for additional acquisition channel.
- Leveraging give-a-aways to stir additional excitement in the schools/classrooms.
- Developing an alternative kit for those customers who have already participated in the Energy Efficiency Education Program.
- Enhancing all data processing methods.

As the program evolves in 2013, there will be additional enhancements to be made and improve the customer's experience when participating in the Energy Efficiency Education Program.

*Low Income Services Program*

The Low Income Services Program provides assistance to low income customers through several measures. The upfront costs of high efficiency equipment are an especially difficult barrier for low income customers to overcome. The Weatherization and Refrigerator Replacement program is available to any low income customer up to 200% of the federal poverty level who has not participated in this program within the past 10 years.

An Electric Maintenance Service program is available for low-income elderly and disabled customers up to 175% of poverty level. This program offers low-cost solutions for energy efficiency. Customers may receive energy efficiency products and services such as compact fluorescent bulbs, low flow showerheads and aerators, water heater wraps, HVAC cleaning, HVAC filters, and energy efficiency education.

These programs are promoted through, but not limited to, Community Action Agencies, Non-Governmental Organizations (NGO's), and direct mail to customers.

*Low Income Services Program Potential Changes:*

Duke Energy Ohio continues to evaluate opportunities to provide new offers to low income customers in the most cost effective manner. Duke Energy Ohio is currently negotiating a contract with a new vendor to provide its refrigerator replacement services. Additionally, on March 15, 2013, Duke Energy filed an application with the Commission to establish a new energy efficiency pilot program for low income customers. The proposed pilot program will allow Duke Energy Ohio to purchase and recognize the energy and demand savings that are achieved through whole-home weatherization in the Duke Energy Ohio service territory that are currently funded by leveraged funds. The proposed pilot is intended to allow the Company to recognize efficiency impacts that were previously unrecognized, achieve these impacts in a cost-effective manner, and create a new funding stream for additional whole-home weatherization to be performed in the Duke Energy Ohio Service Territory.

*Home Energy Comparison Report (HECR) Program*

My Home Energy Report (MyHER) formerly known as, Home Energy Comparison Report (HECR) is a periodic comparative usage report that compares customers' energy use to similar residences in the same geographical area based upon the age, size and heating source of the home. Specific energy saving recommendations are included in the report to encourage energy saving behavior.

The reports are distributed in printed form up to 12 times per year and may not be delivered during the off-peak energy usage months in the fall and spring. The report's energy analysis content for each home is compared to the energy use of neighbors in similar home types for the same period. Customer's usage is compared to the average home (top 50%) in their area as well as the efficient home (top 25%). Suggested energy efficiency improvements given the usage profile for that home are also provided. In addition, measure-specific coupons, rebates or audit follow-ups from other Company Programs are offered to sample customers, based on the customer's energy profile.

Target customers reside in individually-metered, single-family residences with active account and 12 months of usage history. Analyzing only single-family residences eliminates the possibility of erroneous data caused by thermal transfer between adjacent units in multi-family structures. Currently customers on payment plans are not included in the target audience.

*MyHER Program Potential Changes:*

Analysis is underway to assess the benefits of offering this program to Budget Bill customers.

*Power Manager® Program*

The Power Manager Program provides incentives to residential consumers who allow the company to cycle their air conditioner's outdoor compressor and fan during peak energy periods between May and September. Participating customers of the Company who have a functioning outdoor A/C unit are eligible for the program.

Participants in the Power Manager program allow Duke Energy Ohio to control their air conditioners during peak summer demand periods. Customers receive a one-time enrollment incentive of $25 or $35 depending on the Power Manager option they choose. In addition, they receive credits for each Power Manager event. Following the end of the event season, which runs from May through September, if warranted, customers receive a credit that ensures their total credit for the season is a minimum of $5 or $8 depending on the option in which they enrolled.

Due to the record heat and subsequent high electric demand during the summer of 2012, Power Manager was activated on seven different days in Ohio. During these events, Duke Energy cycled customers' air conditioning units off and on, helping shift demand and lower the afternoon peak.

In addition, two shorter duration tests were conducted – one at the beginning of the summer season to ensure systems were working properly, and one near the end of the season in conjunction with regional transmission organization PJM.

A third party installs the device on customers' A/C units.

The program is promoted through but not limited to;

- Zip code specific direct mail
- Telemarketing
- Company website

*Power Manager Program Potential Changes*:

There are no plans to change the operation of the Power Manager program. We do plan on continuing with refinements made in the marketing of the program in 2012. Telemarketing was used with success in the latter part of 2012 resulting in over 500 enrollments. Telemarketing calls will continue in 2013 as long targets and key metrics are met. A new direct mail offer and reminder were introduced in 2013.

## Non-Residential Programs

*Smart $aver® Non-Residential Prescriptive Program*

The Smart $aver® Non-residential Prescriptive Incentive Program provides incentives to commercial and industrial consumers for installation of energy efficient equipment in applications involving new construction, retrofit, and replacement of failed equipment. The program also uses incentives to encourage maintenance of existing equipment in order to reduce energy usage. Incentives are provided based on Duke Energy Ohio's cost effectiveness modeling to assure cost effectiveness over the life of the measure.

Commercial and industrial consumers can have significant energy consumption, but may lack knowledge and understanding of the benefits of high efficiency alternatives. Duke Energy Ohio's program provides financial incentives to customers to reduce the cost of high efficiency equipment. This allows customers to realize a quicker return on investment. The savings on utility bills, allows customers to reinvest in their business. The Smart $aver® program also increases market demand for high efficiency equipment. Because of the increased demand, dealers and distributors will stock and provide high efficient alternatives as they see increased demand for the products. Higher demand can result in lower prices.

The program promotes prescriptive incentives for the following technologies – lighting, HVAC, motors, pumps, variable frequency drives, food services and process equipment. Equipment and incentives are predefined based on current market assumptions and Duke Energy's engineering analysis. The eligible measures, incentives and requirements for both equipment and customer eligibility are listed in the applications posted on Duke's Business and Large Business websites for each technology type.

Prior to January 1, 2013, Duke Energy contracted with Wisconsin Energy Conservation Corporation (WECC) to handle the fulfillment responsibilities of the program and to provide training and technical support to our Trade Ally (TA) network. Prior to January 1, 2013, CustomerLink provided call center services to customers who call the program's toll free number. Effective January 1, 2013, Duke Energy contracted with Ecova to handle both the fulfillment responsibilities and call center services for the Smart $aver® program.

All non-residential customers served by Duke Energy in Ohio are eligible for the Smart $aver® program. Although customers may choose to opt-out of the Duke Energy program and energy efficiency rider, all customers are opted in at this time.

Getting the Trade Allies (TA) to support the program has proven to be the most effective way to promote the program to our business customers. At program rollout, Duke Energy and the WECC Trade Ally team took an aggressive approach to contacting trade allies associated with the technologies in and around Duke Energy's service territory. Trade ally company names and contact information appears on the TA search tool located on the Smart $aver® website. This tool was designed to help customers who do not already work with a TA, to find someone in their location who can serve their needs. WECC manages the Trade Ally database where contact information and participation is reported. Effective January 1, 2013, Duke Energy contracted with Ecova to provide the outreach functions and trade ally database. Existing members of the outreach team transferred from WECC to Ecova which resulted in continuity of service for trade allies.

Duke Energy continues to look for ways to engage the Trade Allies in promotion of the program, including the utilization of focus groups. Duke Energy developed a collateral tool kit to allow trade allies to use the Smart $aver® logo along with white papers, case studies, and other types of collateral developed by Duke Energy. Originally, a tool kit was available for Variable Frequency Drives. Toolkits are now available for Lighting and HVAC. In 2013, Duke Energy plans to offer co-funding to trade allies for approved marketing supplies and activities for promoting the Smart $aver program. Funds will be available on a first come first serve basis.

As part of the contract with Ecova, Duke Energy has also added an outreach team member to focus on the unassigned small and medium business customers. This team member splits time between Ohio, Kentucky, and Indiana and will focus on marketing and program support.

Duke Energy's website is a great source of program information. Customers and trade allies can visit the website and learn about the program, program benefits, search for participating vendors, ask questions on-line, and complete application forms. The website includes a video for programmable thermostats. An HVAC calculator is available in addition to the lighting and VFD calculators.

Duke continues to develop case studies and testimonials from customers who have participated in the program to be used to help promote the program – showing actual savings and benefits for each technology type.

In accordance with new federal standards, Duke Energy Ohio is phasing out the incentives for T5 fixtures replacing T12s and for standard 4 foot T8s replacing T12s. Duke Energy continues to offer incentives for reduced wattage (RW) and high performance (HP) T8 lamps.

*Smart $aver® Non-Residential Prescriptive Program Potential Changes:*

Standards continue to change and new, more efficient technologies continue to emerge in the market. The Company expects to continue to add new measures to provide incentives for customers to take advantage of a broader suite of products. The Company undertakes an annual review of technologies and efficiency levels through internal sources and with the assistance of outside technical experts. The review includes the existing technology categories as well as other emerging areas for energy efficiency such as IT.

*Smart $aver® Custom Rebate Program*

Duke Energy's Smart $aver® Nonresidential Custom Incentive Program offers financial assistance to qualifying commercial, industrial and institutional customers (that have not opted out) to enhance their ability to adopt and install cost-effective electrical energy efficiency projects.

The Smart $aver® Custom Incentive program is designed to meet the needs of Duke Energy customers with electrical energy saving projects involving more complicated or alternative technologies, or those measures not covered by standard Prescriptive Smart $aver® Incentives.

The Custom Incentive application is for projects that are not listed on the applications for Smart $aver® Prescriptive Incentives. Unlike the Prescriptive Incentives, Custom Incentives require approval prior to the project implementation. Proposed energy efficiency measures may be eligible for Custom Incentives if they clearly reduce electrical consumption and/or demand.

Currently there are the following application forms that are located on the Duke Energy website under the Smart $aver® Incentives (Business and Large Business tabs).

- Application Part 1 – Administrative Information
- Applications Part 2 Worksheets – Energy Savings Calculations & Basis
    - Variable Frequency Drives
    - Energy Management Systems
    - Compressed Air
    - Lighting
    - General

The program is promoted through but not limited to the following;

- Trade ally outreach
- Duke Energy Ohio Business Relations Managers
- Duke Energy segment specific workshops
- Company website

*Smart Saver® Custom Rebate Program Potential Changes:*

While no significant changes to the program were made this year, program management continues to look for improvements that will enhance participation and program efficiency. These changes may include calculation assistance for customers that have proposed energy efficiency projects of sufficient value, as determined by Duke Energy, but that lack internal or other resources to perform the engineering calculations required by the Custom Incentive program.

*Mercantile Self-Direct Rebates Program*

The Duke Energy Ohio Mercantile Self-Direct program was enacted in accordance with Public Utilities Commission of Ohio (Commission) Rule 4901:1-39-05(G).A.C., and the

Commission's Opinion and Order in Case No. 10-834-EL-POR. Mercantile and national/regional accounts customers are eligible for the program.

These customers may elect to commit energy savings or demand reductions from projects completed in the prior three calendar years that did not receive Smart $aver® incentives to Duke Energy's benchmark achievements . In return, Duke Energy will assist the customer in filing an application with PUCO for approval of a portion of the incentive the customer would have received had they participated in Duke Energy's standard Smart $aver® Non-Residential programs.

Where applicable, customers that accept a Self-Direct rebate and were opted out of the energy efficiency rider or that paid a lesser rider rate at the time of project completion will be invoiced for the differential in rider charges from the point in time of project completion to present and will continue paying the full rider amount going forward.

The marketing channels for Mercantile Self-Direct project applications closely resemble those of the Smart $aver® Prescriptive and Smart $aver® Custom programs, based on applicability, as described in previous sections of this filing.

Rebates for Self-Direct projects eligible for a cash rebate reasonable arrangement will be a percentage of the dollar amount that would apply to the same project if evaluated in the Smart $aver® Prescriptive & Custom programs. Where measures are ineligible for a cash rebate arrangement, customers may receive a commitment payment, as defined by the Commission.

<u>*Self Direct Prescriptive Program*</u> - The Self-Direct Prescriptive program provides rebates for mercantile customers who implement energy efficiency and/or demand reductions projects to install higher efficiency equipment. Major categories include lighting, motors, pumps, VFD's, food service and process equipment. Eligible measures are reflective of the Smart $aver®

Prescriptive Incentive portfolio. Additionally, projects completed for measures that were removed from the Prescriptive portfolio due to changes in market standards, minimum code requirements and federal/state minimum efficiency legislation will be eligible for rebate if the projects were completed before the measure was removed from the Prescriptive portfolio. While many of the measures recorded under the Smart $aver® Prescriptive program will remain Prescriptive in nature under the Self-Direct program, in accordance with Commission rules and orders on the mercantile program, certain measures must be evaluated under the Self-Direct Custom program to enable the use of as-found baseline.

*Self Direct Custom Program* - The Self-Direct Custom program offers rebates for completed mercantile projects involving more complicated scopes, unique technologies or measures not covered by Self-Direct Prescriptive rebates but that resulted in improvements upon facility electrical energy efficiency. A proposed energy efficiency measure may be eligible for a Self-Direct Custom rebate if it clearly reduces electrical consumption and/or demand. Unlike the Smart $aver® Custom program, measurable and verifiable behavioral and operational measures are eligible in the Mercantile Self Direct program.

*Non-Residential Energy Assessments Program*

The purpose of the Non-Residential Energy Assessment program is to assist non-residential customers in assessing their energy usage and providing recommendations for more efficient use of energy. The program will also help identify those customers who could benefit from other Duke Energy Ohio Energy Efficiency non-residential programs.

Duke Energy Ohio offers several different types of assessments to help customers identify energy efficiency opportunities. The Online Assessment tool is available for all non-residential customers through the Duke Energy website. This tool is available free of charge. For customers with a peak demand over 500 kW, Duke Energy Ohio offers a Telephone Assessment free of charge to the customer. The assessor will gather basic data from the customer and provide recommendations over the phone based on experience and information provided during the interview. Lastly, Duke Energy Ohio offers an On-Site Assessment wherein an assessor will spend one or more days at a customer's site identifying opportunities for increased energy efficiency. After the audit is completed, the customer receives a written report of the audit findings. The cost of the On-Site Assessment varies depending on the length of time an assessor spends at a customer's facility. The cost of the audit is shared by Duke Energy Ohio and the customer. The customer pays 50% of the cost, and Duke Energy Ohio pays 50%, but the customer's cost can be further reduced if they proceed with adopting the recommendations made in the audit.

After evaluating the success of the current audits, Duke Energy Ohio is employing new approaches to higher drive adoption of energy efficiency through audits. One such approach is a comprehensive audit that addresses the entire operation of a building in great detail. In a similar vein, Duke Energy Ohio is testing technology specific audits. The purpose is to help customers identify strategies targeted at their most energy intensive processes, provide them with concrete cost estimates to implement the recommendations, and connect the customer with vendors that deliver the energy efficiency improvements.

Impacts captured as a result of Energy Assessment recommendations are recorded in Duke Energy Ohio's non-residential incentive programs. As a result, they are not presented for this section.

*Non-Residential Energy Assessment Program Potential Changes:*

Duke Energy is considering design assistance efforts to aid in the development of high efficiency designs in planned new construction and major renovation.

*PowerShare® Program*

The PowerShare® program is Duke Energy Ohio's demand side management (or demand response) program geared toward Commercial and Industrial customers. The primary offering under PowerShare® is named CallOption and it provides customers a variety of offers that are based on their willingness to shed load during times of peak system usage. These credits are received regardless of whether an event is called or not. Energy credits are also available for participation (shedding load) during curtailment events. The notice to curtail under these offers is between 6 hrs (emergency) and day-ahead (economic) and there are penalties for non-compliance during an event.

- The program is promoted through but not limited to the following;
  - Duke Energy Ohio Business Relations Managers
  - Email to customers
  - Duke Energy Ohio website

Customer targets in 2012 continued to be large manufacturers, water/wastewater facilities school systems. Program changes due to Duke Energy's move to PJM in 2012 provided minor challenges and most customers chose to continue participation in PowerShare® much as they did in 2011. In addition, 2012 was the first year of a test Duke Energy Ohio has conducted with Automated Demand Response technologies that could simplify the ways for commercial customers to curtail. The preliminary results are positive: the technologies work and participating customers have provided no negative feedback. The biggest challenge is the initial installation costs, which needs to decrease before wide-scale implementation will make economic sense.

*PowerShare® Program Potential Changes:*

Changes for 2013 involve a heightened level of competition being demonstrated by some Curtailment Service Providers in the market that became evident in late Summer 2012. On the whole, Duke Energy feels that it has a competitive offer for customers and the program offering in 2013 has stayed very similar to that in 2012.

On July 20, 2011, Duke Energy Ohio filed to include three new programs to the portfolio, Appliance Recycling, Low Income Neighborhood Program and Home Energy Solutions. An Order in Case No. 11-493-EL-RDR approving these programs was received on August 15, 2012.

*Appliance Recycling Program*

The Ohio Appliance Recycling Program (ARP) launched on October 4, 2012. ARP encourages customers to responsibly dispose of older, functional but inefficient refrigerators and freezers. These are typically second or third units in the home. Customers will have the old unit picked up at their home at no charge and will receive an incentive for participating. Disposed units will have up to 95 percent of material recycled with approximately 5 percent entering landfills. Program marketing will consist of direct mail, bill inserts & messages, digital media, social media, and community presentations and publications like newsletters. Point of sale messaging may be piloted with prominent appliance retailers.

JACO Environmental, Inc. was selected as the ARP Supplier based on responses to the RFP. Customer participation was lower than planned for a program launching in January 2012 due to October 2012 launch completely, missing the April through May peak, as well as, occurring at the start of holiday season.

*Low Income Neighborhood Program*

The Low Income Neighborhood Program ("Program") assists low-income customers in reducing energy costs through energy education and by installing or providing energy efficient measures for each customer's residence. The primary goal of the Residential Neighborhood Program is to empower low income customers to better manage their energy usage.

The Company will target neighborhoods with a significant low income customer base using a grassroots marketing approach to interact on an individual customer basis and gain trust. Participation is driven through a neighborhood kick-off event that includes trusted community leaders explaining the benefits of the Program. The purpose of the kick-off event is to rally the neighborhood around energy efficiency and to educate customers on methods to lower their energy bills. Customers will have the option to sign-up for an energy assessment at the time of the event.

In addition to the kick-off event, the Company plans to use the following avenues to inform potential customers about the Program:

- Direct mail
- Door hangers
- Press releases
- Community presentations and partnerships
- Inclusion in community publications such as newsletters, etc.

Customers participating in the Program will receive an energy assessment to identify energy efficiency opportunities in the customer's home and one-on-one education on energy efficiency techniques and measures. Additionally, the customer receives a comprehensive package of energy efficient measures. Each measure listed is installed or provided to the extent the measure is identified as energy efficiency opportunity based on the results of the energy assessment.

The Program is available only to individually-metered residential customers in neighborhoods selected by the Company, at its sole discretion, which are considered low-income based on third party data, which includes income level and household size. Areas targeted for participation in this Program will approximately have 50% of the households with an income equal to or less than 200% of the federal poverty level established by the U. S. Government.

Duke Energy has selected GoodCents, Inc. as the administrator for the Program and is currently preparing for the Program to launch in the second quarter of 2013.

*Home Energy Solutions (formerly called Home Energy Management)Program*

Home Energy Solutions is an approach to delivering energy efficiency solutions to customers in a way that combines a number of energy efficient measures into more valuable solutions. Home Energy Solutions will combine energy usage information and recommendations with the ability to leverage potential pricing options and energy management offerings into convenient in-home solutions.

Upon notification of portfolio approval in August 2012, Duke Energy Ohio immediately launched an RFP process to select a vendor. In anticipation of receiving approval, the RFP was designed in advance to ensure getting it into the market quickly. Given the fact that this is for a commercialized program, the RFP was very comprehensive and required substantial detail on the part of participating vendors. This included live access to their current product for Duke Energy Ohio evaluation/testing. The objective through the entire process has been to ensure that the solution is tested, scalable, and will deliver the intended features/value for Ohio customers and Duke Energy Ohio. The RFP went out to 11 vendors, all of whom agreed to participate.

Over the last few months, each vendor has been through extensive reviews and testing. This includes lab and employee home testing of their solutions, interviews with each vendor's current customers (utilities), financial risk assessments, etc. As of May 15th, we are now down to two finalists. A vendor will be selected in second quarter 2013.

Once the vendor has been selected, Duke Energy Ohio will work with the vendor to integrate data feeds and finalize the HES solution for launch in the Ohio market. We have established the development/launch timeline with the requirements for this program as well other internal IT work we must align with (such as Ohio meter interval data feed integration work). Given these factors, we are targeting an official program launch of Q1 2014.

**4901:1-39-05(C)(2)(a)(i) Cont'd... Number and Type of Participants and Comparison of Forecasted Savings to Achieved Savings**

The number of participants or measures installed by customer type is summarized above in Table 2. Details on participation by measure are provided in Appendix A.

The Company's programs are approved for implementation through December 31, 2013. A new portfolio filing seeking program approval for January 1, 2014 – December 31, 2016 was filed on April 15, 2013[3]. Table 4 provides a comparison of achieved impacts through 2012 as well as the forecasted impacts. The forecasted impacts for 2013 have been updated to align with the portfolio filed in Case No. 13-0431-EL-POR.

[3] Case No. 13-0431-EL-POR

| Table 4: Comparison of Achievement to Forecasted Impacts and Trend Projection Through 2013 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Achieved Load Impacts | | Forecasted Load Impacts | | | | | |
| | MWH 2012 | MW 2012 | MWH 2012 | MWH 2013 | MWH Total | MW 2012 | MW 2013 | MW Total |
| Other Programs | | | | | | | | |
| Low Income Weatherization | 3,787 | 1 | - | - | 0 | - | - | - |
| Large Transmission Customer | - | 67 | - | - | 0 | - | - | - |
| Powershare Generators | - | (31) | - | - | 0 | - | - | - |
| Residential Programs | | | | | | | | |
| Appliance Recycling Program | 883 | 0 | 5,639 | 7,296 | 12,935 | 1.5 | 2.0 | 3.5 |
| Home Energy Solutions | - | - | 843 | - | 843 | 1.8 | - | 1.8 |
| Low Income Neighborhood Program | - | - | 1,262 | 1,377 | 2,638 | 0.3 | 0.4 | 0.7 |
| Energy Education Program for Schools | 1,149 | 0 | 3,385 | 875 | 4,260 | 0.9 | 0.1 | 1.0 |
| Home Energy Comparison Report | 42,397 | 15 | 25,714 | (806) | 24,908 | 8.4 | (0.2) | 8.2 |
| Low Income Services | - | - | 176 | 108 | 284 | - | 0.0 | 0.0 |
| PowerManager | - | (5) | - | - | 0 | 8.6 | 2.9 | 11.6 |
| Residential Energy Assessments | 4,740 | 1 | 9,122 | 7,388 | 16,511 | 1.3 | 1.0 | 2.3 |
| Smart $aver® Residential | 82,839 | 10 | 35,772 | 15,157 | 50,929 | 6.1 | 3.7 | 9.8 |
| | | | | - | | | - | |
| | | | | - | | | - | |
| Non Residential Programs | | | | - | | | - | |
| Smart $aver Non Residential Custom | 24,904 | 3 | 34,120 | 27,784 | 61,905 | 3.9 | 3.2 | 7.1 |
| Smart $aver Non Residential Prescriptiv | 54,214 | 11 | 65,844 | 55,938 | 121,782 | 14.2 | 11.8 | 26.0 |
| PowerShare | - | 1 | - | - | 0 | (0.4) | (2.8) | (3.2) |
| Mercantile Self-Direct | 47,524 | 9 | - | - | 0 | - | - | - |
| Total for All Programs | 262,437 | 83 | 181,878 | 115,118 | 296,995 | 47 | 22 | 69 |

1. Low Income Weatherization reflects 2010 thru 2012 incremental impacts.
2. Low Income Services includes refrigerator replacement only.
3. 2012 forecasted impacts from previous filing.
4. 2013 forecasted impacts have been updated with more recent estimates than what was originally filed.
5. HECR and DR are shown as incremental to be consistent with achievements.

This table indicates that the achieved MWH and MW impacts through 2012 are above the 2012 forecast.

**4901:1-39-05(C)(2)(a)(ii) Energy Savings Counted Toward Benchmark as a Result of Mercantile Customers**

The energy savings counted towards the benchmark for 2012 as a result of energy efficiency improvements and implemented by mercantile customers and committed to the Company are 47,524 MWH.

**4901:1-39-05(C)(2)(a)(iii) Peak Demand Reduction Counted Toward Benchmark as a Result of Mercantile Customers**

The peak-demand reductions counted towards the benchmark for 2012 as a result of energy efficiency improvements and implemented by mercantile customers and committed to the Company are 9 MW.

**4901:1-39-05(C)(2)(a)(iv) Peak-Demand Reductions Claimed Due to Transmission and Distribution Infrastructure Improvements**

The Company is not claiming any impacts from transmission and distribution infrastructure improvements at this time.

**4901:1-39-05(C)(2)(b) Evaluation, Measurement, and Verification (EM&V)**

Energy savings and peak-demand reduction values are documented in the individual program EM&V studies in the appendices. The following studies have been completed:

- Smart Saver® Custom Incentive (Sept 28, 2012) — Appendix D
- Smart Saver® Residential CFL (Sept 28, 2012) — Appendix E
- 2011 Power Share Impact Review — Appendix F
- Smart Saver® Residential CFLs: Property Manager Channel — Appendix G
- Energy Efficiency Education Program for Schools (NTC) — Appendix H
- Residential Energy Assessments (Home Energy House Call) — Appendix I
- Smart $aver® Residential – HVAC (January 2013) — Appendix J
- Smart Saver® Non-Residential Prescriptive (Other Measures) — Appendix K
- Power Manager Process Evaluation Report (April 24, 2013) — Appendix L

Appendix C provides an up-to-date summary EM&V methodologies and protocols.

The cost effectiveness of the current programs is provided below in Table 5.

Table 5: Cost Effectiveness Test Results of Current Programs

| | Utility Test | TRC Test | RIM Test | Participant Test |
|---|---|---|---|---|
| **RESIDENTIAL CUSTOMER PROGRAMS** | | | | |
| **Appliance Recycling** | 3.59 | 4.25 | 1.99 | NA |
| **Energy Efficiency Education Program for Schools** | 2.35 | 3.64 | 1.52 | NA |
| **Home Energy Comparison Report** | 2.48 | 2.48 | 1.53 | NA |
| **Home Energy Solutions** | 1.59 | 2.35 | 1.44 | 4.29 |
| **Low Income Neighborhood Program** | 1.33 | 2.31 | 1.02 | NA |
| **Low Income Services** | 1.26 | 4.69 | 0.92 | NA |
| **PowerManager** | 3.98 | 4.75 | 3.98 | NA |
| **Residential Energy Assessments** | 2.83 | 3.04 | 1.68 | NA |
| **Residential Smart $aver® Products and Services** | 3.00 | 2.61 | 1.82 | 3.88 |
| | | | | |
| **NON-RESIDENTIAL CUSTOMER PROGRAMS** | | | | |
| **Smart $aver® Prescriptive** | 5.80 | 2.59 | 3.41 | 2.68 |
| **Smart $aver® Custom** | 4.90 | 1.23 | 2.81 | 1.45 |
| **Power Share®** | 4.05 | 7.83 | 4.05 | NA |

1. Home Energy Comparison Report is now the My Home Energy Report

## 4901:1-39-05(C)(2)(c) Continuation of Programs

Based on the success experienced and feedback from customers and trade allies, Duke Energy Ohio proposes continuing with the existing suite of offers, as well as, including additional measures and programs upon approval of Case No. 13-0431-EL-POR into the current portfolio. The portfolio is subject to annual adjustments for changes in efficiency levels or market conditions.

With respect to future program expansion or modification, the Company did not offer any piloted programs in calendar year 2012. However, the following program was submitted for approval for 2014 in Case No. 13-0431-EL-POR[4]:

*Energy Management and Information Services (EMIS)*

Duke Energy Ohio's proposed Energy Management and Information Services program is a systematic approach to reducing energy usage at qualified commercial or institutional customer

[4] The program listed in this section will be implemented upon an approval by the Commission.

facilities and persistently maintaining those savings over time. In order to achieve these goals, the program will deploy an energy management and information system and perform a remote or light onsite energy assessment. The EMIS will be software-as-a-service (SaaS) hosted by a third party vendor. The EMIS SaaS will use next day interval meter data from the customer's meter. The customer commits to implementing a bundle of energy-saving low cost operational based measures that meet certain financial investment criteria. Both the customer and Duke Energy also commit to periodic energy monitoring, analysis and reporting.

This program has the potential to encourage customers to be more proactive in their management of energy. Their interaction with the software and with the energy analysts will likely evolve the customers' views of energy as a manageable expense. Duke Energy Ohio needs to test this program offer with customers in order to prove that it is cost-effective. Several other U. S. utilities are rolling out programs and measures with similar components and are seeing cost-effective results, but Duke Energy needs to test it with our customers and the EMIS vendors that we have prequalified.

**4901:1-39-05(D) Independent Program Evaluator Report**

Appendix C, provides an up-to-date summary EM&V methodologies and protocols. Individual reports have been provided as appendices D through L.

**4901:1-39-05 (E)(1) and (2)(a-b) Peak Demand Reductions**

Duke Energy Ohio has satisfied its peak-demand reduction benchmarks through energy efficiency and peak-demand response programs implemented by the Company and programs implemented on mercantile customer sites where the mercantile program is committed to the electric utility.

**4901:1-39-05(F) and (G)(1-5) Mercantile Customers**

Duke Energy Ohio's Mercantile Self Direct program is the avenue through which mercantile customers commit energy and demand impacts from their energy efficiency projects to Duke Energy Ohio in exchange for cash rebates or commitment payments. The program uses the constructs for calculating and deeming energy and demand savings that are present in the Custom Incentive and Prescriptive Incentive programs, respectively.

As of December 31, 2012, no customers have requested rider exemption in exchange for commitment of energy and demand savings to Duke Energy Ohio. Upon approval of the customer's application, Duke Energy Ohio tenders an offer letter agreement to the customer which outlines the cash rebate or commitment payment offered. After the customer signs the offer letter agreement, Duke Energy Ohio submits a mercantile application to the Commission on behalf of the customer. Upon Commission approval of the application or the passing of 60 days, Duke Energy Ohio remits payment to the customer for the agreed dollar amount.

The offer letter provided to applicants pursuant to each project submitted to Duke Energy Ohio requires the customer to affirm its intention to commit and integrate the energy efficiency projects listed in the offer into Duke Energy Ohio's peak demand reduction, demand response and/or energy efficiency programs. The offer letter agreement also requires the customer to agree to serve as joint applicant in any future filings necessary to secure approval of this arrangement as required by the Commission and to comply with any information and reporting requirements imposed by rule or as part of that approval. Noncompliance by the customer with the terms of the commitment is not applicable at this time.

The attached offer letter agreement template (Appendix O), used for each mercantile application (examples in Appendix M and Appendix N), provides for formal declaration.

Additionally, the attached example application documents request that the applicant allow Duke Energy Ohio to share information only with vendors associated with program administration. The release is limited to use of the information contained within the application and other relevant data solely for the purposes of reviewing the application, providing a rebate offer, submitting documentation to the Commission for approval and payment of the rebate. All program administration vendor contracts strictly prohibit the sharing of customer information for other purposes.

Upon customer request, Duke Energy Ohio will agree, as it is able to do so, to provide information to the Commission in the proper format such that confidential customer information is redacted from the public record.

With regard to the customers in Duke Energy's Ohio territory who have undertaken self-directed energy efficiency projects, these initiatives will not be evaluated by the Company's independent evaluation contactor (TecMarket Works). These efforts have been implemented in the past and were self-directed by our mercantile customers without involvement in Duke Energy Ohio's energy efficiency or demand reduction programs under Duke Energy Ohio's Shared Savings Cost Recovery mechanism. As a result they will not be included in the evaluations of Duke Energy Ohio programs.

**4901:1-39-05(H) Prohibition Against Counting Measures Required by Law Toward Meeting the Statutory Benchmark**

Duke Energy Ohio did not count, in meeting its statutory benchmark, the adoption of measures that were required to comply with energy performance standards set by law or regulation, including but not limited to, those embodied in the Energy Independence and Security Act of 2007, or an applicable building code.

**4901:1-39-05 (I) and (J) Benchmarks Not Reasonably Achievable**

The above referenced sections do not apply to Duke Energy Ohio as it has met and exceeded the statutory benchmarks for the 2012 calendar year.

## III. Conclusion

With this status report, Duke Energy Ohio has demonstrated that it is in compliance with the statutory load impact requirements as measured and reported in its Benchmark Report filed May 15, 2013. Duke Energy Ohio respectfully requests that the Commission find that the Company has met its compliance requirements for the 2012 compliance year.

Respectfully submitted,

DUKE ENERGY OHIO, INC.

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# 4901:1-39-05(C)(1)(b) - SB 221 Appendix A

## 2012 Total Reported Achievement

| Program | Customer | Product Code | Measure | Annual KW Gross FR, @ Plant Total | Annual KWH Gross FR, @ Plant Total | Participants |
|---|---|---|---|---|---|---|
| Grand Total | | | | 82,860 | 262,436,819 | 2,333,285 |

## Other EE Programs

| Program | Customer | Product Code | Measure | Annual KW Gross FR, @ Plant Total | Annual KWH Gross FR, @ Plant Total | Participants |
|---|---|---|---|---|---|---|
| PowerShare Generators | NonRes | | PowerShare Generators | (31,360) | | |
| Large Transmission Customer | NonRes | | Large Transmission Customer | 67,491 | | |
| Low Income Weatherization | Res | | Low Income Weatherization | 1,019 | 3,787,119 | 3,837 |
| **Grand Total** | | | | **37,150** | **3,787,119** | **3,837** |

## Shared Savings and Mercantile Portfolios

| Program | Customer | Product Code | Measure | Annual KW Gross FR, @ Plant Total | Annual KWH Gross FR, @ Plant Total | Participants |
|---|---|---|---|---|---|---|
| **Home Energy Comparison Report** | Res | **HECR** | Home Energy Comparison Report | (575) | (3,240,335) | - |
| **Home Energy Comparison Report** | Res | **HECR** | Home Energy Comparison Report - Commercialized | 15,658 | 45,637,090 | 250,447 |
| **Home Energy Comparison Report** | Res | **HECR Total** | | **15,083** | **42,396,754** | **250,447** |
| **Home Energy Comparison Report Total** | | | | **15,083** | **42,396,754** | **250,447** |
| **PowerManager** | Res | **PWRMGR** | PowerManager -Midwest | (4,709) | | |
| **PowerManager** | Res | **PWRMGR Total** | | **(4,709)** | | |
| **PowerManager Total** | | | | **(4,709)** | | |
| **Powershare** | Res | **PWRSHR** | PS CallOption 0_5 | 1,132 | | |
| **Powershare** | Res | **PWRSHR** | PS CallOption 10_5 | - | | |
| **Powershare** | Res | **PWRSHR** | PS CallOption 15_5 | - | | |
| **Powershare** | Res | **PWRSHR** | PS CallOption 5_5 | 168 | | |
| **Powershare** | Res | **PWRSHR Total** | | **1,300** | | |
| **Powershare Total** | | | | **1,300** | | |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | - | - | - |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 42,694 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 43,637 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 33,449 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 35,115 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 157,951 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 100,806 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 147,597 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 72,356 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | - | - | - |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 26,370 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | 3 | 15,604 | 102 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | 42 | 111,098 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | | 42,685 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | 31 | 520,768 | 1 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | 33 | 215,562 | 229 |
| **Mercantile Self-Direct** | NonRes | **NRCSSD** | SD Custom - | 48 | 332,861 | 335 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 26 | 187,218 | 179 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 107 | 938,167 | 748 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 66,159 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 78,771 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 81,738 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 68,839 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 66,531 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 14 | 118,520 | 181 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 1 | 5,777 | 14 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 43 | 376,048 | 791 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 4 | 19,844 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (2) | 129,072 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (1) | 41,487 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (1) | 64,536 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 9 | 226,810 | 3 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 6 | 119,442 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 3 | 23,985 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 2 | 50,755 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 1 | 30,440 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 3,325,675 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 8 | 90,607 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 121,688 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (2) | 53,407 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 51,107 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 299,068 | 103 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (0) | 8,786 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 33 | 194,222 | 1,022 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 136 | 1,071,600 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (6) | 278,949 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (5) | 85,840 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 184 | 1,045,046 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 21,074 | 6 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 28 | 34,841 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 45 | 55,620 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 46 | 57,311 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 7 | 26,786 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 45 | 55,153 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 10 | 26,174 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 54,735 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 36 | 44,732 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 81,955 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 22,259 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 24 | 29,620 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 76 | 629,366 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (0) | 12,223 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 5 | 100,097 | 4 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 143 | 661,868 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 143 | 558,488 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 374 | 959,570 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 139 | 179,408 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 139 | 309,657 | 1 |

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|---|---|---|---|---|---|---|
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 139 | 265,558 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 136 | 131,351 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 139 | 147,582 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 3 | 56,959 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 4 | 42,891 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 4 | 45,650 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 4 | 38,566 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 26 | 106,501 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 177,211 | 86 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 3,259 | 4 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 7,966 | 63 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 231 | 2,027,231 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 12 | 101,286 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 55 | 483,639 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 20,910 | 19 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 6,744 | 16 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 3,672 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 70,435 | 64 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 24,446 | 58 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 30 | 258,603 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 3 | 14,725 | 107 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 3 | 15,473 | 118 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 59 | 66,540 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 12,808 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 157 | 1,377,870 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 18 | 35,635 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 61,517 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 16 | 2,113,395 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 8 | 33,834 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 91 | 542,102 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 205 | 1,220,452 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 11 | 22,225 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 16,002 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 15 | 28,144 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 13 | 26,011 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 8 | 15,219 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 4 | 6,779 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 10 | 18,449 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 16,441 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 12 | 22,812 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 13 | 25,028 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 29 | 54,936 | 2 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 8 | 16,181 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 6 | 11,398 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 10 | 19,742 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 258,146 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (4) | 129,343 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 42 | 250,455 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 205,748 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 4,832 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 13,406 | 1 |

