# Impact Evaluation of the

# Retrocommissioning, Operation & Maintenance, and Business Sustainability Challenge Programs

Prepared for:
The Connecticut Energy Efficiency Board

by

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Table of Contents

## Executive Summary

This document summarizes the results of the impact evaluation completed by Michaels Energy and Evergreen Economics of the Connecticut Retro-Commissioning (RCx) and Operations and Maintenance (O&M) programs for the 2008 to 2010 program years. The intent of the evaluation was to assess the measured energy and demand savings, as well as to qualitatively assess the persistence of savings associated with compressed air leaks. In addition, this document presents a case study approach impact evaluation of the Business Sustainability Challenge (BSC) pilot program.

### Program Overview

The RCx, O&M, and BSC programs are part of the Conservation & Load Management (C&LM) plan for electric and natural gas energy savings and are funded by the Connecticut Energy Efficiency Fund. These programs are offered by Connecticut Light & Power Company (CL&P) and United Illumination (UI). The Connecticut Energy Efficiency Board (EEB) manages the CEEF, overseeing the programs and their evaluations. Members of the EEB are from private and public entities, representing the interests of companies, environmental organizations, the Attorney General's Office, and organizations representing the interests of residential, commercial, industrial, and limited-income customers. This evaluation measured the results of projects completed from 2008 through 2010 through the RCx, O&M, and BSC programs.

### Evaluation Objectives and Methodologies

The EEB requires periodic evaluations of the C&LM programs to advise and assist the utility distribution companies in the development and implementation of comprehensive and cost effective energy conservation and market transformation plans. The primary objectives of this evaluation include the quantification of adjusted gross savings for both electric and natural gas savings based on several adjustment factors for the RCx and O&M programs, including the persistence of compressed air leak savings. The primary objective of the BSC program evaluation is measure what behavioral changes customers have made as result of program participation.

Michaels Energy conducted file reviews and field verification and data collection on a complete survey of the 21 RCx projects and a statically sampled selection of 44 O&M projects. The BSC program had 15 participants that had completed the program during the evaluation period, with 9 responding to surveys.

Field personnel verified the energy efficiency measures and installed data loggers to record equipments energy usage (kW), hours of operation, and temperature profiles. Site personnel were also interviewed to determine other key parameters specific to each project.

The collected data from the on-site visits were used to analyze the kW, kWh and CCF usage for both average demand and seasonal peak demand for each of the projects. These values were compared to the reported energy savings to determine the adjustment factors and realization rates. The results were then extrapolated to all projects to determine the total savings realized by the RCx and O&M programs from 2008 through 2010.

### RCx Program

### Results

The original claimed savings and the evaluation measured savings for energy as well as summer and winter seasonal peak savings for the RCx program is given in Table 1. Table 1 also presents the magnitude of the savings adjustments for each adjustment type.

The program did not claim the summer and winter peak reductions. The displayed values in Table 3 are the final values measured through the evaluation for each program.

**Table 1 RCx Energy and Peak Savings**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 5,865,555 | 100% | 650.43 | 100% | 378.91 | 100% |
| Documentation Adjustment | -119,226 | -2% | 239.18 | 37% | 50.74 | 13% |
| Technology Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| Quantity Adjustment | 105,120 | 2% | 12.00 | 2% | 12.00 | 3% |
| Operation Adjustment | - 1,593,784 | -27% | -182.06 | -28% | -102.27 | -27% |
| Heating and Cooling Adjustment | 78,134 | 1% | 17.46 | 3% | 0.00 | 0% |
| **Total Savings** | **4,335,799** | **74%** | **737.02** | **113%** | **339.38** | **90%** |

**Table 2 RCx CCF Savings**

| | Energy Savings | | Peak Day Savings | |
|---|---|---|---|---|
| | (CCF) | Adjustment /RR (%) | (CCF/Day) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 77,187 | 100% | 928.89 | 100% |
| Documentation Adjustment | -7 | 0% | -3.47 | 0% |
| Technology Adjustment | 0 | 0% | 0.00 | 0% |
| Quantity Adjustment | 0 | 0% | 0.00 | 0% |
| Operation Adjustment | -30,682 | -40% | -258.91 | -28% |

| | | | | |
|---|---|---|---|---|
| **Heating and Cooling Adjustment** | 0 | 0% | 0.00 | 0% |
| **Total Savings** | 46,498 | 60% | 666.50 | 72% |

**Table 3 RCx Peak Savings**

| | **Summer Peak** | **Winter Peak** | **Extreme Peak Day (Winter)** |
|---|---|---|---|
| | **(kW)** | **(kW)** | **(CCF/Day)** |
| **Total Savings** | 789.35 | 389.81 | 780.95 |

## Confidence and Precision

The evaluation was designed to achieve 90% confidence at 10% precision for energy savings, and 80% confidence and 10% precision for demand savings for each of the individual programs. Table 4 displays the evaluation savings and the precision and confidence levels of the savings for the RCx program. The precision and confidence levels of the savings for the summer and winter peak and extreme peak day savings are shown in Table 5. The peak savings shown in Table 5 were not claimed by the program and all displayed results are from the evaluation.

**Table 4 Project Savings with Precision and Confidence Levels**

| | **RCx** |
|---|---|
| **Energy (kWh)** | 4,335,799 |
| Upper 90% | 0.2% |
| Lower 90% | 0.2% |
| **Summer Seasonal Peak (kW)** | 737.02 |
| Upper 80% | 2% |
| Lower 80% | 2% |
| **Winter Seasonal Peak (kW)** | 339.38 |
| Upper 80% | 1% |
| Lower 80% | 1% |
| **Peak Day (CCF)** | 666.50 |
| Upper 80% | 0% |
| Lower 80% | 0% |

**Table 5 Summer and Winter Peak and Extreme Peak Day Savings with Precision and Confidence Levels**

| | RCx |
|---|---|
| **Summer Peak (kW)** | 737.02 |
| Upper 80% | 2% |
| Lower 80% | 2% |
| **Winter Peak (kW)** | 339.38 |
| Upper 80% | 1% |
| Lower 80% | 1% |
| **Extreme Peak Day (CCF)** | 780.95 |
| Upper 80% | 0% |
| Lower 80% | 0% |

### Program Findings

Overall, the RCx program was found to be successful in identifying projects. Based on the files reviewed, the projects included measures that covered a wide range of technologies and the types of measures identified indicate that the investigation completed was of a high level of rigor. Identified measures, and the associated savings, were clearly identified based on site-specific conditions.

The savings calculations for the completed measures were also found to be in-depth and robust. Additionally, the methodology was found to be consistent and reasonable. However, input parameters were often estimated, rather than measured. Most of the projects evaluated used an assumed motor, chiller, or other equipment load factor to calculate savings. The assumed load factor was often greater than the actual load factor when determined based on the collected data.

The measure calculations also often neglected to account for interactions with other completed measures. For example, savings were claimed for several of the school projects both for scheduling the HVAC equipment and the chiller plant. For both measures, the cooling load in the baseline condition was assumed to be the existing conditions. The savings should have been calculated sequentially, with the scheduling for the HVAC units reducing the cooling load on the plant, then the turning off of the plant eliminating the remaining energy usage.

Many of the changes in the evaluation analysis were not due to calculation errors or oversimplification, but instead due to measures not being implemented as intended. For example, several of the school projects had significant savings levels claimed for the implementation of reductions in operation for equipment during the summer months. However, due to system limitations, the systems needed to be manually changed to a “summer” mode. This was not occurring, resulting in the savings not being realized.

The documentation level for the RCx projects was sufficient, however, often did not clearly indicate what changes were made to the systems. Many of the RCx measures include the replacement or repair of failed equipment. These can include replacing failed sensors that are reading incorrectly or fixing dampers that may be failed open. In the case of a failed temperature sensor, the description should include a description of how the sensor failed and the result on the system, such as: “The temperature sensor for the building was out of calibration and was reading 5°F low, resulting in the system changing over from heating to cooling mode incorrectly. This required and excessive reheating, which will be reduced.” This will facilitate both the implementation and evaluation of the recommended changes.

### Recommendations

Michaels Energy makes the following recommendations:

Recommendation 1: The Companies should employ conservative assumptions when claiming savings for projects that require a manual change to set or maintain efficient operation.

Recommendation 2: The Companies should require that the operational conditions before and after an operational change or repair of failed equipment are fully documented, rather than only including a description of the change.

Recommendation 3: Load factors for motor, chiller, and other equipment should be based on collected data such as instantaneous measurements, short term metering, or BAS/EMS trended data.

Recommendation 4: The Companies should calculate measure savings sequentially. For example, the baseline operation and energy consumption for the second measure should be calculated as incremental to the effects of completion of the first measure. Pre and post demand and energy consumption should be shown for each measure to ease the review process.

## O&M Program

### Results

The original claimed savings and the evaluation measured savings for energy as well as summer and winter seasonal peak for the O&M program is given in Table 6. Table 6 also presents the magnitude of the savings adjustments for each adjustment type.

The program did not claim the summer and winter peak savings. The displayed values in Table 8 are the final values measured through the evaluation for each program.

**Table 6 O&M Energy and Seasonal Peak Savings**

| All Programs | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 12,359,309 | 100% | 1,112.09 | 100% | 1,090.71 | 100% |
| Documentation Adjustment | 184,412 | 1% | -12.98 | -1% | -12.98 | -1% |
| Technology Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| Quantity Adjustment | -635,687 | -5% | -135.82 | -12% | -135.82 | -12% |
| Operation Adjustment | -2,990,012 | -24% | -28.80 | -3% | 154.14 | 14% |
| Heating and Cooling Adjustment | 73,486 | 1% | 3.56 | 0% | 3.79 | 0% |
| Total Savings | 8,991,508 | 73% | 938.05 | 84% | 1,099.84 | 101% |

**Table 7 O&M CCF Savings**

| | Energy Savings | | Peak Day Savings | |
|---|---|---|---|---|
| | (CCF) | Adjustment /RR (%) | (CCF/Day) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 8,948 | 100% | 40.57 | 100% |
| Documentation Adjustment | 0 | 0% | 0.00 | 0% |
| Technology Adjustment | 0 | 0% | 0.00 | 0% |
| Quantity Adjustment | 0 | 0% | 0.00 | 0% |
| Operation Adjustment | -1,139 | -13% | 3.33 | 8% |
| Heating and Cooling Adjustment | 0 | 0% | 0.00 | 0% |
| Total Savings | 7,809 | 87% | 43.90 | 108% |

**Table 8 O&M Peak Savings**

| | Seasonal Summer Peak | Seasonal Winter Peak | Extreme Peak Day (Winter) |
|---|---|---|---|
| | (kW) | (kW) | (CCF/Day) |
| Total Savings | 846.62 | 1,148.94 | 43.90 |

## Confidence and Precision

The evaluation was designed to achieve 90% confidence at 10% precision for energy savings, and 80% confidence and 10% precision for demand savings for each of the individual programs.