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|---|---|---|---|---|---|---|
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 6,500 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 42,714 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | | 811 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | (0) | 109,043 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 23 | 135,016 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 43 | 198,341 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 34 | 203,427 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 38 | 228,029 | 1 |
| Mercantile Self-Direct | NonRes | NRCSSD | SD Custom - | 1,049 | 6,237,723 | 1 |
| **Mercantile Self-Direct** | **NonRes** | **NRCSSD Total** | | **4,719.33** | **32,977,337.44** | **4,365.00** |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Compact Fluorescent Fixture | 3 | 14,762 | 41 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Window Film | 1 | 3,546 | 811 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Compact Fluorescent Screw in | 4 | 18,636 | 89 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD VFD HVAC Fan | 38 | 225,724 | 170 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD VFD HVAC Pump | 51 | 302,616 | 80 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 2ft 2 lamp | 0 | 697 | 6 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 3ft 1 lamp | 0 | 817 | 8 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 4ft 1 lamp | 0 | 470 | 8 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 4ft 2 lamp | 2 | 12,012 | 192 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 4ft 3 lamp | 0 | 501 | 4 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-8 4ft 4 lamp | 2 | 10,351 | 67 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD LED Case lighting | 1 | 17,534 | 36 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Low Watt T8 lamps 2-4ft, replacing standard 32 Watt T8 | 12 | 59,010 | 3,081 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD AC 65,000 - 135,000 per ton | 1 | 3,317 | 53 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD AC 135,000 - 240,000 per ton | 7 | 19,079 | 172 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Night covers for displays | 0 | 2,608 | 32 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD High Performance Low Watt T8 4ft 4 lamp, replacing standard T8 | 37 | 183,108 | 2,109 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD AC < 65,000 3 Ph per ton | 0 | 592 | 13 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD High Performance Low Watt T8 4ft 2 lamp, replacing standard T8 | 26 | 127,016 | 2,618 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD High Performance Low Watt T8 4ft 3 lamp, replacing standard T8 | 37 | 178,306 | 2,182 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-5 4 ft 2 Lamp w/ Electronic Ballast (replacing T-12 fixture) | 1 | 3,505 | 61 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD T-5 4 ft 1 Lamp w/ Electronic Ballast (replacing T-12 fixture) | 0 | 2,434 | 42 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Vending Equipment Controller | | 23,019 | 27 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Air Cooled Chiller Tune Up per ton | 41 | 114,235 | 891 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8) | 4 | 19,019 | 29 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8) | 62 | 328,713 | 321 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Water Cooled Chiller Tune Up per ton | 3,018 | 8,362,908 | 130,456 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Occupancy Sensors over 500 Watts | 429 | 2,101,579 | 1,609 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Occupancy Sensors under 500 Watts | 193 | 930,151 | 1,781 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD LED Exit Signs Electronic Fixtures (Retrofit Only) | 4 | 30,814 | 126 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Air-Cooled Recip Chiller COP = 2.86, IPLV = 3.97 per ton | 26 | 72,119 | 242 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Air-Cooled Screw Chiller COP = 2.86, IPLV = 3.48 per ton | 10 | 26,867 | 155 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Air-Cooled Screw Chiller COP = 2.86, IPLV = 3.97 per ton | 50 | 138,009 | 606 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Air-Cooled Screw Chiller COP = 3.08, IPLV = 4.00 per ton | 30 | 82,945 | 221 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Water-Cooled cent Chiller > 300 ton 0.58 kW_ton w/ 0.35 kW_tonIPLVperton | 137 | 379,067 | 2,025 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Water-Cooled cent Chiller > 300 ton 0.58 kW_ton w/ 0.41 kW_tonIPLVperton | 163 | 452,821 | 3,400 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD ENERGY STAR Commercial Glass Door Refrigerators more than 50ft3 - var | 0 | 957 | 1 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD ENERGY STAR Commercial Glass Door Freezers 30 to 50ft3 - var | 4 | 37,107 | 9 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD ENERGY STAR Commercial Glass Door Refrigerators 15 to 30 ft3 - var | 0 | 712 | 1 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD ENERGY STAR Commercial Glass Door Refrigerators 30 to 50ft3 - var | 0 | 3,105 | 4 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Exterior HID replacement above 175W to 250W HID retrofit | | 7,505 | 17 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mercantile Self-Direct | NonRes | NRPRSD | SD Exterior HID replacement above 250W to 400W HID retrofit | | 110,408 | 146 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Exterior HID replacement to 175W HID retrofit | | 14,907 | 50 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD LW HPT8 4ft 2 lamp, Replace T12 | 2 | 11,997 | 108 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD LW HPT8 4ft 4 lamp, Replace T12 | 2 | 12,066 | 50 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD Snack Machine Controller | 0 | 1,190 | 4 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD 10 Horse Power High Efficiency Pumps | 3 | 10,048 | 4 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD 125-250 Horse Power Motors - Incentives per participant | 3 | 10,360 | 4 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD 1-5 Horse Power Motors - Incentives per participant | 0 | 1,684 | 14 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD 25-100 Horse Power Motors - Incentives per participant | 15 | 55,180 | 49 |
| Mercantile Self-Direct | NonRes | NRPRSD | SD 7.5-20 Horse Power Motors - Incentives per participant | 6 | 20,449 | 47 |
| Mercantile Self-Direct | NonRes | NRPRSD Total | | 4,427 | 14,546,583 | 154,272 |
| Mercantile Self-Direct Total | | | | 9,146 | 47,523,920 | 158,637 |
| Appliance Recycling Program | Res | FRCYCL | Freezer Recycle | 49 | 182,785 | 140 |
| Appliance Recycling Program | Res | FRCYCL Total | | 49 | 182,785 | 140 |
| Appliance Recycling Program | Res | RRCYCL | Fridge Recycle | 188 | 700,356 | 398 |
| Appliance Recycling Program | Res | RRCYCL Total | | 188 | 700,356 | 398 |
| Appliance Recycling Program Total | | | | 238 | 883,141 | 538 |
| Energy Efficiency Education Program for Schools | Res | K12CFL | K-12 Education Program- CFL Distribution (2009) | - | - | - |
| Energy Efficiency Education Program for Schools | Res | | K-12 Education Program | - | - | - |
| Energy Efficiency Education Program for Schools | Res | K12CFL Total | | - | - | - |
| Energy Efficiency Education Program for Schools | Res | K12PRF | K-12 Education Program- Curriculum | 102 | 1,148,881 | 9,516 |
| Energy Efficiency Education Program for Schools | Res | K12PRF Total | | 102 | 1,148,881 | 9,516 |
| Energy Efficiency Education Program for Schools Total | | | | 102 | 1,148,881 | 9,516 |
| Low Income Services | Res | LICFL | Agency Assistance Portal | - | - | - |
| Low Income Services | Res | LICFL Total | | - | - | - |
| Low Income Services | Res | REFRPL | Low Income Weatherization- Refrigerator Replacement | - | - | - |
| Low Income Services | Res | REFRPL Total | | - | - | - |
| Low Income Services Total | | | | - | - | - |
| Residential Energy Assessments | Res | HEHC | Home Energy House Call - Energy Efficiency Starter KIT | 668 | 4,739,374 | 2,208 |
| Residential Energy Assessments | Res | HEHC Total | | 668 | 4,739,374 | 2,208 |
| Residential Energy Assessments | Res | OHEC | SAW Online Audit w_EE kit | - | - | - |
| Residential Energy Assessments | Res | | Online Audit | - | - | - |
| Residential Energy Assessments | Res | OHEC Total | | - | - | - |
| Residential Energy Assessments | Res | PER | Personalized Energy Report | 0 | 709 | 2 |
| Residential Energy Assessments | Res | PER Total | | 0 | 709 | 2 |
| Residential Energy Assessments Total | | | | 668 | 4,740,084 | 2,210 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 31 | 188,084 | 894 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |

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| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |

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| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |

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| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 19,649 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 12 | 37,892 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 27 | 199,648 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 160 | 495,455 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 7,587 | 2 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 10,116 | 3 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 38,608 | 24 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 47,188 | 33 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 899 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 12,106 | 11 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 19,482 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 42 | 99,714 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 22 | 51,345 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 26 | 49,100 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 18 | 45,132 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 30 | 75,287 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 120 | 727,849 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 16,781 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,538 | 6 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 786 | 2 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 15 | 127,202 | 453 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 52 | 385,928 | 574 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 215,801 | 32 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 19 | 370,429 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 8 | 40,582 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 11 | 111,729 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 65 | (25,782) | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 61,691 | 2 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 58 | (26,327) | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 29,164 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 10 | 52,341 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 28,748 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 5 | 26,911 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 8 | 39,545 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 30,845 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 13,974 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 8 | 39,339 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 9 | 44,743 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 7 | 36,016 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 77 | 2,593,885 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 300,223 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 7 | 300,086 | 1 |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 20 | 472,498 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 8,044 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 202 | 2,066,056 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 17 | 144,808 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 10 | 69,574 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 31,040 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 9 | 37,417 | 48 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 11 | 48,870 | 148 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 33,696 | 12 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 71 | 540,178 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 157 | 2,675,632 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 9 | 651,243 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 48 | 1,590,344 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 46 | 146,703 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 88,932 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 94 | 228,122 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 13,915 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 4,494 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 951 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,224 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 8,554 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 14,105 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 15,087 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,012 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 15,618 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,220 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,635 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 287 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,818 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,015 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 5,352 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,260 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,017 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 969 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,079 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,177 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,039 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,211 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,625 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,376 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,091 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,669 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 11,440 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,816 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,937 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 3,622 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 624 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 2,680 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 4,024 | 14 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 111,850 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 8 | 28,931 | 1 |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 235,488 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 22,127 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 235,052 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 11,025 | 34 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 2,643 | 6 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 6 | 16,966 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 18,425 | 245 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 12,108 | 161 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 2 | 7,520 | 150 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | (6) | 174,708 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 12 | 95,504 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 66 | 294,750 | 472 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 25 | 113,471 | 127 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 11 | 99,841 | 146 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 2 | 13,581 | 15 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 20 | 84,637 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 12 | 55,146 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 64 | 560,445 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 29 | 113,663 | 73 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 11 | 55,565 | 70 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 27 | 1,103 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 101 | 424,056 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 7 | 24,985 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 12 | 105,743 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 17,178 | 12 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 12 | 41,425 | 28 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 61 | 223,668 | 96 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 28 | 119,546 | 92 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 102 | 523,770 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 12,636 | 50 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 14,391 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 14,000 | 36 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 2,881 | 3 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 6,318 | 10 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 4 | 22,709 | 138 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 82 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 1,975 | 3 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 0 | 176 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 196,313 | 125 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 13,667 | 16 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 15 | 128,886 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 2,772 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 3,799 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 1 | 2,684 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 2,152 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 328 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 10 | 39,485 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 78,014 | 368 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 252,746 | 1,376 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 120 | 1,155,176 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 10,033 | 1 |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | 40,077 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 8 | 49,958 | 38 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 3 | 12,800 | 822 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 206 | 1,320,932 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 24 | 206,738 | 250 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 5 | 42,175 | 51 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 80 | 295,593 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | 75 | 1,210,364 | 1 |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC | OH Custom | - | - | - |
| Smart $aver Non Residential Custom | NonRes | NRPRSC Total | | 2,781 | 24,904,197 | 7,379 |
| Smart $aver Non Residential Custom Total | | | | 2,781 | 24,904,197 | 7,379 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Beverage Reach-in Controller | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ECM Case Motors | 40 | 465,177 | 1,223 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ECM Cooler and Freezer Motors - ECM replacing PSC | 72 | 856,010 | 456 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Anti-sweat Heater Controls | 4 | 1,198,299 | 670 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Convection Oven | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Fryer | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Holding Cabinet Full Size Insulated | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Holding Cabinet Half Size Insulated | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Icemaker (100 to 500 lbs_day) | 0 | 639 | 1 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Icemaker (500 to 1000 lbs_day) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Icemaker (> 1000 lbs_day) | 0 | 4,118 | 3 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Night covers for displays | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Solid Door Reach-in Freezer (21 to 48 cu ft) Avg 30 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Solid Door Reach-in Freezer (Greater Than 48cu ft) Avg 63 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Solid Door Reach-in Refrig (21 to 48 cu ft) Avg 30 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Solid Door Reach-in Refrig (Greater Than 48cu ft) Avg 63 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Solid Door Reach-in Refrig (Less Than 20 cu ft) Avg 12 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Steamer | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Vending Equipment Controller | 1 | 6,878 | 8 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Steamer_5 pan | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | Combination Oven (90 lbs_hr) | 4 | 19,692 | 1 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Glass Door Freezers 30 to 50ft3 - var | 1 | 12,393 | 3 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Glass Door Refrigerators 30 to 50ft3 - var | 0 | 1,555 | 2 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Freezers < 15ft3 - var | 0 | 635 | 1 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Freezers 15 to 30 ft3 - var | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Freezers 30 to 50ft3 - var | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Refrigerators < 15ft3 - var | 0 | 577 | 2 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Refrigerators 15 to 30 ft3 - var | 0 | 502 | 1 |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Refrigerators 30 to 50ft3 - var | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRFS | ENERGY STAR Commercial Solid Door Refrigerators more than 50ft3 - var | 0 | 1,210 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Smart $aver Non Residential Prescriptive | NonRes | NRFS Total | | 123 | 2,567,683 | 2,372 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 3.08, IPLV = 4.00 per ton | 14 | 35,655 | 95 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 3.08, IPLV = 5.22 per ton | 41 | 131,024 | 244 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP 135,000 - 240,000 per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP 65,000 - 135,000 per ton | 2 | 2,343 | 20 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP < 65,000 1 Ph per ton | 1 | 1,661 | 14 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP < 65,000 3 Ph per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled Cent Chiller < 150 ton 0.63 kW_ton with 0.38 kW_ton IPLV per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller > 300 ton 0.58 kW_ton with 0.35 kW_ton IPLV per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-cooled screw chiller 150 - 300 ton 0.72 kW_ton w/0.57 kW_ton IPLV per ton | 2 | 11,390 | 156 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-cooled screw chiller < 150 ton 0.71 kW_ton with 0.53 kW_ton IPLV per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-cooled screw chiller < 150 ton 0.79 kW_ton with 0.55 kW_ton IPLV per ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water Cooled Chiller Tune Up per ton | 1,544 | 3,265,092 | 76,400 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Guest Room Energy Management, Electric Heating | 95 | 554,680 | 795 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | High Efficiency Commercial Electric Water Heater 4.5 kW EF 0.93 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | SAW Chilled Water EE Cooled Chillers 150 - 300 ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | SAW Chilled Water EE Cooled Chillers greater than 300 ton | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 135,000 - 240,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 240,000 - 760,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 65,000 - 135,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC greater than 760,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC less than 65,000 1 Ph | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC less than 65,000 3 Ph | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | SAW Chilled Air EE Cooled Chillers | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | SAW Chilled Water Reset Air Cooled 100-200 tons | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Energy Star Window AC over 14,000 Btu hr | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP 135,000 - 240,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP 65,000 - 135,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP greater than 240,000 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP less than 65,000 1 Ph | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | HP less than 65,000 3 Ph | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Packaged Terminal AC | 1 | 1,057 | 26 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Setback Programmable Thermostat | (0) | 173,295 | 140 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Thermal Storage Irg C&I | - | | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Window Film | 75 | 172,889 | 39,541 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 3!08, IPLV = 3!80 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 3!08, IPLV = 4!00 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Energy Star Room AC over 14,000 Btu hr | 0 | 453 | 2 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Thermal Storage | 155 | | 1 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller 150 - 300 ton 0!57 kW_ton with 0!4 kW_ton IPLV | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller 150 - 300 ton 0!63 kW_ton with 0!45 kW_ton IPLV | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller greater than 300 ton 0!52 kW_ton with 0!31 kW_ton IPL | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller greater than 300 ton 0!52 kW_ton with 0!37 kW_ton IPL | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller greater than 300 ton 0!58 kW_ton with 0!35 kW_ton IPL | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller greater than 300 ton 0!58 kW_ton with 0!41 kW_ton IPL | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-Cooled cent Chiller greater than 300 ton 0!58 kW_ton with 0!47 kW_ton IPL | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water-cooled screw chiller less than 150 ton 0!71 kW_ton with 0!53 kW_ton IPLV | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | BONUS Air Cooled Chiller Tun Up | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | BONUS Water Cooled Chiller Tune Up | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | BONUS Refrigeration System Tune Up | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air Cooled Chiller Tune Up | - | - | - |

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|---|---|---|---|---|---|---|
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 2.86, IPLV = 4.33 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Water Cooled Chiller Tune Up | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 135,000 - 240,000 per ton | 37 | 29,839 | 417 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 240,000 - 760,000 per ton | 41 | 32,861 | 450 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC 65,000 - 135,000 per ton | 33 | 26,112 | 446 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC > 760,000 per ton | 16 | 12,562 | 225 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC < 65,000 1 Ph per ton | 2 | 1,702 | 28 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | AC < 65,000 3 Ph per ton | 6 | 4,915 | 108 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air Cooled Chiller Tune Up per ton | 339 | 717,898 | 8,959 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 2.86, IPLV = 3.48 per ton | 125 | 265,202 | 1,530 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 2.86, IPLV = 3.97 per ton | 30 | 64,450 | 283 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC | Air-Cooled Screw Chiller COP = 2.86, IPLV = 4.33 per ton | 188 | 397,956 | 965 |
| Smart $aver Non Residential Prescriptive | NonRes | NRHVAC Total | | 2,749 | 5,903,036 | 130,845 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | SAW Occupancy Sensors under 500 Watts | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | SAW Occupancy Sensors over 500 Watts | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | SAW Switching Controls Multilevel Lighting | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Ceramic Metal Halide Integral Ballast | 0 | 1,965 | 9 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | CFL Reflector Flood | 30 | 146,986 | 606 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | CFL Screw high wattage | 21 | 103,238 | 210 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | CFL Screw in, Specialty | 54 | 265,771 | 1,749 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Delamping T12 2ft to T-8 | 0 | 2,037 | 21 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Delamping T12 3ft to T-8 | 2 | 11,788 | 81 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Delamping T12 4ft to T-8 | 0 | 1,662 | 9 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Exterior HID replacement above 175W to 250W HID retrofit | | 265,654 | 602 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Exterior HID replacement above 250W to 400W HID retrofit | | 566,653 | 748 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Exterior HID replacement above 400W HID retrofit | | 377,659 | 277 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Exterior HID replacement to 175W HID retrofit | | 160,658 | 537 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Garage HID replacement above 175W to 250W HID retrofit | 0 | 3,023 | 3 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Garage HID replacement above 250W to 400W HID retrofit | 1 | 5,196 | 3 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Garage HID replacement to 175W HID retrofit | 93 | 813,857 | 1,192 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Downlight | 20 | 97,422 | 379 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Lamps | 618 | 3,042,954 | 13,042 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LW HPT8 4ft 1 lamp, Replace T12 | 9 | 42,913 | 708 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LW HPT8 4ft 2 lamp, Replace T12 | 140 | 688,677 | 8,605 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LW HPT8 4ft 3 lamp, Replace T12 | 226 | 1,112,597 | 7,644 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LW HPT8 4ft 4 lamp, Replace T12 | 248 | 1,218,324 | 7,385 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 High Output 1 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 4 ft 1 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 4 ft 2 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 High Output 2 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 4 ft 3 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 High Output 3 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 4 ft 4 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-5 High Output 4 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay 2L T-5 High Output | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay 3L T-5 High Output | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay 4L T-5 High Output | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay 6L T-5 High Output | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay 8L T-5 High Output | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8) | - | - | - |

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| **Smart $aver® Residential** | Res | SSHP | Smart Saver - Heat Pump | 689 | 4,242,598 | 1,511 |
| **Smart $aver® Residential** | Res | **SSHP Total** | | 689 | 4,242,598 | 1,511 |
| **Smart $aver® Residential Total** | | | | 10,092 | 82,838,767 | 1,489,758 |
| **Grand Total** | | | | **45,710.19** | **258,649,700.30** | **2,329,447.92** |

*Impacts applied January – September based on prior EM&V report effective Jan 2011
**Impacts applied October - December based on current EM&V report effective October 2012.

| | | | | | | |
|---|---|---|---|---|---|---|
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay T8 4ft Fluorescent 3 Lamp (F32 Watt T8) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Bay T8 4ft Fluorescent 8 Lamp (F32 Watt T8) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 1 lamp, replacing T12-HPT8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 1 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 2 lamp, replacing T12-HPT8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 2 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 3 lamp, replacing T12-HPT8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 3 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 4 lamp, replacing T12-HPT8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 4 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Exit Signs Electronic Fixtures (Retrofit Only) | 38 | 278,703 | 1,140 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Pedestrian Signals | 13 | 42,812 | 266 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Light Tube | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Low Watt T8 lamps 2-4ft, replacing standard 32 Watt T8 | (3) | (16,727) | (846) |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance Low Watt T8 4ft 1 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance Low Watt T8 4ft 3 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance Low Watt T8 4ft 4 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance Low Watt T8 4ft 2 lamp, replacing standard T8 | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Occupancy Sensors over 500 Watts | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Occupancy Sensors under 500 Watts | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Plug Load Occupancy Sensors Document Stations | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Pulse Start Metal Halide 320W retrofit only | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 2 lamp, replacing T12 8ft 1 lamp | 1 | 5,278 | 72 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 4 lamp, replacing T12 8ft 2 lamp | 10 | 48,225 | 1,591 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 2 lamp, replacing T12 High Output 8ft 1 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | High Performance T8 4ft 4 lamp, replacing T12 High Output 8ft 2 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 2ft 1 lamp | 0 | 2,377 | 49 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 2ft 2 lamp | 10 | 51,459 | 442 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 2ft 3 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 2ft 4 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 3ft 1 lamp | 4 | 19,478 | 287 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 3ft 2 lamp | 1 | 3,314 | 28 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 3ft 4 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 4ft 1 lamp | 2 | 10,231 | 325 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 4ft 2 lamp | 31 | 150,881 | 4,793 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 4ft 3 lamp | 32 | 159,113 | 2,523 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 4ft 4 lamp | 115 | 555,804 | 7,164 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 8ft 1 lamp | 0 | 202 | 3 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 8ft 2 lamp | 3 | 14,934 | 450 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 High Output 8 ft 1 Lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | T-8 High Output 8 ft 2 Lamp | 2 | 12,170 | 88 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Auto Traffic Signals | - | 456,827 | 1,530 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | 2 High Bay 6L T-5 High Output replacing 1000W HID | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | 2 High Bay Fluorescent 8LF32T8 - Replacing 1000W HID | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Compact Fluorescent Fixture | 60 | 295,111 | 680 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Compact Fluorescent Screw in | 272 | 1,336,121 | 6,165 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Case lighting | 84 | 996,492 | 2,030 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | LED Case lighting sensor control | 4 | 45,176 | 137 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 2 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 3 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 4 Lamp with Electronic Ballast (replacing T-12 fixture) | - | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 High Output 2 Lamp with Electronic Ballast (replacing T-12 fixture) | 0 | 2,212 | 76 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 High Output 3 Lamp with Electronic Ballast (replacing T-12 fixture) | 0 | 102 | 6 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS T-5 High Output 4 Lamp with Electronic Ballast (replacing T-12 fixture) | 0 | 342 | 6 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS 42W 8 Lamp High Bay Compact Fluorescent | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay 2L T-5 High Output | 2 | 12,492 | 30 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay 3L T-5 High Output | 2 | 13,138 | 27 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay 4L T-5 High Output | 353 | 1,908,002 | 1,999 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay 6L T-5 High Output | 146 | 787,856 | 1,958 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay 8L T-5 High Output | 185 | 999,231 | 353 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay Fluorescent 3 Lamp (F32 Watt T8) | 4 | 17,513 | 44 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay Fluorescent 4 Lamp (F32 Watt T8) | 182 | 983,300 | 1,480 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay Fluorescent 6 Lamp (F32 Watt T8) | 1,995 | 10,787,906 | 10,386 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Bay Fluorescent 8 Lamp (F32 Watt T8) | 112 | 605,673 | 863 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS Occupancy Sensors under 500 Watts | 1,017 | 4,901,893 | 9,366 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS Occupancy Sensors over 500 Watts | 172 | 843,827 | 644 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS Pulse Start Metal Halide (retrofit only) | 42 | 208,307 | 462 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS 2 High Bay 6L T-5 High Output replacing 1000W HID | 12 | 61,122 | 36 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS 2 High Bay Fluorescent 8LF32T8 - Replacing 1000W HID | 3 | 14,028 | 6 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 1 lamp, replacing T12-HPT8 | 0 | 2,336 | 41 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 2 lamp, replacing T12-HPT8 | 68 | 335,507 | 4,379 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 3 lamp, replacing T12-HPT8 | 18 | 88,375 | 689 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 4 lamp, replacing T12-HPT8 | 53 | 259,112 | 1,775 |
| *Smart $aver Non Residential Prescriptive* | *NonRes* | *NRLTG* | *BONUS High Performance T8 4ft 1 lamp, replacing standard T8* | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 2 lamp, replacing standard T8 | 1 | 3,882 | 95 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 3 lamp, replacing standard T8 | 0 | 1,200 | 26 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T8 4ft 4 lamp, replacing standard T8 | 0 | 1,919 | 28 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance Low Watt T8 4ft 1 lamp, replacing standard T8 | 4 | 21,121 | 622 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance Low Watt T8 4ft 2 lamp, replacing standard T8 | 68 | 332,098 | 6,846 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance Low Watt T8 4ft 3 lamp, replacing standard T8 | 21 | 102,176 | 1,239 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance Low Watt T8 4ft 4 lamp, replacing standard T8 | 58 | 285,878 | 3,274 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T-8 4ft 2 lamp replacing T-12 8ft 1 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T-8 4ft 4 lamp replacing T-12 8ft 2 lamp | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T-8 4ft 2 lamp replacing T-12 High Output 8ft 1 lamp | 18 | 85,886 | 533 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS High Performance T-8 4ft 4 lamp replacing T-12 High Output 8ft 2 lamp | 178 | 877,571 | 2,969 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | BONUS Low Watt T8 lamps replacing standard 32 Watt T-8's | 599 | 2,998,176 | 151,642 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | CFL12PK_MIXBC_22 | 6 | 31,209 | 12 |
| Smart $aver Non Residential Prescriptive | NonRes | NRLTG | Central Lighting Controls | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | **NRLTG Total** | | 7,463 | 40,970,405 | 274,639 |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | VFD HVAC Fan | 289 | 1,844,300 | 1,389 |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | VFD HVAC Pump | 178 | 2,042,658 | 540 |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | VFD Process Pump 1-50 HP | 67 | 301,621 | 310 |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | 125-250 Horse Power Motors - Incentives per participant | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | 1-5 Horse Power Motors - Incentives per participant | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | 25-100 Horse Power Motors - Incentives per participant | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | 7l5-20 Horse Power Motors - Incentives per participant | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 5 Horse Power Pumps | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 10 Horse Power - Process Pumping | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 10 Horse Power Pumps | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 15 Horse Power - Process Pumping | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 15 Horse Power Pumps | - | - | - |
| Smart $aver Non Residential Prescriptive | NonRes | NRP&M | Variable Frequency Drive 2 Horse Power Pumps | - | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 20 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 20 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 25 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 25 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 3 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 30 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 30 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 40 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 40 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 5 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 50 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 7!5 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | Variable Frequency Drive 7!5 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 1.5 Horse Power High Efficiency Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 10 Horse Power High Efficiency Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 15 Horse Power High Efficiency Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 20 Horse Power High Efficiency Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 3 Horse Power High Efficiency Pumps | 0 | 1,290 | 2 |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 5 Horse Power High Efficiency Pumps | 0 | 2,149 | 2 |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | 7.5 Horse Power High Efficiency Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 2 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 3 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 5 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 7!5 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 10 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 15 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 20 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 25 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 30 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 40 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 50 Horse Power Pumps | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 5 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 10 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 15 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 30 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 40 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M** | BONUS Variable Frequency Drive 50 Horse Power - Process Pumping | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRP&M Total** | | 535 | 4,192,019 | 2,243 |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRPROC** | VSD Air Compressors | 140 | 580,813 | 864 |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRPROC** | Barrel Wraps (Inj Mold & Extruders) | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRPROC** | BONUS PC Network Energy Management | - | - | - |
| **Smart $aver Non Residential Prescriptive** | NonRes | **NRPROC Total** | | 140 | 580,813 | 864 |
| **Smart $aver Non Residential Prescriptive Total** | | | | 11,010 | 54,213,957 | 410,963 |
| **Smart $aver® Residential** | Res | **RCFL** | Smart Saver - RCFL Promo | - | - | - |
| **Smart $aver® Residential** | Res | **RCFL** | RCFL Opt-In Free CFLs (Jan-Sept)* | 7,058 | 63,692,277 | 1,127,224 |
| **Smart $aver® Residential** | Res | **RCFL** | RCFL Opt-In Free CFLs (Oct-Dec)** | 1,398 | 12,620,797 | 343,157 |
| **Smart $aver® Residential** | Res | **RCFL Total** | | 8,456 | 76,313,074 | 1,470,381 |
| **Smart $aver® Residential** | Res | **RCFLPM** | Property Manager 13WCFL | 72 | 648,252 | 15,341 |
| **Smart $aver® Residential** | Res | **RCFLPM Total** | | 72 | 648,252 | 15,341 |
| **Smart $aver® Residential** | Res | **SSAC** | Smart Saver - Central Air Conditioner | 875 | 1,634,843 | 2,525 |
| **Smart $aver® Residential** | Res | **SSAC Total** | | 875 | 1,634,843 | 2,525 |

# Overall Evaluation Approaches
# Duke Energy's Energy Efficiency Programs in Ohio

Prepared for
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Spring 2013

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# Evaluation Objectives

This section provides an overview of the Research Questions that will be addressed in each of the following evaluation components.

a) Impact Evaluation Research Questions
b) Process Evaluation Research Questions
c) Additional Research Questions (if needed)

## Impact Evaluation Research Questions

1. What are the per-unit energy savings?
2. What are the per-home energy savings?
3. What are the demand savings (coincident and non-coincident) by measure?
4. What is the common practice for normal replacement measures not covered by code?

## Process Evaluation Research Questions

1. Are the program management and operations efficient and effective?
2. Are program participants satisfied with the program?
3. Is the program targeting, marketing and outreach effective?
4. What are the reasons for participating and barriers to participation?
5. Are the incentive/rebate levels and effective and influential?
6. Are vendors and stakeholders satisfied with the program?
7. What are the evaluation contractor recommendations for improvements?
8. What is the level of freeridership and spillover associated with this program?

## Additional Research Questions *(if needed)*

There are no plans for market assessments, baseline research, or non-energy benefits research at this time. There are a few program evaluations that include cross-cutting evaluation activities to determine if a certain program leads to higher levels of participation in other Duke Energy programs.

1. Does this program lead to higher levels of participation in other programs?
2. What lessons can be learned from the way rate payers access the variety of Duke Energy web sites.

# Overall Evaluation Approach

## Billing Analysis

For programs that are to be evaluated using a billing data analysis, the standard procedure that will be used involves estimating a fixed-effect panel model. This model uses data both across households (i.e., cross-sectional) and over time (i.e., time-series). With these types of data, it becomes possible to control, simultaneously, for differences across households as well as differences across periods in time. The fixed-effect refers to the model specification aspect that differences across homes that do not vary over the estimation period (such as square footage, heating system, etc.) can be explained, in large part, by customer-specific intercept terms.

In the model, the dependent variable is the customer's monthly energy usage obtained from billing data normalized by number of days in the month (to account for differences in days across months). These data will span both the pre- and post-participation period for the customer. Because the consumption data in the panel model include months before and after the installation of measures through the program, the period of program participation (or the participation window) may be defined specifically for each customer. This feature of the panel model allows for the pre-installation months of consumption to effectively act as controls for post-participation months. In addition, this model specification, unlike annual pre/post-participation models such as annual change models, does not require a full year of post-participation data for all participants (at least some participants should have a full year of past data, and it is preferable if all do). Effectively, the pre-participation data for participants are used as the control group (i.e., used to estimate the baseline), thus eliminating the need for a non-participant group. Note that this approach requires a variation in the date of participation, so it is not appropriate for programs like MyHER, in which all customers have the same treatment date. In that case, the billing data analysis will use the prior selected control group.

The fixed effects model can be viewed as a type of differencing model in which all characteristics of the home, which (1) are independent of time and (2) determine the level of energy consumption, are captured within the customer-specific constant terms. In other words, differences in customer characteristics that cause variation in the level of energy consumption, such as building size and structure, are captured by constant terms representing each unique household.

Algebraically, the fixed-effect panel data model is described as follows:

$$y_{it} = \alpha_i + \lambda_t + \beta x_{it} + \delta \cdot Part_{it} + \varepsilon_{it} \tag{1}$$

where:

$y_{it}$ = energy consumption for customer $i$ during month $t$
$\alpha_i$ = constant term for customer $i$
$\lambda_t$ = monthly indicator variable for time $t$
$\beta$ = vector of coefficients

$x$ = vector of variables that represent non-program factors causing changes in energy consumption for site $i$ during month $t$ (specifically weather terms)
$\delta$ = estimated program impact
$Part_{it}$ = an indicator variable that equals 1 if site $i$ was a participant in the program during month $t$
$\varepsilon_{it}$ = error term for site $i$ during month $t$.

With this specification, the weather data and the monthly indicator variables capture the effect of those non-program factors that vary month to month and affect energy use for each customer.

## Engineering Estimates

Engineering estimates will be developed using a combination of engineering algorithms and building energy simulation modeling. The engineering methods and data collection strategies are designed to follow the International Measurement and Verification Protocol (IPMVP).

### Engineering Algorithms

Engineering algorithms for simple measures such as lighting follow the basic form:

$$kWh = units \times (Watts_{base} - Watts_{ee}) / 1000 \times hours \times (1+WHF_e)$$

$$kW = units \times (Watts_{base} - Watts_{ee}) / 1000 \times (1+WHF_d) \times CF$$

where:

$Watts_{base}$ = baseline watts per unit
$Watts_{ee}$ = efficient watts per unit
hours = annual lighting operating hours
$WHF_e$ = waste heat factor for energy
$WHF_d$ = waste heat factor for demand
CF = coincidence factor

For some measures, unit energy savings will be derived from building energy simulation models:

$$\Delta kWh = units \times (\Delta kWh/unit)$$
$$\Delta kW_S = units \times (\Delta kW/unit) \times CF_S$$

where:

$\Delta kW$ = gross coincident demand savings
$\Delta kWh$ = gross annual energy savings
units = quantity of measures installed
CF = coincidence factor
$\Delta kW/unit$ = electricity demand savings per unit derived from simulation modeling

ΔkWh/unit = electricity consumption savings per unit derived from simulation modeling

### Building Energy Simulation Modeling

Building energy simulations will be used to estimate savings of individual projects, or to develop parameters used in engineering algorithms. The DOE-2.2 building energy simulation program will be used. When developing engineering parameters, the simulations will be conducted using a set of prototypical building models. The prototypical simulation models will be derived from the residential and commercial building prototypes used in the California Database for Energy Efficiency Resources (DEER) study, with adjustments make for local building practices and climate. Simulations will be driven by the TMY3 long-term average weather data for Covington, KY (Cincinnati Airport).

Building specific models will be developed for selected sites in the Nonresidential Smart $aver Custom program, following the IPMVP Option D Calibrated Simulation Model approach. The models will be calibrated to a combination of measure performance and billing data.

## Impact Analysis Reconciliation

For programs that involve a billing data analysis as well as an engineering analysis to determine program impacts, a comparison will between the results of the two will be made to determine if there is a statistically significant difference between them. If there is, then the model in equation will change the participation variable from an indicator variable to the engineering-based savings for that customer (i.e., a statistically-adjusted engineering or SAE model). This will provide further information on the difference between the estimates. Since the billing data use all participants (rather than a sample as is usually the case with the engineering analysis), and uses actual usage to derive impacts, for cases where there are statistically significant differences, the billing analysis is often assumed to provide the most accurate estimate of the effect of the program.

Since the billing data are based upon monthly energy use (kWh), it is not possible to derive the demand (kW) savings from this analysis. To develop these estimates, the ratio of the kW to kWh savings found in the engineering analysis will be applied to the kWh estimates from the billing analysis to get a statistically adjusted estimate of demand. Billing analysis also provides the team with a means to assess take-back effects.

## Process Evaluations

The process evaluation efforts will be somewhat different for each program. However, to a certain extent these studies will follow a similar theme and approach. The process evaluation will consist of program-specific efforts designed to address each program's researchable issues, but will, in general, include the following efforts:

1. Reviewing program materials and methods of operation

2. Holding an evaluation project initiation meeting with Duke Energy to review all study objectives
3. Conducting interviews with program managers and implementers
4. Conducting interviews with trade allies, partners, key managers and implementers
5. Designing interview and survey instruments
6. Conducting surveys with participants and/or non-participants
7. Analyzing process evaluation data
8. Developing process evaluation reports

These activities are described below and apply to the evaluation efforts associated with the process evaluation for each program being assessed. During the planning process the specific researchable issues on which each study will focus will be established and the process evaluation plan will be designed to specifically address those issues.

**1. Review program materials and methods of operation**

Early in the evaluation process, the evaluation team will request program materials and begin a review of all available information to familiarize our team with the operations of the program. We like to gain as much knowledge as possible prior to launching the process evaluation field efforts. This includes reviewing all program-specific documents and incorporating this information with the verbal information obtained during discussions with Duke Energy and discussions with the program implementers.

Together, the review of the documents collected, linked with the verbal information obtained from managers, provides the foundation for a number of activities, including: 1) identification of researchable issues for the process evaluation, 2) obtainment of information needed to start the development of interview and survey protocols and instruments, 3) identification of appropriate analytical methods. Typically we examine between 2 and 6 documents per program during this task.

**2. Hold an evaluation project initiation meeting to review study objectives**

The evaluation team will meet Duke Energy to review the evaluation efforts, finalize general evaluation plans, and develop program-specific plans. The project initiation meeting will be preceded by a conference call with the Duke Energy evaluation managers to review each project and discuss any desired refinements to the overall activities.

Through the initial scheduling process, we will work to identify key individuals that will serve as information sources. Typically these are the Duke Energy evaluation and program managers and others. These are often the same people who are responsible for cost-effective program operations and program delivery and interaction with the market. If possible, we will want to hear from several of these individuals during the initiation meeting, but we will follow up with all identified individuals as necessary.

During the project initiation meeting we will review the upcoming work in detail. We will discuss the programs design, operation, and timing. We will work with Duke Energy to identify researchable issues for each program with the program implementers (through follow up discussions as necessary) to reach an agreement on the issues that will be incorporated into each program's evaluation. The researchable issues will be the dominant focus of the process evaluation efforts. Through this process, we will ensure that key researchable issues are not missed during the planning phase.

3. **Conduct interviews with program managers and implementers**

The evaluation team will also conduct formal interviews with program managers and implementers to obtain a detailed level of knowledge about each program. This is one of the most important tasks in the process evaluation effort. At this point in the study, the evaluation team will be familiar with the program's general program processes and the program managers. We will understand the general operational systems and procedures of the program, but will need additional information on the design and operations of these systems at a level of detail needed to conduct a process evaluation.

Through our formal interviews, we will explore the detailed implementation process associated with each program. We will also discuss intended program designs, operational procedures, marketing and outreach efforts, tracking and data handling systems, interactions with contractors, allies, and participants' application procedures. (Note that the California Evaluation Framework, which was developed under the guidance of Nick Hall at TMW, provides additional details on standard industry practices on the investigative nature of the process evaluation. To minimize the length of this write-up, we have not included all of this information here.)

To guide these interviews, the evaluation team will develop interview protocols that identify who will be interviewed, and each of the questions to be asked of each manager. This protocol will be provided to the managers prior to the interview.

While these interviews are primarily to serve as the initial program-level process evaluation information gathering task, it is also the time at which we will go over the program theories and logic models (if available) with the program managers to identify needed changes. The interview questions and the manager's responses will serve as one of the data sources for the process evaluation's analysis efforts. The responses will also help set the stage for the identification of the issues to be addressed during the interactions with the trade allies, contractors, participants and non-participants.

4. **Conduct interviews with trade allies, partners, key managers and implementers**

For a few of the program evaluations, interviews will be conducted with a sample of partners, trade allies and program implementation staff (note that the specific programs and targeted groups will be identified in the program-by-program planning process). This task is where skilled process interviewers are required. These interviews will focus on the program's design, operations, operational conditions, the interaction between the ally, the program and the participant, the service stream and the activities in that stream, the influence of the program and the ally on the participants' decision to take actions, and other considerations. In addition, the interviews will focus on the interviewee's opinions about which parts of the program work best and least well, and what kind of recommendations are suggested by the interviewee.

We will work with Duke Energy to identify the population of key allies for the interview sample. The key ally sample will be a targeted sample drawn to get at allies that are most involved with the program being evaluated. This allows us to identify a set of "must interview" allies that have been or are significantly involved in the program and who consequently should be high priority interview targets. If Duke Energy can identify a set of high-priority allies, we can identify these allies as interview targets. The remaining key allies not included in the interview sample will be put in the non-key ally sample and a random assignment of the non-key ally sample will be conducted to develop a priority list of sample targets for the ally survey. These approaches allow us to obtain a strong key ally sample and follow-up with a strong ally sample of the remaining key and non-key allies.

The interviews will follow a prescribed protocol that guides the interview to address the key researchable issues. The protocol and the questions to be asked will be developed by the evaluation team and reviewed by Duke Energy managers prior to field implementation. The interviews will be scheduled by the evaluation team to be convenient to the interviewee. The interviews may be recorded to preserve a record to support the analysis, but maintained as confidential information. Process evaluation results are typically confidential so that the interviewee will provide opinions and information that are objective and accurate, without concern that their comments will be linked to them as an individual. However, all issues, comments and concerns, as well as interviewee recommendations for program changes, are reported to Duke Energy.

5. **Design interview and survey instruments**

A separate interview or survey protocol and instrument will be drafted for each of the targeted programs and survey groups as appropriate for each program (allies, participants and non-participants). The protocols and instruments for the allies will focus on a wide range of design, management and operational issues. The surveys with participants will focus on the participation experience, the ability of the program to help the customer, program and program-component satisfaction, ability of the program to accomplish the reasons for participation, actions that would have been taken without the program, and services that the participants indicated to be of values. The development of the participant survey instruments will also be fed by the results of the program managers' interviews and the trade ally interviews and surveys. Typically these interviews and surveys identify a range of issues that need to be tested or assessed in the participant survey. The non-participant survey will focus on customer perceptions of the program, the value of the program, the ability of the program to understand and serve a customer need, program design and operational issues, and the reasons for non-participation. This survey will also explore program changes that can be expected to increase participation and satisfaction rates among the non-participants.

For each of these data collection efforts, Duke Energy managers will be given the opportunity to review and comment on the protocols and the interview and survey data collection instruments.

These instruments and protocols will be used to guide all data collection efforts. Our primary data collection approaches will employ in-depth interviews and surveys, linked to document and records reviews and analysis. All data collection efforts involving key managers or staff, contractors, customers and trade allies will be guided by protocols and instruments that will be reviewed by Duke Energy prior to their use. This is a critical step. This step identifies the information that will be collected to feed the process, analysis, and recommendation efforts.