Table 9 displays the evaluation savings and the precision and confidence levels of the savings for the O&M program. The precision and confidence levels of the savings for the summer and winter seasonal peak savings are shown in Table 10. Summer and winter peak savings were not claimed by the program and all displayed results are from the evaluation.

**Table 9 Project Savings with Precision and Confidence Levels**

| | O&M |
|---|---|
| **Energy** | 8,991,508 |
| Upper 90% | 3% |
| Lower 90% | 3% |
| **Summer Demand** | 938.05 |
| Upper 80% | 8% |

| | |
|---|---:|
| Lower 80% | 8% |
| **Winter Demand** | 1,104.27 |
| Upper 80% | 10% |
| Lower 80% | 10% |
| **Peak Day (CCF)** | 43.90 |
| Upper 80% | 0% |
| Lower 80% | 0% |

**Table 10 Summer and Winter (kW & CCF) Peak Savings with Precision and Confidence Levels**

| | **O&M** |
|---|---:|
| **Summer Peak (kW)** | 846.62 |
| Upper 80% | 8% |
| Lower 80% | 8% |
| **Winter Peak (kW)** | 1,148.94 |
| Upper 80% | 4% |
| Lower 80% | 4% |
| **Extreme Peak Day (CCF)** | 43.90 |
| Upper 80% | 0% |
| Lower 80% | 0% |

### Program Findings

Overall, the O&M program tended to focus on more specific areas, with compressed air leaks and PC projects comprising the vast majority of the projects and the savings.

The savings calculations were found to be simple and more general than the RCx analyses. However, in general, the analyses were reasonable and accurate, with two notable exceptions.

First, the Wattage for the controlled computers in the PC projects was found to be overestimated. This change resulted in all of the PC projects having savings levels reduced.

Second, one of the compressed air projects comprised of 46% of the evaluated O&M program savings and 25% of the entire O&M program savings. Several significant errors were found in the analysis which resulted in a 54% realization rate for the project. This was not representative of the remaining compressed air projects. Aside from this project, the compressed air projects were adjusted upwards by 4% during the evaluation.

While reviewing the compressed air projects, and investigating the persistence of leak repairs, it became apparent that many of the companies were not using the provided leak detectors on a regular basis. This was primarily driven by either a lack of knowledge on the use of the leak detector or the lack of a responsible person tasked to complete the leak audits. The two companies that were performing leak tests had either made it part of the maintenance program or it was driven by a single employee at the site outside of his normal responsibilities. It was clear that sites that did actively search out and repair leaks had much lower leakage rates than companies who were not actively repairing leaks.

### Recommendations

Michaels Energy makes the following recommendations:

Recommendation 5: The Companies should afford greater scrutiny to the large projects that make up a significant portion of the program portfolio. This can be done by additional levels of review to allow additional people to review the project or increased metering requirements by collecting both pre and post data.

Recommendation 6: Equipment energy specifications should be double-checked, especially for projects where equipment wattages are applied over a large number of installations.

Recommendation 7: The customers should be required to make leak detection a regularly occurring part of the facility maintenance.

Recommendation 8: Reinstating the distribution of leak detectors under the O&M Services program should be investigated, along with periodic education or training.

## BSC Program

### Results

The BSC program was evaluated into five distinct areas: sustainability staffing, establishing metrics, setting goals based on established metrics, establishing procedures and protocols and completing projects to make progress to achieve the goals. Nine of the 16 participating companies were interviewed in order to assess the impacts using these metrics. The remaining participants were not available for interviews.

Eight of the companies were found to have some form of sustainability group, green team, or at a minimum a staff member coordinating the efforts. However, only five of the companies had "official" green teams or responsible individuals, with defined roles. For the remaining companies, the sustainability duties were more informal in nature and less well defined within the company.

The same eight companies track energy consumption or some other metric. However, the companies have not been as successful at establishing *meaningful* metrics. The most common metric given by the companies is monthly energy consumption. Companies typically do not normalize to production or any other variable due to inability to determine a useful variable for normalization or not knowing how to normalize usage to facility operation.

The same eight companies interviewed also have established either formal or informal goals with five having formal goals. However, the usefulness of the goals is diminished due to lack of meaningful metrics.

Three of the companies have completed traditional energy efficiency projects (such as lighting or HVAC equipment upgrades). Five of the companies have also implemented non-traditional energy efficiency or sustainability projects as shown below. A detailed breakdown of the recycling and waste reduction actions by company are given in Table 11 below.

**Table 11 Recycling/Waste Reduction Measures**

| Company | Action |
|---|---|
| Company D | • Implemented a single stream recycling program |
| Company E | • Increased the number of recycling bins |

| | |
|---|---|
| | • Increase the signage to promote recycling<br>• Promote recycling through messages on screens in cafeteria |
| Company F | • Install signage for recycling<br>• Set up battery return stations<br>• Recycle shipping skids from production materials |
| Company H | • Train employees on recycling<br>• Switched from Styrofoam cups to mugs<br>• Separate paper and cardboard for recycling or to send to the waste-energy plant<br>• Removed paper towels from bathrooms and installed hand dryers |
| Company I | • Set up recycling program for production waste, including shrink wrap<br>• Re-use pallets from production |

Four of the above five companies have also increased efforts in the areas of employee training, education, or information. Although these efforts have primarily involved education for use in the workplace, two customers have expanded this effort to include information for employee use at home. A detailed breakdown of the employee training and education actions by company are given in Table 12 below.

**Table 12 Employee Training/Education Actions**

| Company | Action |
|---|---|
| Company D | • Regular newsletters to notify employees on the status of sustainability projects<br>• Make green team staff available to discuss home projects with employees |
| Company E | • Send email blasts to employees to encourage sustainability and inform them of current efforts |
| Company H | • Train people to shut down computers and other equipment over lunch, breaks, etc. |
| Company I | • Train employees and post signs to remind employees to shut shipping doors to reduce HVAC energy usage<br>• Have annual "Green Fair" with UI representative to promote CFLS and home energy audits |

## Program Findings

The BSC participants did have staff dedicated to sustainability, however, only approximately half of the companies had an "official" group. The other companies incorporated sustainability into existing meetings or included sustainability as an "unofficial" duty for a staff member.

The companies did use their utility bills as a metric to gauge sustainability; however, few of the companies had progressed beyond reviewing utility bills to developing *meaningful* metrics, such as kWh per part produced or per square foot of area. Several specifically mentioned difficulties in developing or determining meaningful metrics for their facility as a barrier. This process is complex in nature and will be unique to each customer. By working with customers on a one-on-one basis, companies will be more likely to be able to determine what metrics will be meaningful for them. Specifically, two customers indicated a desire to develop metrics regarding trash and recycling volumes. Both indicated that they did not know how to proceed with this task.

Several customers indicated a frustration with the lack of meetings after the completion of the course.

### Recommendations

Michaels Energy makes the following recommendations:

Recommendation 9: The Companies should work with customers to develop a staffing plan to ensure sustainability groups or green teams are "official" positions.

Recommendation 10: Work with customers on a one-on-one basis to develop meaningful metrics.

Recommendation 11: While participants are very interested in the broad range of sustainability issues, the program appears to focus on electricity use only in developing savings metrics. To better serve these participants, the Companies should Increase focus on non-utility metrics, such as recycling volumes, trash volumes, and water usage.

Recommendation 12: The Companies should hold periodic meetings open to all BSC participants, to review successes, challenges, and tools.

# 1. Introduction

This document presents the results of the impact evaluation completed by Michaels Energy and Evergreen Economics of the Connecticut Retro-Commissioning (RCx) and Operations and Maintenance (O&M) programs for the 2008 to 2010 program years. As a result of this study, the following information is presented:

- Evaluation measured savings levels and gross realization rates for electrical energy savings, for each program
- Measured savings and gross realization rates for summer peak demand reductions, for each program
- Measured savings and gross realization rates for winter peak demand reductions, for each program
- Quantification of program savings during seasonal peak load hours, as defined by ISO New England rules governing participation in forward capacity wholesale markets.
- Evaluation measured savings levels and gross realization rates for annual gas savings, for each program
- Quantification of typical peak day and extreme peak day gas savings
- Assessment of the persistence of savings over time for leak repairs completed through the O&M program

In addition, this document presents the case study-based impact evaluation of the Business Sustainability Challenge (BSC) program. For this program, this document will present information on:

- The formation of green teams and other staff resources to sustainability
- The development of meaningful metrics
- The development of goals for sustainability
- Steps taken by companies towards goals

Finally, for each program and assessment of the program data system and data accessibility are presented.

## 2. Overall Approach

### 2.1 Energy Savings and Demand Reductions

The approach taken for impact evaluation of the RCx and O&M programs involved two elements:

- Ex Ante Verification—The ex ante verification is a calculation of savings based on review of the documentation available in the original project documentation as well as through phone interviews of the customer and/or contractors associated with the project. This analysis is a review to ensure that the savings claimed for the project are consistent with the savings calculated for the project, that the savings calculations are reasonable, appropriate, and consistent with program procedures and best practices, and that the inputs to the calculations are reasonable and consistent with the operation as determined prior to the implementation of the project.
- Ex Post Impact Evaluation—The ex post impact evaluation is a calculation of savings based on all available information for the project. This includes all of the information assessed as part of the ex ante verification process as well as information collected through inspection of equipment onsite and analysis of data collected by measurement of equipment parameters, through short- or long-term metering, a review of customer usage histories, as well as any other relevant information. The specific approach will vary by project and program, and is explained further under each program.

Based on these two steps, any adjustments to the energy or demand savings were categorized to allocate changes in savings to the following categories:

- ***The Documentation Adjustment*** reflects any change in savings due to discrepancies in project documentation, calculation errors corrected during the ex ante verification, or claimed savings from the tracking system not matching the savings from the provided calculations.
- ***The Technology Adjustment*** reflects the change in savings due to the identification of a different energy saving application at the site than represented in the tracking system estimate of savings.
- ***The Quantity Adjustment*** reflects the change in savings due to the identification of a different quantity of any particular energy saving applications at the site than presented in the tracking system estimate of savings.
- ***The Operation Adjustment*** reflects the change in savings due to the observation or monitoring of different operating hours and conditions at the site than represented in the tracking system estimate of savings.
- ***The Heating and Cooling Adjustment*** reflects changes in savings not already counted due to interaction between the lighting and HVAC systems among the sampled sites. Generally, these impacts cause a heating penalty and a cooling credit. This adjustment reflects impacts from electric heating and/or cooling, not other fuels.