### 6. Conduct surveys with participants and/or non-participants

In this task we will conduct the process surveys with the participants and non-participants as appropriate. All participant surveys will be coordinated with the impact evaluation team to make sure impact questions are included in the survey as needed. This is particularly important for evaluations that use engineering analysis and modeling approaches that must be calibrated to the participants' use conditions. In addition, all non-participant surveys will be coordinated with the any planned market assessment efforts to minimize data collection costs.

At the kick-off meeting we will discuss and confirm the contact standards in which the process or the impact evaluation can contact a participant. Typically, participants are given an option to participate in the evaluation effort (any part of it). In addition, we have employed a 3 to 5 contact attempt (at different times of the week and days of the week) standard for reaching participants before dropping a participant and adding another contact to the sample.

Participant sample sizes will be determined based on participation in the programs (as well as by measure, if needed). Generally, where ramp up of the program is slow, sample sizes are small. In general, however, participant sampling for process evaluation efforts will employ a 90% +/- 10% level of precision at the program level, but may be expanded or contracted depending on the level of reliability needed for each program, the needs of the impact evaluation effort (specifically NTG estimates), and the available budget for that effort. The data collection approach for the participant is expected to be a random assignment approach across the programs based on downloads from the participant tracking records.

We may also conduct non-participant surveys. We will work with Duke Energy to augment this effort with any needed non-participant efforts, as necessitated by the researchable issues for the process evaluation effort. For non-participants we have used several sampling approaches in the past, including residential neighbor or neighborhood approaches, residential income-certified approaches, commercial business size and type matching approaches, marketing contact approaches or other approaches. When non-participant surveys are indicated, we will work with Duke Energy to identify the best approach for each program.

Surveys with participants will focus on a wide range of issues including their experiences with the program, their reasons for participation, their satisfaction with the program and the service components provided within the program. The survey will inquire about the most and least valuable parts of the program and inquire about their recommended changes. As noted above, surveys will also ask about actions taken and measure use conditions when energy impact estimates must be calibrated to participant use conditions.

Non-participant surveys focus attention on the reasons for non-participation and their perception of the needs for the services provided. These surveys also focus on marketing and outreach efforts and opportunities and ways that Duke Energy can motivate additional participation. When impact estimates need to be adjusted for non-participant considerations, these surveys also focus on actions they have taken on their own, and the measure use conditions associated with those actions.

During the survey development process, Duke Energy managers will be given the opportunity to include additional questions in the participant and non-participant survey instruments. No surveys will be launched prior to the approval of the protocol.

### 7. Analyze process evaluation data

This task covers a wide range of analytical efforts employing analysis strategies and systems that the evaluation team has used successfully for over many years and on which the California Evaluation Protocols are based. It includes analysis of the following types of information consistent with the researchable issues identified for the assessment, and structuring the analysis in a way that allows a documentation of the program's structure and operation, an assessment of these conditions, and the development of recommendations to improve the program.

This assessment includes:

- ✓ Analysis of program materials, manager interviews, ally interviews and surveys, participant interviews and non-participant interviews to understand the organization and operations of the programs in order to identify strengths and weaknesses and make recommendations for program changes.
- ✓ Analysis of marketing materials (when requested) to determine their strengths and weaknesses and coverage to make recommendations on ways to improve the marketing efforts or materials.
- ✓ Analysis of ally interview and survey results to identify strengths and weaknesses in the relationships and operational conditions between the programs and the contractors and allies who help make the programs work well for their customers, the utility and themselves.
- ✓ Analysis of the participant information and survey results to identify drivers of satisfaction and their experiences with the programs from the view of the most important person in the chain of events: the customer who participates. This involves assessing a wide range of participant information and understanding their personal experiences and opinions about the programs, including ways that they think the program can be improved.
- ✓ Analysis of non-participant information to identify the barriers to participation and to assess the program's ability to satisfy customer needs. This analysis will result in the development of recommendations that can be expected to increase participation rates and strengthen program acceptance.

The primary purpose of the analysis efforts is to feed the development of actionable program change recommendations that can be expected to improve the performance and cost effectiveness of the programs.

Much of this analysis is basic statistical comparisons of data collected and the professional assessment of expressed opinions by managers, allies, participants and non-participants. For in-depth statistical analysis we use SPSS and can covert output files to SAS or Excel or in other requested formats.

### 8. Develop Process Evaluation Reports

The evaluation team will deliver both a draft and final process evaluation write-up for each program. The draft report will be provided in time to be reviewed by Duke Energy and their consultant team, so that comments can be provided to the evaluation team. Following the receipt of comments, the report will be finalized into the draft final report. Once Duke Energy accepts the report, it will be made into a final report. As always, the evaluation team is open to other comments from key Ohio or program/portfolio-associated stakeholders including Commission contractors used to help oversee the evaluation efforts. We recognize that in many cases the regulatory body in the state will request to review draft reports and provide comments prior to the final draft report, and we will work with the Ohio Commission and their contractors to meet the needs of all stakeholders.

**Present Evaluation Results**

In this task key members of the research team may travel to Duke Energy and present the results of the study to Duke Energy managers and other information consumers. The presentations will typically consist of a PowerPoint slide show of the evaluation approach, key findings, and a review of the evaluation recommendations. Presentation locations and dates will be arranged by Duke Energy.

## Net to Gross Approaches[1]

Studies conducted by TecMarket Works prior to 2013 used standardized billing analysis techniques linked to net analysis adjustment methods to estimate net impacts for all measures without differentiating between low-cost standard consumable measures (part of normal purchase behaviors because first cost, product availability and transaction barriers are not significant) and measures with significant acquisition barriers. In the last year the field has differentiated analysis approaches associated with normal low-cost item purchase behavior measures (CFLs, aerators, shower heads, caulking, etc.) from products that have significant cost and other purchase barriers (furnaces, air conditioners, compressors, etc.). Impact analysis approaches associated with low-cost low-barrier products that have few if any significant purchase barriers can produce net savings directly from a pre-post participation billing analysis over participants that controls for weather and pre-existing (before the program) changes in market conditions over the evaluation period. In these approaches, the use of a rolling pre-program billing period, consisting of all participants' consumption before they enroll in a program, can be effectively used as a control group and as a result, that analysis produces net savings without identifying gross savings. For these analyses there is no need to adjust savings to account for freeriders. However, for large impact measures that are procured only a few times during a lifetime, the same participant-only analysis approach produces gross savings that have to be adjusted for freeriders. This advancement in the field of evaluation has resulted in the analysis used in this study and as a result, the results provided are net of freerider savings and also include impacts associated with short-term spillover.

[1] Note, it is not always necessary to conduct net to gross analysis when the evaluation uses approaches that produce net savings directly. For example, when energy impact analysis baselines are set to include the practice of freeriders or when quasi-experimental designed are used, the evaluation can produce net savings as the analysis output without identifying gross savings. See text for added information.

Prior to this change in the evaluation approach, impact evaluations employed four different strategies for estimating impacts. These are:

1. **The Experimental Design Approach** in which customers are randomly sorted into a test and control group. In this design savings are based on the difference between the consumption of these two groups over the same period of time. The mathematics of this approach is called the "difference of differences approach". This approach provides net savings because it segregates the two groups independently as a function of their random assignment. Only the test group receives exposure to the program, while the randomly assigned non-participants are used as a control group. When these two groups are compared, in a difference of differences approach, the findings are net savings because the savings are already adjusted for what would have happened without the program by subtracting out the savings from the control group. In this approach, subtracting or adding the differences in the energy use of the control group adjusts the gross savings (pre vs. post consumption of the test group) to compensate for the change in consumption of the non-program-exposed control group. This savings produced from this approach are net.

2. **The Quasi-Experimental Approach** is similar to the experimental design approach. However, the construction of the control group is not based on random assignment. In this approach the evaluation experts purposefully and systematically selects subjects to use as a control group. However, because this type of analysis uses a non-random approach to represent the control group, the term "control group" is not used because it can be confused with a random assignment approach. In the use of the quasi-experimental design the evaluation experts selects the comparison group so that it is as closely matched to the test group (participants) as possible. The term used to represent the group that is used to adjust savings for what would have occurred is the "*comparison group*". Assignments to the comparison group population are carefully considered by the evaluation expert in order to develop a comparison group that is as identical as possible to the test group, except for the participation in the program. The characteristics of the test group that are used for matching are typically demographic characteristics (age, housing type, location, income, etc.), energy use characteristics (amount of energy they use and when they use it) and in some cases psychographic characteristics (attitudes and behaviors). While the match is not as reliable as a true experimental design the results provided from this difference of differences approach are net savings. That is, the savings are already adjusted for what would have occurred without the program via the use of the matched comparison group and the use of the differences of differences analytical approach.

3. **The Pre versus Post with Net Adjustment Approach** is a simpler approach than the experimental or quasi-experimental approach in that the energy savings are based not on the use of the comparison or control groups, but instead are based on the difference between the pre-program and post-program periods of the test group. This approach is a differences approach in that gross savings are estimated as the difference between the pre and post program periods. To convert gross savings to net of freerider savings (what would have occurred without the program), the savings that would have been achieved

without the program are subtracted from the gross savings. The estimation of the savings that would have occurred without the program is typically calculated via the use of a freeridership battery of questions asked of the participants. These questions essentially get at what actions the participants would have taken without the program. Then the estimates of savings that would have occurred are then subtracted from the gross savings to provide net savings that are adjusted for freeridership.

4. **The Engineering Based with Net Adjustment Approach** is another standard energy savings estimation approach using an engineering estimation approach in which savings are estimated via the use of engineering calculations rather than billing or consumption records. In this approach, the actions taken are identified via interviews, surveys or inspections. Then a trained energy evaluation expert calculates the expected savings under the installation and use conditions of the participant's facilities. These are estimated savings based on known conditions about the energy use of the equipment that was going to be in use without the program and the consumption of the program-induced equipment. In this case the savings are gross and need to be adjusted by what the participant would have done without the program. As in the previous approach, the estimation of the savings that would have occurred without the program is typically calculated via the use of a freeridership battery of questions asked of the participants.

The approaches presented above are presented in descending order of their reliability. The approach with the highest level of reliability is the experimental design approach. The least reliable is the engineering based approach. The experimental design approach, when done well, is typically reliable to a couple of percent. The engineering approach, even when done well, is typically reliable to within 20% to 30%.

As stated previous, the latest approach for evaluation is more reliable than the pre versus post or the engineering approach, but is not as costly as the experimental or quasi experimental approaches, the field of evaluation developed the controlled fixed effects net billing analysis approach. This approach delivers net energy savings at a level of reliability that is similar to the experimental or quasi-experimental design but does not include the costs to form and use an independent control or comparison group:

5. **The Controlled Fixed Effects Billing Analysis with and without Net Adjustment** approach has been developed to provide savings estimates when a control or comparison group is not available or advisable because of cost considerations. In this approach, the participant's energy use data is used to econometrically model the energy savings for the participant by employing a rolling comparison time period using the time before customers participated in a program as the comparison period, forming a proxy comparison group. Because customers come into a program at a specific time, the time before that enrollment is grouped with other pre-program periods of all participants. Because the customer's pre-program period is used to control for normal energy changes over time at the population level, it is more reliable than the use of a comparison group. That is, the participants are exactly matched to the comparison group because they are the same individuals. Therefore, there is no selection bias because there is no selection into a control or comparison group. This strengthens the study. Because only the pre-program

energy use is used as the proxy comparison group, there is no program influence on that period of time that is used for the savings estimation. Because people come into the program at different periods of time, essentially providing a full analytical period (timeline) of non-participating energy consumption, the entire pre-program period can be used as the comparison group over the pre and post analytical program period. This analytical approach can also control for the effects of participating in other energy efficiency programs so that the savings achieved via multiple program participation is only counted once and credited to only one program. In cases in which there are multiple program participants, the savings associated with participants who have participated in multiple programs is subtracted from the savings identified within the billing analysis approach by subtracting out the typical savings associated with the typical installation in proportion of their occurrence in the participating population. A further benefit of this approach is that the analysis is conducted over the entire population of participants, thus eliminating any potential sampling error.

This approach has gained considerable use within the evaluation community and has been adopted as standard practice by several of the leading evaluation firms in the United States. The approach has also been peer reviewed within the evaluation community and accepted as one of the more reliable evaluation approaches that is not as reliable as the experimental design approach, but is probably more reliable than the quasi-experimental design because it reduces the bias associated with comparison group selection.

When this approach has been used in the past, typically net savings were estimated by conducting a freeridership questionnaire and then subtracting out the savings associated with freeridership. As an example, this is the approach that was used in the Duke Energy Home Energy House Call 2011 impact evaluation report. However, recent developments in the field of evaluation has indicated that when a program is assessing standard market consumable measures that are inexpensive and have low purchase barriers, there is no need to adjust for freeriders because their market practices are already in the pre-program billing data. These measures that are typically readily available in the market and typically cost under $5 each do not rise to the level that they pose a significant financial or technical barrier once an adoption decision has been made. As a result, there is no need to adjust for freeriders when a program focuses on low-cost, readily available, easily replaced/installed standard measures. Thus the field of evaluation is now moving away from adjusting for freeriders for minor low-cost, readily available measures (CFLs, pipe wrap, aerators, shower heads, etc.) when a billing analysis approach is used that employs a rolling pre-program period as the comparison group. However, when the program offers measures that have significant adoption barriers, such as a high cost or technical uncertainty (air-conditioners, major Energy Star appliances, motors, chillers, pumps compressors, etc.), then this approach must also include a freerider analysis to estimate net effect. Because major measures are not a standard market consumable product, the savings from these measures would not typically be net savings from the use of a rolling comparison period consisting of the pre-program period for all enrolling participants.

TecMarket Works adopted the controlled fixed effects billing analysis with and without net adjustment approach as a standard practice in 2012. With this adoption, TecMarket Works acknowledges that the 2011 Home Energy House Call evaluation studies that subtracted the savings of self-expressed freeriders for minor measures essentially double-counted freerider adjustments and provided a net savings estimate that is lower than what the program achieved. While that study was conducted using the industry's standard best-practice analysis approaches of 2011, the field has since changed in its acceptance of this practice and TecMarket Works agrees with this change for future evaluations. As with all fields, the field of energy efficiency program evaluation is evolving. Our field is establishing protocols that reflect improvements in the ability to estimate net energy impacts. As the evaluation field develops and adopts more reliable net energy analysis approaches, these approaches will be incorporated into our industry's protocols and standard practices. For example, the state of Indiana has (in 2012) adopted the approach that recognizes standard market operational practices (such as the pre-program period for participants) as the baselines for conducting energy impact analysis in which the results are net savings without the need for freerider adjustments. This protocol is included in the Indiana and Delaware[2] Evaluation Frameworks and is now being used as a standard practice in other states. TecMarket Works has abandoned the practice of adjusting minor or low-cost standard market products to account for freeriders when pre-program energy use practices are set as the net baseline analysis platform.

[2] The Delaware Evaluation Framework is pending final approval. When it is made public, it will be available at: http://www.dnrec.delaware.gov/energy/information/otherinfo/Pages/Evaluation.aspx.

# Reporting

The report outline follows PUCO's Evaluation Report Template. TecMarket Works developed a report template that includes all of PUCO's required information. The outline of the report template is presented in the three images below, and will be modified accordingly for the type of evaluation and the methodologies therein.

## Executive Summary

### Key Findings and Recommendations

The key findings and recommendations identified through this evaluation are presented below.

1.

#### Implementation Rates: Key Findings

#### Engineering Impact Estimates: Key Findings

**Table 1. Summary of Program Savings by Measure**

| Measure | Participation Count | Ex Ante Per unit kWh impact | Ex Ante Per unit kW impact | Gross Ex Ante kWh Savings | Gross Ex Ante kW Savings |
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## Introduction and Purpose of Study

### Summary Overview

#### Summary of the Evaluation

#### Evaluation Objectives

#### Researchable Issues

## Description of Program

### Program Participation

| Program | Participation Count for 2010 |
|---|---|
| Non-Residential Energy Assessments | 20 |

# Methodology

## Overview of the Evaluation Approach

### Study Methodology

**Data collection methods, sample sizes, and sampling methodology**

**Number of completes and sample disposition for each data collection effort**

**Expected and achieved precision**

**Description of baseline assumptions, methods and data sources**

**Description of measures and selection of methods by measure(s) or market(s)**

**Use of TRM values and explanation if TRM values not used**

**Threats to validity, sources of bias and how those were addressed**

# Evaluation Findings

## Impact Evaluation

## Process Evaluation

## Market Analysis

# Conclusions and Recommendations for Program Changes

# Appendix A: Required Savings Tables

The required table showing measure-level participation counts and savings for each program is below. **Also include tables showing calculations done to achieve Adjusted Gross Savings for each program.**

Required tables will include the following (see Excel file for details):

1. Participation counts and ex ante savings estimates at the measure level for each program
2. Gross savings calculations at the measure level for each program
    - At a minimum, *Gross Verified Savings* must be reported.
    - If additional adjustments are made, *Adjusted Gross Savings* can be reported using Option A, B, C only.

| Measure | Participation Count | Verified Per unit kWh impact | Verified Per unit kWh impact | Gross Verified kWh Savings | Gross Verified kW Savings |
|---|---|---|---|---|---|
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Final Report

# Evaluation of the 2009 – 2011 Smart $aver Non-Residential Custom Incentive Program in Ohio

Results of an Impact Evaluation

Prepared for
**Duke Energy**
139 East Fourth Street
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September 13, 2012

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# Executive Summary

## Key Findings and Recommendations

The key findings and recommendations identified through this evaluation are presented below.

### Engineering Impact Estimates: Key Findings

1. The overall realization rate across all projects was 1.03, indicating that the program evaluation results matched the expected kWh savings very closely. On an individual project basis, the realization rates ranged from 0.37 to 3.23, indicating a wide variation in the evaluated vs. expected kWh savings on any individual project.
2. The cool roof project did not perform to program expectations. The calculations done for the project application used roofing system vendor estimates that overstated savings. Future cool roof projects should be more thoroughly screened. Project savings estimates prepared with vendor-supplied software should be independently verified, including comparisons to unit savings estimates (kWh/SF and kW/SF) from the Ohio TRM. Projects with pre-existing roof insulation levels at or near code should be carefully reviewed.
3. About 33% of the total program savings come from lighting. Based on our review, it appears there is enough data to support moving some measures to the Prescriptive Program by expanding the list of eligible fixtures. This will reduce application burden on customers and reduce the application review burden on Duke Energy staff. Candidates for inclusion in the prescriptive lighting program include interior and exterior induction lighting fixtures, high-bay fluorescent lighting in refrigerated spaces, exterior LED fixtures, and exterior metal halide fixtures.
4. Several HVAC systems were observed to have no mechanical ventilation. This situation can potentially cause indoor air quality problems, although buildings may have adequate ventilation due to infiltration. Enabling mechanical ventilation will increase energy consumption, but will bring buildings into compliance with ASHRAE Indoor Air Quality standards for commercial buildings.
5. The age of the equipment in one of the projects deemed to be early replacement was well past normal industry values for effective useful life. The customer was interviewed and asserted that they would have continued to operate and maintain the existing equipment in the absence of the program, including questions about the remaining useful life of existing equipment in the application is an industry best practice, and will reduce the risk of lifetime savings erosion in projects with equipment that is near the end of its service life. This information should be collected for early replacement projects, and include documentation to justify the claimed value. The justification and documentation of remaining useful life for early replacement projects should be examined as a normal component of the application review process.
6. Several of the new construction projects claimed savings for measures that were required by code. Application reviewers should screen new construction projects carefully to make sure measures exceed code minimum requirements.
7. One lighting project participant installed additional lighting measures without applying for a rebate from either the prescriptive or custom programs. This action could represent additional savings caused by the program due to customer "spillover." The impacts of

customer spillover at this site were not calculated, thus the net savings are likely conservative.

## Table 1: Evaluated Savings Estimate Breakdown by Customer

| Customer | kWh | NCP kW[1] | CP kW[2] | MMBtu[3] |
|---|---|---|---|---|
| Site 1 | 258,169 | 42.00 | 42.00 | N/A |
| Site 2 | 399,610 | 226.00 | 70.00 | N/A |
| Site 3 | 3,378,176 | 483.00 | 483.00 | N/A |
| Site 4 | 4,798 | 13.40 | 8.20 | N/A |
| Site 5 | 3,775,031 | 588.00 | 588.00 | N/A |
| Site 6 | 5,591,557 | 603.26 | 603.00 | N/A |
| Site 7 | 360,188 | 56.00 | 56.00 | N/A |
| Site 8 | 587,214 | 61.30 | 0.00 | N/A |
| Site 9 | 247,604 | 24.50 | 28.20 | N/A |
| Site 10 | 329,359 | 64.40 | 0.00 | N/A |
| Site 11 | 52,653 | 13.70 | 13.70 | N/A |
| Site 12 | 449,297 | 21.00 | 21.00 | N/A |
| Site 13 | 1,813,844 | 768.00 | 384.00 | N/A |
| Site 14 | 161,110 | 5.10 | 27.70 | N/A |
| Site 15 | 347,394 | 28.60 | 28.60 | N/A |
| Site 16 | 237,527 | 319.20 | 22.00 | N/A |
| Site 17 | 22,341 | 9.90 | 2.60 | N/A |
| Site 18 | 719,314 | 75.00 | 75.00 | N/A |
| Site 19 | 113,766 | 0.00 | 0.00 | N/A |
| Site 20 | 470,380 | -99.20 | -52.00 | N/A |
| Site 21 | 95,107 | 22.80 | 0.00 | N/A |
| Site 22 | 287,240 | 28.90 | 28.90 | N/A |
| Site 23 | 203,477 | 76.70 | 65.40 | N/A |
| Site 24 | 130,149 | 161.30 | 199.20 | N/A |
| Site 25 | 657,570 | 117.85 | 69.33 | N/A |
| Site 26 | 39,340 | 6.20 | 6.20 | N/A |
| Site 27 | 194,606 | 21.90 | 21.90 | N/A |
| Site 28 | 75,476 | 7.80 | 7.80 | N/A |

## Table 2. Summary of Evaluated Gross Savings by Measure Type

| Measure Type | Partici-pation Count | Evaluated Per unit kWh impact | Evaluated Per unit NCP kW impact | Evaluated Per unit CP kW impact | Evaluated kWh Savings | Evaluated NCP kW Savings | Evaluated CP kW Savings |
|---|---|---|---|---|---|---|---|
| Lighting | 7 | 154,387 | 26 | 13 | 1,080,709 | 185 | 94 |
| HVAC | 13 | 940,065 | 211 | 143 | 12,220,840 | 2,737 | 1,858 |
| Process | 8 | 962,594 | 103 | 106 | 7,700,749 | 825 | 847 |

[1] NCP kW is an abbreviation for non-coincident peak kW
[2] CP kW is an abbreviation for coincident peak kW
[3] The study evaluated electricity savings only.

**Table 3. Summary of Ex Ante Savings by Measure Type**

| Measure Type | Partici-pation Count | Ex Ante Per unit kWh impact | Ex Ante Per unit NCP kW impact | Ex Ante Per unit CP kW impact | Ex Ante kWh Savings | Ex Ante NCP kW Savings | Ex Ante CP kW Savings |
|---|---|---|---|---|---|---|---|
| Lighting | 7 | 162,417 | 24 | 23 | 1,136,918 | 166 | 159 |
| HVAC | 13 | 873,117 | 184 | 131 | 11,350,519 | 2,391 | 1,705 |
| Process | 8 | 978,612 | 121 | 116 | 7,828,897 | 969 | 926 |

**Table 4. Ex-Ante Savings Estimates by Customer**[4]

| Customer | Ex Ante kWh Savings | Ex Ante NCP kW Savings | Ex Ante CP kW Savings |
|---|---|---|---|
| Site 1 | 167,454 | 44.10 | 41.66 |
| Site 2 | 479,209 | 108.28 | 80.58 |
| Site 3 | 1,284,468 | 233.77 | 182.36 |
| Site 4 | 10,100 | 4.16 | 3.10 |
| Site 5 | 4,832,346 | 552.00 | 462.50 |
| Site 6 | 5,991,963 | 686.14 | 686.14 |
| Site 7 | 190,343 | 34.18 | 9.56 |
| Site 8 | 698,742 | 62.55 | 62.55 |
| Site 9 | 191,139 | 21.92 | 21.92 |
| Site 10 | 528,652 | 60.30 | 60.50 |
| Site 11 | 40,915 | 15.40 | 15.40 |
| Site 12 | 632,527 | 86.17 | 106.37 |
| Site 13 | 1,910,023 | 610.85 | 528.37 |
| Site 14 | 106,952 | 12.19 | 16.67 |
| Site 15 | 252,206 | 38.64 | 11.13 |
| Site 16 | 148,014 | 80.00 | 17.65 |
| Site 17 | 60,259 | 9.17 | 9.17 |
| Site 18 | 716,028 | 81.69 | 77.90 |
| Site 19 | 217,522 | 73.53 | 0.00 |
| Site 20 | 463,752 | 105.58 | 31.94 |
| Site 21 | 61,296 | 5.32 | 0.00 |
| Site 22 | 271,999 | 76.73 | 85.38 |
| Site 23 | 63,041 | 14.00 | 14.00 |
| Site 24 | 103,510 | 188.90 | 13.67 |
| Site 25 | 507,265 | 271.47 | 202.03 |
| Site 26 | 43,578 | 7.49 | 7.49 |
| Site 27 | 255,828 | 31.84 | 31.83 |
| Site 28 | 87,203 | 10.27 | 10.27 |

[4] Savings shown for entire project as unit savings are not applicable for custom projects.

# Introduction and Purpose of Study

## Summary of the Evaluation

This report presents the results of an impact evaluation of the Ohio Smart $aver Non-Residential Custom Incentive Program, herein referred to as the "Custom Program".

## Evaluation Objectives

An impact analysis was performed utilizing an M&V plan that was developed following the International Performance Measurement and Verification Protocol (IPMVP)[5]. The projects were separated into lighting, HVAC, and process categories, and samples were drawn from each category. The goal of the impact analysis was to estimate a savings realization rate for each category that can be projected into the full program participant population, and then could be applied to each new application Duke Energy Ohio receives by category.

This report is structured to provide program energy impact estimations via the engineering analysis. The impact tables reporting total savings are based on the savings identified from 28 surveyed participants extrapolated to the program's total participants through December 31, 2011. The engineering estimates were calculated using data from the sample of participants using the date range of January 2009 through April 2011.

## Researchable Issues

The evaluation issues researched in this study are listed below:

1. Estimate kWh, non-coincident peak (NCP) kW and coincident peak (CP) kW savings for each project in the sample
2. Calculate kW and kWh realization rates for each project
3. Calculate average kW and kWh realization rates by lighting, HVAC, and process projects
4. Calculate confidence intervals around the realization rates
5. Identify causes for differences between evaluated savings and ex-ante savings estimates

[5] International Performance Measurement and Verification Protocol. Concepts and Options for Determining Energy and Water Savings. Volume 1. Prepared by Efficiency Valuation Organization. www.evo-world.org. September, 2010. EVO 10000 – 1:2010.

# Description of Program

The Duke Energy Custom Program is intended to supplement the Smart $aver® Non-Residential Prescriptive Incentive Program, which provides prescriptive rebates on pre-selected measures. Customers who want to install measures not on the Smart $aver Non-residential Prescriptive Incentive Program list are provided the opportunity to apply for a rebate through the Custom Program. The number of project applications that were reviewed and approved is shown below.

**Table 5. Program Participation Count**

| Program | Participation Count for January 2009 through April 2011 |
|---|---|
| Smart $aver Non-Residential Custom Incentive Program | 77 |

# Methodology

## Overview of the Evaluation Approach

This impact evaluation was performed using an engineering analysis of a sample of 28 out of 77 projected[6] total program participants.

### Study Methodology

The impact methodology consisted of engineering analysis following the International Performance Measurement and Verification Protocol (IPMVP)[7]. The projects were separated into lighting, HVAC, and process categories, and samples were drawn from each category. An M&V plan was developed following the IPMVP. Site surveys and metering equipment were installed to gather data according to the M&V plan. Pre and post installation measurements were taken whenever possible. Energy and demand savings estimates were developed for each sampled project. The goal of the impact analysis was to estimate a savings realization rate for each category that can be prospectively projected into the full program participant population.

### Data collection methods, sample sizes, and sampling methodology

Based on the projected participation of 77 projects, an initial sample of 31 projects was chosen to meet a sampling error of +/- 10% at 90% confidence.

[6] Projected participation included projects at the contract approval stage (where the incentive offer was accepted by the customer), along with projects that were completed and paid. It was possible that some of the projects at the contract approval stage may not be completed, hence the total participation count was a projection.
[7] International Performance Measurement and Verification Protocol. Concepts and Options for Determining Energy and Water Savings. Volume I. Prepared by Efficiency Valuation Organization. www.evo-world.org. September, 2010. EVO 10000 – 1:2010.

Site surveys were conducted and metering equipment was installed to gather data according to the M&V plan. Pre and post installation measurements were taken whenever possible. Energy and demand savings estimates were developed for each sampled project.

## Number of completes and sample disposition for each data collection effort

The sample disposition for the impact study is shown in Table 6.

**Table 6. Status of 2009-2011 Sample**

| Group | Sample Size | Completed | Notes |
|---|---|---|---|
| Lighting | 7 | 7 | Sample completed |
| HVAC | 15 | 13 | Construction not completed in time for post-period monitoring |
| Process | 9 | 8 | Construction not completed in time for post-period monitoring |
| **Total** | **31** | **28** | |

## Expected and achieved precision

The sample design was expected to return a sampling error of +/- 10% at 90% confidence. Due to sample dropout and actual sample variability, the achieved precision was +/- 11.1% at 90% confidence.

## Description of baseline assumptions, methods and data sources

For early replacement projects, the baseline assumption was the existing equipment. For normal replacement projects where the equipment is covered by state or federal energy standards, the minimally code compliant efficiency is the baseline. For normal replacement projects not covered by state or federal energy standards, industry common practice is the baseline.

## Description of measures and selection of methods by measure(s) or market(s)

The custom program encompasses a wide variety of measures. Current applications include a variety of lighting, HVAC, and industrial process projects. Lighting projects include fixture types not currently covered under the Smart $aver Non-Residential Prescriptive Incentive Program. HVAC projects include HVAC controls, equipment upgrades, and cool roof projects. Process projects include refrigeration systems, compressed air, and injection molding machines.

All projects were evaluated in compliance with the IPMVP. All projects were evaluated under either IPMVP Option A[8] or IPMVP Option D[9].

## Use of TRM values and explanation if TRM values not used

The study relied on primary data collection, engineering algorithms, building energy simulation modeling, and statistical regression modeling. Since this is a custom program, TRM algorithms and values do not apply.

[8] IPMVP Option A – Partially Measured Retrofit Isolation. See impact section below for more information.
[9] IPMVP Option D – Calibrated Simulation. See impact section below for more information.

## Threats to validity, sources of bias and how those were addressed

The study utilized a pre/post M&V protocol when feasible. Due to project timing, post-only measurements were made for some projects. The use of post-only measurements for these projects is not expected to significantly bias the results. Early sites were studied systematically before moving to a random selection process. The systematic selection of early projects could introduce some bias in the sample, but the project selection seems representative of the overall program participation. State of the art engineering modeling techniques, including building energy simulation modeling were employed to reduce engineering bias.

## Snapback and Persistence

The theoretical additional energy and capacity used by customers that may occur from implementing an energy efficiency product, often called "snapback" is not factored into this evaluation. In addition, TecMarket Works does not believe that snapback is an issue in evaluations of Custom programs. This is because of two key reasons: First, customers participating in the Custom Programs do not typically base energy-intensive investment decisions on the degree of savings being achieved from previous installed energy efficiency measures. Instead, these customers tend to base energy efficient investment decisions on the benefits and costs associated with a single project requiring an investment decision. Second, the very concept of snapback is theoretical in nature. There has yet to be an evaluation conducted of an energy efficiency program that has reliably documented a snapback effect. Studies of snapback based on the last 20-plus years of California's well-funded and aggressive energy efficiency portfolio demonstrate that snapback does not exist. California's per person energy consumption has remained flat for 20 years with energy efficiency programs; while other states not offering aggressive portfolios of energy efficiency programs over that period (more than 20 years) have increased per-person energy consumption. If snapback existed to any degree, per-person energy consumption in California would have increased at the same rate as states that have not offered a long history of energy efficiency programs. TecMarket Works does not believe that snapback exists for the Duke Energy Custom program and does not incorporate approaches to adjust savings for theoretical and unproven concepts.

The evaluation did not address how long these savings are likely to persist over time because the time span of the available data was not sufficient to address this issue.

# Impact Evaluation Findings

## Engineering-Based Impact Analysis

The impact evaluation employed a tracking system review, sample design and selection, an engineering review of the custom program applications, field measurement and verification (M&V) of selected projects, data analysis and reporting. Tracking data obtained from Duke Energy from January 2009 through April, 2011 shows the following breakdown of ex-ante energy savings by measure:

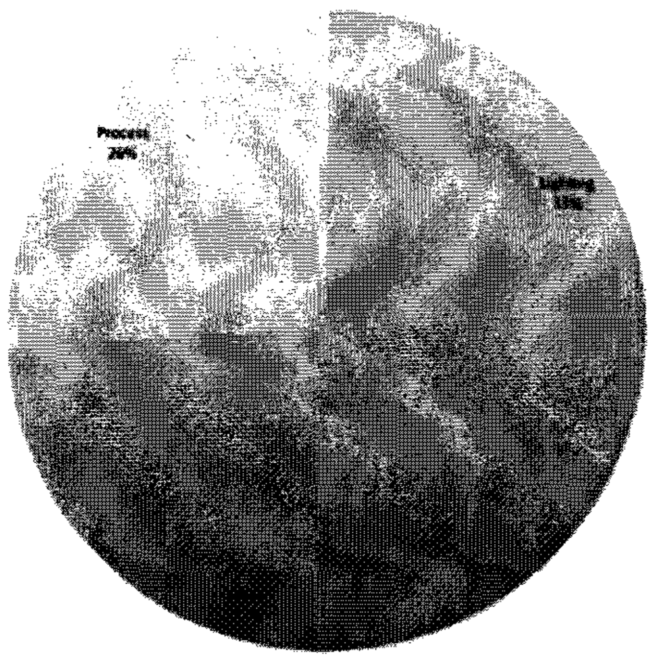



**Figure 1. Energy Savings by Project Type**

## Sample Design

The program evaluation started in June of 2009. Program participation was light in the early stages of the program, but program managers were interested in getting early feedback. Thus, the initial projects were evaluated as they were approved. As program participation increased, projects were studied on a sample basis. The projects were assigned as the program developed to one of three categories: Lighting, HVAC, and Process. The projects were grouped into similar technology categories to minimize the variation in the realization rates across projects and provide better precision in the overall program results. The realization rates across the technology categories also provided an idea of which types of projects are performing closer to original expectations.

The program tracking system is based on the Sales Force customer relationship management tool. Project leads are entered into the Sales Force system, and tracked as they progress in the system. In general, the process is as follows:

1. ***Initial Application***. Customer submits an application for the project, including a project description and energy savings calculations.
2. ***Application Review***. Applications are reviewed by a Duke Energy contractor for program eligibility and reasonableness. Modifications are made to the savings estimates as necessary. Project cost effectiveness is calculated and the incentive offer is determined.
3. ***Proposal to Customer***. A rebate proposal based on the reviewed and adjusted (as necessary) savings estimate and incentive offer is presented to the customer.
4. ***Contract Approval***. The customer has accepted the incentive and plans to move forward with the project.
5. ***Project Completion***. The customer has completed the project, and requested and received their incentive.

Projects that are at the Proposal to Customer stage are put in a list of potential candidates. Once the project proceeds to Contract Approval, it is eligible for sampling. The intention is to capture as many projects in the contract approval phase before construction begins in order to obtain pre-installation data.

The sampling plan incorporates a stratified random sample approach, where the projects are stratified according to technology type (lighting, HVAC, or process), and sampled randomly within each stratum. Early projects were evaluated systematically to satisfy the needs for early feedback. As program participation increased, a random sample approach was introduced.

The total sample size is calculated from the following equation[10]:

$$n = \frac{\left(\sum_k \left(kWh_k \times cv_k\right)\right)^2}{\left(\frac{P \times kWh}{Z}\right)^2 + \sum_k \frac{\left(kWh_k \times cv_k\right)^2}{N_k}}$$

where:

n = total sample size required
$kWh_k$ = estimated savings from group k
$cv_k$ = assumed coefficient of variation for group k

[10] Bonneville Power Administration, *Sampling Reference Guide. Research Supporting an Update of BPA's Measurement and Verification Protocols*, August, 2010.

P = desired precision
KWh = total kWh savings
Z = z statistic (1.645 at 90% confidence)
$N_k$ = population size of group k

Samples are allocated to each group based on the following equation:

$$n_k = n \times \frac{kWh_k \times cv_k}{\sum_k (kWh_k \times cv_k)}$$

The Ohio participation at the time of sample selection is summarized in Table 7. This projection assumed all projects in the Contract Approval stage would complete construction and would be paid in this evaluation cycle.

**Table 7. Sample Selection for Custom Component of Ohio Custom Program**

| Group | kWh | cv | Total Projects | Sample Size |
|---|---|---|---|---|
| Lighting | 13,881,282 | 0.3 | 20 | 7 |
| HVAC | 17,044,128 | 0.5 | 42 | 15 |
| Process | 10,803,126 | 0.5 | 15 | 9 |
| Total | | | 77 | 31 |

Since lighting projects are generally more predictable, an initial assumption of 0.3 was used for the coefficient of variation. Otherwise, a coefficient of variation of 0.5 was used, consistent with sampling criteria in the IPMVP for projects where previous variability data are not available. A sample of 31 projects was used in the program evaluation, split across lighting, HVAC, and Process projects.

## Sample Status

At the conclusion of the evaluation, three of the projects in the sample did not complete and thus were eliminated from the sample. The achieved sample is shown in the table below.

**Table 8. Status of 2009-2011 Sample**

| Group | Sample Size | Completed | Notes |
|---|---|---|---|
| Lighting | 7 | 7 | Sample completed |
| HVAC | 15 | 13 | Construction at 2 sites not completed in time for post-period monitoring |
| Process | 9 | 8 | Construction at 1 site not completed in time for post-period monitoring |
| | 31 | 28 | |

The completed projects are summarized in Table 9 below.

**Table 9. Summary of Completed Projects**

| Site Number | Facility Type | Project Type | Expected kWh savings | Expected NCP kW savings | Expected CP kW savings |
|---|---|---|---|---|---|
| Site 1 | School | Lighting | 167,454 | 44.10 | 41.66 |
| Site 2 | Healthcare | HVAC | 479,209 | 108.28 | 80.58 |
| Site 3 | Hotel | HVAC | 1,284,468 | 233.77 | 182.36 |
| Site 4 | Gymnasium | HVAC | 10,100 | 4.16 | 3.10 |
| Site 5 | Convenience Store | HVAC | 4,832,346 | 552.00 | 462.50 |
| Site 6 | Grocery | Process | 5,991,963 | 686.14 | 686.14 |
| Site 7 | Grocery | Process | 190,343 | 34.18 | 9.56 |
| Site 8 | School district | HVAC | 698,742 | 62.55 | 62.55 |
| Site 9 | Refrigerated Warehouse | Lighting | 191,139 | 21.92 | 21.92 |
| Site 10 | Convenience Store | Lighting | 528,652 | 60.30 | 60.50 |
| Site 11 | Refrigerated Warehouse | Lighting | 40,915 | 15.40 | 15.40 |
| Site 12 | Hospital | HVAC | 632,527 | 86.17 | 106.37 |
| Site 13 | School | HVAC | 1,910,023 | 610.85 | 528.37 |
| Site 14 | Industrial | Process | 106,952 | 12.19 | 16.67 |
| Site 15 | Industrial | Process | 252,206 | 38.64 | 11.13 |
| Site 16 | School | HVAC | 148,014 | 80.00 | 17.65 |
| Site 17 | Gymnasium | Lighting | 60,259 | 9.17 | 9.17 |
| Site 18 | Industrial | Process | 716,028 | 81.69 | 77.90 |
| Site 19 | Industrial | HVAC | 217,522 | 73.53 | 0.00 |
| Site 20 | Office | HVAC | 463,752 | 105.58 | 31.94 |
| Site 21 | Prison | Lighting | 61,296 | 5.32 | 0.00 |
| Site 22 | Industrial | Process | 271,999 | 76.73 | 85.38 |
| Site 23 | Office | HVAC | 63,041 | 14.00 | 14.00 |
| Site 24 | School | HVAC | 103,510 | 188.90 | 13.67 |
| Site 25 | Hotel | HVAC | 507,265 | 271.47 | 202.03 |
| Site 26 | Industrial | Process | 43,578 | 7.49 | 7.49 |
| Site 27 | Industrial | Process | 255,828 | 31.84 | 31.83 |
| Site 28 | Office | Lighting | 87,203 | 10.27 | 10.27 |

## Application Review

The customer application for each site was obtained from Duke Energy, along with any supporting documentation. Each application was reviewed to gain an understanding of the measures included and the expected savings. The Duke Energy Business Relations Manager (BRM) associated with each sampled site was contacted to secure customer participation in the evaluation. Once contact was established with the customer, follow-on phone calls and emails were exchanged to better understand the facility, the measures, and the construction schedule.