## 2.2 Analysis and Data Collection

### 2.2.1 Ex Ante Verification

The first step in the evaluation process for each project was the ex ante verification. This step was comprised of a desk review of the project documentation. The desk review first allowed the analyst to become familiar with the project calculations and descriptions to ensure that the calculations were consistent with the described project. The analyst was also able to review the calculations and identify areas of uncertainty that would then be addressed through the site-specific measurement and verification efforts.

Second, the desk review was used to review the custom calculations for calculation errors and that they were completed using engineering fundamentals, appropriate assumptions, and equipment characteristics consistent with the supplied documentation. Finally, the savings in the calculation files were verified against the values in the tracking system.

Any changes to the calculations made at this time are reflected as a documentation adjustment.

### 2.2.2 Data Collection

Prior to performing an onsite inspection, a site-specific measurement and verification plan (SSMVP) was written for each site. The SSMVP included the results of the ex ante verification as well as a description of the measures involved in the project, the method used to calculate savings in the original analysis, and any comments regarding or adjustments made to the analysis.

The SSMVP also included a description of the various parameters used to determine the savings, and describe the data collection efforts and the measurement plan to be undertaken to verify the project savings.

Specifically, the SSMVP addressed the actions to be taken to complete the following steps:

- Verify the installation and continued operation of the measure as described
- Verify make/model number of affected equipment
- Verify operational parameters such as hours of operation, motor load factors, heating and cooling efficiencies, etc.
- Verify baseline system operation
- Collection of instantaneous measurements
- Installation of data loggers for short or long-term metering

Instantaneous measurements of demand were taken using a NIST-calibrated three-phase RMS power meter. Short and long term metering was completed using equipment consistent with the relevant sections of the M-MVDR.

### 2.2.3 Ex Post Analysis

#### 2.2.3.1 Non-Weather Sensitive Measures

For non-weather sensitive measures, the short-term data collected was used to relate the operating characteristics (such as kW) of the affected equipment to other parameters such as time of day, day-type, production levels, operating schedules, and other factors specific to the project, as determined through examination of the original calculations as well as through on-site interviews. Typically, multiple relationships were required to sufficiently account for annual expected operating patterns and variations.

The relationships were then annualized based on the expected annual patterns in production, day-type relationships, and other factors to determine the savings for each hour of the year using an 8760 hour analysis.

#### 2.2.3.2 Weather Sensitive Measures

For weather sensitive measures, the short-term metered data collected was used to relate the operating characteristics (such as kW) of the affected equipment to outdoor air temperature and humidity levels, as applicable. Typically, multiple regression analyses were required for each individual piece of equipment to account for variations in operation for occupied vs. unoccupied periods, day-types, as well as other factors.

The results of the regression analysis were then used to calculate savings for each hour of the year using an 8760 hour analysis. For each hour of the year, the expected kW was determined using the regressions developed and TMY3 data.

## 2.3 Persistence

This study includes an assessment of the results of maintenance-focused activities in support of the O&M Services Program, with attention directed at air compressor leak detection.

Customers were interviewed to determine if they had established leak reduction programs. The customers who had established leak reduction programs were interviewed to determine how frequently and what method are used to screen for leaks. Finally, the compressed air systems were inspected to assess if the leakage level at the facility is less than the leakage level at the time of the project implementation as well as lower than would be expected based on “typical” leak levels for compressed air systems. Leakage levels for facilities were compared for facilities that established leak programs and those that did not.

## 2.4 Business Sustainability Challenge

In order to assess the impacts of the Business Sustainability Challenge program eleven participants were interviewed with a series of open ended questions designed to identify the actions of the businesses due to participation in the BSC program. As needed, additional information or clarification was collected via email.

The interview focused on four areas:

- Have staff and resources been dedicated towards sustainable development?
- Has the facility set up metrics that can be used effectively to identify the level of or progress towards a goal of sustainability
- Has the facility set goals in the areas of sustainability
- Have projects or efforts been made to improve the sustainability of the facility

# 3. RCx Program

## 3.1 Background

The objective of the RCx program is to identify electric and non-electric energy savings opportunities for Connecticut customers by making building owners and operators aware of operating inefficiencies in their system. In addition, the objective is to assist the building owners and operators in systematically addressing the inefficiencies to produce lasting energy savings.

In order to accomplish this objective, the RCx program for the Connecticut program uses a four step approach.

1. **Screening—**The first step is that potential participants for the RCx program are screened to ensure that they eligible and are good candidates for the program. The eligibility requirements for the program are:
    - The building must be over 100,000 sq. ft. and have a building management system (BMS) that serves a minimum of 100,000 sq. ft.
    - The building must have a direct digital control system with trending and reporting capability.
    - The building must have a current Energy Star® benchmark.
2. **Building Survey—** Once a participant has been screened and accepted into the program, a building survey is completed. The building survey is an initial audit of the facility to identify opportunities for energy efficiency improvements. Based on this audit, the building owner or operator and the utility determine which projects the customer would to investigate further.
3. **Investigation—** The investigation phase is an in-depth examination of measures identified during the survey phase. Additional measures may also be identified at this time. The investigation involves a rigorous analysis of the building operation, supported with data collected through observation, functional testing, and trended data analysis. At the completion of this measure, the commissioning provider generates a report that an implementation and verification report, scope of work (SOW), and persistence strategy for each measure. The implementation and verification report includes the expected cost to complete the measure as well as both the energy and cost savings associated with measure. The scope of work document is a guiding document to assist in ensuring that work with outside contractors is completed in a manner consistent with the intent of the project. The persistence strategy is a guide for the owner or operator to verify the operation periodically, to ensure that the system does not re-degrade to an inefficient condition.
4. **Implementation—** Once the investigation is complete, the projects can be implemented. Once a project has been implemented, the customer staff must be trained on the measure operation and persistence strategy before the utility incentive can be paid out.

## 3.2 Sample Selection

For this study, the evaluation was designed to achieve ±10% precision at a 90% confidence level for energy savings as well as a ±10% precision at a 80% confidence level for peak reductions, to be consistent with the current protocols and requirements of the ISO New England Manual M-MVDR. Although this requirement applied to the evaluation as a whole, the decision was made to apply these targets to each program individually.

For the RCx program, only seventeen projects for 13 distinct customers were completed in the years included in this evaluation. The decision to sample 100% of the RCx program was based on the review of the participant data. With such a limited sample, all or nearly all of the projects must be selected in order to achieve a reasonable level of confidence in the savings estimates. Additionally, the projects completed by each customer were expected to be very unique. Site findings for one site may or may not be transferrable or applicable to other sites. Therefore, the decision was made to analyze a census of participants.

Using this approach, the savings for all the projects is measured; therefore, the precision would be 100% confidence. The breakdown of all electric projects, based on program documentation is detailed in Table 13.

**Table 13 RCx Project List**

| Project Number | Building Type | Program calculated kWh | Program calculated (Summer Seasonal Peak) | Program calculated (Winter Seasonal Peak) |
|---|---|---|---|---|
| **CE07M017** | School | 499,754 | 10.31 | 5.98 |
| **EA07M003** | School | 295,586 | 11.30 | 7.00 |
| **WE06M026** | Medical | 1,788,060 | 167.43 | 155.97 |
| **EA08M010** | School | 137,643 | 0.00 | 0.00 |
| **CE07M016** | School | 452,593 | 8.80 | 39.30 |
| **EA08M003** | Office | 442,863 | 207.00 | 26.00 |
| **CE07M019** | School | 435,811 | 71.30 | 1.80 |
| **WE06M021** | Office | 154,109 | 8.46 | 8.46 |
| **WE07M001** | Office | 179,069 | 11.69 | 11.69 |
| **WE06M022** | Office | 137,017 | 6.25 | 6.25 |
| **WE06M023** | Office | 142,541 | 6.96 | 6.96 |
| **WE07M002** | Office | 144,356 | 7.20 | 7.20 |
| **WE06M028** | School | 235,012 | 31.23 | 19.67 |
| **WE06M027** | School | 282,390 | 57.50 | 27.43 |
| **CE07M018** | School | 241,718 | 2.00 | 28.30 |
| **EA08M007** | School | 257,536 | 41.00 | 24.90 |
| **EA07M006** | School | 39.497 | 2.00 | 2.00 |
| **Total** | | **5,865,555** | **650.43** | **378.91** |

It should be noted that evaluated savings were not developed for one measure completed in the program. This measure was inspected by the evaluation team; however, insufficient information could be collected to adequately estimate the savings for the measure. Therefore, the evaluated savings for the program were based on the savings for all the other measures completed in the program save this one. Because this measure was small, and the evaluation team did complete an inspection of the system to verify operation, the uncertainty and bias from this process is expected to be small.

Only four gas savings projects were included in the program for the years covered in the evaluation. Therefore, a census approach was taken for these projects as well. The gas program calculated savings are detailed in Table 14 below.

**Table 14 Gas Measure Savings**

| Project Number | Projects | Program calculated CCF | Program calculated CCF/day (Summer) | Program calculated CCF/day (Winter) |
|---|---|---|---|---|
| **CE08G049** | School | 8,350 | 22.9 | 0 |
| **EA09G081** | School | 2,746 | 0 | 708 |
| **WE09G058** | School | 34,430 | 0 | 220.9 |
| **WE08G031** | School | 31,661 | 0 | 0 |
| **Total** | | 77,187 | 22.9 | 928.9 |

## 3.3 Evaluation Methodology

The evaluation methodology for the RCx program involved review of all available project documentation, development of a site specific measurement and verification plan, on-site measurement and analysis, and finally completion of the analysis.

Prior to the site visit, the project documentation was reviewed to identify the project, verify the claimed savings, and identify any areas of concern. Once the project documentation was reviewed, a site specific measurement and verification plan (SSMVP) was written for each project. The SSMVP lays out for the site engineer the project description describing both the baseline and proposed conditions. It also lays out the questions for the site personal and the metering plan.

During the site visit for each project, the site representative is questioned to verify the conditions before the project implementation as well as after. In addition, the customer is also asked questions that clarify the characteristics of the baseline condition, hours of operation, and any affects production or operations changes could have on the project. The equipment installation is verified and manufacturer and model numbers are recorded.

Additional data is collected based on each site's specific SSMVP using installed data loggers, Energy Management System trend files, and utility bills. For each project savings can be calculated using one or a combination of these methods. The majority of the RCx projects involved short term metering with data loggers as well as long term metering using the EMS trend files. The short term metering was used to calibrate and verify the EMS trend files. The metering either involved direct metering of the equipments kW; which was used to determine the equipments load profile and hours of operation, or the installation of loggers that recorded the state of the equipment such as lights being either on or off to record hours of operation and instantaneous measurements or manufacture specification sheets were used for the equipments load. The evaluation methodology used for each individual project can be found in the final site reports for each project in Appendix D—Final Site Reports.

## 3.4 Results and Conclusions

Table 15 and Table 19 present the program savings and realization rates, as well as the magnitudes of each adjustment factor. Table 16 through Table 18 and Table 20 through Table 22 present the savings and adjustments for each project in the sample.

As shown in Table 15, the expected gross realization rate for the RCx program electric savings are 74% ± 0.2% at a 90% confidence level for electrical energy savings. For the summer and winter seasonal peak savings, the expected gross realization rate is 113% ± 2% and 90 % ± 1%, respectively, at an 80% confidence level. Table 19 shows the gross realization rate for the RCx program gas savings as 60% CCF savings and 72% peak day CCF savings. Because all gas savings project in the population were included in the sample, the sampling precision does not apply to these savings. The savings are exact for this particular population.

**Table 15 RCx Program Results - Electric**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | | Summer Peak Savings | Winter Peak Savings |
|---|---|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) | (kW) | (kW) |
| **Program calculated Savings Estimate** | 5,865,555 | 100% | 650.43 | 100% | 378.91 | 100% | 0.00 | 0.00 |
| **Documentation Adjustment** | -119,226 | -2% | 239.18 | 37% | 50.74 | 13% | 0.00 | 0.00 |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% | 0.00 | 0.00 |
| **Quantity Adjustment** | 105,120 | 2% | 12.00 | 2% | 12.00 | 3% | 0.00 | 0.00 |
| **Operation Adjustment** | -1,593,784 | -27% | -182.06 | -28% | -102.27 | -27% | 772.26 | 389.81 |
| **Heating and Cooling Adjustment** | 78,134 | 1% | 17.46 | 3% | 0.00 | 0% | 17.09 | 0.00 |
| **Total Savings** | **4,335,799** | **74%** | **737.02** | **113%** | **339.38** | **90%** | **789.35** | **389.81** |

**Table 16 Energy Savings (kWh) Adjustments**

| Project Number | Program calculated Savings | Documentation Adjustment | Technology Adjustment | Quantity Adjustment | Operation Adjustment | Heating & Cooling Adjustment | Total Measured |
|---|---|---|---|---|---|---|---|
| **CE07M017** | 499,754 | -10,991 | 0 | 0 | -47,533 | 0 | 441,230 |
| **EA07M003** | 295,586 | -48,061 | 0 | 0 | -141,875 | 12,409 | 118,060 |
| **WE06M026** | 1,788,060 | -223,286 | 0 | 105,120 | 172,501 | 34,618 | 1,877,013 |
| **EA08M010** | 137,643 | 0 | 0 | 0 | -137,643 | 0 | 0 |
| **CE07M016** | 452,593 | -76,914 | 0 | 0 | -69,819 | 7,537 | 313,396 |
| **EA08M003** | 442,863 | -24,493 | 0 | 0 | -243,722 | 0 | 174,649 |
| **CE07M019** | 435,811 | 96,801 | 0 | 0 | -217,363 | 6,054 | 321,302 |
| **WE06M021** | 154,109 | 51,457 | 0 | 0 | -148,603 | 0 | 56,963 |
| **WE07M001** | 179,069 | 72,552 | 0 | 0 | -183,475 | 0 | 68,147 |
| **WE06M022** | 137,017 | 37,011 | 0 | 0 | -122,078 | 0 | 51,951 |
| **WE06M023** | 142,541 | 41,681 | 0 | 0 | -155,435 | 0 | 28,787 |
| **WE07M002** | 144,356 | 43,215 | 0 | 0 | -132,072 | 0 | 55,498 |
| **WE06M028** | 235,012 | -34,170 | 0 | 0 | -24,576 | 4,826 | 181,092 |
| **WE06M027** | 282,390 | -34,437 | 0 | 0 | -15,949 | 0 | 232,004 |
| **CE07M018** | 241,718 | -9,591 | 0 | 0 | -64,321 | 5,111 | 172,917 |
| **EA08M007** | 257,536 | 0 | 0 | 0 | -49,275 | 0 | 208,261 |
| **EA07M006** | 39,497 | 0 | 0 | 0 | -12,548 | 7,579 | 34,528 |
| **Total** | **5,865,555** | **-119,226** | **0** | **105,120** | **-1,593,784** | **78,134** | **4,335,799** |

**Table 17 Summer Seasonal Peak Adjustments**

| Project Number | Program calculated Savings | Documentation Adjustment | Technology Adjustment | Quantity Adjustment | Operation Adjustment | Heating & Cooling Adjustment | Total Measured |
|---|---|---|---|---|---|---|---|
| **CE07M017** | 10.31 | 0.00 | 0.00 | 0.00 | 147.30 | 0.00 | 157.61 |
| **EA07M003** | 11.30 | 0.00 | 0.00 | 0.00 | -1.16 | 1.10 | 11.25 |
| **WE06M026** | 167.43 | 28.08 | 0.00 | 12.00 | 2.47 | 6.77 | 216.76 |
| **EA08M010** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **CE07M016** | 8.80 | 0.09 | 0.00 | 0.00 | 19.71 | 2.28 | 30.88 |
| **EA08M003** | 207.00 | 173.00 | 0.00 | 0.00 | -372.10 | 0.00 | 7.90 |
| **CE07M019** | 71.30 | 3.13 | 0.00 | 0.00 | -3.37 | 2.73 | 73.79 |
| **WE06M021** | 8.46 | 7.10 | 0.00 | 0.00 | 1.56 | 0.00 | 17.13 |
| **WE07M001** | 11.69 | 9.87 | 0.00 | 0.00 | -1.99 | 0.00 | 19.57 |
| **WE06M022** | 6.25 | 5.22 | 0.00 | 0.00 | 4.47 | 0.00 | 15.94 |
| **WE06M023** | 6.96 | 5.84 | 0.00 | 0.00 | -3.31 | 0.00 | 9.49 |
| **WE07M002** | 7.20 | 6.08 | 0.00 | 0.00 | 3.97 | 0.00 | 17.25 |
| **WE06M028** | 31.23 | 0.76 | 0.00 | 0.00 | -14.97 | 2.22 | 19.23 |
| **WE06M027** | 57.50 | 0.00 | 0.00 | 0.00 | -7.85 | 0.00 | 49.65 |
| **CE07M018** | 2.00 | 0.00 | 0.00 | 0.00 | 29.84 | 0.91 | 32.74 |
| **EA08M007** | 41.00 | 0.00 | 0.00 | 0.00 | 11.90 | 0.00 | 52.90 |
| **EA07M006** | 2.00 | 0.00 | 0.00 | 0.00 | 1.48 | 1.45 | 4.93 |
| **Total** | **650.43** | **239.18** | **0.00** | **12.00** | **182.06** | **17.46** | **737.02** |

**Table 18 Winter Seasonal Peak Adjustments**

| Project | Program calculated Savings | Documentation Adjustment | Technology Adjustment | Quantity Adjustment | Operation Adjustment | Heating & Cooling Adjustment | Total Measured |
|---|---|---|---|---|---|---|---|
| **CE07M017** | 5.98 | 0.00 | 0.00 | 0.00 | 20.72 | 0.00 | 26.70 |
| **EA07M003** | 7.00 | 0.00 | 0.00 | 0.00 | -1.37 | 0.00 | 5.63 |
| **WE06M026** | 155.97 | 17.39 | 0.00 | 12.00 | -44.38 | 0.00 | 140.98 |
| **EA08M010** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **CE07M016** | 39.30 | 0.61 | 0.00 | 0.00 | -2.10 | 0.00 | 37.81 |
| **EA08M003** | 26.00 | 0.00 | 0.00 | 0.00 | -23.14 | 0.00 | 2.86 |
| **CE07M019** | 1.80 | -0.01 | 0.00 | 0.00 | 55.64 | 0.00 | 57.43 |
| **WE06M021** | 8.46 | 7.10 | 0.00 | 0.00 | -15.56 | 0.00 | 0.00 |
| **WE07M001** | 11.69 | 9.87 | 0.00 | 0.00 | -12.57 | 0.00 | 8.99 |
| **WE06M022** | 6.25 | 5.22 | 0.00 | 0.00 | -7.47 | 0.00 | 4.00 |
| **WE06M023** | 6.96 | 5.84 | 0.00 | 0.00 | -12.32 | 0.00 | 0.49 |
| **WE07M002** | 7.20 | 6.08 | 0.00 | 0.00 | -7.44 | 0.00 | 5.84 |
| **WE06M028** | 19.67 | 0.93 | 0.00 | 0.00 | -3.41 | 0.00 | 17.19 |
| **WE06M027** | 27.43 | 0.00 | 0.00 | 0.00 | -15.99 | 0.00 | 11.44 |
| **CE07M018** | 28.30 | -2.30 | 0.00 | 0.00 | -5.34 | 0.00 | 20.66 |
| **EA08M007** | 24.90 | 0.00 | 0.00 | 0.00 | -27.03 | 0.00 | -2.13 |
| **EA07M006** | 2.00 | 0.00 | 0.00 | 0.00 | -0.51 | 0.00 | 1.49 |
| **Total** | **378.91** | **50.74** | **0.00** | **12.00** | **-102.27** | **0.00** | **339.38** |

**Table 19 RCx Program Results - Gas**

| RCx Savings | Energy Savings | | Summer Peak Day Savings | | Winter Peak Day Savings | | Extreme Peak Day Savings |
|---|---|---|---|---|---|---|---|
| | (CCF) | Adjustment / RR (%) | (CCF/Day) | Adjustment / RR (%) | (CCF/Day) | Adjustment / RR (%) | (CCF/Day) |
| Program calculated Savings Estimate | 77,187 | 100% | 22.88 | 100% | 928.89 | 100% | 0.00 |
| Documentation Adjustment | -7 | 0% | -22.88 | -100% | -3.47 | 0% | 0.00 |
| Technology Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% | 0.00 |
| Quantity Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% | 0.00 |
| Operation Adjustment | -30,682 | -40% | 0.00 | 0% | -258.91 | -28% | 780.95 |
| Heating and Cooling Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% | 0.00 |
| **Total Savings** | **46,498** | **60%** | **0.00** | **0%** | **666.50** | **72%** | **780.95** |

**Table 20 CCF Adjustments**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | CCF | CCF | CCF | CCF | CCF | CCF | CCF |
| CE08G049 | 8,350 | -7 | 0 | 0 | 913 | 0 | 9,256 |
| EA09G081 | 2,746 | 0 | 0 | 0 | -2,746 | 0 | 0 |
| WE09G058 | 34,430 | 0 | 0 | 0 | -14,148 | 0 | 20,282 |
| WE08G031 | 31,661 | 0 | 0 | 0 | -14,702 | 0 | 16,960 |
| **Total** | **77,187** | **-7** | **0** | **0** | **-30,682** | **0** | **46,498** |

**Table 21 Summer Peak Day CCF Adjustments**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day |
| CE08G049 | 22.88 | -22.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA09G081 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE09G058 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE08G031 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | **22.88** | **-22.88** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |

**Table 22 Winter Peak Day CCF Adjustments**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day |
| CE08G049 | 0.00 | 22.88 | 0.00 | 0.00 | 106.25 | 0.00 | 129.13 |
| EA09G081 | 708.00 | 0.00 | 0.00 | 0.00 | -708.00 | 0.00 | 0.00 |
| WE09G058 | 220.89 | -26.35 | 0.00 | 0.00 | 39.69 | 0.00 | 234.23 |
| WE08G031 | 0.00 | 0.00 | 0.00 | 0.00 | 303.15 | 0.00 | 303.15 |
| **Total** | **928.89** | **-3.47** | **0.00** | **0.00** | **-258.91** | **0.00** | **666.50** |

In order to better understand the results presented above, each of the technology categories are also summarized.