## M&V Plan Development

An M&V plan was developed by Architectural Energy Corporation for each sampled site. The M&V plan covered the following topic areas:

***Introduction.*** The project and the measures installed were described in sufficient detail to understand the M&V project scope and methodology. Savings by measure were shown and the M&V priorities for measures within the project were listed. The project baseline assumptions were also described.

***Goals and Objectives.*** The overall goals and objectives of M&V activity were listed.

***Building Characteristics.*** An overview of the building, with a summary table of relevant building characteristics, such as building size (square footage), number of stories, building envelope, lighting system, HVAC system type, etcetera, was provided.

***Data Products and Project Output.*** Specific end products – kWh savings, coincident and noncoincident kW savings, and therm savings were listed. Raw and processed data to be supplied at the conclusion of the study were identified.

***M&V Option.*** The M&V Option according to the International Performance Measurement and Verification Protocol (IPMVP) was described. The options are summarized below:

- ***Option A - Partially Measured Retrofit Isolation***. Savings under Option A are determined by partial field measurement of the energy use of the system(s) to which an energy conservation measure (ECM) was applied separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that some parameter(s) affecting the building's energy use may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Savings are estimated from engineering calculations based on stipulated values and spot, short-term and/or continuous post-retrofit measurements.
- ***Option B - Retrofit Isolation.*** Savings under Option B are determined by field measurement of the energy use of the systems to which the ECM was applied separate from the energy use of the rest of the facility. Savings are estimated directly from measurements. Stipulated values are not allowed.
- ***Option C - Whole Facility.*** Savings under Option C are determined by measuring energy use at the whole-facility level. Short-term or continuous measurements are taken throughout the post-retrofit period and compared to 12 to 24 months of pre-retrofit data. Savings are estimated from analysis of whole-facility utility meter or sub-meter data using techniques ranging from simple comparison of utility bills to regression analysis.
- ***Option D - Calibrated Simulation.*** Savings under Option D are determined through building energy simulation[11] of the energy use of components or the whole facility, calibrated with hourly or monthly utility billing data, and/or end-use metering.

***Data Analysis.*** The engineering methods and/or equations used to generate the data products identified above were listed. The data sources, either measurements or stipulated values from secondary data sources, were identified.

[11] DOE-2 is a commonly used building energy simulation program.

***Field Data Points.*** Specific field data points collected through the M&V plan were listed. The field data were a combination of survey data, one-time measurements, and time series data collected from data loggers installed for the project or trend data collected from the site energy management system (EMS).

***Data Accuracy.*** Meter and sensor accuracy for each field measurement point was listed.

***Verification and Quality Control.*** The steps taken to validate the accuracy and completeness of the raw field data were listed.

***Recording and Data Exchange Format.*** The format of the raw and processed data files used in the analysis and supplied as data products were listed.

The M&V plans, along with the processed data summary and project results are shown in Appendix B. A summary of the M&V plan for each site is shown in Table 10.

**Table 10. M&V Plan Summary**

| Customer | Project Type | IPMVP Option | M&V Plan Summary |
|---|---|---|---|
| Site 1 | Lighting | A | Spot measurements of lighting fixture power combined with stipulated operating hours |
| Site 2 | HVAC | A | Engineering analysis combined with post installation monitoring |
| Site 3 | HVAC | A | Pre/post measurements of packaged terminal air conditioner (PTAC) current combined with spot kW |
| Site 4 | HVAC | D | DOE-2 model based on post-installation survey |
| Site 5 | HVAC | A | Pre/post measurements of HVAC and condensing unit current combined with spot kW |
| Site 6 | Process | A | Post only measurements of LED case lighting and occupancy sensors |
| Site 7 | Process | A | Pre/post measurements of refrigeration compressor amps combined with spot kW |
| Site 8 | HVAC | A | Fixture count verification at a sample of 9 schools; monitoring at a sample of 2 |
| Site 9 | Lighting | A | Post only monitoring of a sample of lighting circuits. Field verification of installed fixture count and type |
| Site 10 | Lighting | A | Post-only spot watts of lighting fixtures; log lighting circuit current to verify operating hours |
| Site 11 | Lighting | A | Time series current logging on a sample of lighting circuits |
| Site 12 | HVAC | A | Load from one-time gpm (from energy management system) and measured chilled water loop temperature difference. Post only time series kW. Pre kW estimated from chilled water temperature, condenser water temperature, outdoor wetbulb temperature and typical chiller performance curves |

| Customer | Project Type | IPMVP Option | M&V Plan Summary |
|---|---|---|---|
| Site 13 | HVAC | A | Short term post only monitoring of a sample of lighting circuits across the 10 schools. |
| Site 14 | Process | A | Post only monitoring of variable frequency drive equipped compressor combined with vendor monitoring of existing compressor plant |
| Site 15 | Process | A | Post only monitoring of variable frequency drive equipped compressor combined with vendor monitoring of existing compressor plant |
| Site 16 | HVAC | D | Onsite survey of building characteristics combined with energy management system trend logs of measure operation |
| Site 17 | Lighting | A | Post only monitoring of a sample of lighting circuits |
| Site 18 | Process | A | Vendor measurements of existing system kWh combined with Post measurements of compressor kW |
| Site 19 | HVAC | A | Post measurements of humidifier kW and latent humidification load. Pre estimated from load and steam generator efficiency. |
| Site 20 | HVAC | D | Building onsite survey used to develop DOE-2 model. Short term trend logs from a sample of 16 heat pumps used to verify measure operation. |
| Site 21 | Lighting | A | Spot measurements of lighting circuit kW and current combined with time series current measurements |
| Site 22 | Process | A | Post time series logging of new and backup compressors |
| Site 23 | HVAC | D | Onsite survey of treated and untreated floors. Data logging of treated and non-treated HVAC equipment |
| Site 24 | HVAC | D | Onsite survey of building characteristics data to build DOE-2 model. |
| Site 25 | HVAC | D | Onsite survey of a sample of guest rooms. Trend data showing occupancy and setpoints. Survey hotel personnel to establish baseline control strategies. |
| Site 26 | Process | A | Time series measurements of pump kW |
| Site 27 | Process | A | Spot watt measurement of existing compressor kW combined with vendor measurements of compressor operating hours. Post installation time series kW monitoring of variable frequency drive equipped compressor. |
| Site 28 | Lighting | A | Lighting circuit logging of a sample of circuits |

## Measurement and Verification

Field data were collected by Duke Energy contractors according to the M&V plan. The Duke Energy contractors were trained by personnel from Architectural Energy Corporation and BuildingMetrics Incorporated. In addition to the training, meter installations were observed by contractors representing the Public Utility Commission of Ohio (PUCO). Metering equipment consisted of a combination of light loggers, portable data acquisition equipment (capable of measuring temperature, relative humidity, electric current, etc.), as well as true electric power meters. The specific instrumentation used at each site is described in Appendix B and summarized below. Survey data and spot measurements were obtained during meter installation. The metering equipment was installed for a period ranging from 2 weeks to 6 weeks, depending on the nature and variability of the energy consumption of the metered equipment. The metering duration used in each site is also described in Appendix B and summarized in Table 11 below.

**Table 11. M&V Approach Summary**

| Customer | Project Type | Measurements Taken | Monitoring Duration |
|---|---|---|---|
| Site 1 | Lighting | Spot measurements of post-installation fixture power | One-time |
| Site 2 | HVAC | True electric power measurements of air handling unit (AHU) fans, AHU and outdoor temperatures and relative humidity. | 5+ weeks post only |
| Site 3 | HVAC | Pre/post PTAC current | 3+ weeks pre/ 2+ weeks post |
| Site 4 | HVAC | Comprehensive onsite survey for DOE-2 model development | N/A |
| Site 5 | HVAC | Spot watt and time series current for Rooftop air conditioners, refrigeration system condensing units, display cases, water heater | 4 weeks pre and 4 weeks post |
| Site 6 | Process | Light logger on occupancy sensor controlled case lighting | 3 weeks post only |
| Site 7 | Process | Spot watt and time series current for refrigeration compressors | 3 weeks pre/post |
| Site 8 | HVAC | Outdoor fixture circuit current | 3 weeks |
| Site 9 | Lighting | Time series lighting circuit current and spot circuit kW measurements | 3 weeks |
| Site 10 | Lighting | Spot watts and time series current on sample of lighting circuits | 3 weeks |
| Site 11 | Lighting | Post-only time series current measurements on sample of lighting circuits. Spot watt measurements of circuit power and current | 3 weeks |
| Site 12 | HVAC | Chiller kW, chilled water loop temperature difference, condenser water temperature, outdoor temperature and relative humidity. | 4 weeks |
| Site 13 | HVAC | Spot watt measurements of lighting circuit power and current, time series current measurements on a sample of lighting circuits | 3 weeks |
| Site 14 | Process | Compressor kW | 3 weeks |
| Site 15 | Process | Time series true electric power for variable frequency drive equipped compressor | 3 weeks |
| Site 16 | HVAC | Outdoor temperature, Air hander supply air, mixed air and return air temperatures, CO2 concentration, energy recovery ventilator entering and leaving air temperature. | 3 weeks |
| Site 17 | Lighting | Spot measurements of lighting circuit kW and current. Time series current measurements | 3 weeks |
| Site 18 | Process | Existing Compressor kW, new compressor kW, air dryer current | 3 weeks |

| Customer | Project Type | Measurements Taken | Monitoring Duration |
|---|---|---|---|
| Site 19 | HVAC | Humidifier kW, humidifier entering temperature and relative humidity humidifier leaving temperature and relative humidity, outdoor temperature and relative humidity. | 3 weeks |
| Site 20 | HVAC | Heat pump current, supply air temperature, outdoor air temperature and relative humidity. | 3 weeks |
| Site 21 | Lighting | Lighting circuit current, spot kW and current | 3 weeks |
| Site 22 | Process | True electric power for new and backup compressors | 3 weeks |
| Site 23 | HVAC | Comprehensive onsite data collection for DOE-2 model development plus time series data on air handers, cooling tower, pneumatic controls compressor, outdoor temperature and relative humidity. | 3 weeks |
| Site 24 | HVAC | Comprehensive onsite data collection for DOE-2 model development plus time series data on lighting circuits to verify daylighting controls operation | 3 weeks |
| Site 25 | HVAC | Trend data on a sample of guest rooms | 1 week |
| Site 26 | Process | Time series measurements of injection molding machine | 4 weeks |
| Site 27 | Process | Compressor kW pre (one time) and post (time series) | 3 weeks |
| Site 28 | Lighting | Spot kW and time series current | 3 weeks |

## Calculations and Reporting

Pre and post installation data were collected by Duke Energy contractors and forwarded to Architectural Energy Corporation for analysis. The data were analyzed according to the M&V plan developed for each project. Data analysis consisted of pre / post comparisons of monitored data extrapolated to annual consumption and demand using simple engineering models or linear regression techniques as described in the M&V plan. A site report was developed for each completed project. The reports are attached in Appendix B. The calculations and analysis techniques are summarized in Table 12.

**Table 12. Calculation Approach Summary**

| Site Number | Project Type | Calculations |
|---|---|---|
| Site 1 | Lighting | Engineering equations |
| Site 2 | HVAC | Engineering equations and regression model expanded using bin data. |
| Site 3 | HVAC | Regression model expanded using bin data. |
| Site 4 | HVAC | DOE-2 building energy simulation |
| Site 5 | HVAC | Engineering equations and regression model expanded using bin data. |
| Site 6 | Process | Engineering equations |
| Site 7 | Process | Regression model expanded using bin data |
| Site 8 | HVAC | Engineering calculations with short term monitoring (STM) of lighting hours. HVAC measures passed through. |
| Site 9 | Lighting | Engineering calculations supported by monitored lighting power. Interactions with refrigeration system included |
| Site 10 | Lighting | Short term measurements adjusted for nighttime hours across the year. Standard values used for baseline lighting fixtures. Measure values used for efficient fixtures. |

| Site Number | Project Type | Calculations |
|---|---|---|
| Site 11 | Lighting | Engineering calculations using standard baseline wattage assumptions, mfg. catalog post watt and monitored lighting hours. |
| Site 12 | HVAC | Regression model used to project STM into annual kWh |
| Site 13 | HVAC | Engineering calculations of lighting savings. |
| Site 14 | Process | Pre/post analysis of time series data by daytype |
| Site 15 | Process | Engineering calculations of pre/post kWh by daytype projected to annual savings |
| Site 16 | HVAC | Whole building analysis using ASHRAE Standard 90.1-2004 baseline |
| Site 17 | Lighting | Engineering calculations of lighting savings using monitored lighting hours |
| Site 18 | Process | Pre post kWh comparison adjusted for cfm differences |
| Site 19 | HVAC | Humidification energy estimated from AHU cfm and entering and leaving conditions. Pre kWh estimated from latent heat addition from an electric resistance heat source. Regression model applied to daily kWh estimates pre and post |
| Site 20 | HVAC | Short term data processed to inform DOE-2 model inputs. Model calibrated to billing data |
| Site 21 | Lighting | Engineering calculations of lighting savings |
| Site 22 | Process | Pre/post kWh comparisons, adjusted for no loss drains and leak sealing. Pre-monitoring conducted by vendor. |
| Site 23 | HVAC | DOE-2 building energy simulation, inputs derived from treated and untreated equipment |
| Site 24 | HVAC | Building energy simulation using DOE-2. ASHRAE Standard 90.1-2004 used as baseline |
| Site 25 | HVAC | DOE-2 building energy simulation, inputs derived from trend data |
| Site 26 | Process | True electric power measurements of injection molding machine input power |
| Site 27 | Process | Adjust Pre kW for reduction in system pressure |
| Site 28 | Lighting | Engineering calculations of lighting savings. One of two buildings upgraded. Untreated building used as baseline. |

## Results

The results of the evaluation are reported in this section. Annual savings for kWh and kW are reported along with their realization rates for each project. These data are summarized by project type. An independent assessment of the project life is also reported.

### Annual Savings

A summary of the annual savings from each project is shown in Table 14. The average annual realization rate by project type is shown in Table 15.

The estimated sampling precision in the realization rates is shown in Table 13.

**Table 13. Realization Rate Achieved Sampling Precision**

| Project Type | Population Size | Sample Size | Actual Sample cv | Relative Precision |
|---|---|---|---|---|
| Lighting | 20 | 7 | 0.42 | +/- 23% |
| HVAC | 42 | 13 | 0.54 | +/- 20% |
| Process | 15 | 8 | 0.15 | +/- 6% |
| Total | 77 | 28 | | +/- 11.1% |

**Table 14. Annual Results Summary**

| Site | Project Type | kWh Savings | | | NCP kW Savings | | | CP kW Savings | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Evaluated | Expected | RR | Evaluated | Expected | RR | Evaluated | Expected | RR |
| Site 1 | Lighting | 258,169 | 167,454 | 1.54 | 42.00 | 44.10 | 0.95 | 42.00 | 41.66 | 1.01 |
| Site 2 | HVAC | 399,610 | 479,209 | 0.83 | 226.00 | 108.28 | 2.09 | 70.00 | 80.58 | 0.87 |
| Site 3 | HVAC | 3,378,176 | 1,284,468 | 2.63 | 483.00 | 233.77 | 2.07 | 483.00 | 182.36 | 2.65 |
| Site 4 | HVAC | 4,798 | 10,100 | 0.48 | 13.40 | 4.16 | 3.22 | 8.20 | 3.10 | 2.65 |
| Site 5 | HVAC | 3,775,031 | 4,832,346 | 0.78 | 588.00 | 552.00 | 1.07 | 588.00 | 465.50 | N/A |
| Site 6 | Process | 5,591,557 | 5,991,963 | 0.93 | 603.26 | 686.14 | 0.88 | 603.00 | 686.14 | 0.88 |
| Site 7 | Process | 360,188 | 190,343 | 1.89 | 56.00 | 34.18 | 1.64 | 56.00 | 9.56 | 5.86 |
| Site 8 | HVAC | 587,214 | 698,742 | 0.84 | 61.30 | 62.55 | 0.98 | 0.00 | 62.55 | 0.00 |
| Site 9 | Lighting | 247,604 | 191,139 | 1.30 | 24.50 | 21.92 | 1.12 | 28.20 | 21.92 | 1.29 |
| Site 10 | Lighting | 329,359 | 528,652 | 0.62 | 64.40 | 60.30 | 1.07 | 0.00 | 60.50 | 0.00 |
| Site 11 | Lighting | 52,653 | 40,915 | 1.29 | 13.70 | 15.40 | 0.89 | 13.70 | 15.40 | 0.89 |
| Site 12 | HVAC | 449,297 | 632,527 | 0.71 | 21.00 | 86.17 | 0.24 | 21.00 | 106.37 | 0.20 |
| Site 13 | HVAC | 1,813,844 | 1,910,023 | 0.95 | 768.00 | 610.85 | 1.26 | 384.00 | 528.37 | 0.73 |
| Site 14 | Process | 161,110 | 106,952 | 1.51 | 5.10 | 12.19 | 0.42 | 27.70 | 16.67 | 1.66 |
| Site 15 | Process | 347,394 | 252,206 | 1.38 | 28.60 | 38.64 | 0.74 | 28.60 | 11.13 | 2.57 |
| Site 16 | HVAC | 237,528 | 148,014 | 1.60 | 319.20 | 80.00 | 3.99 | 22.00 | 17.65 | 1.25 |
| Site 17 | Lighting | 22,341 | 60,259 | 0.37 | 9.90 | 9.17 | 1.08 | 2.60 | 9.17 | 0.28 |
| Site 18 | Process | 719,314 | 716,028 | 1.00 | 75.00 | 81.69 | 0.92 | 75.00 | 77.90 | 0.96 |
| Site 19 | HVAC | 113,766 | 217,522 | 0.52 | 0.00 | 73.53 | 0.00 | 0.00 | 0.00 | |
| Site 20 | HVAC | 470,380 | 463,752 | 1.01 | -99.20 | 105.58 | -0.94 | -52.00 | 31.94 | -1.63 |
| Site 21 | Lighting | 95,107 | 61,296 | 1.55 | 22.80 | 5.32 | 4.29 | 0.00 | 0.00 | N/A |
| Site 22 | Process | 287,240 | 271,999 | 1.06 | 28.90 | 76.73 | 0.38 | 28.90 | 85.38 | 0.34 |
| Site 23 | HVAC | 203,477 | 63,041 | 3.23 | 76.70 | 14.00 | 5.48 | 65.40 | 14.00 | 4.67 |
| Site 24 | HVAC | 130,149 | 103,510 | 1.26 | 161.30 | 188.90 | 0.85 | 199.20 | 13.67 | 14.57 |
| Site 25 | HVAC | 657,570 | 507,265 | 1.30 | 117.85 | 271.47 | 0.43 | 69.33 | 202.03 | 0.34 |
| Site 26 | Process | 39,340 | 43,578 | 0.90 | 6.20 | 7.49 | 0.83 | 6.20 | 7.49 | 0.83 |
| Site 27 | Process | 194,606 | 255,828 | 0.76 | 21.90 | 31.84 | 0.69 | 21.90 | 31.83 | 0.69 |
| Site 28 | Lighting | 75,476 | 87,203 | 0.87 | 7.80 | 10.27 | 0.76 | 7.80 | 10.27 | 0.76 |

**Table 15. Average Annual Realization Rate by Project Type**

| Project Type | kWh Savings | | | NCP kW Savings | | | CP kW Savings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Evaluated | Expected | RR | Evaluated | Expected | RR | Evaluated | Expected | RR |
| Lighting | 1,080,709 | 1,136,918 | 0.95 | 185 | 166 | 1.11 | 94 | 159 | 0.59 |
| HVAC | 12,220,840 | 11,350,519 | 1.08 | 2,737 | 2,391 | 1.14 | 1,858 | 1,705 | 1.09 |
| Process | 7,700,749 | 7,828,897 | 0.98 | 825 | 969 | 0.85 | 847 | 926 | 0.91 |
| Overall | 21,002,298 | 20,316,334 | 1.03 | 3,747 | 3,527 | 1.06 | 2,800 | 2,790 | 1.00 |

A summary of the specific findings from each project are shown in Table 16. See Appendix B for more information on each sampled project.

**Table 16. Findings Summary**

| Site Number | Project Type | Notes |
|---|---|---|
| Site 1 | Lighting | Additional operating hours verified |
| Site 2 | HVAC | Initial savings estimate provided by vendor with little detail, but realization rate was above 80% |
| Site 3 | HVAC | Occupancy controls along with heat pumps replacing PTACs with electric heat were very effective |
| Site 4 | HVAC | Cool roof savings less than simplified vendor calculations. |
| Site 5 | HVAC | All roof top unit outdoor air dampers shut off. No mechanical ventilation or outdoor air economizers. |
| Site 6 | Process | Limited savings from occupancy sensors |
| Site 7 | Process | Old compressor near end of effective useful life. Remaining life unknown. |
| Site 8 | HVAC | Site assigned to HVAC category, but is majority lighting. Not all projects are complete; savings based on projected completion of remaining projects. |
| Site 9 | Lighting | Straightforward lighting project that performed well. |
| Site 10 | Lighting | Additional non-rebated lamps observed during field work. Application based on 24/7 operation of lighting. Some override of photocell controls noticed. |
| Site 11 | Lighting | Combination of LVD (induction) and T8 fixtures. Original application showed only induction fixtures. |
| Site 12 | HVAC | Chiller sequencing changed, reducing effect of variable frequency drive on chiller compressor. Limits on minimum condenser water temperature due to other chillers in the plant also reduced savings. |
| Site 13 | HVAC | Assigned to HVAC stratum, but measures were mostly lighting. HVAC measures denied by Duke, with the exception of window replacements. Some exterior lighting photocells malfunctioned. Some planned fixture replacements did not occur. Several projects are planned but not completed. Savings based on completion of remaining projects. |
| Site 14 | Process | Straightforward compressed air project. Comprehensive analysis conducted by vendor provided sound technical basis for project. |
| Site 15 | Process | Straightforward compressed air project. Comprehensive analysis conducted by vendor provided sound technical basis for project. |
| Site 16 | HVAC | Savings claimed for economizers and heating system setback thermostats that are required by code. Lighting savings higher than expected. |
| Site 17 | Lighting | Occupancy sensors installed by owner outside of project reduced lighting operating hours |
| Site 18 | Process | Straightforward compressed air project. Comprehensive analysis conducted by vendor provided sound technical basis for project. |
| Site 19 | HVAC | Ultrasonic humidifiers only; ECM 1 (boiler replacement) not implemented |
| Site 20 | HVAC | Off-hour controls of a series of zone level water loop heat pumps. Return from off hour control caused a start-up peak, thus increasing non-coincident peak demand. Other measures denied by Duke. |
| Site 21 | Lighting | Observed operating hours less than application. Savings claim based on 76 fixtures; 145 fixtures verified. |
| Site 22 | Process | Straightforward air compressor project |
| Site 23 | HVAC | Project in progress; savings extrapolated from observed work to whole building. No savings assigned to thermostat calibration or AC compressor rebuilds. Claim reduced by 65% from value in application. |

| Site Number | Project Type | Notes |
|---|---|---|
| Site 24 | HVAC | Whole building new construction project assigned to HVAC stratum. Savings observed across lighting and HVAC end-uses. Lighting controls operating correctly. |
| Site 25 | HVAC | Setpoint schedules for Rented & Occupied, Rented & Unoccupied, Unrented (but available) and Unavailable (Off) modes projected into annual occupancy. Savings due primarily to fan energy reductions at room fan-coil units. |
| Site 26 | Process | VFD on injection molding machine performed to expectations. Machine throughput difficult to predict due to economy. |
| Site 27 | Process | Straightforward compressed air project. Comprehensive analysis conducted by vendor provided sound technical basis for project. |
| Site 28 | Lighting | Savings based on completion of one of two projects totaling 74 fixtures. Claim based on 79 fixtures. |

## Project Life

An independent assessment of the project life was conducted and compared to the project life estimates prepared by Wisconsin Energy Conservation Corporation[12] (WECC), in consultation with Duke Energy program managers. The WECC project life estimates were used to set incentive levels, and calculate the lifecycle savings and benefits of each project. The project life estimates for each project are shown in Table 17.

**Table 17. WECC Project Life Estimates**

| Site Number | Project Type | WECC Project Life |
|---|---|---|
| Site 1 | Lighting | 10.0 |
| Site 2 | HVAC | 2.0 |
| Site 3 | HVAC | 10.0 |
| Site 4 | HVAC | 15.0 |
| Site 5 | HVAC | 5.5 |
| Site 6 | Process | 8.0 |
| Site 7 | Process | 20.0 |
| Site 8 | HVAC | 10.0 |
| Site 9 | Lighting | 10.0 |
| Site 10 | Lighting | 7.0 |
| Site 11 | Lighting | 10.0 |
| Site 12 | HVAC | 10.0 |
| Site 13 | HVAC | 10.4 |
| Site 14 | Process | 10.0 |
| Site 15 | Process | 15.0 |
| Site 16 | HVAC | 10.0 |
| Site 17 | Lighting | 10.0 |

[12] WECC is a contractor hired by Duke Energy to assist in program implementation and application review.

| | | |
|---|---|---|
| Site 18 | Process | 15.0 |
| Site 19 | HVAC | 7.0 |
| Site 20 | HVAC | 7.0 |
| Site 21 | Lighting | 7.0 |
| Site 22 | Process | 10.0 |
| Site 23 | HVAC | 7.0 |
| Site 24 | HVAC | 20.0 |
| Site 25 | HVAC | 10.0 |
| Site 26 | Process | 10.0 |
| Site 27 | Process | 7.0 |
| Site 28 | Lighting | 10.0 |

An independent assessment of the project life was conducted by examining the measures making up each project and assigning an effective useful life (EUL) to each measure. EUL estimates were obtained from the Draft Ohio Technical Reference Manual (TRM), the California Database for Energy Efficiency Resources (DEER) EUL table or California IOU workpapers developed for new measures not yet incorporated into DEER. A project level EUL was calculated as the weighted average of the measure EULs. The results of this assessment are shown in Table 18.

**Table 18. Evaluated Project Life Estimates**

| Site No. | Project Type | Measures | EUL | Wt | Wt EUL | Source |
|---|---|---|---|---|---|---|
| Site 1 | Lighting | Induction Lighting | 16 | 100% | 16.0 | 2006 PG&E Workpaper |
| Site 2 | HVAC | HVAC Controls | 15 | 33% | 12.0 | DEER, Energy Management System |
| | | Peak Energy Reduction Through HVAC Controls | 11 | 34% | | DEER, HVAC Controls |
| | | Stack Effect Control System | 10 | 33% | | DEER, Reducing Over ventilation. |
| Site 3 | HVAC | 7000 Btuh Heat Pump | 15 | 25% | 15.0 | Ohio TRM |
| | | 12000 Btuh Heat Pump | 15 | 25% | | Ohio TRM |
| | | Wireless Thermostats and Energy management system | 15 | 50% | | DEER, EMS |
| Site 4 | HVAC | Cool Roof | 15 | 100% | 15.0 | Ohio TRM |
| Site 5 | HVAC | Energy Management System | 15 | 85% | 14.0 | DEER TRM, Energy management System |
| | | LED Refrigerated Case Lighting | 8 | 15% | | Ohio TRM |
| Site 6 | Process | LED Refrigerated Case Lighting | 8 | 100% | 8.1 | Ohio TRM |
| Site 7 | Process | Refrigeration Compressor Update | 15 | 100% | 15.0 | DEER Refrigeration Upgrades |
| Site 8 | HVAC | Exterior Induction Lighting | 16 | 78% | 15.9 | 2006 PGE Workpaper |
| | | Ventilation Controls | 15 | 23% | | DEER, EMS |
| Site 9 | Lighting | Refrigerated Lighting | 15 | 70% | 12.9 | Ohio TRM |
| | | Occupancy Sensors | 8 | 30% | | Ohio TRM |
| Site 10 | Lighting | Outdoor LED Lighting | 16 | 100% | 16.0 | 2006 PGE Workpaper |
| Site 11 | Lighting | High Bay Induction Lamps | 16 | 82% | 15.8 | 2006 PGE Workpaper |
| | | High Bay Fluorescent Lamps | 15 | 18% | | Ohio TRM |
| Site 12 | HVAC | Chiller | 20 | 53% | 17.7 | Ohio TRM |
| | | Chiller VFD | 15 | 47% | | Ohio TRM, HVAC VFD |
| Site 13 | HVAC | Linear Fluorescent | 15 | 87% | 14.5 | Ohio TRM |
| | | Pulse Start Metal Halide | 8 | 7% | | Ohio TRM |
| | | LED | 16 | 4% | | 2006 PGE Workpaper |
| | | Induction | 16 | 2% | | 2006 PGE Workpaper |
| Site 14 | Process | Air Compressor with VFD | 15 | 100% | 15.0 | Ohio TRM |
| Site 15 | Process | Air Compressor with VFD | 15 | 100% | 15.0 | Ohio TRM |
| Site 16 | HVAC | Lighting | 15 | 82% | 15.0 | Ohio TRM, linear fluorescent |
| | | Demand Controlled Ventilation | 15 | 18% | | DEER EMS |
| Site 17 | Lighting | Induction | 16 | 86% | 15.4 | 2006 PGE Workpaper |
| | | Hardwired CFL | 12 | 14% | | Ohio TRM |
| Site 18 | Process | Air Compressor with VFD | 15 | 100% | 15.0 | Ohio TRM |

| Site No. | Project Type | Measures | EUL | Wt | Wt EUL | Source |
|---|---|---|---|---|---|---|
| Site 19 | HVAC | Ultrasonic Humidifier | 7 | 100% | 7.0 | Independent estimate not available; Duke project life used |
| Site 20 | HVAC | EMS | 15 | 50% | 15.0 | DEER, EMS |
| | | Tstat Recalibration and Relocation | 15 | 50% | | DEER, EMS |
| Site 21 | Lighting | Ceramic Metal Halide | 15 | 100% | 15.0 | Ohio TRM |
| Site 22 | Process | Compressors | 15 | 100% | 15.0 | Ohio TRM |
| Site 23 | HVAC | Digital Control System | 15 | 100% | 15.0 | DEER, EMS |
| Site 24 | HVAC | HVAC | 20 | 41% | 17.1 | Ohio TRM |
| | | Linear Fluorescent | 15 | 59% | | Ohio TRM |
| Site 25 | HVAC | EMS Upgrades | 15 | 100% | 15.0 | DEER, EMS |
| Site 26 | Process | PLC-controlled AC inverter drive system | 15 | 100% | 15.0 | Ohio TRM, HVAC VFD |
| Site 27 | Process | Air Compressor with VFD | 15 | 100% | 15.0 | Ohio TRM |
| Site 28 | Lighting | Induction Lighting | 16 | 80% | 14.4 | 2006 PGE Workpaper |
| | | Photo Sensors | 8 | 20% | | DEER, Timeclock with or without photosensors |

The WECC estimated project life and the independent project life estimates were weighted by the expected kWh savings and the evaluated kWh savings respectively, and a weighted average project life was calculated for each project type. The realization rate on project life was calculated as the ratio of the evaluated EUL to the WECC project life estimate. These results are shown in Table 19.

**Table 19. Summary of Project Life Estimates by Project Type**

| Project Type | WECC Project Life | Evaluated EUL | Realization Rate |
|---|---|---|---|
| Lighting | 8.4 | 15.1 | 1.79 |
| HVAC | 7.7 | 14.5 | 1.88 |
| Process | 9.2 | 14.1 | 1.53 |

Note, the evaluated project life estimates for Lighting, HVAC, and Process were 78%, 88%, and 53% higher, respectively, than the WECC estimates, indicating WECC and Duke Energy used a conservative approach to establishing project lifetimes for these types of projects.

# Appendix A: Required Savings Tables

| Project | Ex Ante kWh Savings | Ex Ante NCP kW Savings | Ex Ante CP kW Savings |
|---|---|---|---|
| Site 1 | 167,454 | 44.10 | 41.66 |
| Site 2 | 479,209 | 108.28 | 80.58 |
| Site 3 | 1,284,468 | 233.77 | 182.36 |
| Site 4 | 10,100 | 4.16 | 3.10 |
| Site 5 | 4,832,346 | 552.00 | 462.50 |
| Site 6 | 5,991,963 | 686.14 | 686.14 |
| Site 7 | 190,343 | 34.18 | 9.56 |
| Site 8 | 698,742 | 62.55 | 62.55 |
| Site 9 | 191,139 | 21.92 | 21.92 |
| Site 10 | 528,652 | 60.30 | 60.50 |
| Site 11 | 40,915 | 15.40 | 15.40 |
| Site 12 | 632,527 | 86.17 | 106.37 |
| Site 13 | 1,910,023 | 610.85 | 528.37 |
| Site 14 | 106,952 | 12.19 | 16.67 |
| Site 15 | 252,206 | 38.64 | 11.13 |
| Site 16 | 148,014 | 80.00 | 17.65 |
| Site 17 | 60,259 | 9.17 | 9.17 |
| Site 18 | 716,028 | 81.69 | 77.90 |
| Site 19 | 217,522 | 73.53 | 0.00 |
| Site 20 | 463,752 | 105.58 | 31.94 |
| Site 21 | 61,296 | 5.32 | 0.00 |
| Site 22 | 271,999 | 76.73 | 85.38 |
| Site 23 | 63,041 | 14.00 | 14.00 |
| Site 24 | 103,510 | 188.90 | 13.67 |
| Site 25 | 507,265 | 271.47 | 202.03 |
| Site 26 | 43,578 | 7.49 | 7.49 |
| Site 27 | 255,828 | 31.84 | 31.83 |
| Site 28 | 87,203 | 10.27 | 10.27 |

**Table 20. Evaluated Savings Estimate Breakdown by Customer**

| Customer | kWh | NCP kW | CP kW | MMBtu[13] |
|---|---|---|---|---|
| Site 1 | 258,169 | 42.00 | 42.00 | N/A |
| Site 2 | 399,610 | 226.00 | 70.00 | N/A |
| Site 3 | 3,378,176 | 483.00 | 483.00 | N/A |
| Site 4 | 4,798 | 13.40 | 8.20 | N/A |
| Site 5 | 3,775,031 | 588.00 | 588.00 | N/A |
| Site 6 | 5,591,557 | 603.26 | 603.00 | N/A |
| Site 7 | 360,188 | 56.00 | 56.00 | N/A |
| Site 8 | 587,214 | 61.30 | 0.00 | N/A |
| Site 9 | 247,604 | 24.50 | 28.20 | N/A |
| Site 10 | 329,359 | 64.40 | 0.00 | N/A |
| Site 11 | 52,653 | 13.70 | 13.70 | N/A |
| Site 12 | 449,297 | 21.00 | 21.00 | N/A |
| Site 13 | 1,813,844 | 768.00 | 384.00 | N/A |

[13] The study evaluated electricity savings only.

| Customer | kWh | NCP kW | CP kW | MMBtu[13] |
|---|---|---|---|---|
| Site 14 | 161,110 | 5.10 | 27.70 | N/A |
| Site 15 | 347,394 | 28.60 | 28.60 | N/A |
| Site 16 | 237,528 | 319.20 | 22.00 | N/A |
| Site 17 | 22,341 | 9.90 | 2.60 | N/A |
| Site 18 | 719,314 | 75.00 | 75.00 | N/A |
| Site 19 | 113,766 | 0.00 | 0.00 | N/A |
| Site 20 | 470,380 | -99.20 | -52.00 | N/A |
| Site 21 | 95,107 | 22.80 | 0.00 | N/A |
| Site 22 | 287,240 | 28.90 | 28.90 | N/A |
| Site 23 | 203,477 | 76.70 | 65.40 | N/A |
| Site 24 | 130,149 | 161.30 | 199.20 | N/A |
| Site 25 | 657,570 | 117.85 | 69.33 | N/A |
| Site 26 | 39,340 | 6.20 | 6.20 | N/A |
| Site 27 | 194,606 | 21.90 | 21.90 | N/A |
| Site 28 | 75,476 | 7.80 | 7.80 | N/A |

# Appendix B: Site M&V Reports – Customer Detail Redacted

[redacted]

# Site 1

# M&V Plan Results Summary

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED ON:
March 2011

## INTRODUCTION

Architectural Energy Corporation was hired to evaluate the Duke Energy custom incentive program for the lighting retrofit of the interior hallway lights at [redacted]. The original proposal called for a one-for-one replacement of 21 fixtures at each [redacted], an existing 1000 Watt Metal Halide lamp, with a 200 Watt High-bay Induction lamp.

Energy savings were estimated at $8,340 annually for this upgrade at each [redacted], totaling $16,680 for the measure. The M&V portion of the project involved conducting post-installation spot measurements of the lighting circuits. Annual lamp runtime hours were determined from staff interviews prior to installation and are found in a brief explanation included with the application.

## GOALS AND OBJECTIVES

The project goal was electric use savings of 166,800 kWh annually and demand savings of 41 kW annually, or approximately $16,680, as noted in the M&V Plan. The specific objective of this M&V project was to complete a pre and post implementation site survey of the affected lighting in order to determine the true power reduction. Then apply the pre-installation counts to the new fixtures and interviewed operating hours to determine the actual annual energy savings and realization rate.

## PROJECT CONTACTS

Approval shall be requested from the two Duke Energy contacts listed below prior to making direct contact with the Customer or undertaking work on this M&V Plan.

| | | |
|---|---|---|
| **Duke Energy M&V Administrator** | Frankie Diersing | [redacted] |
| **Duke Energy BRM** | Mike Harp | [redacted] |
| **Customer Contact** | | |
| **Site Locations** | [redacted] | |

## DATA PRODUCTS AND PROJECT OUTPUT

- Count post fixtures to verify quantity installation.
- Annual energy savings and verification of calculations.

## M&V OPTION

IPMVP Option A

# Verification and Quality Control

1. Verify pre and post-retrofit lighting fixture specifications and quantities are consistent with the application. If they are not consistent, record discrepancies.
2. Verify pre-retrofit lighting fixtures are removed from the project. If they are abandoned in place, please note if the wiring is removed or not. If the fixtures have been removed, check to see if the existing lighting fixture lamps and ballasts have been stored on site.
3. Verify electrical voltage of pre and post lighting circuits.
4. Visually inspect pre/post lighting data sheets for correlation to incentive plan savings.
5. Verify lighting data and correlate to incentive plan savings.

# Recording and Data Exchange Format

1. Pre-installation Lighting Survey Form and notes.
2. Post-installation Lighting Survey Form and notes.
3. CT logger data files.

# Results Summary

## Data Analysis

1. Verify Proposed Measures Were Implemented:

The 21 new fixtures were installed as planned at each site. There were increased annual hours of operation found compared to those deduced from the application calculation, based on an explanatory note included in the application. The calculation originally assumed that lighting would operate 4,000 hours annually. However, this note specifies a lighting operation time of 6:00 am through 10:00 pm each day (16 hours per day, or 4160 annually, with the assumption of Monday-Friday operation only).

2. Verify Lighting Control:

Lighting control was not part of this application.

3. Calculation Methodology:

Since the lighting is specified as being on through the peak demand period, kW savings should be included in this measure. However, a rate of $0.10 per kWh was used in the proposal calculation and is not clear where it was derived from. This value is close to the kWh rate published by the utility, thus does not appear to include demand savings. For this reason, and to maintain consistency, the same cost per kWh ($0.10) was also used to determine the realized post-install savings based on a kWh reduction only.

Annual lighting electric energy is calculated as follows:

$$kWh / year = a \times b \times c$$

Where:

a = Number of fixtures, counted during site visit, for replacement
b = kW per fixture, often from manufacturer specification
c = Total estimated annual "hours on"

4. Savings Verification and Realization Rate:

Compare Pre/Post values to obtain total lighting kWh/year savings. Once the savings are calculated, the realization rate is calculated by the following formula:

Realization Rate = $kWh_{actual} / kWh_{application}$

## CALCULATION OUTPUT

The following Excel Tables demonstrate real achieved lighting savings and summarize the results of the lighting retrofit application. For additional details, see included post-retrofit measurement and calculation spreadsheets.