### 3.4.1 School Projects

The schools accounted for 10 of the 17 projects completed through the program in the years covered by the evaluation, with a total program calculated savings of 2,877,540 kWh and 235.44 kW of summer seasonal peak and 156.38 kW of winter seasonal peak. There are a total of four gas projects with a total of 77,187 CCF savings and 22.88 CCF of summer demand and 929 CCF of winter demand. The schools accounted for 49% of the program kWh savings and 100% of the gas savings in the years coved by the evaluation.

The savings for the schools are attributed to six different measure types; chilled water optimization, hot water optimization, air handling unit optimization, occupancy control of lights and HVAC equipment, lighting, and other. The majority of the savings at 52% are attributed to air handling unit optimization followed by occupancy senor controlled lights and HVAC equipment at 20%. The chilled water optimization accounts for 11%, lighting for 9%, hot water optimization for 8%, and other for 1%.

Table 23 summarizes the results for the school projects. The overall realization rate for the energy savings for the school projects was 70%. The adjustments were due to documentation adjustments, operation adjustments, and heating and cooling adjustments.

**Table 23 School Electrical Project Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) |
| **Program calculated Savings Estimate** | 2,877,540 | 100% | 235.44 | 100% | 156.38 | 100% |
| **Documentation Adjustment** | -117,364 | -4% | 3.97 | 2% | -0.77 | 0% |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Quantity Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Operation Adjustment** | -780,902 | -27% | 182.88 | 78% | 20.60 | 13% |
| **Heating and Cooling Adjustment** | 43,516 | 2% | 10.69 | 5% | 0.00 | 0% |
| **Total Savings** | **2,022,791** | **70%** | **432.98** | **184%** | **176.21** | **113%** |

Documentation adjustments accounted for approximately 4% of the reduction in the evaluation measured savings estimate. The savings adjustments were primarily due to corrections in the hours of operation and adjusting the kW/ton values used in the HVAC measures to be consistent with the kW/ton values calculated for the chilled water system.

Operation adjustments accounted for approximately 27% of the reduction in the ex post savings estimate. The reduction in savings is due to multiple factors.

The largest factor is that in many cases, the measures are no longer functioning or not functioning as designed. It is not clear if these measures were not functioning from the beginning or if they have failed since the project completion date. Some examples include air handling units that were expected to have reduced schedules; however the observed schedule includes more operating hours than the baseline schedule. It appears that program providers recommended separate school year and summer schedules of use to the schools. However, several of these schools had EMS systems that did not include the capability to record multiple schedules. Therefore, the user would need to switch over the schedule manually. Based on the data collected, this manual switch-over have not occurred.

The measure providing optimization of an energy recovery unit; however in the observed post-period, the unit never ran and outside air no longer is provided to the served portion of the school. There were also several occupancy sensors that did not function properly and some timer controls on kitchen exhaust fans that were not functioning.

A second factor that affected the savings is that the majority of the fan kW used to determine calculated savings, especially for scheduling, was based on nameplate nominal horsepower with an assumed load factor. Many of these load factors were found to be lower than the assumed value reducing the potential for savings. This was also true for building heating and cooling loads.

A third factor that affected the energy savings are the calculation errors in the original analysis with the largest being the double counting of cooling energy for several of the schools. The scheduling savings for both the chillers and the air handling units calculated cooling savings separately. This resulted in the cooling savings be claimed at the air handling units and again at the chiller when the chiller is the only device providing cooling. Calculating the cooling energy separately for the chiller and the air handling units will also not guarantee you have the same cooling load on both pieces of equipment. The savings should be calculated together as they are dependent systems.

Heating and cooling adjustments accounted for approximately 2% increase in the evaluation measured savings estimates. Heating and cooling adjustments were made to all lighting measures that did not claim heating and cooling savings due to reduced light fixture wattage and operating hours.

There are a total of four schools that have gas savings. The gas savings are attributed to any gas savings that resulted due to interaction with claimed electric measures. The majority of the gas savings are due to air handling unit optimization. Table 24 summarizes the results for the school gas projects. The overall realization rate for the school gas projects was 60%. All of the adjustments were due to documentation and operation adjustments.

**Table 24 School Gas Project Results**

| | Energy Savings | | Summer Peak Day Savings | | Winter Peak Day Savings | |
|---|---|---|---|---|---|---|
| | (CCF) | Adjustment /RR (%) | (CCF/Day) | Adjustment /RR (%) | (CCF/Day) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 77,187 | 100% | 22.88 | 100% | 928.89 | 100% |
| Documentation Adjustment | -7 | 0% | -22.88 | -100% | -3.47 | 0% |
| Technology Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| Quantity Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| Operation Adjustment | -30,682 | -40% | 0.00 | 0% | -258.91 | -28% |
| Heating and Cooling Adjustment | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| Total Savings | 46,498 | 60% | 0.00 | 0% | 666.50 | 72% |

The reduction in savings for the school gas projects are attributed to the same factors as the electrical savings with the primary reason being measures not functioning as designed based on scheduling and/or set-points. One of the school projects also incorrectly claimed peak day savings during the summer instead of the winter.

### 3.4.2Office Projects

The offices accounted for 6 of the 17 projects completed through the program in the years covered by the evaluation, with a total program calculated savings of 1,199,955 kWh and 247.56 kW of summer seasonal peak and 66.56 kW of winter seasonal peak. The offices accounted for 20% of the program kWh in the years coved by the evaluation.

Table 25 summarizes the results for the office projects. The overall realization rate for the office projects was 36%. All of the adjustments were due to documentation and operation adjustments.

**Table 25 Office Project Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) |
| Program calculated Savings Estimate | 1,199,955 | 100% | 247.56 | 100% | 66.56 | 100% |
| Documentation Adjustment | 221,424 | 18% | 207.12 | 84% | 34.12 | 51% |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Quantity Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Operation Adjustment** | -985,384 | -82% | -367.41 | -148% | -78.50 | -118% |
| **Heating and Cooling Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Total Savings** | **435,995** | **36%** | **87.28** | **35%** | **22.18** | **33%** |

It should be noted that five of the six projects are almost identical office buildings all managed by the same company. These five buildings had the same measures completed at each of them. The sixth project involved sequencing the chiller plant and repairing the chilled water plants' economizer controls.

Documentation adjustments accounted for approximately 18% of the increase in the evaluations measured savings estimate. Five of the twelve measures adjustments increased the savings due to inaccurate assumptions regarding the unloading characteristics for fans controlled by variable frequency drives. The remaining seven projects had slightly decreased the savings due to load factors and motor efficiencies not being appropriately applied.

Operation adjustments account for approximately 82% of the reduction in the evaluation measured savings estimate. The primary reason for the large operation reduction is due to the metered building cooling loads not being nearly as large as predicted in the original analysis. Specifically many of the projects included the assumption that the cooling equipment would be operating at full load during the high temperature bins. Based on the collected data, much of the cooling equipment was found to be oversized, therefore reducing the energy consumption and the associated savings potential.

For one building, the operation adjustment was due to a change in building ownership and building use and occupancy. This resulted in the cooling load of the building to be lower than at the time of the measure was installed. The project measure involved optimizing the chiller sequence at higher building loads which no longer occur at the current building operation resulting in the measure having minimal savings. The other five office buildings were found also to have lower than predicted cooling loads, which reduced the potential for savings due to condenser water reset. The second measure for the five buildings also did not realize the expected pressure reduction for the static pressure reset.

### 3.4.3Medical Projects

The medical facilities accounted for 1 of the 17 projects completed through the program in the years covered by the evaluation, with a total program calculated savings of 1,788,060 kWh, 167.43 kW of summer seasonal peak and 155.97 kW of winter seasonal peak. The medical facility accounted for 30% of the program kWh in the program years coved by the evaluation.

Table 26 summarizes the results for the medical projects. The overall realization rate for the medical projects was 105%. The adjustments were due to documentation, quantity, operation, and heating and cooling adjustments as shown below.

**Table 26 Medical Project Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment/RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) |
| **Program calculated Savings Estimate** | 1,788,060 | 100% | 167.43 | 100% | 155.97 | 100% |
| **Documentation Adjustment** | -223,286 | -12% | 28.08 | 17% | 17.39 | 11% |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Quantity Adjustment** | 105,120 | 6% | 12.00 | 7% | 12.00 | 8% |
| **Operation Adjustment** | 172,501 | 10% | 2.47 | 1% | -44.38 | -28% |
| **Heating and Cooling Adjustment** | 34,618 | 2% | 6.77 | 4% | 0.00 | 0% |
| **Total Savings** | **1,877,013** | **105%** | **216.76** | **129%** | **140.98** | **90%** |

Documentation adjustments accounted for approximately 12% of the reduction in the evaluation measured savings estimate. Five of the 17 measures did not have documentation that matches the claimed savings including documentation provided by the customer. The remaining adjustments were due to calculation errors that could be corrected based on information provided in the project files, typically involving operating hours of equipment or equipment specifications.

Quantity Adjustment accounted for approximately 6% of the increase in the evaluation measured savings estimate and are attributed to one project.

Operation adjustments accounted for approximately 10% of the increase in the evaluation measured savings estimate. Seven of the 17 measures increased the savings while five of the measures decreased the savings. The decrease in savings is largely due to lower than expected loads and operating hours on the equipment including the air compressors, lights, and garage exhaust fans. The increase in savings is largely due to the air handling unit optimization measures due to a larger average CFM than assumed in the original analysis, allowing for more savings potential.

Heating and Cooling adjustment accounted for approximately 2% of the increase in the measured savings estimate. One of the 17 measures was adjusted due to lack of e original calculations taking into account the HVAC interactive affects.

### 3.4.4 Documentation

The total project list was provided through a data extract of the CL&P project tracking system for the RCx program. The tracking system included information at both the project and measure level. It included the project number, name, contact information and address, program, and completion date at the project level. The measure level descriptions included the project number and name, measure status, measure description, and measure savings, and dates for status updates. The tracking system included all of the necessary information for project sampling as well as customer contact information.

The project documentation for the RCx program was collected as a combination of electronic files and hard copy files. All of the RCx projects had electronic files supplied with a few of the projects having additional documentation scanned from the hard copy files at the CL&P office by Michael's personnel. The electronic copies included multiple separate versions of the report and savings analyses files. Typically at least one version of the report and the analysis was included in the project documentation and details the final three steps of the four step approach the RCx program uses, starting with the survey and ending with implementation. The implementation files included the final calculations and as well as a complete copy of the O&M manual that was submitted to the customer.

Complete calculation files were included for all projects covered in the evaluation; however for eight of the 21 projects evaluated, the savings in the tracking system did not match the savings in the final version of the calculations in the project folders. For the largest electric saving project in the program, which accounted for over 30% of the claimed electrical energy savings for the years covered in the evaluation, no calculation files from the implementation portion of the project were supplied. The calculations were done by three different vendors with at least one project for each vender not having calculations that matched the claimed savings. There were no major differences between vendors.

At the project level, the documentation supplied did include a description of the findings from the audit, the measure intent, the design intent, and a list of hardware to complete the measure. These descriptions gave an explanation of the project; however their detail was not sufficient to fully describe the operation of the systems, especially for the case prior to completion of the project. For example, the project description may say that an air handling unit is being rescheduled; however, the hours of operation prior to being rescheduled are often not given.

This is extremely important in a program like RCx as the measures are not simple replacement of equipment and the energy savings are based on product specification. The savings are instead attributed to changing sequencing, set points, schedules, repairing damaged, worn, or out of calibration equipment including but not limited to sensors and dampers. The assessment of the baseline operating conditions is difficult to assess at the time of evaluation and thus the baseline operating condition is modeled based on the project description and customer interview.

## 3.5 Recommendations

In the evaluation process several recommendations were identified that could improve the RCx program to achieve more accurate energy savings.

- **Recommendation 1: The Companies should employ conservative assumptions when claiming savings for projects that require a manual change to set or maintain efficient operation. Our assessment demonstrates that those changes are frequently undone.**

  Several of the school projects had significant savings levels claimed for the implementation of reductions in operation for equipment during the summer months. However, due to system limitations, the systems needed to be manually changed to a "summer" mode. This was not consistently occurring. Therefore, we suggest using extreme caution when claiming savings for schedule or other changes that require a manual change in order for the savings to be realized.

- **Recommendation 2: The Companies should require that the operational conditions before and after an operational change or repair of failed equipment are fully documented, rather than only including a description of the change.**

  Many of the RCx measures include the replacement or repair of failed equipment. These can include replacing failed sensors that are reading incorrectly or fixing dampers that may be failed open. In the case of a failed temperature sensor, the description should include a description of how the sensor failed and the result on the system, such as: "The temperature sensor for the building was out of calibration and was reading 5°F low, resulting in the system changing over from heating to cooling mode incorrectly. This required and excessive reheating, which will be reduced."

  In addition, for operation changes the schedule or conditions before and after should be given, rather than saying the schedule was reduced by one hour or one inch of pressure drop was eliminated.

- **Recommendation 3: Load factors for motor, chiller, and other equipment should be based on collected data such as instantaneous measurements, short term metering, or BAS/EMS trended data.**

  Most of the projects evaluated used an assumed motor, chiller, or other equipment load factor to calculate savings. The assumed load factor was often greater than the actual load factor when determined based on the collected data. Therefore, we recommend that, when possible, load factors be based on collected data.

- **Recommendation 4: The Companies should calculate measure savings sequentially. For example, the baseline operation and energy consumption for the second measure should be calculated as incremental to the effects of completion of the first measure. Pre and post demand and energy consumption should be shown for each measure to ease the review process.**

  Savings were claimed for several of the school projects at both the chiller and HVAC equipment. In addition the HVAC cooling loads were not consistent with the chiller cooling loads. Therefore, we recommend that, savings be calculated including all building systems that interact with the energy efficiency measure to ensure the interactive affects are accounted for correctly and that the savings associated with each measure affecting the building system be calculated sequentially.

## 4. O&M Services Program

### 4.1 Background

The objective of the O&M Services program is to generate electric and non-electric energy savings for Connecticut customers through operational changes and repairs, rather than through capital investments. In addition, the objective is to assist the building owners and operators in systematically addressing the inefficiencies to produce lasting energy savings.

Within the O&M program, a significant area of focus is on compressed air systems and in particular the reduction of compressed air leaks. In order to address this, participants in the program complete a compressed air audit or at minimum a leak study. The leak study includes the marking or tagging of leaks found through physical inspection of the compressed air system as well as calculating the savings expected by repairing the tagged leaks. A compressed air audit will include a leak study as well as the identification of other inefficiencies of the compressed air system.

### 4.2 Sample Design

In order to determine the impacts for the O&M program, an appropriate sample needed to be selected (additional information is found in Appendix A). The requirement for the evaluation was to achieve ±10% precision at a 90% confidence level for energy savings as well as a ±10% precision at a 80% confidence level for demand reductions, to be consistent with the current protocols and requirements of the ISO New England Manual M-MVDR.

The projects were first stratified by technology. For the O&M program, the majority of the measures were found to be compressed air system improvements or PC energy management projects. These two categories included over 80% of the projects, comprising 87% of the electrical energy savings, 93% of the summer peak demand savings, and 95% of the winter peak demand savings. Therefore, all non-compressed air, non-PC energy management measures were grouped into the third technology strata. The breakdown of measures by strata is detailed in Table 27.

**Table 27 Measure Breakdown by Technology**

| Project Number | Measures | Program calculated kWh | Program calculated (Summer Seasonal Peak) | Program calculated (Winter Seasonal Peak) |
|---|---|---|---|---|
| **Compressed Air** | 57 | 6,667,577 | 1,038.6 | 1,038.6 |
| **PC Energy Management** | 55 | 4,076,631 | - | - |
| **All Other Measures** | 27 | 1,615,101 | 73.5 | 52.2 |
| **Total** | 139 | **12,359,309** | **1,112.1** | **1,090.7** |

Within each of the three technology strata, the projects were again examined and stratified by size. Projects that were very large within each technology group were included in a “certainty” stratum. All projects in the certainty stratum are targeted for evaluation. The remaining projects within each technology were classified based on logical breaks in savings levels. All measures in the certainty strata were targeted for evaluation. Within the non-certainty strata, measures were selected randomly for inclusion in the sample.

Table 28 shows the distribution of kWh measures by strata for the sample and population. Overall, our sample is consisted of 32% of the projects by count, 58% of the program energy savings, as well as approximately 80% of the summer and winter seasonal peak savings.

**Table 28: Sampling Frame, Sample Quotas, and Sample Size**

| Strata | | Universe | | Sample | |
|---|---|---|---|---|---|
| | | Count | Program Calculated kWh | Count | Program Calculated kWh |
| Air Certainty | >300,000 kWh | 4 | 3,338,587 | 4 | 3,338,587 |
| Air Large | 80,000 to 300,000 kWh | 14 | 2,463,116 | 5 | 794,909 |
| Air Medium | 40,000-80,000 kWh | 8 | 510,468 | 4 | 239,780 |
| Air Small | <40,000 kWh | 31 | 355,406 | 5 | 68,377 |
| Other Certainty | >100,000 kWh | 4 | 1,308,300 | 4 | 1,308,300 |
| Other Large | 20,000 to 100,000 kWh | 9 | 281,212 | 5 | 145,927 |
| Other Small | <20,000 kWh | 14 | 25,589 | 5 | 20,363 |
| PC Large | >100,000 kWh | 13 | 2,312,619 | 5 | 818,658 |
| PC Medium | 40,000 to 100,000 kWh | 25 | 1,583,218 | 5 | 343,486 |
| PC Small | <40,000 kWh | 17 | 180,794 | 2 | 37,005 |
| **All O&M** | | 139 | 12,359,309 | 44 | 7,115,392 |

Only three gas savings measures were included in the program for the years covered in the evaluation. All three of these projects were selected as a certainty sample. The gas savings are detailed in Table 29 below.

**Table 29 Gas Measure Savings**

| Sample Stratification | Projects | Program calculated CCF | Program calculated CCF/day (Winter) |
|---|---|---|---|
| **Gas** | 3 | 8,948 | 40.6 |

## 4.3 Evaluation and Methodology

The evaluation methodology for the O&M program involved review of all available project documentation, development of a site-specific measurement and verification plan, on-site measurement, and finally the analysis.

Prior to the site visit the project documentation was reviewed to identify the project and savings, verify the claimed savings, and identify any areas of concern. Once the project documentation has been reviewed a site specific measurement and verification plan (SSMVP) was written for each project. The SSMVP lays out for the site engineer the project description describing both the baseline and proposed conditions. It also lays out the questions for the site personal and the metering plan.

During the site visit for each project the site representative is questioned to verify the conditions before the project implementation as well as after. In addition the customer is also asked questions that clarify the state of the baseline condition, hours of operation, and any affects production or operations changes could have on the project. The equipment installation is verified and manufacturer and model numbers are recorded.

Additional data is collected based on each site's specific SSMVP using installed data loggers, Energy Management System trend files, and utility bills. For each project savings can be calculated using one or a combination of these methods. The O&M projects evaluation methodology was very similar within the different measure types; compressed air, PC control, and other projects.

The compressed air projects are largely dependent upon both equipment loads as well as hours of operation. Energy loggers were installed on all of the air compressors in the projects compressed air system. The metered data provides both the compressor loading as well as its time of use. This information combined with the manufacturer specification sheets and compressor control curves the metered kW is converted into flow profiles. The calculated flow profile is then adjusted based on the energy efficiency measure included leak repairs, artificial demand reduction, and new equipment including compressors, dryers, and blowers. The metered energy usage and calculated baseline energy usage are then used to make weekly hourly profiles that are compared to verify project savings.