**Reported in Application:**

| Baseline | | |
|---|---|---|
| kW per Fixture | | 1.200 |
| Fixture Count | | 42 |
| Run Hours (annual) | | 4,000 |
| Annual Energy (kWh) | | 201,600 |
| Electric Rate ($/kWh) | $ | 0.10 |
| Demand Rate ($/kW) | $ | - |
| Operating Cost | $ | 20,160 |

| Proposed | | |
|---|---|---|
| kW per Fixture | | 0.207 |
| Fixture Count | | 42 |
| Run Hours (annual) | | 4,000 |
| Annual Energy (kWh) | | 34,776 |
| Electric Rate ($/kWh) | $ | 0.10 |
| Demand Rate ($/kW) | $ | - |
| Operating Cost | $ | 3,478 |

**Savings:**

kWh: 166,824
Cost: $16,682

**Adjustments Based on Duke Energy Project Review:**

The Duke Energy project review adjusted the savings from 166,824 to 167,454. The incentive offer was based on a savings of 167,454 kWh.

**Reported Following Installation:**

| Baseline | | |
|---|---|---|
| kW per Fixture | | 1.200 |
| Fixture Count | | 42 |
| Run Hours (annual) | | 5,840 |
| Annual Energy (kWh) | | 294,336 |
| Peak demand (kW) | | 50.4 |
| Electric Rate ($/kWh) | $ | 0.10 |
| Demand Rate ($/kW) | $ | - |
| Operating Cost | $ | 29,434 |

| Installed | | |
|---|---|---|
| kW per Fixture | | 0.207 |
| Fixture Count | | 42 |
| Run Hours (annual) | | 4,160 |
| Annual Energy (kWh) | | 36,167 |
| Peak demand (kW) | | 8.7 |
| Electric Rate ($/kWh) | $ | 0.10 |
| Demand Rate ($/kW) | $ | - |
| Operating Cost | $ | 3,617 |

**Savings:**

kWh: 258,169
kW: 41.7
Cost: $25,817

### Project Savings Summary

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 258,169 | 167,454 | 1.54 | 42 | 44 | 0.95 | 42 | 44 | 0.95 |

*Notes:

Lighting fixture power values were taken from the M&V Plan document.
Proposed savings were back calculated from the Application.
Electric Rate used was derived from the rebate application savings.

# M&V Summary

# Site 2

[redacted] – [redacted] – Stack Effect Control
Prepared by Dan Bertini
April, 2011

## Introduction

This document summarizes the third-party M&V activities for a Non-Residential Custom Incentive application for the first phase of an energy improvement project administered by [redacted] at their [redacted] location.

The project is being carried out in phases at three hospitals:

- [redacted]
- 
- 

Throughout the phases of the project there will be three measures implemented overall:

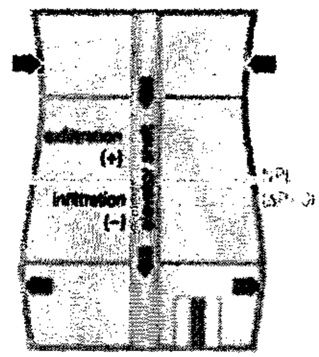
1. Stack Effect Control
2. Control System Optimization
3. Peak Load Shedding

The first measure was implemented at the three hospitals during the first phase of the project. The other two measures will be implemented in future phases. This document summarizes the M&V findings related only to the implementation of the Stack Effect Control measure at the [redacted] location.

The description of the measure is copied verbatim from [redacted] application as follows in *italics*:

*"Stack Effect Control:*

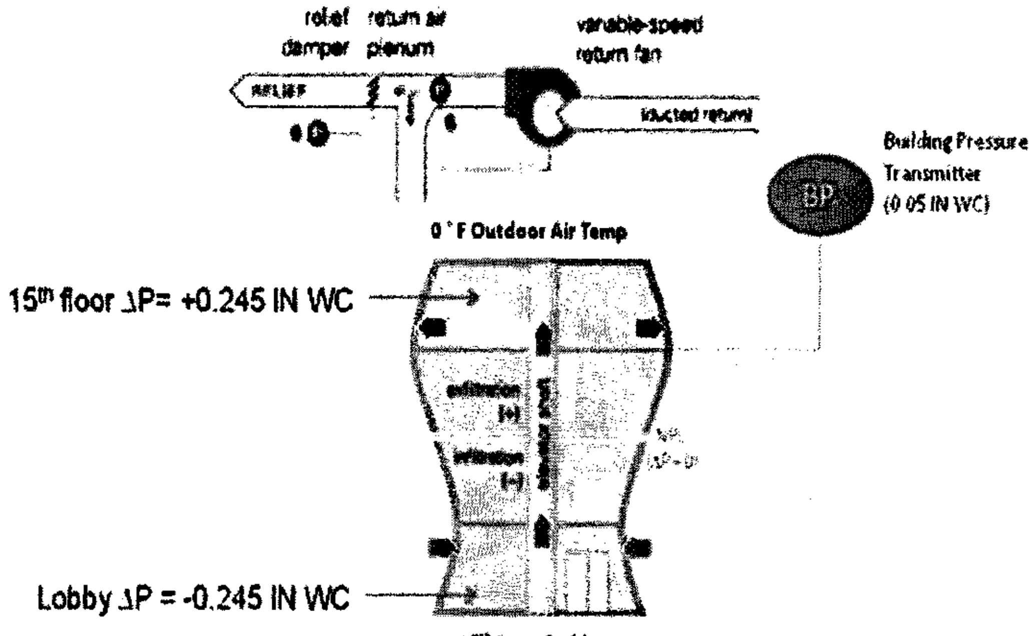
*"Stack Effect is a phenomenon that creates differential air pressure forces between the upper and lower floors of tall buildings. In the winter, the forces pressurize the upper floors of the building and make the lower floors negative. The opposite is true for the summer. See below:*




**Summer (reverse) stack effect**

- Outward-swinging doors may stand open
- Infiltrating outdoor air drives moisture into building envelope

*"In the case of the* [redacted] *hospital, at zero degree outside air temperature, the building is affected as follows:*




15th Story Building
**Winter (normal) stack effect**

- Inward-swinging doors may not latch
- Exfiltrating indoor air drives moisture into building envelope

*"The total stack effect pressure exerted on the building is almost 0.5 IN WC at zero degrees, which is 10 times the building pressure setpoint of 0.05 IN WC. This causes the HVAC control*

*systems to exhaust air needlessly out of the building. The more air the HVAC system exhausts, the worse the problem gets and the building becomes a chimney as the conditioned air is exhausted out of the building.*

*"To correct the problem, all the HVAC primary air handling units must be reprogrammed and exhaust air dampers of the air handlers need to be retrofitted to operate independently of other control dampers in the building. In addition, several VFD drives will need to be installed. Savings from this project are estimated at 2% of the total energy use of the facility and are based on field observations at the hospitals. The exception is [redacted] off peak kWh estimates are 10%. They are higher because we are installing more VFD's at this facility and heating kWh will be impacted as a result."*

## Goals

For the Stack Effect Control measure at [redacted] the following savings are expected:

- 479,208 Gross kWh
- 84 On-Peak kW

## Project Contacts

| | | |
|---|---|---|
| Duke Energy M&V Administrator | Frankie Diersing | [redacted] |
| Duke Energy BRM | Nick Beck | |
| Duke Energy BRM (alternate) | Mike Harp | |
| [redacted] (Customer) Contact | [redacted] | |
| [redacted] (Project Engineer) Contact | [redacted] | |

## Data Products and Project Output

- Average pre/post load shapes for controlled equipment
- Model predicting pre/post kWh as a function of outdoor temperature
- Summer peak demand savings
- Annual Energy Savings
- Miscellaneous diagnostics (cooling delta T, supply air temperature)
- Outdoor air fraction; economizer operation (if equipped).

## M&V Option

IPMVP Option A – Stipulated and Measured

# Field Data

## Pre-Implementation

Historical 15 minute interval data was obtained from the site's two utility meters for a roughly 2.5 year period starting January 1st, 2008 and ending June 8th, 2010. Unfortunately, since M&V activities were not scheduled prior to the implementation of the measure, other than the old T&B reports obtained during the post-implementation site survey, this historical site data represents the only actual pre-implementation operating data available to the investigation.

## Post-Implementation

Survey Data

- Copy of engineer's notebook containing equipment schedules, existing control strategies, and implementation plans for respective equipment
- Copy of owners working AHU equipment schedule
- Screen captures from control system front-end graphics
- Miscellaneous photos
- Copies of selected equipment schedules from original construction
- Copies of selected T&B reports from original construction
- Interview with the engineer who designed and commissioned the measure

One-time Measurements

- Spot measurements of supply and return fan kW at selected AHUs
- Spot measurements of supply and return fan % Speed at those selected AHUs that were VFD-driven
- Spot measurements of supply, return and mixed air temperatures at selected AHUs

Time series data on selected equipment

- While there are (37) AHUs in the hospital, the Stack Effect Control measure was implemented only on the (27) AHUs that at the time were under the control of the Siemens automation system. Of those (27) AHUs, (10) were randomly selected to be monitored for M&V purposes, representing roughly 60% of the overall designed CFM capacity of the (27)

- Loggers were deployed to record data at 5 minutes intervals for 40 full days starting on midnight June 12th and ending on midnight July 22nd, 2010 on the following (10) AHUs: 3,9,27,28,32,35,36,37,40,43
    - Dent Elite Pro loggers measured supply and return fan kW
    - Onset Hobo U-12s measured supply, return and mixed air temperatures
    - Onset Hobo U-10s measured OA, supply, return and mixed air temperature and relative humidity

## Data Accuracy

| Measurement | Sensor | Accuracy | Notes |
|---|---|---|---|
| Temperature | thermistor | ±0.5° | |
| Amps | current transducer | ±1% | 10% of rating < Amps < 130% of rating |
| %RH | capacitive element | ±3.5% | 25% < RH < 85% |
| kW | Elite Pro (7.28 kHz) | <1% | exclusive of current transducer |

## Verification and Quality Control

6. Visually inspect time series data for gaps
7. Compare readings to nameplate values; identify out of range data
8. Look for physically impossible combinations e.g. Tsupply > Tmix when AC unit is cooling

## Recording and Data Exchange Format

4. Dent and Hobo binary files
5. Excel spreadsheets

## Data Analysis Summary

### Approach

**Energy Savings**
Discussions with the engineer established that the new Stack Effect Control sequence operates at each AHU essentially as follows:

- Supply Fan modulates to maintain downstream duct static pressure setpoint as downstream VAV dampers modulate to maintain space temperature
- Return Fan modulates to maintain return plenum static pressure setpoint

- Exhaust Damper modulates to maintain average building static pressure per patent-pending algorithm

For this evaluation it is assumed that the Stack Effect Control measure, by virtue of maintaining positive pressure entirely throughout the inside of the building, impacts the selected AHUs by essentially reducing to zero the infiltration component of their respective cooling loads, which in turn has the effect of reducing the overall fan and chiller plant load in the summer, but in winter, when the "free cooling" of infiltration is eliminated, may have the opposite effect. The objective of the analysis then is to calculate the amount by which the overall hourly electrical demand is reduced over the course of a year as a result of the change in fan and chiller plant demand, as shown in Equation 1:

**Equation 1 – *Annual kWh Savings***

$$Annual\ kWh\ Savings = \frac{\sum_{t=1}^{8760\ hrs}\left(kW_{plant\_pre_t} - kW_{plant\_post_t} + kW_{fans\_pre_t} - kW_{fans\_post_t}\right)}{S}$$

where

$kW_{plant\_pre}$ = *pre implementation hourly kW of chiller plant resulting from coil load on (10) AHUs*

$kW_{plant\_post}$ = *post implementation hourly kW of chiller plant resulting from coil load on (10) AHUs*

$kW_{fans\_pre}$ = *pre implementation hourly kW of fans on (10) AHUs*

$kW_{fans\_post}$ = *post implementation hourly kW of fans on (10) AHUs*

$S$ = *ratio of total CFM of (10) sampled AHUs to total CFM of (27) site AHUs*

## Demand Reduction

From the hourly set of demand derived in Equation 1 is also found the following two key measures:

1. Maximum on-peak kW reduction
2. Minimum grid-coincident-peak kW reduction

### $kW_{fans\_post}$

The last term in the numerator of Equation 1, $kW_{fans\_post}$, is the hourly kW of all the fans in the (10) sampled AHUs. This is calculated through the use of the regression model shown in Equation 2. The parameters $m1_T$ and $b1_T$ are calculated using the logged data by regressing total daily logged AHU fan kWh against average daily logged outdoor air temperature.

**Equation 2 - $kW_{fans\_post}$**

$$kW_{fans\_post} = \frac{\left(m1_T T_{o_t} + b1_T\right)}{24}$$

where

$T_o$ = *hourly outdoor drybulb*

$m1_T$ = *slope of daily total AHU fan kWh regressed against average daily outdoor drybulb*

$b1_T$ = *intercept of daily total AHU fan kWh regressed against daily outdoor drybulb*

$kW_{fans\_pre}$

The third term in the numerator of Equation 1, $kW_{fans\_pre}$, is the sum of broken out as follows in Equation 3:

**Equation 3 - $kW_{fans\_pre}$**

$$kW_{fans\_pre} = kW_{sf\_pre} + kW_{rf\_pre}$$

where

$kW_{sf\_pre}$ = *pre implementation hourly total supply fan kW*
$kW_{rf\_pre}$ = *pre implementation hourly total return fan kW*

Equation 3 requires hourly values for $kW_{sf\_pre}$ and $kW_{rf\_pre}$. The former is found in Equation 4:

**Equation 4 - $kW_{sf\_pre}$**

$$kW_{sf\_pre} = \frac{(m_Q \dot{Q}_{pre} + b_Q)}{24}$$

where

$\dot{Q}_{pre}$ = *pre implementation average hourly coil load of (10) AHUs (tons)*
$m_Q$ = *slope of daily total supply fan kWh regressed against daily average coil load*
$b_Q$ = *intercept of daily total supply fan kWh regressed against daily average coil load*

Equation 4 represents the total supply fan kW required to satisfy the total pre-implementation coil load, $\dot{Q}_{pre}$ and requires knowledge of $\dot{Q}$ not only in its solution but also in the formulation of the regression parameters. The regression parameters are calculated using logged data by regressing the daily average logged post-implementation coil load of all (10) AHUs against the corresponding daily total logged supply fan kWh. It is assumed that the coil load is zero whenever the calculated value for $\dot{Q}_{pre}$ is less than or equal to zero.

In general, since ducted returns connect to all AHUs in the hospital, it is assumed that all infiltration is seen by the AHUs as an adjustment in space load, which implies that $\dot{Q}_{Pre}$ is equal to $\dot{Q}_{Post}$ plus (or minus) an adjustment to offset a proportion, $S$, of the total building infiltration load, $\dot{Q}_{inf}$, as shown in Equation 5.

**Equation 5 - $\dot{Q}_{Pre}$**

$$\dot{Q}_{Pre} = \dot{Q}_{Post} + S\dot{Q}_{inf}$$

where

$\dot{Q}_{Post}$ = *post implementation total hourly coil load (tons)*
$\dot{Q}_{inf}$ = *pre implementation hourly infiltration load (tons)*
$S$ = *ratio of total CFM of (10) sampled AHUs to total CFM of (27) site AHUs*

The first term in Equation 5, $\dot{Q}_{Post}$, is found in Equation 6 as follows:

**Equation 6 - $\dot{Q}_{Post}$**

$$\dot{Q}_{Post} \quad c_u \rho \left(\overline{h_{ma} \quad h_{sa}}\right) \sum_{i=1}^{\# Supply\ Fans} CFM_{sf\_post,i}$$

where

$c_u$ = units conversion of $60\left(\frac{min}{hr}\right) / 12000\left(\frac{btu}{ton}\right)$

$CFM_{sf\_post}$ post implementation supply fan airflow (CFM)

$\overline{h_{ma} \quad h_{sa}}$ CFM weighted average coil enthalpy drop $\left(\frac{btu}{lbm}\right)$

The post-implementation supply fan airflow that is required in Equation 6 for each supply fan, $CFM_{sf\_post}$, is found implicitly in the flow ratio, $f$, of the Englander-Norford equation for a VFD-driven fan, which is shown below in Equation 7:

**Equation 7 - $H_{sf\_post}$**

$$H_{sf\_post} \quad a + bf + df^3$$

where

$f \quad \frac{CFM_{sf\_post}}{CFM_{sf\_max}}$ supply fan airflow ratio

$H_{sf\_post} \quad \frac{kW(f)}{kW_{sf\_max}}$ supply fan power ratio

$a \quad \left(\frac{p_0}{2}\right)^{1.5}$

$p_0$ = ratio of static pressure setpoint of the controller to the static pressure at the fan discharge

$b \quad p_0(1 \quad a)$

$d \quad 1 \quad a \quad b$

$kW_{sf\_max}$ supply fan full load kW

$CFM_{sf\_max}$ supply fan full load CFM

Note that when $p_0 = 1$, as is the case for a return fan controlling the static pressure immediately downstream, Equation 7 reduces to the familiar cubic relation in Equation 8:

**Equation 8 - $H$**

$$H \quad f^3$$

Two of the critical parameters called out in Equation 7 for each fan, $CFM_{max}$ and $kW_{max}$, are presumed to be equal to those values given in the T&B reports if available or alternately from the design BHP and CFM found in the equipment schedules. However, in this investigation it is assumed instead that $kW_{max}$ for each fan is approximately equal to the maximum kW measured during the investigation, which occurred during what was perhaps the hottest time of the year. Furthermore, $CFM_{max}$ is then assumed to be approximately equal to the following shown in Equation 9.

**Equation 9 - $CFM_{max}$**

$$CFM_{max} = CFM'_{max}\left(\frac{kW_{max}}{kW'_{max}}\right)^{\frac{1}{3}}$$

where

$CFM'_{max}$ maximum CFM presumed from T&B or design documents

$kW'_{max}$ maximum of measured kW and kW presumed from T&B or design documents

The second term in Equation 5 includes $\dot{Q}_{inf}$, which is a function of the total building infiltration airflow, $CFM_{inf}$. For this analysis $CFM_{inf}$ is calculated following the ASHRAE enhanced method, which seeks to combine the effects of both ambient wind and internal stack pressures as shown in Equation 10:

**Equation 10 - $CFM_{inf}$**

$$CFM_{inf} = \sqrt{(CFM_w)^2 + (CFM_s)^2}$$

The wind and stack effect components are defined, respectively, in Equation 11 and Equation 12:

**Equation 11 - $CFM_w$**

$$CFM_w = cC_w(sfV_w)^{2n}$$

**Equation 12 - $CFM_s$**

$$CFM_s = cC_s(|T_o - T_i|)^n$$

where

$c$ flow coefficient $\left(\frac{CFM}{in\,wc^n}\right)$

$C_w$ wind coefficient $\left(\left(\frac{in\,wc}{mph^2}\right)^n\right)$

$C_s$ stack coefficient $\left(\left(\frac{in\,wc}{°F}\right)^n\right)$

$sf$ shelter factor

$V_w$ outdoor windspeed $(mph)$

$n$ pressure coefficient

$T_o$ outdoor ambient drybulb temperature (°F)

$T_i$ typical indoor drybulb temperature (°F)

The hourly infiltration load, $\dot{Q}_{inf}$, is then found by inserting the result from Equation 10, $CFM_{inf}$, into Equation 13:

**Equation 13 - $\dot{Q}_{inf}$**

$$\dot{Q}_{inf} = c_u\rho(h_o - h_i)CFM_{inf}$$

where

$c_u$ = units conversion of $60\left(\frac{min}{hr}\right)/12000\left(\frac{btu}{ton}\right)$

$\rho$ nominal air density $\left(\frac{lbm}{ft^3}\right)$

$h_a$ $enthalpy\ of\ outdoor\ ambient\ air\ \left(\frac{btu}{lbm}\right)$

$h_i$ $enthalpy\ of\ typical\ indoor\ air\ \left(\frac{btu}{lbm}\right)$

$CFM_{inf}$ $total\ building\ infiltration\ (CFM)$

It is significant that $\dot{Q}_{inf}$ can be positive or negative, thereby increasing or decreasing the pre-implementation coil load.

Having now calculated $\dot{Q}_{Post}$ in Equation 6 and $\dot{Q}_{inf}$ in Equation 13, the sum of the two provides the solution to Equation 5, $\dot{Q}_{Pre}$, which is then applied to Equation 4 to give the pre-implementation supply fan kW, $kW_{sf\_pre}$, which is one of the two variables required in Equation 3 to solve for $kW_{fans\_pre}$.

Note however that Equation 6, as presented thus far, can only be solved using logged data. To extrapolate over 8760 hours in a year requires creating another regression model from the logged data as shown in Equation 14.

**Equation 14 - $\dot{Q}_{Post}$ Regression**

$$\dot{Q}_{Post} = (m2_T T_o + b2_T)$$

where

$\dot{Q}_{Post}$ $post - implementation\ total\ hourly\ coil\ load\ (tons)$

$T_o$ $hourly\ outdoor\ drybulb$

$m2_T$ $slope\ of\ daily\ total\ coil\ load\ regressed\ against\ average\ daily\ outdoor\ drybulb$

$b2_T$ $intercept\ of\ daily\ total\ coil\ load\ regressed\ against\ average\ daily\ outdoor\ drybulb$

The regression parameters $m2_T$ and $b2_T$ are calculated using logged data by regressing the daily average logged post-implementation coil load of all (10) AHUs against the corresponding daily average logged outdoor air temperature. It is assumed that the post-implementation coil load is zero whenever the calculated value for $\dot{Q}_{Post}$ is less than or equal to zero.

The second variable required by Equation 3, $kW_{rf\_pre}$, is obtained through the application of Equation 8 as shown in Equation 15:

**Equation 15 - $kW_{rf\_pre}$**

$$kW_{rf\_pre} = kW_{totalrf\_max}(f_{rf\_pre})^3$$

where

$f_{rf\_pre}$ $total\ pre - implementation\ return\ fan\ airflow\ ratio$

$kW_{totalrf\_max}$ $total\ return\ fan\ full\ load\ kW$

The survey reveals that the pre-implementation return fans generally were intended to maintain a fixed airflow differential with respect to the supply fans in order to continuously return from the spaces only the balance of the volume not exhausted by the building exhaust fans nor required to maintain building pressurization. In this case then $f_{rf\_pre}$ is assumed to be as shown in Equation 16:

**Equation 16 – Pre-Implementation Return Fan Airflow Ratio**

$$f_{rf\_pre} = \frac{CFM_{totalsf\_pre} - t}{CFM_{totalrf\_max}}$$

where

$t$ = return fan airflow tracking differential (CFM)

$CFM_{totalsf\_pre}$ = total pre-imlementation supply fan airflow

$CFM_{totalrf\_max}$ = total return fan full load airflow

The solution of Equation 16, however, requires knowing the total pre-implementation supply airflow, $CFM_{totalsf\_pre}$, which is found implicitly via the application of the Englander-Norford equation for a VFD-driven fan as shown in Equation 17:

**Equation 17 - $H_{totalsf\_pre}$**

$$H_{totalsf\_pre} = a + b(f_{sf\_pre}) + d(f_{sf\_pre})^3$$

where

$f_{sf\_pre} = \frac{CFM_{totalsf\_pre}}{CFM_{totalsf\_max}}$ = total pre-implementation supply fan airflow ratio

$H_{totalsf\_pre} = \frac{kW_{sf\_pre}(\frac{?}{?})}{kW_{totalsf\_max}}$ = total pre-implentation supply fan power ratio

$kW_{totalsf\_max}$ = total supply fan full load kW

$a = \left(\frac{p_s}{2}\right)^{1.5}$

$p_s$ = ratio of static pressure setpoint of the controller to the static pressure at the fan discharge

$b = p_s(1 - a)$

$d = 1 - a - b$

Solving Equation 17 for $CFM_{totalsf\_pre}$ and inserting it into Equation 16 gives $f_{rf\_pre}$, which, when applied to Equation 15, returns $kW_{rf\_pre}$.

Inserting $kW_{sf\_pre}$ and $kW_{rf\_pre}$ into Equation 3 finally enables the calculation of $kW_{fans\_pre}$.

### $kW_{plant\_post}$

The second term in the numerator of Equation 1, $kW_{plant\_post}$, is obtained by inserting the solution to Equation 6, $\dot{Q}_{Post}$, into Equation 18:

**Equation 18 - $kW_{plant\_post}$**

$$kW_{plant\_post} = \frac{\varepsilon_{Plant}\dot{Q}_{Post}}{S}$$

where

$\dot{Q}_{Post}$ post implementation total hourly coil load (tons)

$\varepsilon_{Plant}$ overall plant efficiency $\left(\frac{kW}{ton}\right)$

$S$ ratio of total CFM of (10) sampled AHUs to total CFM of (27) site AHUs

$kW_{plant\_pre}$

With ducted returns connected to all the AHUs in the hospital, it is assumed that all infiltration must be met with a corresponding increase or decrease in load on the chilled water plant, depending on whether the outdoor ambient enthalpy is greater or less than the typical indoor enthalpy. The first term in the numerator of Equation 1, $kW_{plant\_pre}$, is therefore obtained by inserting $\dot{Q}_{Post}$ and the solution to Equation 13, $\dot{Q}_{inf}$, into Equation 19:

**Equation 19 - $kW_{plant\_pre}$**

$$kW_{plant\_pre} \quad \varepsilon_{Plant}(\dot{Q}_{Post} + \dot{Q}_{inf})$$

## Summary of Required Parameters and Independent Variables

The overall set of numbers required to solve all the equations described above are summarized below in

Table 1 and Table 2. Required hourly independent variables are from logged data and/or TMY. Required parameters are derived by one of three means:

1. Survey
2. Stipulation
3. Regression of logged data

**Table 1 – Required Parameters**

| Parameter | Description | Source |
|---|---|---|
| $m1_T$ | slope of daily total AHU fan kWh regressed against daily average outdoor drybulb (sampled supply and return fans) | regression of logged data |
| $b1_T$ | intercept of daily total AHU fan kWh regressed against daily average outdoor drybulb (sampled supply and return fans) | regression of logged data |
| $S$ | ratio of total CFM of (10) sampled AHUs to total CFM of (27) site AHUs | survey |
| $m_{\dot{Q}}$ | slope of daily total supply fan kWh regressed against daily total coil load (sampled AHUs) | regression of logged data |
| $b_{\dot{Q}}$ | intercept of daily total supply fan kWh regressed against daily total coil load (sampled AHUs) | regression of logged data |
| $\rho$ | nominal air density | stipulated |
| $p_u$ | ratio of controlled static pressure setpoint to static pressure at fan discharge | stipulated |
| $CFM_{sf\_max}$ | full load CFM of individual supply fan | survey |
| $kW_{sf\_max}$ | full load kW of individual supply fan | survey |
| $\varepsilon_m$ | nominal efficiency of fan motors | stipulated |
| $\varepsilon_{drive}$ | nominal efficiency of VFD drives | stipulated |

| | | |
|---|---|---|
| $C$ | flow coefficient | stipulated |
| $C_s$ | stack coefficient | stipulated |
| $C_w$ | wind coefficient | stipulated |
| $sf$ | shelter factor | stipulated |
| $n$ | flow exponent | stipulated |
| $T_i$ | typical indoor drybulb | survey |
| $h_i$ | typical indoor enthalpy | survey |
| $m2_r$ | slope of daily average coil load regressed against daily average outdoor drybulb (sampled supply and return fans) | regression of logged data |
| $b2_r$ | intercept of daily average coil load regressed against daily average outdoor drybulb (sampled supply and return fans) | regression of logged data |
| $CFM_{totalsf\_max}$ | sum of full load CFM of all (10) supply fans | survey |
| $CFM_{totalrf\_max}$ | sum of full load CFM of all (10) return fans | survey |
| $kW_{totalrf\_max}$ | sum of full load kW of all (10) supply fans | survey |
| $kW_{totalsf\_max}$ | sum of full load kW of all (10) return fans | survey |
| $t$ | return fan airflow tracking differential | survey |
| $\varepsilon_{Plant}$ | overall plant efficiency | stipulated |

**Table 2 – Required Independent Hourly Variables**

| Variable | Description | Source |
|---|---|---|
| $kW_{fans\_post}$ | post-implementation kW of all fans sampled | logged |
| $T_o$ | outdoor drybulb temperature | logged and TMY |
| $\overline{\Delta h}$ | post-implementation CFM-weighted overall average coil enthalpy drop | logged |
| $V_w$ | outdoor windspeed | TMY |
| $h_o$ | outdoor enthalpy | psychrometrics applied to TMY |

## Surveyed Parameters

The values assigned for maximum $CFM$ and $kW$ for each fan, as well as the total $CFM$ and $kW$ for the full set of supply and return fans, respectively, are shown below in Table 3. Values assigned to the remaining surveyed parameters are shown in Table 4:

**Table 3 –Fan Full Load CFM and kW**

| Fan | $CFM_{sf\_max}$ | $kW_{sf\_max}$ | $CFM_{rf\_max}$ | $kW_{rf\_max}$ |
|---|---|---|---|---|
| AHU-3 | 5823 | 9.2 | 5028 | 2.0 |
| AHU-9 | 40515 | 33.5 | 40480 | 11.3 |
| AHU-27 | 64000 | 54.6 | 60000 | 35.0 |
| AHU-28 | 13682 | 10.6 | 11562 | 2.3 |
| AHU-32 | 7744 | 10.8 | 5608 | 2.5 |
| AHU-35 | 53743 | 48.7 | 40760 | 33.7 |
| AHU-36 | 56161 | 55.6 | 45308 | 46.2 |
| AHU-37 | 57692 | 60.2 | 33210 | 18.2 |

| | | | | |
|---|---|---|---|---|
| AHU-40 | 17760 | 5.6 | 13422 | 1.7 |
| AHU-43 | 42501 | 22.7 | 26422 | 5.0 |
| | **359,620** | **312** | **281,800** | **158** |
| | $CFM_{totalsf\_max}$ | $kW_{totalsf\_max}$ | $CFM_{totalrf\_max}$ | $kW_{totalrf\_max}$ |

**Table 4 - Other Surveyed Parameters**

| Parameter | Nominal Value |
|---|---|
| $T_i$ | 72 |
| $h_i$ | 26.3 (RH=50%) |
| $S$ | 0.6 |
| $t$ | $CFM_{totalsf\_max}$ $CFM_{totalrf\_max}$ |

## Stipulated Parameters

The stipulated parameters, shown below in Table 5, are based on engineering standards.

**Table 5 – Stipulated Parameters**

| Parameter | Nominal Value |
|---|---|
| $p_2$ | 0.4 |
| $\varepsilon_{drive}$ | 0.95 |
| $\varepsilon_m$ | 0.85 |
| $c$ | 400,000 |
| $c_s$ | 0.005 |
| $c_w$ | 0.0025 |
| sf | 1 |
| n | 0.65 |
| $\rho$ | 0.075 |
| $\varepsilon_{fans}$ | 0.75 |

## Logged Variables and Regression Parameters

The logged kW, temperature and humidity data are used only to create the (6) regression parameters shown in Table 1 that are required to find the extrapolated hourly results for Equation 2, $kW_{fans\_post}$, Equation 3, $kW_{fans\_pre}$, and Equation 14, $\dot{Q}_{post}$, as further described below.

## TMY Variables

Hourly Typical Meteorological Year (TMY) data for Cincinnati are applied for purposes of extrapolating annual savings results, as described below. Only three TMY values are required:

1. $V_w$, outdoor windspeed
2. $T_o$, outdoor drybulb temperature
3. $RH_o$, outdoor relative humidity

A standard psychrometric formula applied to the latter two variables gives the hourly variable, $h_o$, outdoor enthalpy, which is required in Equation 13.

# TMY Annual Extrapolation

All the necessary equations and data are now in place to solve Equation 1 for each hour of a typical meteorological year (TMY). This hourly extrapolation is performed as follows for each of the terms in Equation 1.

$kW_{fans\_post}$

1. TMY drybulb, $T_a$, is applied directly to Equation 2 to calculate the hourly value for $kW_{fans\_post}$.

$kW_{fans\_pre}$

1. TMY drybulb, $T_a$, and wind speed, $V_w$, are applied to Equation 10 to calculate hourly infiltration, $CFM_{inf}$, which is combined with TMY $h_a$ in Equation 13 to obtain hourly infiltration load, $\dot{Q}_{inf}$.
2. TMY drybulb, $T_a$, is also applied to Equation 14 to obtain hourly average overall post-implementation coil load, $\dot{Q}_{post}$.
3. The values for $\dot{Q}_{inf}$ and $\dot{Q}_{post}$ calculated above are applied to Equation 5 to obtain hourly $\dot{Q}_{pre}$, which, when inserted into Equation 4 gives $kW_{sf\_pre}$. $kW_{sf\_pre}$ is then plugged into Equation 17, the result of which is plugged into Equation 15 to give $kW_{rf\_pre}$. Combining $kW_{sf\_pre}$ and $kW_{rf\_pre}$ in Equation 3 gives the hourly value for $kW_{fans\_pre}$.

$kW_{plant\_post}$

1. The value $\dot{Q}_{post}$ calculated above is applied directly to Equation 18 to obtain the hourly value for $kW_{plant\_post}$.

$kW_{plant\_pre}$

1. The value $\dot{Q}_{pre}$ calculated above is applied directly to Equation 19 to obtain the hourly value for $kW_{plant\_pre}$.

## Sensitivity Analysis

The partial variation in overall annual savings with respect to various parameters is identified by adjusting, alone and in turn, each of the selected parameters shown below in Table 6.

**Table 6 - Sensitive Parameters**

| Parameter | Nominal Value |
|---|---|
| $p_3$ | 0.4 |
| $\varepsilon_m$ | 0.85 |
| $c$ | 400,000 |
| $c_s$ | 0.005 |

| | |
|---|---|
| $c_w$ | 0.0025 |
| $sf$ | 1 |
| $\eta$ | 0.65 |
| $\varepsilon_{Plant}$ | 0.75 |
| $T_i$ | 75 |
| $RH_i$ | 50 |
| $S$ | 0.6 |
| $CFM_{totalsf\_max}$ | 359,620 |
| $CFM_{totalrf\_max}$ | 281,800 |
| $kW_{totalsf\_max}$ | 312 |
| $kW_{totalrf\_max}$ | 158 |
| $\tau$ | 77,821 |

# Results Summary

## Regressions

Logged data yielded the required regression parameters shown in Table 7 and depicted in Figure 1- Logged Daily AHU kWh and Coil Load v Average Daily Outside Air Temperature" and Figure 2 – Logged Daily Supply Fan kWh v Daily Average Coil Load".

**Table 7 - Regression Parameters**

| Parameter | Description | Value |
|---|---|---|
| $m1_T$ | slope of daily total AHU fan kWh regressed against daily average outdoor drybulb (sampled supply and return fans) | 44.6 |
| $b1_T$ | intercept of daily total AHU fan kWh regressed against daily average outdoor drybulb (sampled supply and return fans) | 3254 |
| $m_Q$ | slope of daily total supply fan kWh regressed against daily total coil load (sampled AHUs) | 2.0 |
| $b_Q$ | intercept of daily total supply fan kWh regressed against daily total coil load (sampled AHUs) | 3798 |
| $m2_T$ | slope of daily average coil load regressed against daily average outdoor drybulb (sampled supply and return fans) | 12.7 |
| $b2_T$ | intercept of daily average coil load regressed against daily average outdoor drybulb (sampled supply and return fans) | 400 |

**Figure 1- Logged Daily AHU kWh and Coil Load v Average Daily Outside Air Temperature**

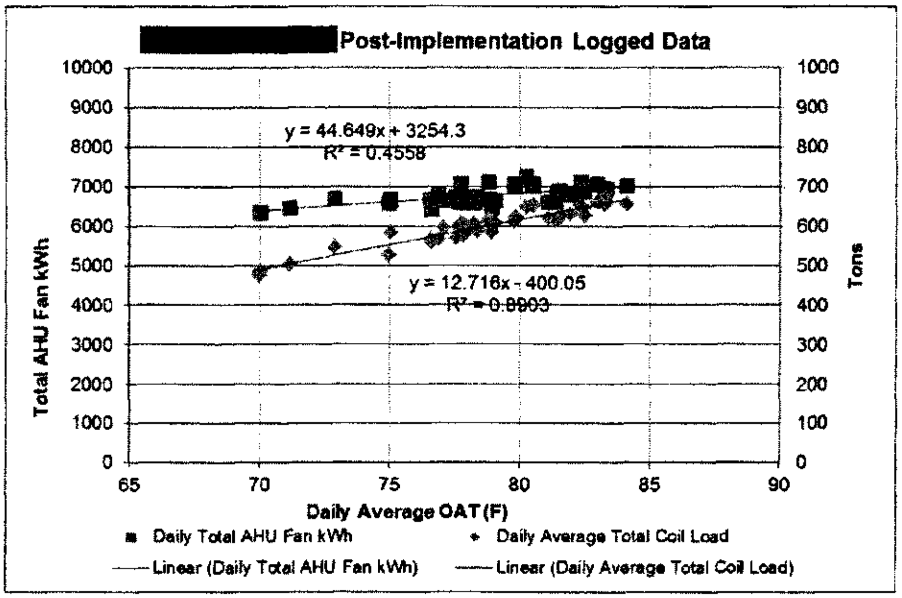
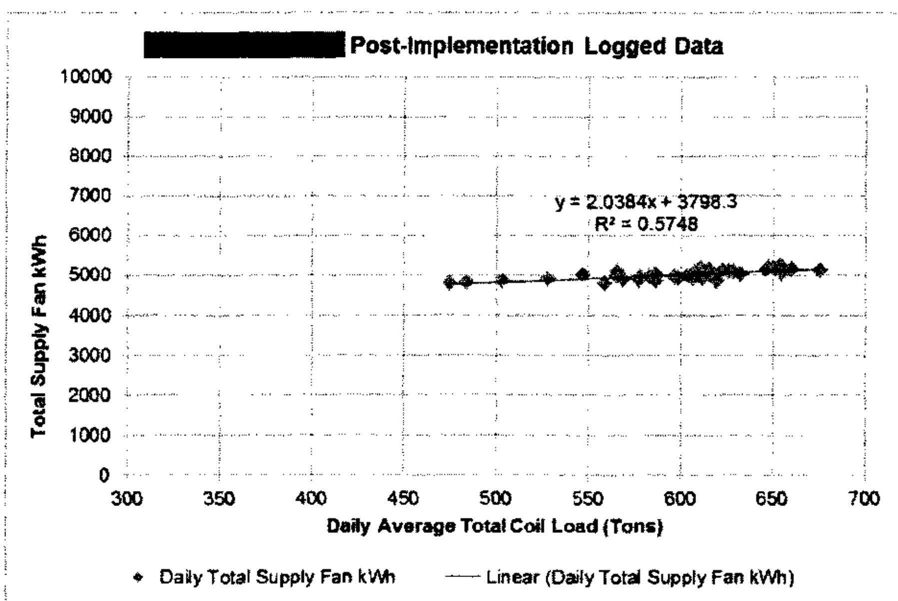



**Figure 2 – Logged Daily Supply Fan kWh v Daily Average Coil Load**




## Energy Use and Savings

Applying the parameters given in Tables 3, 4 and 5, the solution to Equation 1 – ***Annual kWh Savings*** is given below in

Table 8. This represents the estimated savings associated with implementing the Stack Effect Control measure on (27) AHUs in the hospital. Annual energy savings amount to almost 400,000 kWhs, which is equal to ~6% of the pre-implementation energy use associated with the (27) AHUs. Note that in post-implementation while overall return fan energy drops dramatically, overall supply fan and plant energy actually rises. The drop in return fan energy is expected considering that the return fans work much less to maintain return plenum static pressure than they did to maintain airflow differential. On the other hand, the increase in work by the supply fans and chiller plant may indicate that the respective AHU economizers have not compensated for the loss of the "free cooling benefit" associated with infiltration. It is expected that this effect will be remedied in Phase 2 of the project.

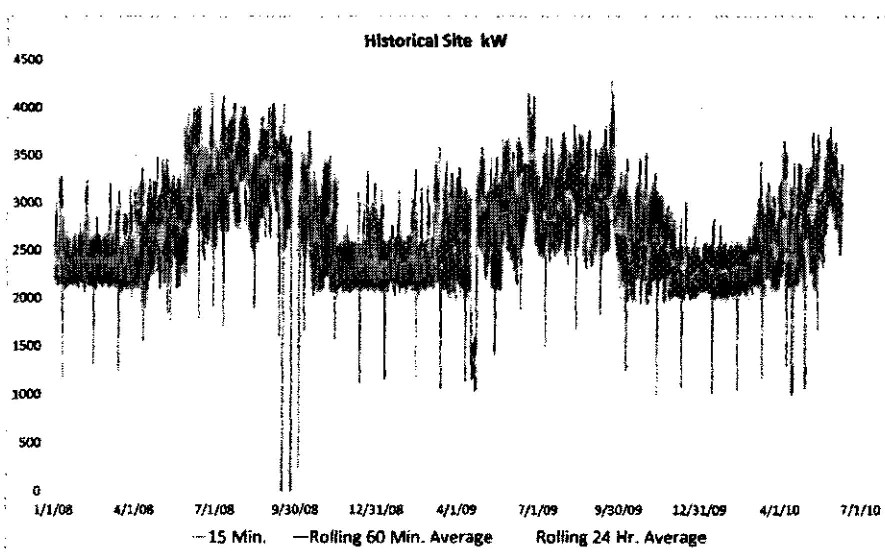
**Table 8 – Annual Energy Savings**

| | kWhs Pre | kWhs Post | kWh Savings |
|---|---|---|---|
| **Supply Fans** | 2,668,225 | 2,696,164 | -27,938 |
| **Return Fans** | 1,330,933 | 754,269 | 576,664 |
| **Plant** | 3,149,007 | 3,298,122 | -149,115 |
| **Total** | **7,148,165** | **6,748,555** | **399,610** |

## Demand Savings

The historical 15 minute demand data obtained from the site's two utility meters is shown in Figure 3 – Historical Site Interval Data". In 2008 the on-peak maximum demand of 4152 kW occurred on Thursday, June 26th at 12:15 pm. In 2009 the on-peak maximum of 4282 kW occurred on Monday, September 20th at 1:00 pm.

**Figure 3 – Historical Site Interval Data**



Integrating this data for the years 2008 and 2009 shows average annual consumption during that time to be ~23,700,000 kWh. The savings associated with the Stack Effect Control measure therefore amounts to ~1.7% of the whole site.

The results of Equation 1 are shown by equipment type in annual profile in Figure 4, and then specifically for January (winter) and July (summer) in Figure 5 and Figure 6, respectively. Peak values are shown in

**Table 9 – Demand Savings**

| | kW | Time and Date |
|---|---|---|
| On-Peak Max Demand Savings | 226 | Wednesday August 8, 1:00 PM |
| Grid-Coincident Min Demand Savings | 70 | Thursday August 2, 3:00 PM |
| Grid-Coincident Max Demand Savings | 150 | Monday August 20, 3:00 PM |

**Figure 4 – TMY Annual Demand Savings Profile**

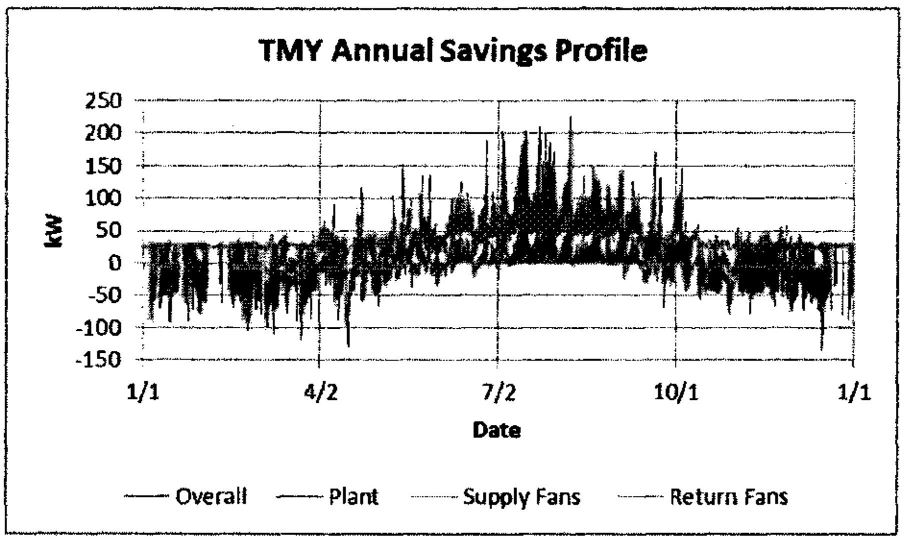


**Figure 5 – January Demand Savings Profile**

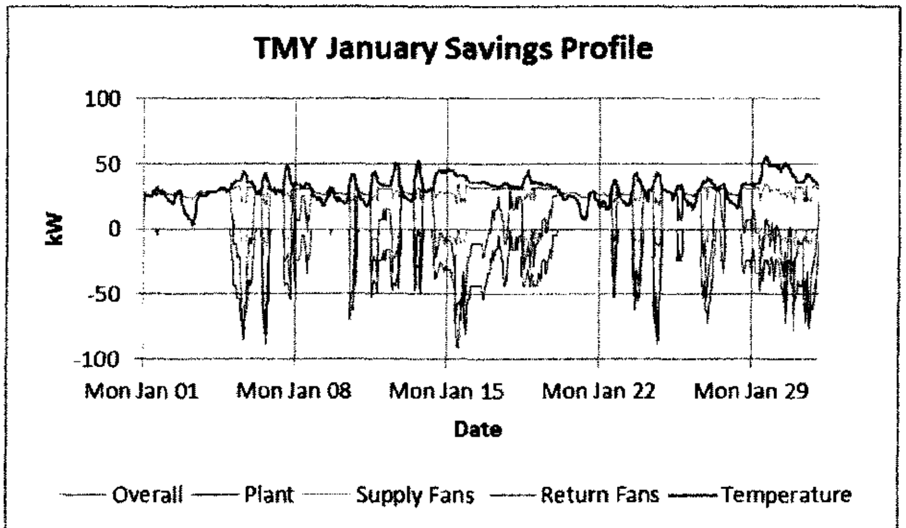



**Figure 6 – July Demand Savings Profile**

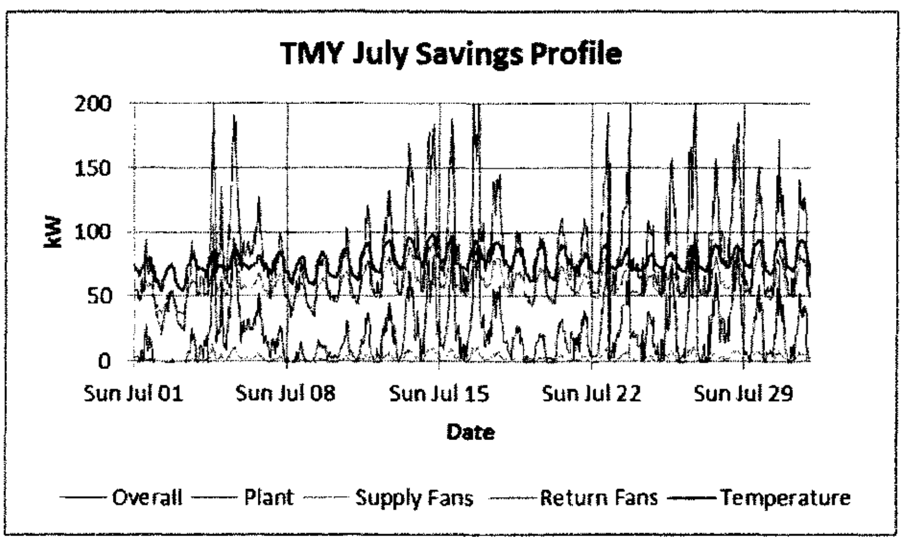
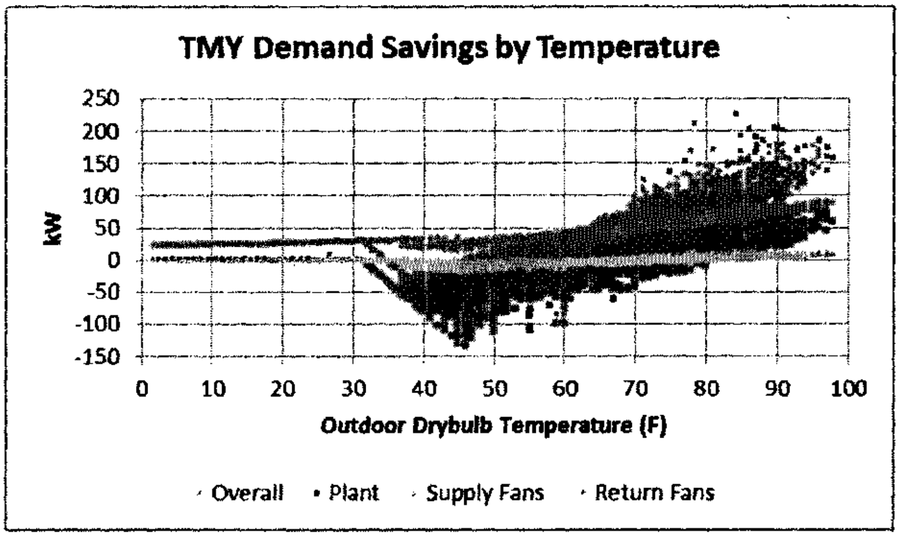



Figure 7 below depicts the respective demand savings according to outdoor temperature rather than date. As mentioned above, note the penalty associated with the plant in the range of "swing" temperatures, between ~35F to ~65F, when the economizers should be working to provide free cooling. Below ~30F the difference between pre and post electrical use appears to be limited to the return fans (humidification impacts are not addressed here).

**Figure 7 – Demand Savings by Temperature**




## Realization Rate

Savings realizations rates are shown in Table 10.

**Table 10 – Realization Rates**

| | Predicted | Measured | Realization Rate |
|---|---|---|---|
| Energy Consumption (kWh) | 479,208 | 399,610 | 83% |
| Coincident Peak Demand (kW) | 108 | 70 | 65% |

## Sensitivity

The partial variation in overall annual savings with respect to various parameters is identified by adjusting within Equation 1, alone and in turn, each of the selected parameters shown in Table 6. Shown below in Table 11 are the results presented as the ratio of the %variation in savings to the %variation in parameter. For example, a 1% increase in $CFM_{totalsf\_max}$ will result in a 12.5% increase in savings. Conversely, a 1% increase in $CFM_{totalrf\_max}$ will result in a 9.4% decrease in savings.

**Table 11 - Sensitive Parameters**

| Parameter | Nominal Value | Sensitivity |
|---|---|---|

| | | |
|---|---|---|
| $CFM_{totalsf\_max}$ | 359,620 | 12.5 |
| $kW_{totalsf\_max}$ | 312 | -9.4 |
| $CFM_{totalrf\_max}$ | 281,800 | -9.4 |
| $T_i$ | 75 | -5.0 |
| $kW_{totalrf\_max}$ | 158 | 3.1 |
| $\tau$ | 77,821 | -3.1 |
| $p_a$ | 0.4 | 1.5 |
| $S$ | 0.6 | -1.3 |
| $RH_i$ | 50 | -1.0 |
| $\eta$ | 0.65 | -0.7 |
| $\varepsilon_{Fmax}$ | 0.75 | -0.4 |
| $c$ | 400,000 | -0.3 |
| $c_s$ | 0.005 | -0.2 |
| $\varepsilon_m$ | 0.85 | -0.2 |
| $sf$ | 1 | -0.1 |
| $c_w$ | 0.0025 | -0.1 |

**Site Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 399,610 | 479,209 | 0.83 | 226 | 108 | 2.1 | 70 | 81 | 0.87 |

# Site 3

[redacted]

# M&V Plan Results Summary

PREPARED FOR:
Duke Energy
OHIO

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
March 2011

## INTRODUCTION

Architectural Energy Corporation was hired to evaluate the Duke Energy custom incentive evaluation program for [redacted] in downtown Cincinnati. The energy conservation measures (ECM) were provided by [redacted] and AEC designed the plan to measure and quantify the results. The ECM measures include:

1. Replace 163 existing 15,000 BTU McQuay Dx and electric resistance heating PTACs with GE Zoneline 7,000 BTU heat pumps and add wireless thermostats.
2. Replace 179 existing 15,000 BTU McQuay Dx and electric resistance heating PTACs with GE Zoneline 12,000 BTU heat pumps and add wireless thermostats.
3. Implement a wireless thermostat mesh-network that is monitored and controlled by an energy management control system.

Measures #1 and #2 will involve removing and replacing existing HVAC equipment with a more efficient technology and adding thermostatic control. The two new models have dramatically different energy results and thus are reflected as separate measures.

Measure #3 will tie the new thermostats into a wireless mesh network and control them by the energy and demand management software. With the direct integration to the property management software at the front desk, the "unsold" rooms will be deeply setback. The system will allow [redacted] to perform demand forecasting and reduction as well as monitor the energy use of each PTAC.

## GOALS AND OBJECTIVES

Gross kWh and peak kW savings

- Total kiloWatt hour forecasted reduction is 1,821,204 kWh
- Total peak kiloWatt reduction is 266 kW

The specific objective of this M&V project is to create a realization rate based on [redacted] applications. The realization rate is the actual savings, based on monitored data, versus the projected savings presented in the applications.

## BUILDING CHARACTERISTICS

The building characteristics of the building are summarized below:

Table 1: Building Characteristics

| Characteristic | Value |
|---|---|
| Building size | 180,000 SF |

| | |
|---|---|
| Number of stories | 17 |
| Age | 27 years old |
| HVAC system | 2 15,000 BTU PTAC in each suite |
| Thermostat | Integral to unit |

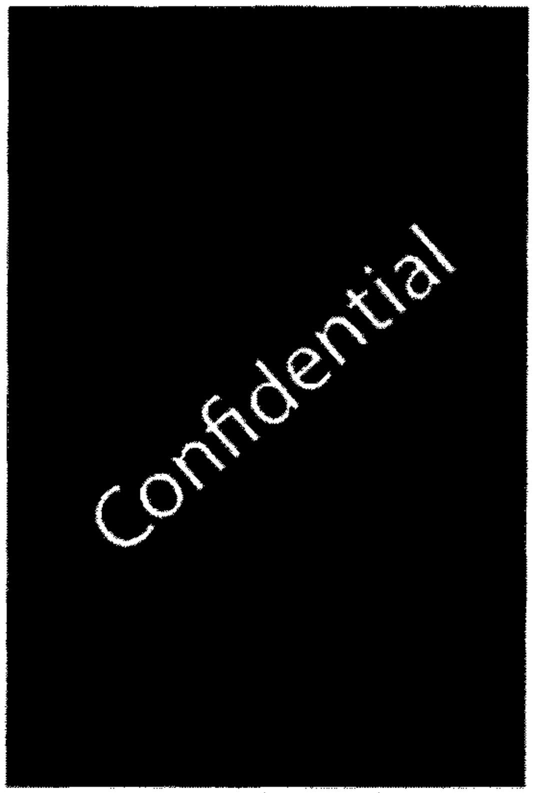



Figure 1: Building site photo

## Data Products and Project Output

- Measured data used to model annual Pre/Post load shapes
- Verify heating/cooling runtime hrs reduced through occupancy controls
- Peak demand savings verification
- Annual Energy Savings verification

## M&V Option

IPMVP Option A

# Data Analysis

Two sets of data were recorded. "Pre" data refers to data recorded with the original equipment. "Post" data was recorded after the energy conservation measures (ECM) are applied. In this study the Pre data was recorded during the cooling season and the Post data was recorded during the heating season. This left the challenge of using the data to verify the energy saving under different conditions. The Pre and Post units operate differently when either heating or cooling, however, from the data there is a lot of information and the following steps were used to show that our analysis concludes that [redacted] did meet their predicted realization rate.

There are two main aspects to the energy savings on this project. The first is the installation of efficient equipment and second, occupancy controls that will setback thermostats in unsold rooms.

# Field Data

Field procedures are repeated as written for both the Pre measurement period and Post measurement period.

Survey data

- PTAC unit(s) make and model

One-time measurements

- PTAC kW with logger installed and compressor running. This measurement is used to correlate the recorded PTAC amps to kW

Time series data on controlled equipment

- PTAC unit power (Amps)
- PTAC return and Supply temperatures (F)

Set up loggers for 5 minute instantaneous readings. The loggers were deployed for 3 weeks. The data that was retrieved was reviewed for quality. Any data that appeared to be inaccurate was removed. The actual time period for the usable data was 25.5 days Pre retrofit, during the cooling season, and 15.5 days of data after the retrofit during the heating season.

# Data Accuracy

Table 2: Data accuracy by sensor

| Measurement | Sensor | Accuracy | Notes |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Temperature | MDL thermistor | ±0.5° | |
| Current | Magnelab CT | ±1% | > 10% of rating |

## Verification and Quality Control

9. Visually inspect time series data for gaps
10. Compare readings to data sheet values; identify out of range data
11. Look for physically impossible combinations e.g. supply << Return air and no current draw (unit is cooling)

## Recording and Data Exchange Format

6. MDL binary files
7. Excel spreadsheets

## Results Summary

### Data Analysis

Two sets of data were recorded. "Pre" data refers to data recorded with the original equipment. "Post" data is recorded after the energy conservation measures (ECM) are applied. In this study the Pre data was recorded during the cooling season and the Post data was recorded during the heating season. This left the challenge of using the data to verify the energy saving under different conditions. The Pre and post units operate differently when either heating or cooling, however, from the data there is a lot of information and the following steps were used to show that our analysis concludes that [redacted] did meet their predicted realization rate.

There are two main aspects to the energy savings on this project. The first is the installation of efficient equipment and second, occupancy controls that will setback thermostats in unsold rooms.

### Unoccupied Room setback

The first step was to determine the Pre and post run time percentages of the units in the room. Setbacks are programmed from the main office; this and more accurate thermostats installed in the rooms contribute to runtime savings.

- Convert raw Amp data to kW using spot measurements

$$kW_{measured} = A_{measured} \times \frac{kW_{spot}}{A_{spot}}$$

- The kW data for each room was charted
- A function was written to count points with kW > .2
- The total number of points greater than .2 kW was converted to hrs and divided by the number of hrs that the MDLs logged. The result was hrs/day that each unit ran

$$\frac{ON_{Total}}{12} = HRS$$
$$\frac{HRS}{TotalHRS\,{}^{12}\!/_{24}} = {}^{HRS}\!/_{DAY}$$

*Assumption: kW measurements less than .2 represent a unit that is not running*

- This process was repeated for the Post data
- The final answer is the Post divided by the Pre

$$\%Runtime = \frac{Post\,{}^{HRS}\!/_{DAY}}{\Pr e\,{}^{HRS}\!/_{DAY}}$$

*Assumption: The hrs/day that the PTAC runs is representative of occupancy and thermostat control savings. The occupancy rate of the hotel would affect this value, however, it is not considered in our model.*

## Efficient Equipment

The Pre data was recorded during the cooling season and the Post data during the heating season. This situation allowed us to use each set of measured data as a baseline for our annual model. The baseline was adjusted for the changes in equipment to model the projected use before and after the retrofit.

Cooling

- Data was plotted, separated by Bedroom and Living Room units. The value for each room type was averaged to find the per unit energy average and then multiplied by the number of rooms of that type. That data was again averaged per hour and summed daily. This was graphed. From the graph a regression line was plotted that represented average daily kWh vs OAT.

$$\underline{kW_{total} = avgkW_{bedroom} \times 179 + avgkW_{LivingRoom} \times 163}$$

*Assumption: Bedroom units use more energy therefore they are the larger PTAC unit. 179 12,000 BTU units and 163 7,000 BTU units are being installed*

- The formula for the regression line was multiplied by TMY3 to model the cooling kWh in a typical year. This value represents daily kWh and TMY3 data is given in hours. The results must be divided by 24.

$$kWh = (m \times (TEMP) + b) / 24$$

Where: *m & b are values from the regression line*

*Assumption: The regression line crossed the x axis at 55 deg, this temperature was used as the cut off for the cooling data*

- The first stage in the model is to compare the energy use for the same conditions based on the improved efficiency of the new equipment. This is done by multiplying each type of equipment by the ratio of the new and old EERs. EER stands for Energy Efficiency Ratio.

$$kWh_{EER} = kWh_{pre} \times \frac{EER_{post}}{EER_{pre}}$$

$$EER = \frac{BTU/Hr_{output}}{Watt_{input}}$$

- The final improvement in energy saving will be made by multiplying the above value by the run time ratio calculated earlier. With improved run time and efficiency the final number will represent Post cooling values.

$$kWh_{post} = kWh_{EER} \times \%runtime$$

<u>Heating</u>

- Post data was plotted, as before, separated by Bedroom and Living Room units. The value for each room type was averaged to find the per unit energy average and then multiplied by the number of rooms of that type. That data was again averaged per hour and then summed daily. This was graphed. From the graph a regression line was plotted that represented average daily kWh vs OAT.

- The formula for the regression line was multiplied by TMY3 to model the heating kWh in a typical year. This value represents daily kWh and TMY3 data is given in hours so the results must be divided by 24.

$$kWh = (m \times (TEMP) + b) / 24$$

Where: *m & b are values from the regression line*

*Assumption: 55 deg was used as the upper limit of the heating data.*

- The original equipment used electric resistance heating, the new equipment will attempt to control temperature with the heat pump first and utilize resistance heating as a backup. Resistance heat has a Coefficient of Performance (COP) of 1, while the heat pumps have COPs of 3.6 and 3.4 for the Bedroom and Living Room units respectively. This model is done in a similar way to the cooling EER calculations except in reverse.

$$kWh_{COP} = kWh_{Post} \times \frac{COP_{pre}}{COP_{post}}$$

$$COP = \frac{Watt_{output}}{Watt_{input}}$$

- Because the new units have resistance heat as a back up this has to be accounted for. The data can be graphed as kW vs time, from this two distinct bands can be seen in the power. The first band is roughly 200 – 1000 W and the second band is between 2500-3500 W. The first band is the heat pump and the second is made when the resistance heat kicks in. A statement was written to distinguish values between 200 and 1000 W. If the data fell in this range it was multiplied by the COP to model a unit with only resistance heating.

*Assumption: Data that falls between .2 – 1.0 kW is heat Pump Data*

- As in the Cooling model the final step was to reapply the % runtime ratio.

$$kWh_{pre} = kWh_{COP} \div \%runtime$$

## Savings Verification and Realization Rate:

- Compare Pre/Post values to obtain total kWh/year savings. Once the savings are calculated, the realization rate is calculated by the following formula:

$$Realization\ Rate = kWh_{actual} / kWh_{application}$$

## Calculation Output

The following Table summarizes energy savings as the results of this energy conservation measure.

Table 3: Data analysis results and realization rate

| Criteria | Bedroom | Living Room | | |
|---|---|---|---|---|

| | | | Adjusted Total | |
|---|---|---|---|---|
| PRE - Running hrs/day (Power > 200W) | 20.1 | 19.1 | | |
| POST - Running Hrs/Day (Power > 200W | 3.9 | 4.9 | | |
| % run time difference based on Pre and Post run hrs/day | 19% | 25% | 22% | |
| | | | | |
| Cooling Regression | PRE kWh (measured) | KWh adjusted for EER | Runtime (kWh based on occupancy control) | |
| Total kWh | 1,032,059 | 791,566 | 175,681 | |
| Peak kW | 258 | 199 | N/A | |
| | | | | |
| Heating Regression | Adjusted for occupancy | Adjusted for Heat Pump COP | Post install (measured) | |
| Total kWh | 2,788,599 | 618,905 | 266,800 | |
| Peak kW | N/A | 767 | 284 | |
| | | | | |
| Total | Pre | | Post | savings |
| Energy kWh | 3,820,657 | | 442,482 | 3,378,175.81 |
| Peak kW | 767 | | 284 | 483 |
| | | | | |
| Dollars | $343,859.16 | | $39,823.34 | $304,035.82 |
| | | | | |
| | | Application | Modeled | |
| Realization rate (%) | | 1,821,204 | 3,378,175.81 | 185.49% |

**Site Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rates**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 3,378,176 | 1,284,468 | 2.63 | 483 | 234 | 2.07 | 483 | 182 | 2.65 |

# Site 4

[redacted]

## - Cool Roof Retrofit -

# M&V Plan Results Summary

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
April 2011

## INTRODUCTION

Architectural Energy Corporation was hired to evaluate the Duke Energy custom incentive program addressing upgrades to the roof of the [redacted]. The measures were to replace the existing roof with a white membrane "cool roof" to reduce the heat gain on by the building envelope, as well as add insulation to the roof deck providing for better space conditioning retention.

Energy savings were estimated at 36,983 kWh, or near $3,300 annually. These calculations were initially completed by the roofing contractor to complete the installation.

## GOALS AND OBJECTIVES

The project goal was electric use savings of 36,983 kWh annually. The specific objective of this M&V project was to complete a post-implementation site survey of the existing building systems and new roof to determine the energy reduction in heating and cooling needs of the building. Ultimately, a realization rate can be determined to validate the intended energy savings.

## PROJECT CONTACTS

Approval shall be requested from the two Duke Energy contacts listed below prior to making direct contact with the Customer or undertaking work on this M&V Plan.

| | | |
|---|---|---|
| **Duke Energy M&V Administrator** | Frankie Diersing | [redacted] |
| **Duke Energy Account Manager** | Ira Poston | [redacted] |
| **Customer Contact** | [redacted] | |
| **Site Location** | [redacted] | |

## DATA PRODUCTS AND PROJECT OUTPUT

- SurveyIT model output comparison of existing 'black' and retrofit 'white' roof systems.

## M&V OPTION

IPMVP Option D

## DATA ANALYSIS

Survey Form data entry into SurveyIT program provides DOE2 analysis output of improved building performance.

## FIELD DATA

These are examples of the data collected to obtain a complete picture of the building operation.

Completion of Building Survey Form:

1. General Information
   - Size, building type
   - Areas included
2. Areas
   - Occupancy schedules, holidays
   - Lighting schedules, plug loads
   - Thermostat setpoints
3. HVAC Systems
   - Make/model, type, capacity, efficiency
   - Quantity, location, control method
4. Zones
   - Exterior surfaces (if applicable)
   - Roof (if applicable)
   - Window types and geometry (if applicable)
5. Spaces
   - Occupancy style
   - Lighting, miscellaneous equipment
6. Important Details
   - Domestic water heating, kitchen equipment
   - Exterior lighting and other schedules
   - Meters serving the building
   - Space/Zone/Area assignment and association

## VERIFICATION AND QUALITY CONTROL

12. Review Error Logs for critical issues or unintended data omission.
13. Review size and type of building for reliable reduction proposal.

## RECORDING AND DATA EXCHANGE FORMAT

8. DOE2 text output files.

# RESULTS SUMMARY

## DATA ANALYSIS

1. Verify Proposed Measures Were Implemented:

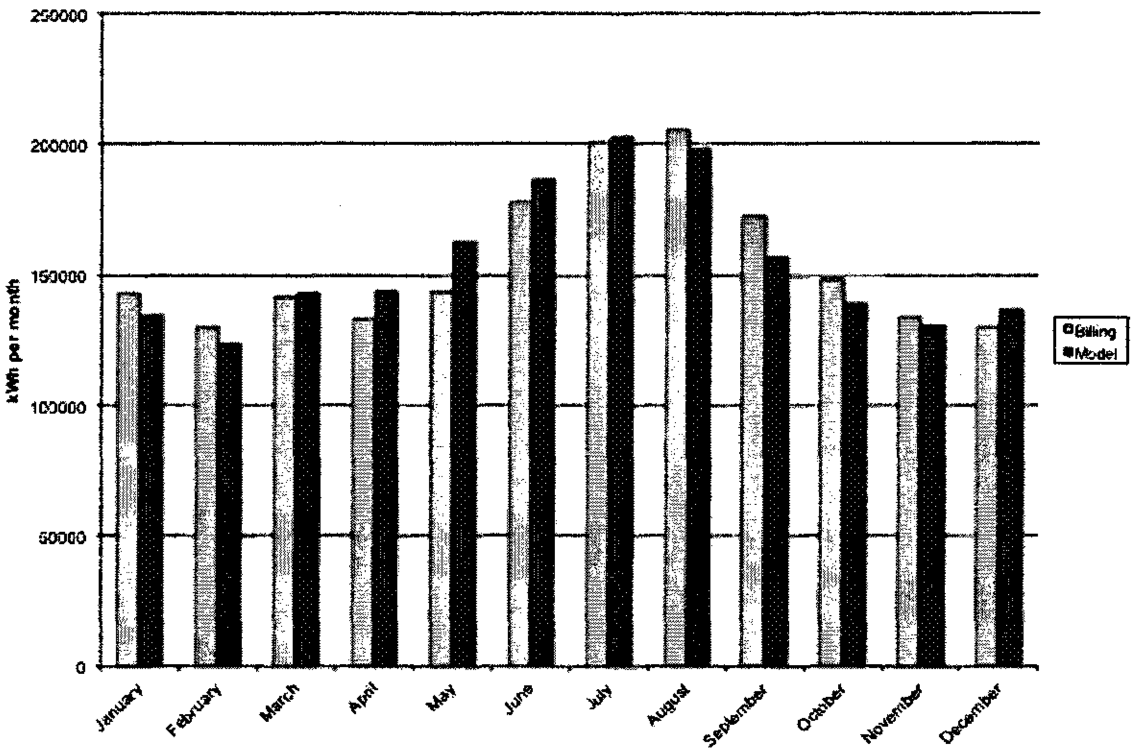
   The "cool roof" was installed on the [redacted] per the scope intended.

2. Calculation Methodology:

A Survey Form was filled out for the building during a site walk following the roof install. The information requested by the form helps attain a complete picture of the facility operation and equipment necessary to determine annual energy use. This form was then transferred directly to a MS Access Database (SurveyIT) that runs DOE2 (Department of Energy) software to calculate the building energy performance and a host of other information. From these outputs, the necessary annual energy use in kWh and Therms can be compared to determine the savings attributed to the roofing retrofit performed for this measure.

3. Model Calibration

Once the inputs were defined, as-built model was calibrated to billing data. A comparison of the simulated monthly kWh from the calibrated model and the monthly utility bills is shown below:




The calibration statistics are summarized below. Note, the calibration statistics are better than the targets established by ASHRAE Guildeline 14 - Measurement of Energy and Demand Savings.

| Parameter | Calibration Result | ASHRAE Guideline 14 Target |
|---|---|---|
| RMS Error | 0.5% | +/- 15% |
| Mean Bias Error | 0.1% | +/- 5% |
| Maximum monthly deviation | -13.5% | Not addressed |

4. Savings Verification and Realization Rate:

Pre/Post values are compared to obtain annual kWh and Therm savings for the facility. Once the savings are calculated, the realization rate is calculated by the following formula:

$$Realization\ Rate = kWh_{actual} / kWh_{application}$$

## Calculation Output

Below are two tables that demonstrate achieved savings based on the DOE2 calculation through ModelIT. Only electricity savings was included here due to only that commodity being included on the Rebate Application.

**Savings reported in Application:**

| Commodity | Value |
|---|---|
| Electricity | 36,983 |
| Natural Gas | 0 |
| Cost | $ 3,328 |

**Following Installation of 'Cool Roof':**

| Annual Energy Savings | | |
|---|---|---|
| Electricity | 4,798 | kWh |

| Approximate Annual Cost Savings | |
|---|---|
| Electricity | $ 432 |

Realization Rate: 4,798 / 36,983 = 13%

*Notes:
- A rate of $0.09 per kWh was used to estimate cost savings, taken from the Application breakout of cost per kWh.

**Site Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 4,798 | 10,100 | 0.48 | 13 | 4 | 3.22 | 8 | 3 | 2.65 |

# M&V Summary

## Site 5

Prepared by Architectural Energy Corporation
February, 2011

## Introduction

Architectural Energy Corporation was hired by TecMarket Works to evaluate the Duke Energy custom incentive evaluation program for *n* [redacted] stores in the Cincinnati area. Of the population, 5 specific stores were selected for sampling and data-logging. The following ECM measures were the target of the data analysis:

1. Emerson E-2 Energy Management System
   - System provides remote control of:
     a. HVAC
     b. Milk cooler
     c. Display freezer
     d. Walk-in freezer
     e. Water heater
     f. Ice storage
   - The E-2 system implements the following control strategies:
     a. Space temperature setpoints and setback
     b. Case temperature reset
     c. Anti-sweat heater controls
     d. HVAC and lighting scheduling
     e. Peak demand limiting
     f. Rotational load shedding
2. LED case lighting for milk cooler and freezer
   - Replace T12 case lighting for GE LED case lighting

## Goals and Objectives

The projected savings goals identified in the application are:

- Total population (*n* stores) reduction of 4,900,840 kWh.

Specific objectives of this M&V project were to verify the actual:

- Annual gross kWh savings
- Summer peak kW savings (at actual peak and grid peak)
- kWh and kW realization rates

## Building Characteristics

The building characteristics of each store are summarized below:

| Characteristic | Value |
|---|---|
| Building size | 3200 SF |
| Number of stories | 1 |
| Age | Varies from 23 – 69 years old |
| HVAC system | 1-2 rooftop units |
| Refrigeration system | 1 walk-in cooler with remote condensing unit |
| | 1 walk-in freezer with remote condensing unit |
| | 1 ice chest |
| Water heater` | 1 electric water heater |
| | |

## Data Products and Project Output

- Model predicting pre/post kWh as a function of outdoor temperature
- Summer peak demand savings
- Annual Energy Savings

## M&V Option

1. IPMVP Option A

## Field Data Points

1.. Survey existing equipment and note the following information:

- Refrigerated case lighting survey
- Refrigerated case make and model
- Thermostat type and setpoints
- Canopy lighting survey
- RTU make and model
- Condensing unit(s) make and model
- Water heater make and model

2. Data loggers were installed to trend amperage for the following equipment at 5 minute intervals over the course of 1 month (each pre and post ECM implementation) for each of the 5 selected locations. Supply and return temperatures for each RTU were also logged.

- HVAC unit(s)
- Milk cooler

- Hardening freezer
- Ice chest
- Domestic hot water heater
- Ice cream display case(s)

3. Spot watt measurements were taken for all logged equipment during data logger installation. The following readings were taken at a single point in time and simultaneously compared to instantaneous data logger readings:

- Kilowatts
- Amperage
- Voltage
- Power factor

## Data Accuracy

| Measurement | Sensor | Accuracy | Notes |
|---|---|---|---|
| Temperature | MDL thermistor | ±0.5° | |
| Current | Magnelab CT | ±1% | > 10% of rating |

## Verification and Quality Control

14. Visually inspect time series data for gaps
15. Compare readings to nameplate values; identify out of range data

## Recording and Data Exchange Format

9. MDL binary files
10. Excel spreadsheets

## Data Analysis Summary

**EMS Data Analysis**

1. The following calculations were performed for each piece of logged equipment for both the pre and post logged interval data:

- Find ratio of kW to amps for each piece of equipment from spot watt measurements.
- Multiply Logged amperage interval data by kW/amp ratio to obtain 5 minute interval kW.
- Convert 5 minute interval kW to kWh by multiplying by 5/60.
- Sum 5 minute kWh values per day to obtain kWh/day.
- Average daily outside air temperatures.

- Regress HVAC and refrigeration kWh/day into a temperature dependent load model. Form of the regression equation is:

  $$kWh/day = a + b \times T_{avg}$$

  where:

  kWh/day = daily energy consumption
  $T_{avg}$ = Daily average drybulb temperature

- Average daily TMY3 outside air temperature data.
- Extrapolate each equipment regression by plugging in average daily TMY3 outside air temperature data to obtain kWh/day for the year.
- Sum kWh/day extrapolations to obtain kWh/year.
- Compare Pre/Post kWh/year to show kWh decrease/increase due to ECM implementation.

**Refrigerated Case Anti-sweat heater control (Deemed Savings)**

1. A deemed savings of 1674 kWh/year per door of each refrigerated case was included in the sample savings estimation. This value was obtained from the Duke Energy measure savings database, which is derived from DOE-2 simulations of anti-sweat heater control performance in prototypical grocery stores. A deemed savings approach was used because it was not cost-effective to monitor the power going to the anti-sweat heaters given the relatively small savings expected from the anti-sweat heater controls.

**Refrigerated Case LED Lighting Data Analysis**

1. A survey which included lighting fixture type, count and wattage was conducted for each of the 5 sampled locations.

2. The following calculations were performed for each piece of logged equipment for both the pre and post logged interval data:

   - Use the following formula to obtain total fixture kW:

     $$kW_{total} = a \times \frac{b}{1000}$$

     Where:

     a = Number of fixtures
     b = Fixture wattage

- Determine direct kWh/year (kWh consumed by lighting) by using the following equation:

$$kWh/year_{direct} = kW_{total} \times 8760$$

- Determine indirect kWh/year (kWh converted to heat) by using the following equations:

$$kWh/year_{indirect(milkcooler)} = a \times 0.37 \times \frac{3.413}{b}$$

Where:

a = kWh/year$_{direct}$
b = Equipment energy efficiency ratio (EER)

$$kWh/year_{indirect(selfserve)} = a \times \left(\frac{1}{b}\right) \times \left(0.37 \times \frac{3.413}{c}\right) + 0.63$$

Where:

a = kWh/year$_{direct}$
b = RTU coefficient of performance (COP)
c = Equipment energy efficiency ratio (EER)

- Sum direct and indirect values to obtain total kWh/year
- Compare Pre/Post values to obtain total lighting kWh/year savings.

**Outdoor Lighting Data Analysis**

1. Outdoor lighting calculations were based on an assumed "time on." Store hours for non-24 hr stores was assumed to be 5 am to 1 am.
2. "Pre" calculations were done assuming the timer was set for the worst case during the year or the winter solstice and operated at that time for the entire year.
3. "Post" calculations were done based on actual sunrise/sunset times during the year to simulate the photocell operation.
    - Calculate "hours on" by determining hours from store open to sunrise and from sunset to store close.
    - Calculate kWh savings per year by using the following equation:

$$kWh / year = a \times b \times c$$

Where:

a = Number of fixtures
b = kW per fixture
c = Total estimated "hours on"

- Compare Pre/Post values to obtain total lighting kWh/year savings.

**Population Extrapolation**

Sample kWh/year savings were extrapolated to the population of *n* stores by using the following equation:

$$kWh / year_{totalsavings} = \frac{a \times b}{c}$$

Where:

a = Total Sample Savings
b = Total kWh/year for entire population (actual billing usage)
c = Total sample kWh/year (actual billing usage)

# Results Summary

The following results account for benefits of the EMS retrofit and the case lighting LED retrofit. The estimated savings attributable to the EMS retrofit reflect the new on/off scheduling at those stores that close at night as well as the rotational load shedding for all stores.

Savings attributable to the LED retrofit are assumed to be constant regardless of outdoor air temperature. The retrofitted case lights were not trended during either the Pre or Post survey period and are assumed to be energized 24/7, regardless of store operating schedule.

During data analysis, it was noted that outside air dampers on all sampled RTU's were shut and not operating.

A summary of the estimated annual savings from the 5 sampled stores is shown in the Table 1, broken out by the HVAC and refrigeration savings expected from the EMS system and the refrigeration LED case lighting.

**Table 1**

| Realization Rates | | | |
|---|---|---|---|
| Site | EMS Realization Rate | Case LED Lighting Realization Rate | Total Realization Rate |
| Site 1 | 68% | 106% | 108% |
| Site 2 | 27% | 108% | 74% |
| Site 3 | 67% | 103% | 84% |
| Site 4 | 99% | 68% | 76% |
| Site 5 | 56% | 106% | 99% |

| | |
|---|---|
| Average Sample RR = | 88% |

Realization rates for the EMS and refrigerated case LED ECM's at the sampled stores are noted in Table 2. On average, the sampled stores achieve a realization rate of 88%.

**Table 2**

| Realization Rates | | | |
|---|---|---|---|
| Site | EMS Realization Rate | Case LED Lighting Realization Rate | Total Realization Rate |
| Site 1 | 68% | 106% | 108% |
| Site 2 | 27% | 108% | 74% |
| Site 3 | 67% | 103% | 84% |
| Site 4 | 99% | 68% | 76% |
| Site 5 | 56% | 106% | 99% |

| | |
|---|---|
| Average Sample RR = | 88% |

When extrapolated to the entire population of *n* stores, the realization rate dropped slightly to 77%. The overall population realization rate was determined by dividing the estimated population savings by the total expected kWh savings. A summary of the estimated annual savings for all UDF stores is shown in Table 3.

**Table 3**

| UDF Total Savings | | |
|---|---|---|
| Sample Total Savings | 237381 | kWh |
| Sample Total Usage | 1729120 | kWh |
| Population Total Usage | 27497949 | kWh |
| **Population Savings** | **3775031** | **kWh** |
| **Total Population RR** | **77%** | |

Evidence of peak demand reduction is shown in Table 4. Peak demand from actual billing data was compared from 2009 to 2010 in the months of June, July, and August. The greatest peak demand reductions were noted in the month of July.

**Table 4**

| Billing Peak Demand Reduction (2009 to 2010) | | | |
|---|---|---|---|
| | June (kW) | July (kW) | August (kW) |
| Site 1 | 2.4 | 7.2 | 6 |
| Site 2 | 8 | 9.6 | 5.6 |
| Site 3 | 9.6 | 10.4 | 8 |
| Site 4 | 2.97 | 2.9 | 1.98 |
| Site 5 | 2.2 | 2.2 | 0.8 |

The average peak demand reduction is 6.46 kW per store. Total peak demand savings over the *n* store project is 588 kW.