The PC control projects utilized software that turned of the computers at fixed times of the day. This software reported energy savings based on the software's assumed PC wattage and recorded hours PCs are turned off. This information was used to calculate the number of hours the PCs was turned off by the software. During the on-site the time of days which the PCs are turned off by the software was collected and used to determine peak hour savings. Additionally a list of the PCs make and models was collected from the IT departments. This information was used to collect manufacture rated idle and sleep wattages. The calculated hours of operation and PC wattage was used to verify project savings.

The other projects are all of the projects that do not fit into the compressed air or PC control categories. These projects were unique and have their own evaluation methodology dependent upon the type of project. Projects that have fixed loads and are time dependent, such as lighting, were metered with time of used meters and either instantaneous kW readings or manufacture specification sheets were used to calculate the savings. Projects that both the hours and load of the equipment varied were metered using energy loggers that recorded the systems kW profile and hours of operation. Using the metered data the energy efficiency project was modeled including both the baseline and proposed conditions to verify energy savings.

## 4.4 Results and Conclusion

Table 30 and Table 34 present the program savings and realization rates, as well as the magnitudes of each adjustment factor. Table 31 through Table 33 and Table 35 through Table 36 show the savings and adjustments for each project in the sample.

As shown in Table 30, the expected gross realization rate for the O&M program is 73%±3% at a 90% confidence level for electrical energy savings. For the summer and winter seasonal peak savings, the expected gross realization rate is 84%±8% and 101%±10%, respectively, at an 80% confidence level. Table 34 shows the gross realization rate for the O&M program gas savings as 87% yearly CCF savings and 108% peak day CCF savings. All projects in the population were sampled; therefore, there is no associated confidence interval.

**Table 30 O&M Program Results - Electric**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | | Summer Peak Savings | Winter Peak Savings |
|---|---|---|---|---|---|---|---|---|
| | (kWh) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) | (kW) | Adjustment /RR (%) | (kW) | (kW) |
| **Program calculated Savings Estimate** | 12,359,309 | 100% | 1,112.09 | 100% | 1,090.71 | 100% | 0.00 | 0.00 |
| **Documentation Adjustment** | 184,412 | 1% | -12.98 | -1% | -12.98 | -1% | 0.00 | 0.00 |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% | 0.00 | 0.00 |
| **Quantity Adjustment** | -635,687 | -5% | -135.82 | -12% | -135.82 | -12% | 0.00 | 0.00 |
| **Operation Adjustment** | -2,990,012 | -24% | -28.80 | -3% | 154.14 | 14% | 844.84 | 1,147.01 |
| **Heating and Cooling Adjustment** | 73,486 | 1% | 3.56 | 0% | 3.79 | 0% | 1.78 | 1.92 |
| **Total** | **8,991,508** | **73%** | **938.05** | **84%** | **1,099.84** | **101%** | **846.62** | **1,148.94** |

**Table 31 Energy Savings (kWh) Adjustments - O&M Sample**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | kWh | kWh | kWh | kWh | kWh | kWh | kWh |
| CE06M003 | 354,654 | 0 | 0 | 0 | -14,493 | 0 | 340,161 |
| CE07M006 | 431,394 | 0 | 0 | 0 | 19,769 | 0 | 451,163 |
| CE09M005 | 237,348 | 86,591 | 0 | 0 | 100,662 | 0 | 424,601 |
| CE09M007 | 120,949 | 0 | 0 | 0 | -11,506 | 0 | 109,443 |
| CE09M007 | 13,906 | 0 | 0 | 0 | 11,542 | 0 | 25,448 |
| CE09M007 | 29,496 | 0 | 0 | 0 | -29,496 | 0 | 0 |
| EA06M011 | 85,760 | 0 | 0 | 0 | -8,192 | 0 | 77,568 |
| EA07M010 | 76,200 | 0 | 0 | 0 | 0 | 0 | 76,200 |
| EA09M015 | 57,934 | 0 | 0 | 0 | -33,681 | 0 | 24,253 |
| EA09M018 | 26,295 | 0 | 0 | 0 | -12,100 | 0 | 14,195 |
| WE06M038 | 175,437 | 0 | 0 | -66,971 | -17,456 | 0 | 91,010 |
| WE07M005 | 35,075 | 0 | 0 | 10,578 | -25,154 | 0 | 20,499 |
| WE07M015 | 164,016 | 0 | 0 | -12,849 | -84,599 | 0 | 66,568 |
| WE07M019 | 156 | 0 | 0 | 0 | -116 | 0 | 40 |
| WE07M022 | 58,156 | 0 | 0 | -4,556 | -29,386 | 0 | 24,214 |
| WE07M029 | 3,474 | 0 | 0 | 5,790 | -5,555 | 0 | 3,709 |
| WE07M034 | 1,930 | 0 | 0 | -965 | -432 | 0 | 533 |
| WE07M039 | 56,472 | 0 | 0 | -2,496 | -33,946 | 0 | 20,030 |
| WE07M041 | 48,048 | 0 | 0 | 7,800 | -36,713 | 0 | 19,135 |
| WE07M047 | 214,032 | 0 | 0 | 0 | -155,190 | 0 | 58,842 |
| WE07M049 | 75,192 | 0 | 0 | 0 | -60,302 | 0 | 14,890 |
| WE07M053 | 77,688 | 0 | 0 | -16,848 | -39,452 | 0 | 21,388 |
| WE07M056 | 1,872 | 0 | 0 | 936 | -1,950 | 0 | 858 |
| WE07M060 | 232,748 | 0 | 0 | 0 | 92,419 | 0 | 325,167 |
| WE07M064 | 2,191,048 | 0 | 0 | 0 | -785,067 | 0 | 1,405,981 |
| WE07M064 | 261,602 | 0 | 0 | 0 | -259,539 | 0 | 2,063 |
| WE07M064 | 19,875 | 0 | 0 | 0 | 3,012 | 0 | 22,887 |
| WE07M064 | 396,085 | 0 | 0 | -333,702 | 281 | 0 | 62,664 |
| WE07M064 | 218,150 | 0 | 0 | -24,585 | -12,967 | 0 | 180,598 |
| WE08M008 | 8,974 | 0 | 0 | 0 | 9,783 | 0 | 18,757 |
| WE08M012 | 114,371 | 0 | 0 | 0 | -18,510 | 26,961 | 122,821 |
| WE08M012 | 3,027 | 0 | 0 | 0 | 5,570 | 2,418 | 11,015 |
| WE09M030 | 375,255 | 0 | 0 | 0 | -66,662 | 0 | 308,593 |
| WE09M030 | 8,206 | 0 | 0 | 0 | -8,206 | 0 | 0 |
| WE09M030 | 28,858 | 0 | 0 | 0 | 51,439 | 0 | 80,297 |
| WE09M037 | 23,962 | 0 | 0 | 0 | -3,979 | 0 | 19,983 |
| WE10M004 | 186,144 | 0 | 0 | -12,389 | -13,315 | 0 | 160,441 |
| WE10M009 | 38,127 | 0 | 0 | 0 | -11,421 | 16,291 | 42,997 |
| AmGo | 30,727 | 0 | 0 | 0 | -17,072 | 0 | 13,655 |
| B1uK | 32,675 | 0 | 0 | 0 | -11,159 | 0 | 21,516 |
| Akiu | 65,016 | 0 | 0 | 0 | -12,054 | 0 | 52,962 |
| Aio7 | 12,110 | 0 | 0 | 0 | -2,906 | 0 | 9,204 |
| EA07M001 | 39,938 | 0 | 0 | 0 | 15,789 | 0 | 55,727 |
| EA06M004 | 640,000 | 0 | 0 | 0 | 0 | 0 | 640,000 |
| **Total** | **7,334,529** | **86,591** | **0** | **-450,257** | **-1,550,850** | **45,670** | **5,465,683** |

**Table 32 Summer Seasonal Peak kW Adjustments - O&M Sample**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | kW | kW | kW | kW | kW | kW | kW |
| CE06M003 | 56.40 | 0.00 | 0.00 | 0.00 | -26.65 | 0.00 | 29.75 |
| CE07M006 | 43.78 | 0.00 | 0.00 | 0.00 | 7.78 | 0.00 | 51.56 |
| CE09M005 | 51.67 | -6.68 | 0.00 | 0.00 | 3.92 | 0.00 | 48.91 |
| CE09M007 | 10.00 | 0.00 | 0.00 | 0.00 | 3.25 | 0.00 | 13.25 |
| CE09M007 | 4.00 | 0.00 | 0.00 | 0.00 | -0.39 | 0.00 | 3.61 |
| CE09M007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA06M011 | 1.40 | 0.00 | 0.00 | 0.00 | 11.21 | 0.00 | 12.61 |
| EA07M010 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA09M015 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA09M018 | 7.40 | 0.00 | 0.00 | 0.00 | -3.40 | 0.00 | 4.00 |
| WE06M038 | 0.00 | 0.00 | 0.00 | 0.00 | 1.83 | 0.00 | 1.83 |
| WE07M005 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.26 |
| WE07M015 | 0.00 | 0.00 | 0.00 | 0.00 | 3.65 | 0.00 | 3.65 |
| WE07M019 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.03 |
| WE07M022 | 0.00 | 0.00 | 0.00 | 0.00 | 1.31 | 0.00 | 1.31 |
| WE07M029 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M034 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.17 |
| WE07M039 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M041 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M047 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M049 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M053 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M056 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M060 | 49.00 | 0.00 | 0.00 | 0.00 | -11.88 | 0.00 | 37.12 |
| WE07M064 | 214.00 | 0.00 | 0.00 | 0.00 | -65.04 | 0.00 | 148.96 |
| WE07M064 | 35.00 | 0.00 | 0.00 | 0.00 | -35.12 | 0.00 | -0.12 |
| WE07M064 | 1.07 | 0.00 | 0.00 | 0.00 | 5.24 | 0.00 | 6.31 |
| WE07M064 | 52.89 | 0.00 | 0.00 | -45.77 | -5.18 | 0.00 | 1.94 |
| WE07M064 | 69.92 | 0.00 | 0.00 | -47.82 | -18.20 | 0.00 | 3.90 |
| WE08M008 | 0.00 | 0.00 | 0.00 | 0.00 | 1.53 | 0.00 | 1.53 |
| WE08M012 | 9.49 | 0.00 | 0.00 | 0.00 | 1.45 | 0.00 | 10.94 |
| WE08M012 | 0.28 | 0.00 | 0.00 | 0.00 | 0.65 | 0.00 | 0.93 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 7.40 | 0.00 | 7.40 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 16.62 | 0.00 | 16.62 |
| WE09M037 | 1.19 | 0.00 | 0.00 | 0.00 | 3.96 | 0.00 | 5.15 |
| WE10M004 | 0.00 | 0.00 | 0.00 | 0.00 | 0.83 | 0.00 | 0.83 |
| WE10M009 | 0.00 | 0.00 | 0.00 | 0.00 | 2.91 | 1.78 | 4.69 |
| AmGo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B1uK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Akiu | 10.80 | 0.00 | 0.00 | 0.00 | -10.80 | 0.00 | 0.00 |
| Aio7 | 25.00 | 0.00 | 0.00 | 0.00 | 4.78 | 0.00 | 29.78 |
| EA07M001 | 6.30 | 0.00 | 0.00 | 0.00 | -3.47 | 0.00 | 2.83 |
| EA06M004 | 162.70 | 0.00 | 0.00 | 0.00 | -152.79 | 0.00 | 9.91 |
| **Total** | **822.38** | **-6.68** | **0.00** | **-93.59** | **-260.23** | **1.78** | **463.66** |