Figures 1-5 depict graphs of energy consumption and savings for the metered equipment (HVAC and refrigeration) in each of the sampled stores over the course of 1 year.

**Figure 1**

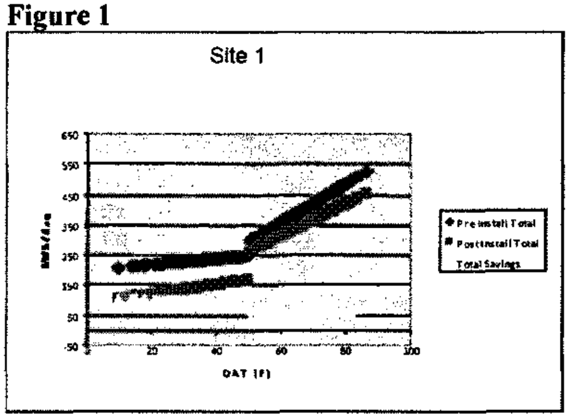



**Figure 2**

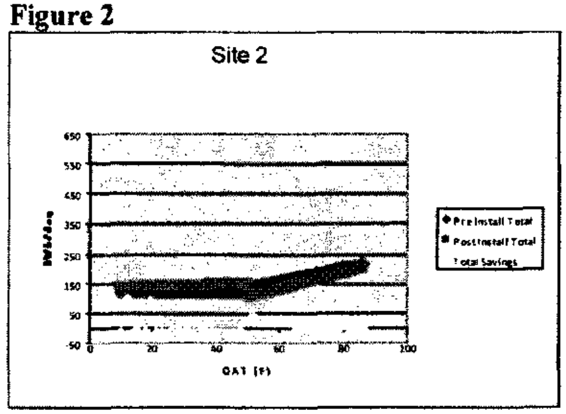



**Figure 3**

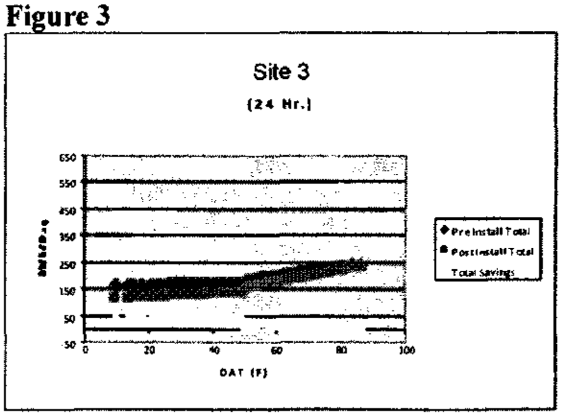



**Figure 4**

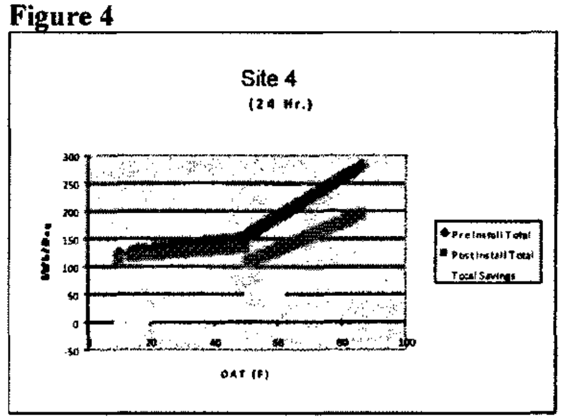
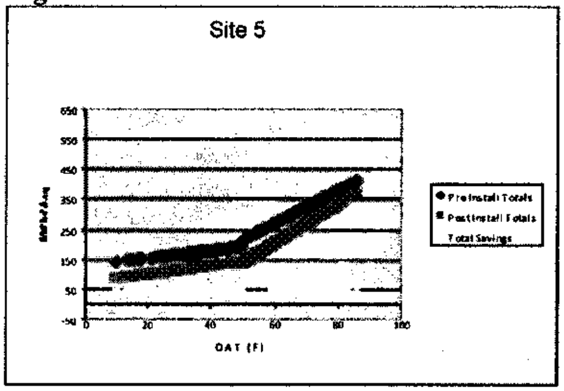


**Figure 5**




Figures 6-16 depict kWh/day vs. average daily outside air temperature for the 5 sampled stores. The rooftop units were the only load that showed a strong temperature dependence. The RTU loads were separated from the r kWh/day were then extrapolated for the year by substituting TMY3 outside air temperatures into the linear regression equations for both pre and post ECM install.

**Figure 6**

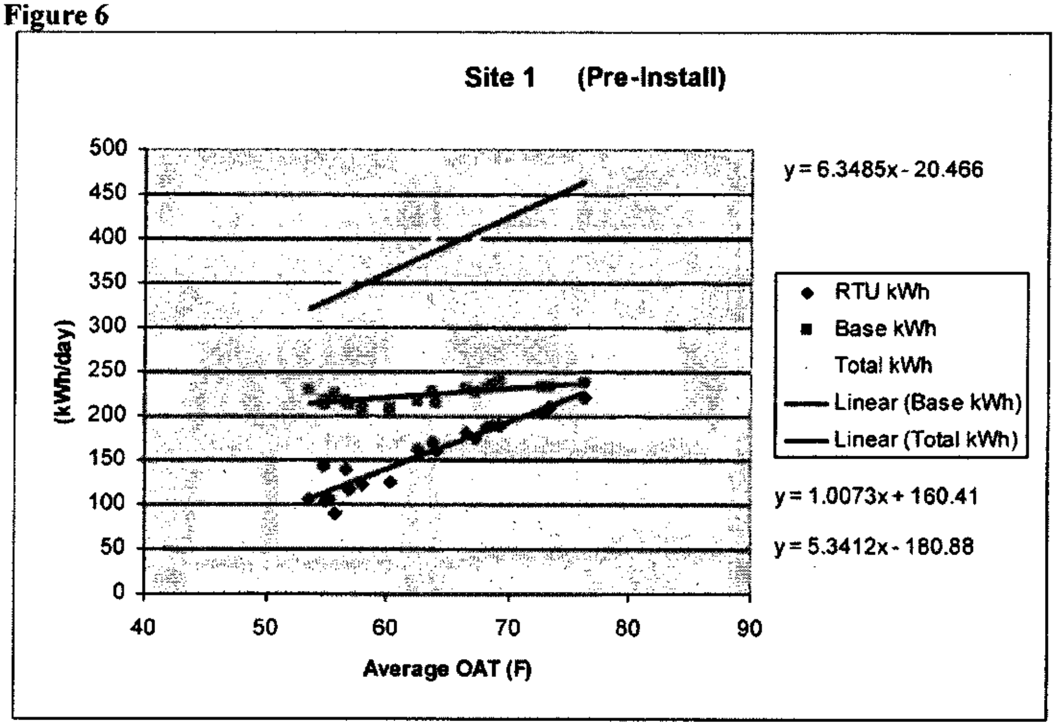


Figure 7

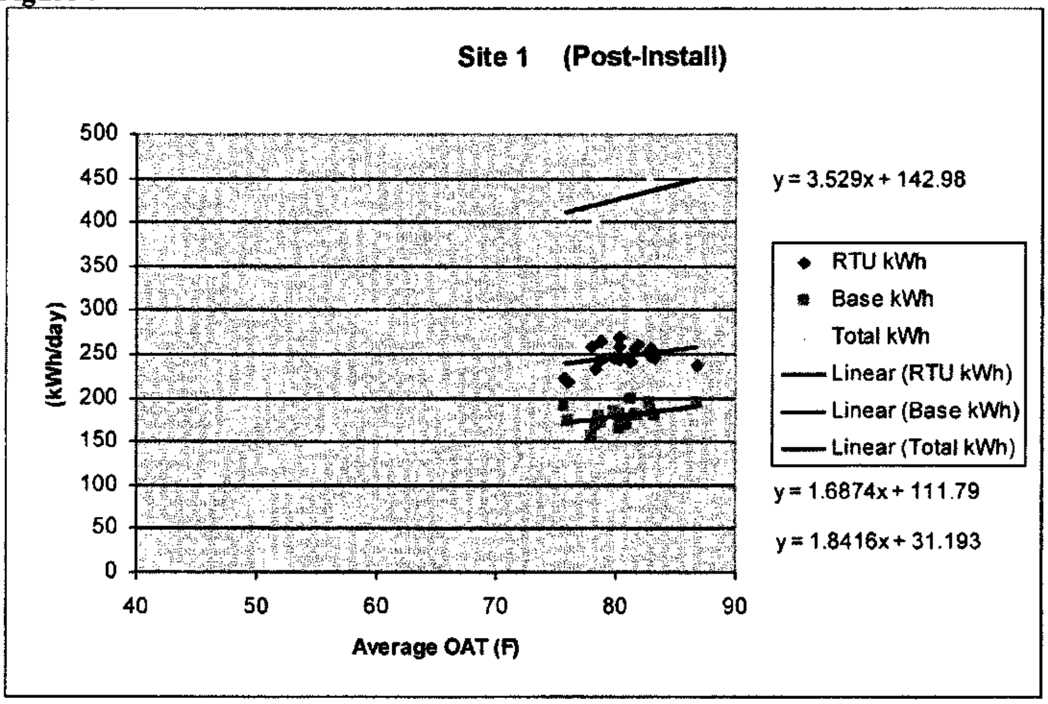



Figure 8

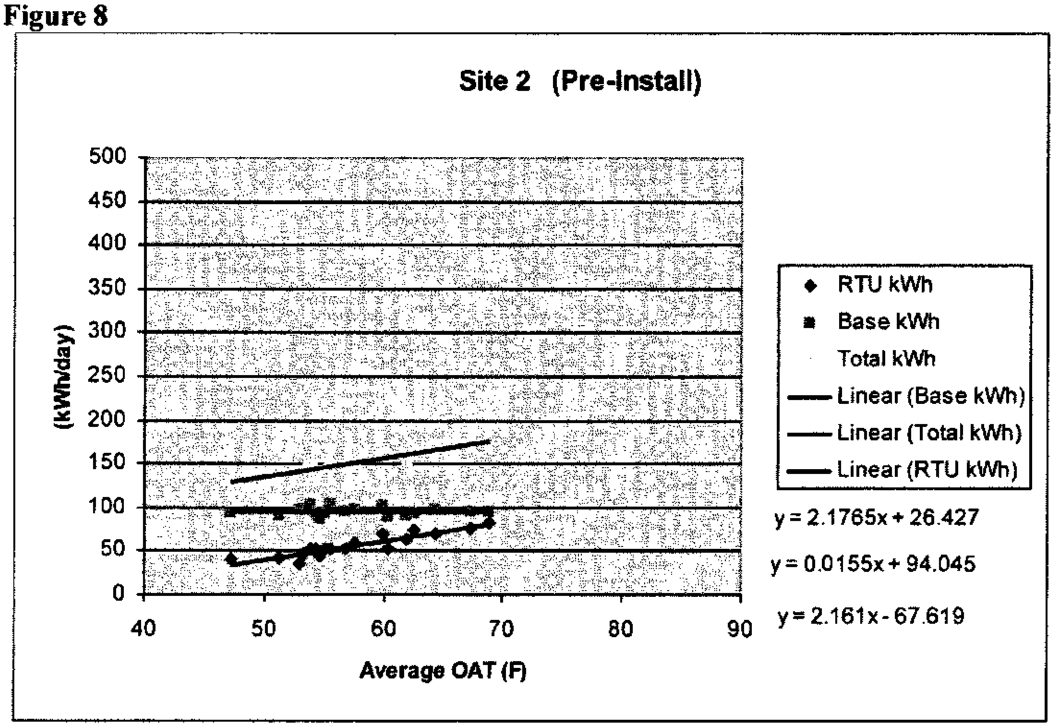


Figure 9

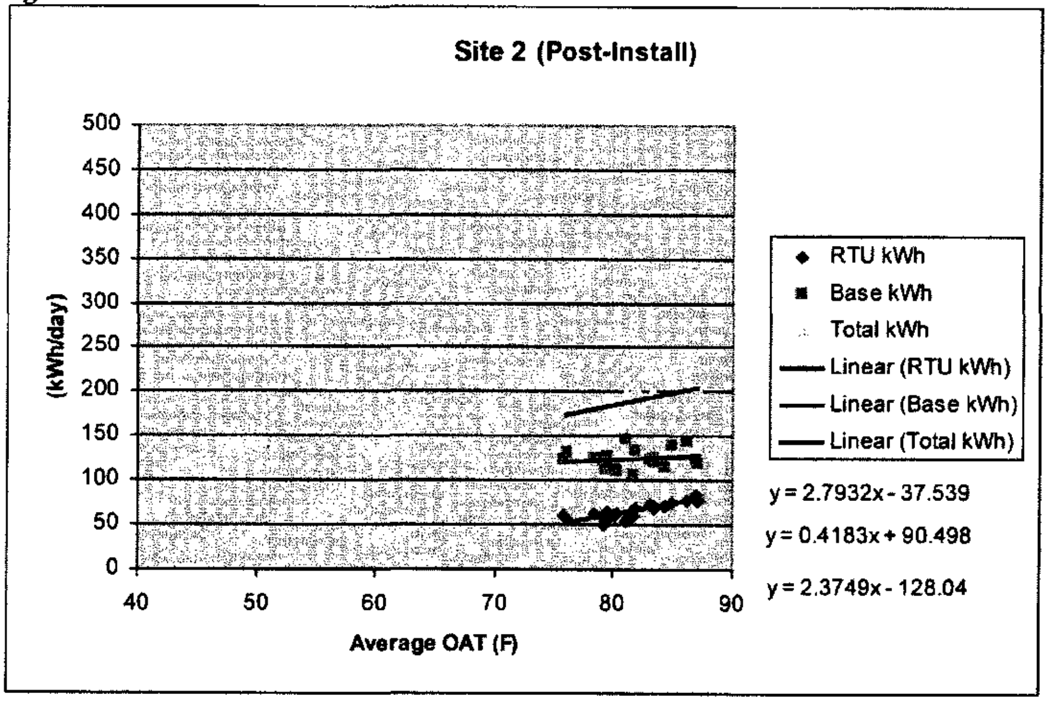



Figure 10

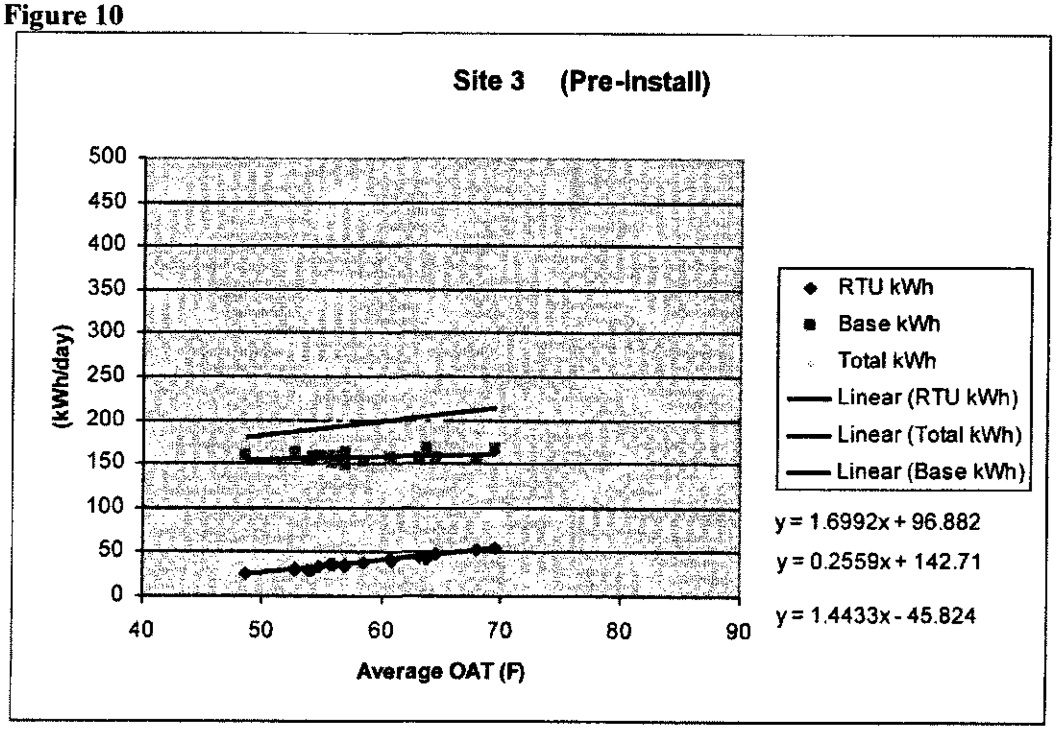


Figure 11

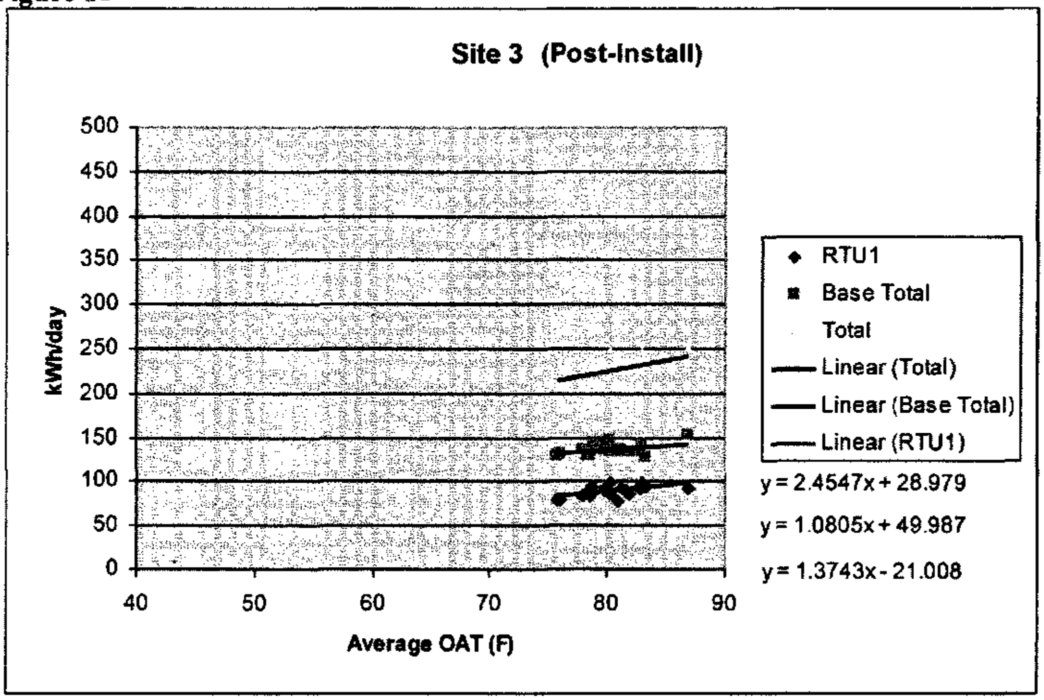



Figure 12

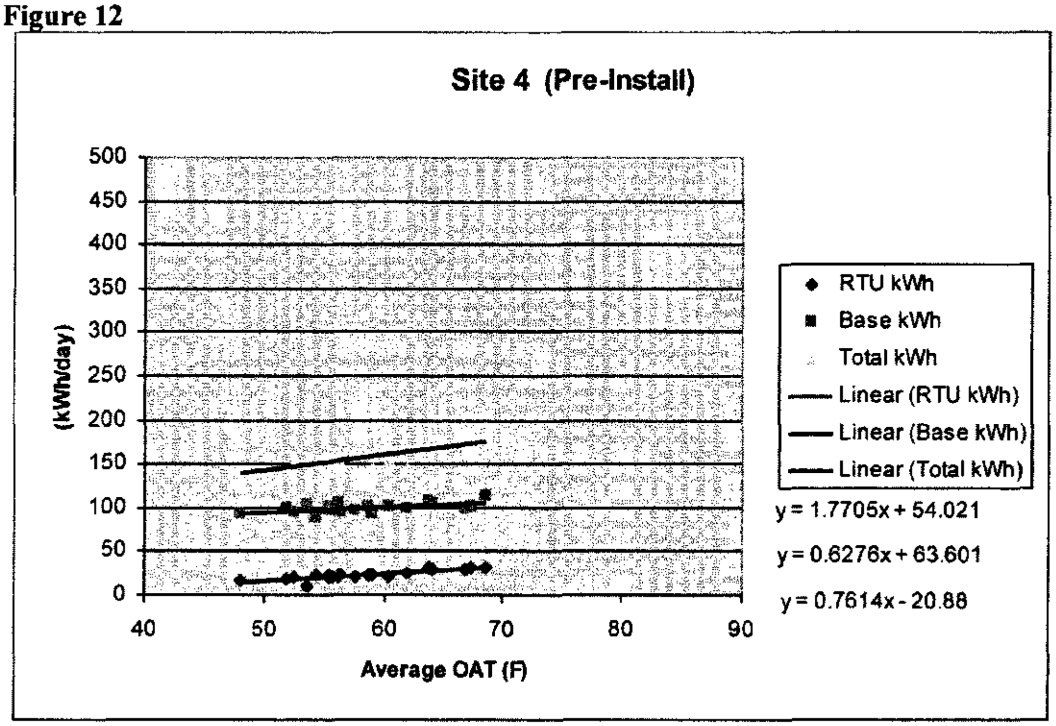


Figure 13

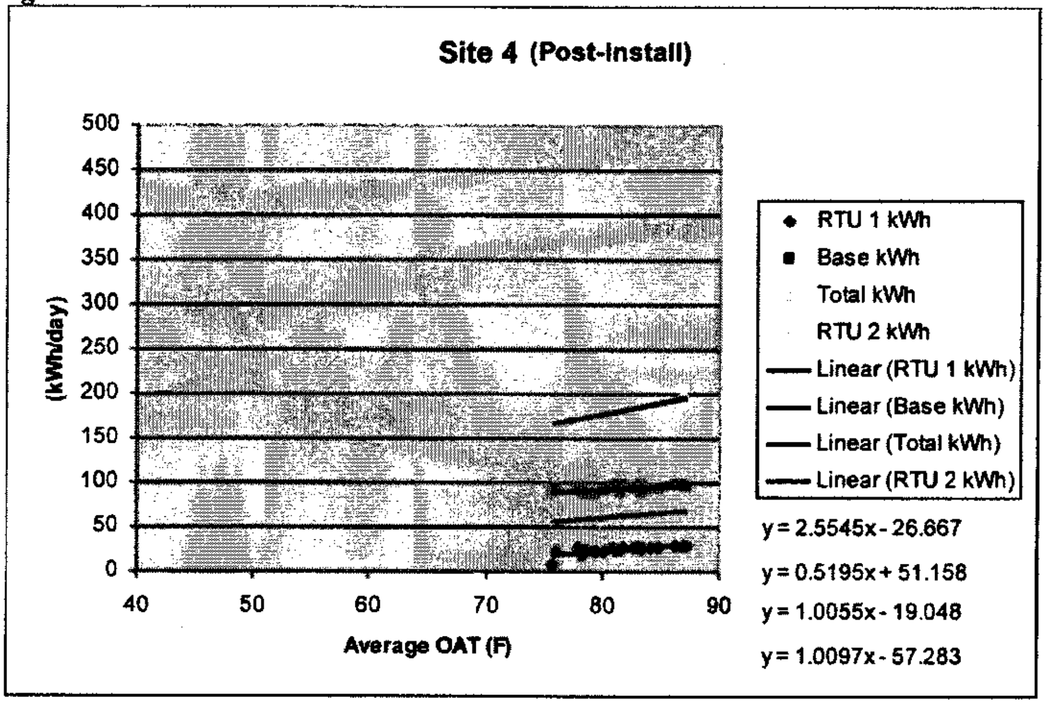



Figure 14

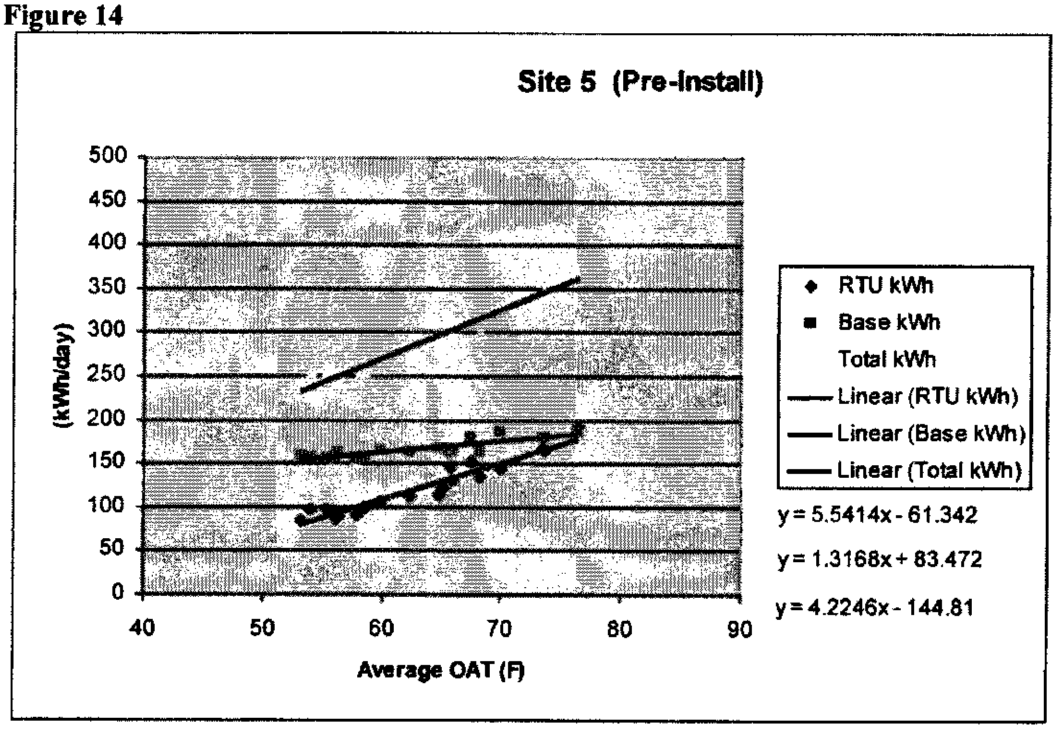
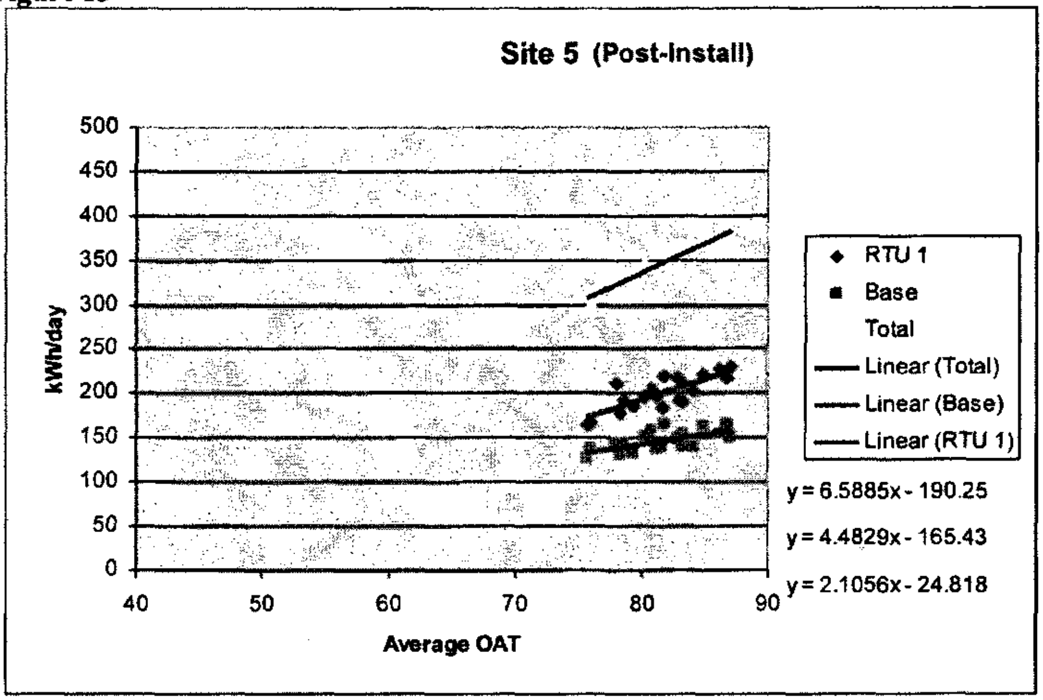


Figure 15




**Site Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 3,775,031 | 4,832,346 | 0.78 | 588 | 552 | 1.07 | 588 | 0 | N/A |

# Site 6

[redacted]

## Refrigerated Case Lighting Retrofits

# M&V Plan Results Summary

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
March 2011

## INTRODUCTION

Architectural Energy Corporation was hired by TecMarket Works to evaluate the Duke Energy custom incentive evaluation program for 60 [redacted] stores in the Cincinnati area. Of the population, five specific stores were selected for sampling and data-logging. The following ECM measures were the target of the data analysis:

LED refrigerated case lighting was the target of the data analysis. Fluorescent case lighting was replaced by LED case lighting, controlled by motion sensors.

## OBJECTIVES

The specific objectives of this M&V project were to verify the actual annual gross kWh savings, as well as the summer peak kW savings associated with the lighting retrofits.

Post data was obtained from the following 5 stores:

| Store | Suburb | Address | City |
|---|---|---|---|
| 1 | [redacted] | [redacted] | [redacted] |
| 2 | [redacted] | [redacted] | [redacted] |
| 3 | [redacted] | [redacted] | [redacted] |
| 4 | [redacted] | [redacted] | [redacted] |
| 5 | [redacted] | [redacted] | [redacted] |

## DATA PRODUCTS AND PROJECT OUTPUT

- Average pre/post load shapes by daytype for controlled equipment
- Summer peak demand savings
- Annual Energy Savings

## M&V OPTION

IPMVP Option A

## DATA ANALYSIS

5. Convert time series data on logged equipment into post average load shapes by daytype. Estimate peak demand savings.

# Field Data Points

Calendar schedule:

- Post data should be gathered during a time period when the store is expected to operate under normal conditions (i.e., not during the holidays)

Store survey data:

- [redacted] Store #
- Survey all cases and condensing units that are part of the retrofit project for store
    - Case lighting survey
        - number of LED sticks or fluorescent lamps
    - Case lighting on/off schedule (PRE only)
- Record locations of installed loggers by logger number and case name or number
- Photos
    - store front
    - typical case front and typical condensing unit
    - typical logger installation

Time series data on controlled equipment:

- Lighting status loggers on all cases that are part of the retrofit project (set up for 3 week deployment.)

# Verification and Quality Control

16. Visually inspect time series data for gaps
17. Compare readings to nameplate values; identify out of range data

# Recording and Data Exchange Format

11. Excel spreadsheets

# Data Analysis Summary

**Refrigerated Case LED Lighting Data Analysis**

3. A survey which included lighting fixture type, count and wattage was conducted for each of the 5 sampled locations.

4. The following calculations were performed for each piece of logged equipment for both the pre- and post-logged interval data:

   - Use the following formula to obtain total fixture kW:

     $$kW_{total} = a \times \frac{b}{1000}$$

     Where:

     a = Number of fixtures
     b = Fixture wattage

   - Determine direct kWh/year (kWh consumed by lighting) by using the following equation:

     $$kWh/year_{direct} = kW_{total} \times 8760 \times F$$

     Where:

     F= percentage of time that the lighting equipment is ON. For the PRE- measurements, this number is 100%. For POST- measurements, the number is less than 100%, and originates from the logger data collected.

   - Determine indirect kWh/year (kWh converted to heat) by using the following equations:

     $$kWh/year_{indirect(milkcooler)} = a \times COP$$

     Where:

     a = kWh/year$_{direct}$
     COP = Equipment energy efficiency (Coefficient of Performance)

   - Sum direct and indirect values to obtain total kWh/year

   - Compare Pre/Post values to obtain total lighting kWh/year savings.

**Population Extrapolation**

Sample kWh/year savings were extrapolated to the population of 60 stores by using the following equation:

$$kWh / year_{totalsavings} = \bar{a} \times b$$

Where:

$\bar{a}$ = Average kWh/year savings per sample LED stick
b = Total number of LED sticks installed

## RESULTS SUMMARY

The following results account for benefits of the case lighting LED retrofit. The estimated savings attributable to the LED retrofit are assumed to be constant regardless of outdoor air temperature. The retrofitted case lights were trended only during the Post survey period, as the schedules during the Pre period assumed to be energized 24/7, regardless of store operating schedule.

During data analysis, it was noted that outside air dampers on all sampled RTU's were shut and not operating.

A summary of the estimated annual savings from the 5 sampled stores is shown in the Table 1, broken out by the consumption and demand savings from the LED case lighting measure.

**Table 1**

| Store | Pre- Runtime | Post- Runtime | Total kWh Savings/Year | Peak Demand Savings (kW) |
|---|---|---|---|---|
| 1 | 8,760 | 7,936 | 120,607 | 13 |
| 2 | 8,760 | 5,825 | 146,175 | 15 |
| 3 | 8,760 | 8,716 | 132,830 | 15 |
| 4 | 8,760 | 8,699 | 143,045 | 16 |
| 5 | 8,760 | 6,517 | 133,327 | 14 |
| **Average** | **8,760** | **7,539** | **135,197** | **14.6** |

Figures 1 and 2 show example hours-of-operation profiles for the retrofitted LED case lighting, as controlled by motion sensors. Figure 1 is from the floral refrigeration case in Store 1, while Figure 2 is from one of the refrigerated cases in Store 2.

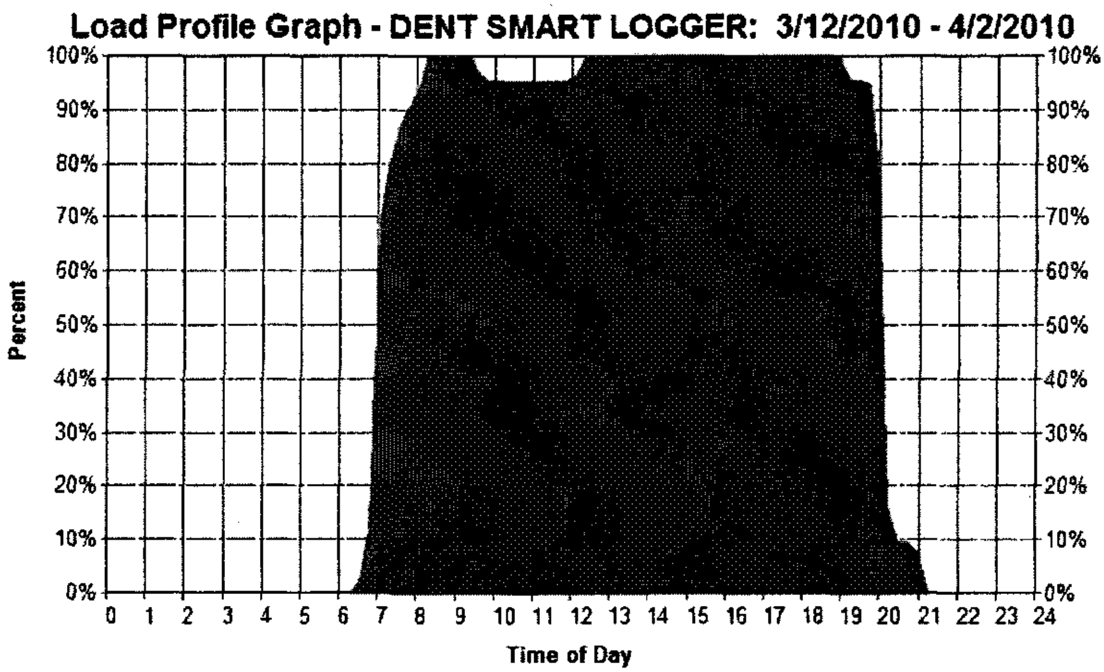



Figure 8: Lighting use profile, store 1

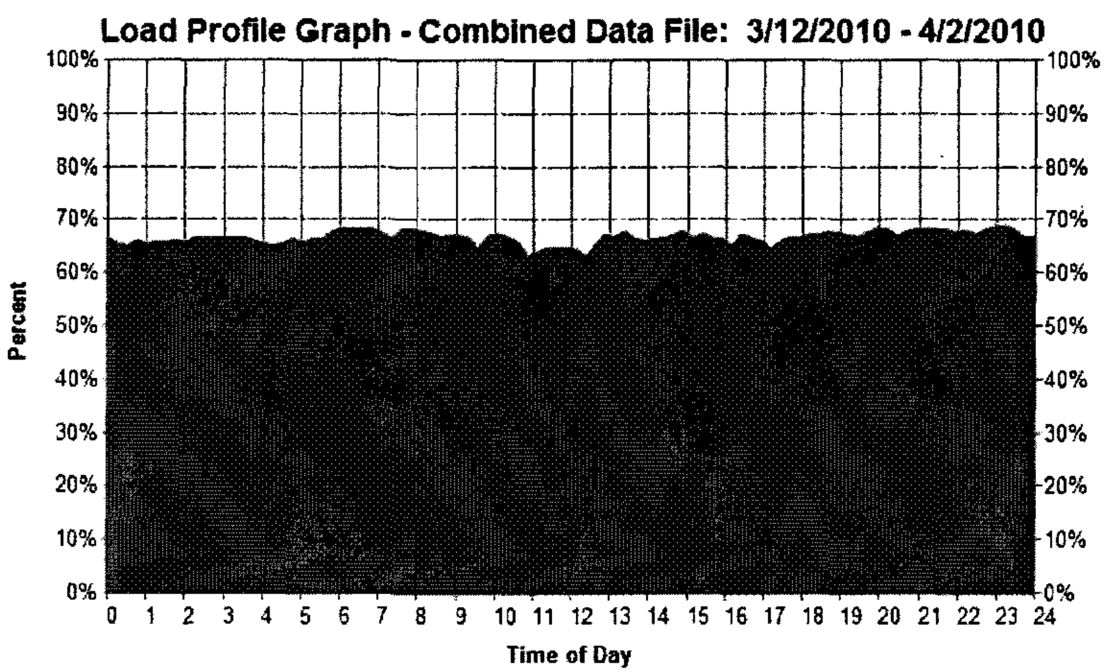



Figure 9: Lighting use profile, store 2

Figures 3, 4, and 5 display images of the lighting and data logging operations.

Figure 10: Mounting position of a light data logger.


Figure 11: One of the sampled refrigerated cases.

[redacted]

Confidential

Figure 12: [redacted] store.

## RESULTS

### Store 1

| | | | | |
|---|---|---|---|---|
| Knowns: | | | | |
| Compressor COP: | 0.35 | | | |
| Existing Florescent: | 248 lamps | 58 watts | 14.384 Lighting only | |
| Base runhours: | 8760 hours | | 19.42 Lighting and refrigeration to remove heat | |
| New LED: | 231 sticks | 20 watts | 4.62 Lighting only | |
| motion sensor savings: | 0.09404 % | of prior runhours | 6.24 Lighting and refrigeration to remove heat | |
| runtime of LED: | 7936 hours | | | |
| | | | 13.18 KW | 170105.184 KWH BEFORE |

**Existing Load of Florescent:**

Lamp wattage + Refrigeration load because of lamp wattage in the case:

(254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW) + {[254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW]*0.35 COP}

**170,105 kWh/year**

**New Load of LED:**

Stick wattage + Refrigeration load because of stick wattage in the case:

[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] + {[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] * 0.35 COP}

**49,498 kWh/year**

49498.1393 KWH AFTER

**Energy Savings from Florescent to LED Case Lighting:** **13.18 kW**

**170,105 - 49,498 = 120,607 kWh/year** 120,607 KWH SAVINGS

## Store 2

| | | | | |
|---|---|---|---|---|
| Knowns: | | | | |
| Compressor COP: | 0.35 | | | |
| Existing Florescent: | 267 lamps | 58 watts | 15.486 | Lighting only |
| Base runhours: | 8760 hours | | 20.91 | Lighting and refrigeration to remove heat |
| New LED: | 235 sticks | 20 watts | 4.7 | Lighting only |
| motion sensor savings: | 0.335 % | of prior runhours | 6.35 | Lighting and refrigeration to remove heat |
| runtime of LED: | 5825 hours | | | |
| | | | 14.56 KW | 183137.436 KWH BEFORE |

**Existing Load of Florescent:**
Lamp wattage + Refrigeration load because of lamp wattage in the case:
[254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW] + ([254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW] *0.35 COP)
**183,137 kWh/year**

**New Load of LED:**
Stick wattage + Refrigeration load because of stick wattage in the case:
[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] + ([224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] * 0.35 COP)
**36,962 kWh/year**

36962.163 KWH AFTER

**Energy Savings from Florescent to LED Case Lighting:** **14.56 kW**
**183,137 - 36,962 = 146,175 kWh/year** 146,175 KWH SAVINGS

## Site 3

| | | | | |
|---|---|---|---|---|
| Knowns: | | | | |
| Compressor COP: | 0.35 | | | |
| Existing Florescent: | 276 lamps | 58 watts | 16.008 | Lighting only |
| Base runhours: | 8760 hours | | 21.61 | Lighting and refrigeration to remove heat |
| New LED: | 240 sticks | 20 watts | 4.8 | Lighting only |
| motion sensor savings: | 0.005 % | of prior runhours | 6.48 | Lighting and refrigeration to remove heat |
| runtime of LED: | 8716 hours | | | |
| | | | 15.13 KW | 189310.608 KWH BEFORE |

**Existing Load of Florescent:**
Lamp wattage + Refrigeration load because of lamp wattage in the case:
[254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW] + ([254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW]*0.35 COP)
**189,311 kWh/year**

**New Load of LED:**
Stick wattage + Refrigeration load because of stick wattage in the case:
[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] + ([224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] * 0.35 COP)
**56,481 kWh/year**

56480.976 KWH AFTER

**Energy Savings from Florescent to LED Case Lighting:** **15.13 kW**
**189,311 - 56,481 = 132,830 kWh/year** 132,830 KWH SAVINGS

**Site 4**

Knowns:
Compressor COP: 0.35

Existing Florescent: 301 lamps 58 watts 17.458 Lighting only
Base runhours: 8760 hours 23.57 Lighting and refrigeration to remove heat

New LED: 270 sticks 20 watts 5.4 Lighting only
motion sensor savings: 0.007 % of prior runhours 7.29 Lighting and refrigeration to remove heat
runtime of LED: 8699 hours
16.28 KW 206458.308 KWH BEFORE

**Existing Load of Florescent:**
Lamp wattage + Refrigeration load because of lamp wattage in the case:
(254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW] + {[254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW]*0.35 COP}
**206,458 kWh/year**

**New Load of LED:**
Stick wattage + Refrigeration load because of stick wattage in the case:
[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] + {[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] * 0.35 COP}
**63,413 kWh/year**
63413.3772 KWH AFTER

**Energy Savings from Florescent to LED Case Lighting:** **16.28 kW**
**206,458 - 63,413 = 143,045 kWh/year** 143,045 KWH SAVINGS

**Site 5**

Knowns:
Compressor COP: 0.35

Existing Florescent: 248 lamps 58 watts 14.384 Lighting only
Base runhours: 8760 hours 19.42 Lighting and refrigeration to remove heat

New LED: 209 sticks 20 watts 4.18 Lighting only
motion sensor savings: 0.256 % of prior runhours 5.64 Lighting and refrigeration to remove heat
runtime of LED: 6517 hours
13.78 KW 170105.184 KWH BEFORE

**Existing Load of Florescent:**
Lamp wattage + Refrigeration load because of lamp wattage in the case:
(254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW] + {[254 lamps * 58w/lamp * 8760 hours/year*1/1000 watts/kW]*0.35 COP}
**170,105 kWh/year**

**New Load of LED:**
Stick wattage + Refrigeration load because of stick wattage in the case:
[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] + {[224 sticks * 20w/stick *8760 hours/year * 1/1000 watts/kW *.7 ontime] * 0.35 COP}
**36,778 kWh/year**
36777.9139 KWH AFTER

**Energy Savings from Florescent to LED Case Lighting:** **13.78 kW**
**170,105 - 36,778 = 133,327 kWh/year** 133,327 KWH SAVINGS

## Results Summary

The data from the five sampled stores were combined to obtain an average savings per LED stick installed. The results are summarized below:

| Store | kWh | kW | Sticks | kWh/stick | kW/stick |
|---|---|---|---|---|---|
| 1 | 120,607 | 13.2 | 231 | 522.1 | 0.057 |
| 2 | 146,175 | 14.6 | 235 | 622.0 | 0.062 |
| 3 | 132,830 | 15.1 | 240 | 553.5 | 0.063 |
| 4 | 143,045 | 16.3 | 270 | 529.8 | 0.060 |
| 5 | 133,327 | 13.8 | 209 | 637.9 | 0.066 |
| Total | 675,984 | 72.9 | 1,185 | 570.5 | 0.062 |

The sample produced an average savings of 570.5 kW and 0.062 kW per LED stick installed. The total project savings were based on a total of 9,802 LED sticks installed.

| | Expected | Evaluated |
|---|---|---|
| Number of Sticks | 9802 | 9802 |
| kWh per stick | 611.3 | 570.5 |
| kW per stick | 0.070 | 0.062 |
| Total kWh | 5,991,963 | 5,591,557 |
| Total kW | 686 | 603 |

**Project Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 5,591,557 | 5,991,963 | 0.93 | 603 | 686 | 0.88 | 603 | 686 | 0.88 |

# Site 7

[redacted]

## Refrigeration Compressor Updates

# M&V Plan Results Summary

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
March 2011

## INTRODUCTION

Architectural Energy Corporation was hired to evaluate the Duke Energy custom incentive program addressing upgrades to the [redacted] refrigeration equipment. The measures were to replace an old refrigeration compressor rack and condenser systems (Rack 'A' and Rack 'B') with two new more efficient systems.

Energy savings were estimated at 50% and 8% of current use, for Rack 'A' and 'B' respectively. Pre and post-retrofit power measurements on controlled equipment were conducted on a sample of the rack compressors to validate energy savings.

## GOALS AND OBJECTIVES

The project goal was electric use savings of 190,998 kWh annually. The specific objective of this M&V project was to complete a pre and post implementation site survey of the compressor racks in order to determine the true power reduction. Ultimately, a realization rate can be determined to validate the intended energy savings.

## PROJECT CONTACTS

Approval shall be requested from the two Duke Energy contacts listed below prior to making direct contact with the Customer or undertaking work on this M&V Plan.

| | | |
|---|---|---|
| **Duke Energy M&V Administrator** | Frankie Diersing | [redacted] |
| **Duke Energy Account Manager** | Ira Poston | [redacted] |
| **Customer Contact** | [redacted] | |
| **Site Location** | [redacted] | |

## DATA PRODUCTS AND PROJECT OUTPUT

- Average pre/post load shapes by day type for controlled equipment.
- Model predicting pre/post kWh as a function of outdoor temperature.
- Summer peak-demand savings.
- Annual energy savings verification.

## M&V Option

IPMVP Option A

## Data Analysis

6. Convert time series data on logged equipment into pre/post average load shapes by day-type.

Refrigeration Rack and Condenser kW

7. Regress data into a temperature dependent load model. Form of the regression equation is:

   $$kWh/day = a + b \times T_{avg}$$

   Where:

   $kWh/day$ = Daily energy consumption
   $T_{avg}$ = Daily average dry-bulb temperature (°F)
   $a$, $b$ = Constants determined during regression development

8. Apply equation above to TMY3 data processed into average dry-bulb temperature for each day of the year.

9. Create diagnostic plots
   a) Plot time series fan and compressor kW; look for cycling

## Field Data

Applies to Pre and Post Installation:

7. Survey Data
   - Rack nameplate and photo
   - Condenser nameplate and photo
   - Compressor nameplate and photo
8. One-time Measurements
   - Compressor and condenser kW, amps and power factor (fan and fan plus compressor)
   - Case or walk-in temperatures
9. Time Series Data on Controlled Equipment
   - For each Rack A and B, obtain amps from a sample of the Rack compressors and the remote condensing unit.
   - Outside air temperature
10. Set up loggers for 5 minute instantaneous readings. Deploy for 3 weeks. Anticipate installing:
   - (1) Onset Weatherstation

- (1) U-12 with 4 CTs on Rack 'A'
- (1) U-12 with 4 CTs on Rack 'B'
- (1) U-12 with 1 CT on remote condensing unit serving Rack 'A'
- (1) U-12 with 1 CT on remote condensing unit serving Rack 'B' (if remote condensing units are in close proximity, then maybe can get away with a single U-12 for both)

## DATA ACCURACY

| Measurement | Sensor | Accuracy | Notes |
|---|---|---|---|
| Temperature | MDL thermistor | ±0.5° | |
| Current | Magnelab CT | ±1% | > 10% of rating |

## VERIFICATION AND QUALITY CONTROL

18. Visually inspect time series data for gaps.
19. Compare readings to nameplate values; identify out of range data.

## RECORDING AND DATA EXCHANGE FORMAT

12. Hobo U-12 binary files.
13. Excel spreadsheets.

## RESULTS SUMMARY

### DATA ANALYSIS

5. Verify Proposed Measures Were Implemented:

The compressor racks were installed as planned at [redacted] to operate the refrigeration system.

6. Calculation Methodology:

Power measurements were first collected and compared for the pre-install and post-install scenarios. A regression equation was determined for each case and they are shown here.

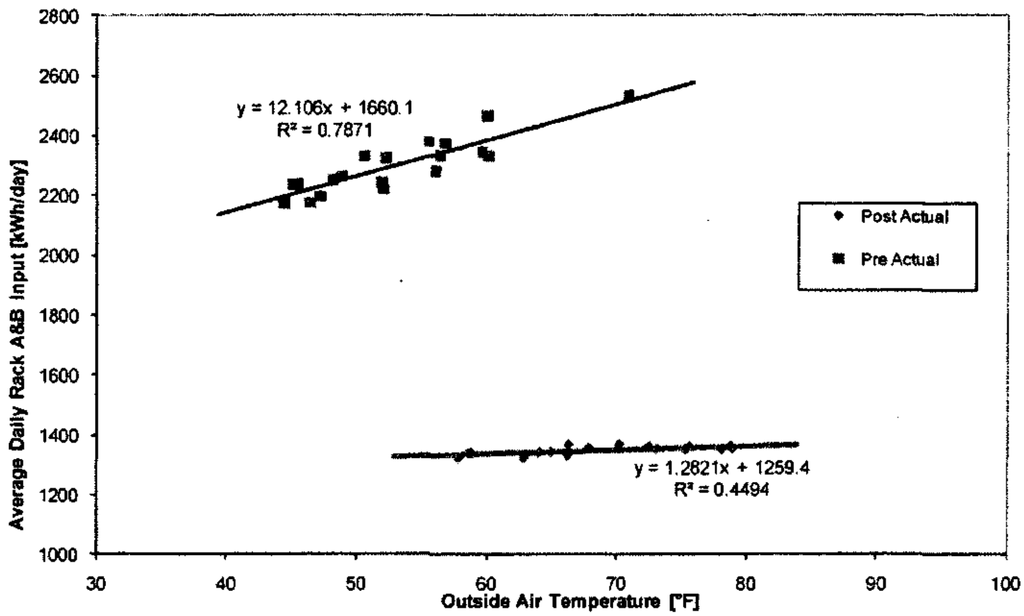



Figure 13: System Power Data Collected Before and After Measure Installation.

Making energy consumption (kWh) a function of outside air temperature allowed for an approximation the refrigeration system energy consumption for the entire year based on Version 3 of the Typical Meteorological Year (TMY3) weather data. An example of this TMY analysis is displayed in the table here.

Table 12: Daily Extrapolation of the Regression Equations in Figure 1.

| NOAA Date [M/D/Y] | NOAA Time [H:M] | NOAA Dry Bulb [C] | NOAA RH [%] | CALC Dry Bulb [F] | CALC PRE Input kWh/Day | CALC POST Input kWh/Day | CALC Input Savings kWh/Day |
|---|---|---|---|---|---|---|---|
| 1/1 | 12:30 | -2.4 | 67.8 | 27.6 | 1994.3 | 1294.8 | 699.5 |
| 1/2 | 12:30 | -5.7 | 69.4 | 21.7 | 1923.2 | 1287.2 | 636.0 |
| 1/3 | 12:30 | -7.7 | 70.5 | 18.2 | 1880.8 | 1282.7 | 598.0 |
| 1/4 | 12:30 | -1.4 | 72.8 | 29.4 | 2016.1 | 1297.1 | 719.0 |
| 1/5 | 12:30 | 3.1 | 64.4 | 37.6 | 2114.7 | 1307.5 | 807.2 |
| 1/6 | 12:30 | 0.5 | 68.6 | 32.9 | 2058.7 | 1301.6 | 757.1 |
| 1/7 | 12:30 | 1.7 | 73.7 | 35.1 | 2085.4 | 1304.4 | 781.0 |
| 1/8 | 12:30 | -0.5 | 59.2 | 31.2 | 2037.4 | 1299.3 | 738.1 |
| : | : | : | : | : | : | : | : |
| : | : | : | : | : | : | : | : |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12/26 | 12:30 | 0.2 | 54.7 | 32.4 | 2052.5 | 1300.9 | 751.6 |
| 12/27 | 12:30 | -3.2 | 67.2 | 26.3 | 1978.7 | 1293.1 | 685.6 |
| 12/28 | 12:30 | -4.8 | 78.0 | 23.3 | 1942.7 | 1289.3 | 653.4 |
| 12/29 | 12:30 | 1.2 | 65.3 | 34.1 | 2073.0 | 1303.1 | 769.9 |
| 12/30 | 12:30 | 6.7 | 67.3 | 44.0 | 2192.8 | 1315.8 | 877.0 |
| 12/31 | 12:30 | 3.1 | 77.5 | 37.6 | 2115.7 | 1307.6 | 808.1 |
| **Totals** | | | | | **845,199** | **485,011** | **360,188** |

The figure below shows these extrapolated results in total.

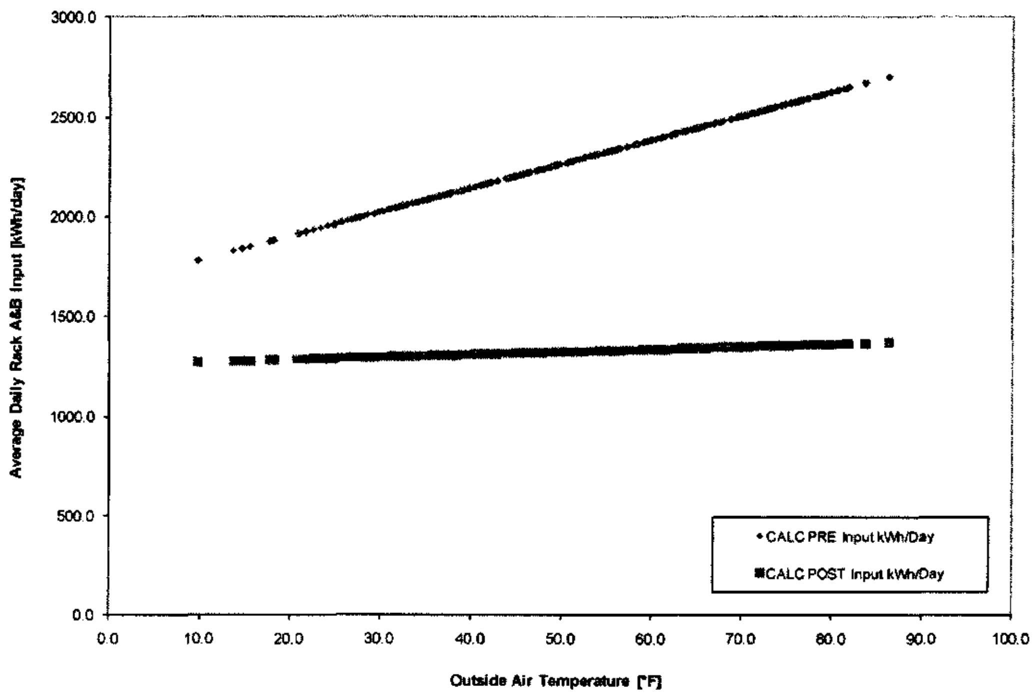



Figure 14: Annual Power Consumption Reduction from This Measure.

Cost savings rates applied to the energy savings reference the $0.10 per kWh mentioned in the rebate application PDF and it is also applied in the calculation to approximate cost savings.

Peak demand savings were estimated from the regression equations. According to the TMY3 dataset, the daily average temperature on the hottest day of the year is 88.1°F. Evaluating the pre and post regression equations at 88.1°F yields the following:

| Daily Average Temperature | kWh/day pre | kWh /day post | kWh/day Savings | Avg kW savings |
|---|---|---|---|---|
| 88.1 | 2726.6 | 1372. | 1354. | 56.4 |

Refrigeration compressor hourly load data are generally constant over the day, so the daily average demand savings is a reasonable estimate of the peak hourly savings. Note: the application did not claim any kW savings for this project.

7. Savings Verification and Realization Rate:

Compare Pre/Post values to obtain total kWh/year savings. Once the savings are calculated, the realization rate is calculated by the following formula:

$$Realization\ Rate = kWh_{actual} / kWh_{application}$$

## CALCULATION OUTPUT

The following Excel Tables demonstrate real achieved savings and summarize the results of the refrigeration system retrofit. For additional details, see included post-retrofit measurement and calculation spreadsheets.

**Reported in Application:**

| Description | Value | Units |
|---|---|---|
| Pre-install Annual Energy Use | 812,177 | kWh |
| Post-install Annual Energy Use | 621,179 | kWh |
| Expected Savings | 190,998 | kWh |
| Converted Cost Savings | $ 19,100 | |

**Reported Following Installation:**

| Description | Value | Units |
|---|---|---|
| Pre-install Annual Energy Use | 845,199 | kWh |
| Post-install Annual Energy Use | 485,011 | kWh |
| Realized Annual Energy Savings | 360,188 | kWh |
| Converted Cost Savings | $ 36,019 | |

kWh Realization Rate: 360,188 / 190,998 = 189%

*Notes:
- A rate of $0.10 per kWh was used to estimate cost savings, taken from the calculation Excel file and use at the time of the application. (See page 24-26 of the application PDF)

### Final Project Savings Summary

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

### Final Project Savings and Realization Rate

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 360,188 | 190,343 | 1.89 | 56 | 34 | 1.65 | 56 | 10 | 5.86 |

# Site 8

## M&V Summary

**[redacted] Schools "House Bill" Application**

**Replacement of Exterior Lighting Fixtures**

Prepared by Dan Bertini

December, 2011

## Introduction

This document summarizes the 3rd-party M&V activity and findings for a Non-Residential Custom Incentive application submitted by [redacted] Schools. Capital funding for the project was provided by the Ohio State Legislature. The application covers 21 schools in the [redacted] area. This report covers only the Exterior Lighting ECM, the second of the three measures covered in the application. The three measures in the application are:

**ECM-1 - Electrostatic "Dynamic" Filters**

- *Electrostatic "Dynamic" filters containing activated carbon media will reduce the required amount of ventilation air by code thereby reducing associated energy costs to condition outdoor air.*

**ECM-2 - Replacement of Exterior Lighting Fixtures**

- *Exterior lighting fixtures will be replaced with new lower wattage induction type incandescent fixtures.*

**ECM-3 - Summer Ventilation Controls**

- *Implementation of reduced summer outdoor air ventilation schedules via the DDC control system to reduce ventilation in select buildings during summer months when school is not in session, thereby reducing associated energy costs.*

## Goals and Objectives

The projected savings goals identified in the application are:

| ECM | Vendor Estimated | Duke Projected |
|---|---|---|
| 1 | 819 | - |
| 2 | 475,031 | - |
| 3 | 109,276 | - |
| **Total** | **642,515** | **699,752** |

The objective of this M&V project will be to verify the actual:

- Annual gross kWh savings
- Summer peak kW savings
- kWh & kW Realization Rates

## Project Contacts

| | | |
|---|---|---|
| Duke Energy M&V Admin. | Frankie Diersing | [redacted] |
| Duke Energy BRM | Mike Harp | |
| Customer Contact | [redacted] | |

## Site Locations/ECM's

| Site | Address | Sq. Footage/Age | ECM's Implemented |
|---|---|---|---|
| [redacted] | [redacted] | 62675/22 | 1,2,3 |
| | | 74652/18 | 1,2,3 |
| | | 64543/32 | 2 |
| | | 85197/32 | 2 |
| | | 76612/16 | 2,3 |
| | | 79612/16 | 2,3 |
| | | 76138/3 | 2,3 |
| | | 76138/3 | 2,3 |
| | | 60620/18 | 2,3 |
| | | 60070/20 | 2,3 |
| | | 66792/20 | 2,3 |
| | | 83903/48 | 2 |
| | | 75874/37 | 2 |
| | | 126903/2 | 2 |
| | | 22616/34 | 2 |
| | | 50600/49 | 2 |
| | | 113777/7 | 2 |
| | | 27000/7 | 2 |
| | | 90901/7 | 2 |
| | | 320551/13 | 2 |
| | | 320551/13 | 2 |

## M&V Option

IPMVP Option A

## Data Analysis

- ECM-2

Calculated kWh/year saved for each fixture type as follows:

$$kWh / year = a \times b \times c$$

where

a = fixture number
b = fixture wattage savings
c = yearly operating hours

# Results of Field Survey and Data Logging

- **ECM-2**

Fixture counts and their respective wattages were obtained at a sample of 9 of the 21 facilities identified in the project. Actual observed fixture counts and wattages matched the expected counts almost perfectly, the only exception being at [redacted], where 21 of the highest wattage pole fixtures were expected but only 17 were counted. The actual saved wattage therefore amounted to 98% of expected. However, replacement work has yet to be carried out at 2 of the 9 schools sampled. In fact, according to the vendor, as of this date work has yet to be carried out at 3 schools in all. Final completion is scheduled to be in January, 2011.

In the application all the lights were assumed to operate 4004 hours per year. By contrast, actual operating hours of 2913 and 3630 were logged at 2 of the facilities, respectively. By weighting them equally, since the two schools' lighting wattages are equal, the actual operating hours are therefore assumed to be 3272 hrs, or 82% of expected.

ECM-1 and ECM-3.

Savings for ECM-1 are small (0.1%) compared to the total project savings, thus the evaluation team accepts the vendor estimated savings. Savings for ECM-3 represent about 19% of the savings. Since the savings for ECM-3 occur over the summer, it was not possible to evaluate this measure. The vendor estimated savings were accepted.

# Realization Rate and Annual Savings

- **ECM-2**
  - **380,928 kWh/yr**
  - **Realization rate: 80%**

The savings for all measures at the nine sites where M&V was conducted are summarized below:

**Savings Estimates from M&V Sample**

| ECM | Vendor Estimated | Evaluated |
|---|---|---|
| 1 | 819 | 819 |
| 2 | 475,031 | 380,928 |
| 3 | 109,276 | 109,276 |
| Total | 585,126 | 491,023 |
| Realization Rate | | 0.84 |

The savings from the evaluated sites are extrapolated to the full project as shown below:

**Full Project Savings**

| Parameter | kWh | Non-coincident kW |
|---|---|---|
| Total project estimated savings | 699,752 | 63 |
| Realization rate from M&V sample | 0.84 | 0.98 |
| Total project evaluated savings | 587,214 | 61 |

Note: since the ECM-2 savings occur at night, the coincident peak savings are zero. ECM-1 peak savings are negligible. It was not possible to evaluate the peak demand savings associated with ECM-3.

**Project Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

**Final Project Savings and Realization Rate**

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 587,214 | 698,742 | 0.84 | 61 | 63 | 0.98 | 0 | 63 | 0.00 |

# Site 9

[redacted]

## - Refrigerated Lighting Replacement -

# M&V Report

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
December 2011

***Note: This project has been randomly selected from the list of applications for which incentive agreements have been authorized under Duke Energy's Smart $aver® Custom Incentive Program.***

***The M&V activities described here are undertaken by an independent third-party evaluator of the Smart $aver® Custom Incentive Program.***

***Findings and conclusions of these activities shall have absolutely no impact on the agreed upon incentive between Duke Energy and [redacted].***

## INTRODUCTION

This report addresses M&V activities for a refrigerated case lighting retrofit at [redacted] that replaced existing lighting fixtures with more efficient fixtures.

### ECM-1 – Refrigerated Lighting

The project involves a replacement of (77) 400 watt metal halide lamps with (35) Orion ENCF6PSWS 6 lamp T8 Cooler fixtures and (41) Orion ENCF6PIDS 6 lamp T8 Freezer fixtures. All fixtures are equipped with occupancy sensors. Freezer fixtures are equipped with dual switching; leaving 3 of the 6 bulbs on at all times even after occupancy sensors are activated.

## GOALS AND OBJECTIVES

The projected savings goals identified in the application are:

| Application Proposed Annual savings (kWh) | Application Proposed Peak Savings (kW) | Duke Projected Annual Savings (kWh) | Duke Projected Peak Savings (kW) |
|---|---|---|---|
| 183,936 | 19 | 199,139 | 22 |

The objective of this M&V project were to verify the actual:

- Annual gross kWh savings
- Peak kW savings
- Summer Utility coincident peak kW savings
- kWh & kW Realization Rates

## PROJECT CONTACTS

| | | |
|---|---|---|
| Duke Energy M&V Admin. | Frankie Diersing | [redacted] |
| Duke Energy BRM | Roshena Ham | [redacted] |
| Customer Contact | [redacted] | |

## SITE LOCATION

| Address |
|---|
| [redacted] |

## Data Products and Project Output

- Post retrofit survey of lighting fixtures
- Post retrofit time series data on logged equipment converted into average load shapes by day type
- Peak demand savings
- Coincident peak demand savings
- Annual Energy Savings

## M&V Option

IPMVP Option A

## M&V Implementation Schedule

- Monitoring period included both weekday and weekend periods.

## Field Survey Points

Post – installation

Survey data (for all equipment logged)

- Lighting survey
  - Fixture Type
  - Fixture Count
  - Fixture wattage
  - Current lighting on/off scheduling

- Conducted the Post retrofit survey after the customer performed the lighting retrofit.
- Spot measured the lighting load connected to the circuit by measuring the kW load and current of the circuit during the post retrofit survey. Spot measured the lighting load at the panel.
- Pre-retrofit operating hours and pre fixture information was recorded from the application. Interviewed the building owner/operator to verify pre fixture information in application is correct.
  - Mon-Sat; Half-day on Sunday (8,112 hours, pre-retrofit)
- Determined how lighting is controlled and recorded the controller settings

- During the post survey, verified that all existing fixture specifications and quantities are consistent with the application. Differences are noted below:
    - Cooling shipping area used five(5) 4-lamp versus five (5) 6-lamp fixtures. Remaining quantities and types are consistent
- During the post survey, verified that all pre (existing) fixtures were removed.
    - Yes
- During the post survey, verified that all post (new) fixture specifications and quantities are consistent with the application.
    - Yes
- Determine what holidays the building observes over the year, and if the lighting zones are disabled during the holidays.
    - 5 holidays per year; lighting not disabled during holidays

Collected one-time measurements for all equipment logged (to establish ratio of kW/amp and simultaneous logger amp/temperature readings)

- Lighting circuits volts, amps, kW and power factor

## .Data Accuracy

| Measurement | Sensor | Accuracy | Notes |
|---|---|---|---|
| Current | Magnelab CT | ±1% | > 10% of rating |

## Field Data Logging

- **ECM-1**

1. Deployed dataloggers during post survey to measure operating hours
    a. Deployed current measurement CT loggers to measure current at the panelboard, logging individual circuits.
2. Set up loggers for 5 minute instantaneous readings and allowed loggers to operate between October 11 to November 2, 2011.

## Logger Table

The following table summarizes all logging equipment used to measure the above noted ECM's:

| Area | Hobo U-12 | 20 amp CT's | Post-Monitoring Notes | # of fixtures monitored |
|---|---|---|---|---|
| Cooler #1 | 1 | 1 | 1 chan | 8 |
| Cooler Shipping | | 1 | 1 chan | 4 |
| Cooler #2 | | | Not Monitored | |
| Freezer #1 (Dual Switched) | 1 | 2 | 2 chan | 6 |
| Freezer Shipping (Dual Switched) | | 2 | 2 chan | 5 |
| Freezer #2 (Dual Switched) | 1 | 2 | 2 chan | 8 |
| Cooler Meat | | | Not monitored | |
| **Total** | | **8** | | |

## Data Analysis

- **ECM-1**

1. "Synthesized" Pre time series data by using the following equation:

$$\frac{kWh}{year_{pre}} = No._{fixtures} * Watts_{fixture} * HoursOn_{year}$$

2. Converted time series data on logged equipment into pre/post average load shapes by day type.
3. The Post annual kWh was calculated using the following equations:

Weekdays:

$$\frac{kWh}{year_{post}} = \sum \left[ \frac{kW_{spot}}{Ampacity_{spot}} * Current_{time-measured} * \frac{5\min._{intervals}}{\frac{60\min.}{hour}} * \frac{24hour}{day} * \frac{260days}{year} \div \frac{weekdays}{monitoringperiod} \right]$$

Weekends:

$$\frac{kWh}{year}_{post} = \sum\left[\frac{kW_{spot}}{Ampacity_{spot}} * Current_{time-measured} * \frac{5\min._{intervals}}{\frac{60\min.}{hour}} * \frac{24hour}{day} * \frac{104days}{year} \div \frac{WEdays}{monitoringperiod}\right]$$

Annual Total:

$$\frac{kWh}{year} = \sum\left[\frac{kWh}{year}_{weekday} + \frac{kWh}{year}_{weekend}\right]$$

4. The annual kWh ***saved*** was calculated using the previous data in the following equation:

$$\frac{hWh_{saved}}{year} = \frac{kWh_{pre}}{year} - \frac{kWh_{post}}{year}$$

Interactive effects of lighting savings on refrigeration system were also included.

## Verification and Quality Control

20. Visual inspection of time series data identified no problems
21. Compared readings to nameplate and spot-watt values and identify no problems

## Recording and Data Exchange Format

14. Hobo logger binary files
15. Excel spreadsheets

## Post Data Results

The post-data results were based on three loggers deployed as shown in the lighting logger table above. The shipping cooler area had different fixtures than the other areas, being 4-lamp fixtures as opposed to the 6-lamp fixtures installed elsewhere. In summary a total of (77) 400watt metal halide fixtures were replaced with 71 high bay, 6 lamp T8 fixtures with occupant sensor control, and five 4 lamp T8 fixtures in the Cooler Shipping area. There are 35 new fixtures in cooler area and 41 fixtures in freezer area. The pre-install estimated savings for replacing the (77) metal halides is 183,936 kWh per year.

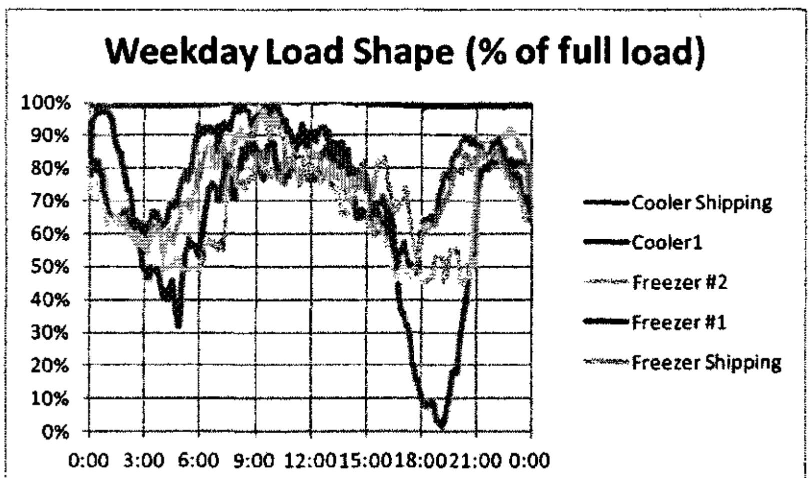
The following table summarizes the energy and demand savings resulting from these ECMs. The projected annual savings based on post install trend data is 196,398 kWh based on the lighting savings alone, and 247,604 kWh when the additional savings due to reducing the refrigeration load is included. The refrigeration load reduction was based on a chiller efficiency of 0.8 kW/ton for the coolers, and 1.0 kW/ton for the freezers.

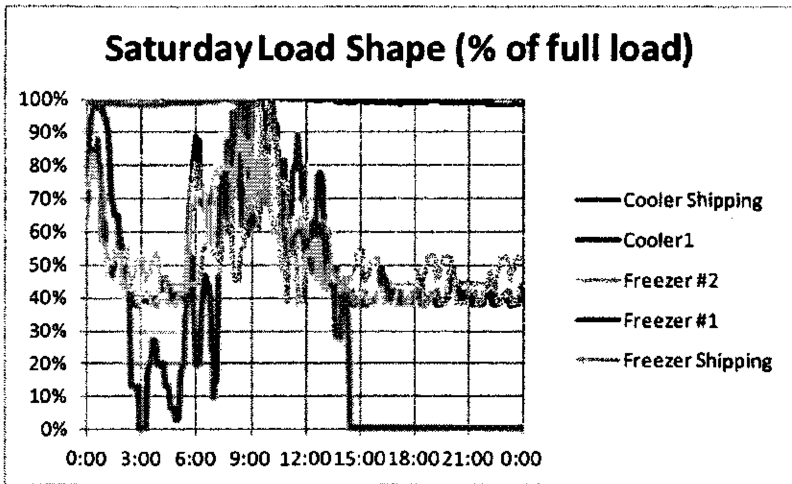
| Existing Fixtures Replaced | | | | | Post Retrofit Results | | | | Lighting Savings | | Refrigeration Savings | | Total Savings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Qty | Watts | Annual Hours | Annual kWh | Qty | Average Watt per Fixture | Equivalent Full Load Hours | Annual kWh | Energy savings (kWh) | Demand Savings (kW) | Energy savings (kWh) | Demand Savings (kW) | Total Energy Savings | Total Demand Savings |
| Cooler | 30 | 465 | 8112 | 113,162 | 29 | 221; 145 | 5,202 | 31,371 | 81,791 | 7.9 | 18,610 | 1.8 | 100,401 | 9.7 |
| Freezer | 47 | 465 | 8112 | 177,288 | 47 | 221 | 6,035 | 62,681 | 114,607 | 11.5 | 32,596 | 3.3 | 147,202 | 14.7 |
| Total | 77 | | | 290,450 | 76 | | | 94,053 | 196,398 | 19.4 | 51,206 | 5.1 | 247,604 | 24.5 |

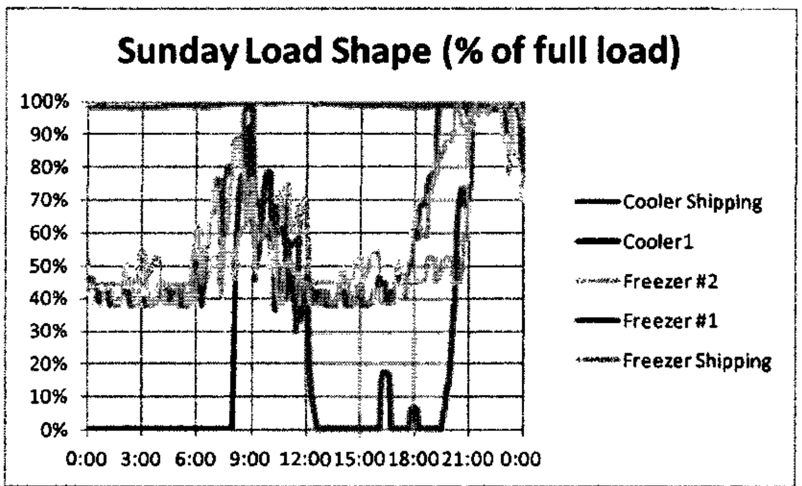
The realization rate for these ECMs relative to the savings claimed in the application is shown in the following table. The energy and demand savings exceed the projected savings.

| Realization Rate | Energy | Demand |
|---|---|---|
| Lighting only | 107% | 102% |
| Lighting and Refrigeration savings | 135% | 129% |

The graphs below show the average daily load shapes for the monitored areas. These plots average the entire monitoring period into the three day types shown. The lights in the Cooler Shipping area are on continuously. The occupancy sensors reduce the lighting load for the other areas throughout the three day types.






From the monitored load profiles above, the average % of full load at 2pm on a weekday in the cooler is 85.8%, while the average % of full load at 2pm on a weekday in the freezer is 77.4%. The coincident peak kW savings are summarized below:

**Coincident Peak Demand Savings**

| Area | % full load at 2pm | Lighting CP kW Savings | Refrigeration CP kW Savings | Total CP kW Savings |
|---|---|---|---|---|
| Cooler | 85.8% | 8.5 | 1.9 | 10.4 |
| Freezer | 77.4% | 13.8 | 4.0 | 17.8 |
| Total | | 22.3 | 5.9 | 28.2 |

**Project Savings Summary**

The evaluated savings were compared to the final savings estimates from the DSMore runs. This comparison is shown in the Table below:

Final Project Savings and Realization Rate

| Evaluated kWh Savings | Expected kWh Savings | kWh RR | Evaluated NCP kW Savings | Expected NCP kW Savings | NCP kW RR | Evaluated CP kW Savings | Expected CP kW Savings | CP kW RR |
|---|---|---|---|---|---|---|---|---|
| 247,604 | 191,139 | 1.30 | 25 | 22 | 1.12 | 28.2 | 22 | 1.29 |

# Site 10

[redacted]

## Parking Lot Lighting Replacement

# M&V Report

PREPARED FOR:
Duke Energy
Ohio

PREPARED BY:
Architectural Energy Corporation
2540 Frontier Avenue, Suite 100
Boulder, Colorado 80301

PREPARED IN:
December 2011
Version 1.0

***Note: This project has been randomly selected from the list of applications for which incentive agreements have been authorized under Duke Energy's Smart $aver® Custom Incentive Program.***

***The M&V activities described here are undertaken by an independent third-party evaluator of the Smart $aver® Custom Incentive Program.***

***Findings and conclusions of these activities shall have absolutely no impact on the agreed upon incentive between Duke Energy and [redacted].***

# INTRODUCTION

This report addresses M&V activities for new LED parking lot lighting fixtures in 10 [redacted] stores in the Cincinnati area.

The net effect was a reduction in power consumption by the lighting fixtures.

**Note: ECM's have already been installed and implemented for this application. Data collection was for Post install only.**

The measures included:

**ECM-1 – Area Lighting**

ECM-1 involves replacing lighting fixtures in the parking area of 10 [redacted] stores. Fixtures to be replaced are as follows:

(13) existing 250w MH fixtures will be replaced with 71w LED fixtures.
(82) existing 400w MH fixtures will be replaced with 71w LED fixtures.
(38) existing 1000w MH fixtures will be replaced with 138w LED fixtures.

# GOALS AND OBJECTIVES

The projected savings goals identified in the application are:

| Facility | Application Proposed Annual savings (kWh) | Application Proposed Peak Savings (kW) | Duke Projected savings (kWh) | Duke Projected savings (kW) |
|---|---|---|---|---|
| Store #58 | 66,576 | 7 | - | - |
| Store #63 | 74,854 | 9 | - | - |
| Store #65 | 43,231 | 5 | - | - |
| Store #67 | 31,702 | 4 | - | - |
| Store #71 | 34,584 | 4 | - | - |
| Store #74 | 24,624 | 3 | - | - |
| Store #75 | 37,063 | 5 | - | - |
| Store #550 | 87,074 | 11 | - | - |
| Store #551 | 52,200 | 6 | - | - |
| Store #552 | 91,743 | 11 | - | - |
| **Total** | **543,651** | **65** | **543,654** | **62** |

The objective of this M&V project was to verify the actual:

- Annual gross kWh savings

- Summer peak kW savings
- Summer Utility coincident peak kW savings
- kWh & kW Realization Rates

## Project Contacts

Approval has not yet been granted from the Duke Energy contacts listed below to plan and schedule the site visit with the Customer.

| | | |
|---|---|---|
| Duke Energy M&V Admin. | Frankie Diersing | [redacted] |
| Duke Energy BRM | Terry Holt | [redacted] |
| Customer Contact | [redacted] | [redacted] |

## Site Locations/ECM's

| Store | Address | Area | 250w (71w) | 400w (71w) | 1000w (138w) |
|---|---|---|---|---|---|
| a | [redacted] | 2960 | - | 10 | 5 |
| b | [redacted] | 2800 | 3 | 6 | 7 |
| c | [redacted] | 3500 | - | 15 | - |
| d | [redacted] | 2560 | - | 11 | - |
| e | [redacted] | 3040 | - | 12 | - |
| f | [redacted] | 2640 | 1 | 8 | - |
| g | [redacted] | 2640 | - | 5 | 3 |
| h | [redacted] | 4784 | 3 | 5 | 9 |
| i | [redacted] | 4784 | 3 | 6 | 4 |
| j | [redacted] | 4784 | 3 | 4 | 10 |

## Data Products and Project Output

- Post retrofit survey of lighting fixtures
- Summer peak demand savings
- Coincident peak demand savings
- Annual Energy Savings

## M&V Option

IPMVP Option A