**Table 33 Winter Seasonal Peak kW Adjustments - O&M Sample**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | kW | kW | kW | kW | kW | kW | kW |
| CE06M003 | 56.40 | 0.00 | 0.00 | 0.00 | -19.77 | 0.00 | 36.63 |
| CE07M006 | 43.78 | 0.00 | 0.00 | 0.00 | 7.56 | 0.00 | 51.34 |
| CE09M005 | 51.67 | -6.68 | 0.00 | 0.00 | 3.57 | 0.00 | 48.56 |
| CE09M007 | 10.00 | 0.00 | 0.00 | 0.00 | 3.25 | 0.00 | 13.25 |
| CE09M007 | 4.00 | 0.00 | 0.00 | 0.00 | -1.02 | 0.00 | 2.98 |
| CE09M007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA06M011 | 1.40 | 0.00 | 0.00 | 0.00 | 11.16 | 0.00 | 12.56 |
| EA07M010 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EA09M015 | 0.00 | 0.00 | 0.00 | 0.00 | 4.73 | 0.00 | 4.73 |
| EA09M018 | 7.40 | 0.00 | 0.00 | 0.00 | -3.84 | 0.00 | 3.56 |
| WE06M038 | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 0.00 | 1.19 |
| WE07M005 | 0.00 | 0.00 | 0.00 | 0.00 | 1.59 | 0.00 | 1.59 |
| WE07M015 | 0.00 | 0.00 | 0.00 | 0.00 | 15.03 | 0.00 | 15.03 |
| WE07M019 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M022 | 0.00 | 0.00 | 0.00 | 0.00 | 5.48 | 0.00 | 5.48 |
| WE07M029 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M034 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE07M039 | 0.00 | 0.00 | 0.00 | 0.00 | 5.33 | 0.00 | 5.33 |
| WE07M041 | 0.00 | 0.00 | 0.00 | 0.00 | 2.31 | 0.00 | 2.31 |
| WE07M047 | 0.00 | 0.00 | 0.00 | 0.00 | 7.09 | 0.00 | 7.09 |
| WE07M049 | 0.00 | 0.00 | 0.00 | 0.00 | 1.80 | 0.00 | 1.80 |
| WE07M053 | 0.00 | 0.00 | 0.00 | 0.00 | 2.58 | 0.00 | 2.58 |
| WE07M056 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.10 |
| WE07M060 | 49.00 | 0.00 | 0.00 | 0.00 | -11.88 | 0.00 | 37.12 |
| WE07M064 | 214.00 | 0.00 | 0.00 | 0.00 | -41.65 | 0.00 | 172.35 |
| WE07M064 | 35.00 | 0.00 | 0.00 | 0.00 | -35.33 | 0.00 | -0.33 |
| WE07M064 | 1.07 | 0.00 | 0.00 | 0.00 | 1.94 | 0.00 | 3.01 |
| WE07M064 | 52.89 | 0.00 | 0.00 | -45.77 | -4.90 | 0.00 | 2.22 |
| WE07M064 | 69.92 | 0.00 | 0.00 | -47.82 | -23.80 | 0.00 | -1.71 |
| WE08M008 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE08M012 | 6.98 | 0.00 | 0.00 | 0.00 | 3.96 | 0.00 | 10.94 |
| WE08M012 | 0.21 | 0.00 | 0.00 | 0.00 | 0.73 | 0.00 | 0.94 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 52.26 | 0.00 | 52.26 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE09M030 | 0.00 | 0.00 | 0.00 | 0.00 | 13.17 | 0.00 | 13.17 |
| WE09M037 | 1.19 | 0.00 | 0.00 | 0.00 | 3.85 | 0.00 | 5.04 |
| WE10M004 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE10M009 | 0.00 | 0.00 | 0.00 | 0.00 | 3.04 | 1.86 | 4.90 |
| AmGo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B1uK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Akiu | 10.80 | 0.00 | 0.00 | 0.00 | 33.10 | 0.00 | 43.90 |
| Aio7 | 25.00 | 0.00 | 0.00 | 0.00 | -25.00 | 0.00 | 0.00 |
| EA07M001 | 6.30 | 0.00 | 0.00 | 0.00 | -3.78 | 0.00 | 2.52 |
| EA06M004 | 162.70 | 0.00 | 0.00 | 0.00 | -152.79 | 0.00 | 9.91 |
| **Total** | **819.80** | **-6.68** | **0.00** | **-93.59** | **-145.59** | **1.86** | **575.79** |

**Table 34 O&M Program Results - Gas**

| O&M Savings | Energy Savings | | Peak Day Savings | | Extreme Peak Day Savings |
|---|---|---|---|---|---|
| | (CCF) | Adjustment /RR (%) | (CCF/Day) | Adjustment /RR (%) | (CCF/Day) |
| Program calculated Savings Estimate | 8,948 | 100% | 40.57 | 100% | 0.00 |
| Documentation Adjustment | 0 | 0% | 0.00 | 0% | 0.00 |
| Technology Adjustment | 0 | 0% | 0.00 | 0% | 0.00 |
| Quantity Adjustment | 0 | 0% | 0.00 | 0% | 0.00 |
| Operation Adjustment | -1,139 | -13% | 3.33 | 8% | 43.90 |
| Heating and Cooling Adjustment | 0 | 0% | 0.00 | 0% | 0.00 |
| **Total Savings** | **7,809** | **87%** | **43.90** | **108%** | **43.90** |

**Table 35 CCF Adjustments**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | CCF | CCF | CCF | CCF | CCF | CCF | CCF |
| CE09G002 | 888 | 0 | 0 | 0 | -888 | 0 | 0 |
| EA08G007 | 1377 | 0 | 0 | 0 | -1377 | 0 | 0 |
| WE09G061 | 6683 | 0 | 0 | 0 | 1126 | 0 | 7809 |
| **Total** | **8948** | **0** | **0** | **0** | **-1139** | **0** | **7809** |

**Table 36 Peak Day CCF Adjustments**

| Project Info | Program | Documentation | Technology | Quantity | Operation | HVAC | Total Measured |
|---|---|---|---|---|---|---|---|
| Project # | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day | CCF/Day |
| CE09G002 | 0.80 | 0.00 | 0.00 | 0.00 | -0.80 | 0.00 | 0.00 |
| EA08G007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WE09G061 | 39.77 | 0.00 | 0.00 | 0.00 | 4.13 | 0.00 | 43.90 |
| **Total** | **40.57** | **0.00** | **0.00** | **0.00** | **3.33** | **0.00** | **43.90** |

In order to better understand the results presented above, each of the technology categories are also summarized.

### 4.4.1 Compressed Air Projects

The compressed air projects included a variety of compressed air system improvements. A total of 57 compressed air projects were completed through the program in the years covered by the evaluation, with a total program calculated savings of 6,657,577 kWh and 1,038.6 kW of summer and winter seasonal peak reductions. Eleven projects, totaling 4,367,127 kWh of savings and 604.9 kW of summer and winter seasonal peak reductions, were included in the sample for evaluation.

The most common system improvement was leak reductions. Of the eleven compressed air projects evaluated, ten included reductions in compressed air leaks with eight of the projects being limited to leak reductions. Within the sample, leak reductions accounted for approximately 1,930,121 kWh of savings, however the exact savings could not be determined as savings calculations were not included for all projects.

In addition to leak reductions, two projects included reductions in system pressure resulting in more efficient compressor operation and reduced artificial demand, one project involved compressor scheduling, installing solenoid valves and other system modifications. One project also included the installation of new compressors and dryers.

Table 37 summarizes the results for the compressed air projects. Based on the sampled sites, the overall realization rate for the energy savings for the compressed air projects was 81% for energy savings. All of the adjustments were due to documentation, quantity and operation adjustments.

**Table 37 Compressed Air Project – Program Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustments /RR (%) | (kW) | Adjustments /RR (%) | (kW) | Adjustments /RR (%) |
| **Program calculated Savings Estimate** | 6,667,577 | 100% | 1,038.55 | 100% | 1,038.55 | 100% |
| **Documentation Adjustment** | 184,412 | 3% | -12.98 | -1% | -12.98 | -1% |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Quantity Adjustment** | -363,403 | -5% | -135.82 | -13% | -135.82 | -13% |
| **Operation Adjustment** | -1,086,285 | -16% | -239.79 | -23% | -226.22 | -22% |
| **Heating and Cooling Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Evaluation measured Savings** | **5,402,301** | **81%** | **649.96** | **63%** | **663.53** | **64%** |

It should also be noted that a single project accounted for nearly 3.1GWh of the program calculated savings, or approximately 45% of the compressed air project savings for the years covered by the evaluation. The savings for this for this project were reduced to approximately 1.7 GWh. Several factors contributed to the reductions to this project.

First, the cfm reductions due to the leaks and solenoid valves appeared excessive. For example, by fixing the leaks and installing the solenoid valves, the original project documentation indicated a potential reduction in compressed air demands of 1,288 cfm. However, also based on the supplied documentation, the compressed air system only used an average of 787 cfm during non-production periods, when these savings were expected to occur.

Second, the installation of the occupancy sensor controlled solenoid valves was expected to reduce the cfm demands of the workstations when the workstations were unoccupied, approximately 7,488 hours. However, based on discussions with the customer, these workstations were found to be occupied approximately 6,100 hours per year, or unoccupied only approximately 2,660 hours per year.

For the remainder of the sampled projects, individual sites had savings adjusted up or down based on the observed and metered site conditions; overall the savings for the remainder of the sample were adjusted upwards.

### 4.4.2Computer Projects

The PC controls projects involve the installation of a PC power management software package. The software would turn off the computer workstations during times that they are not expected to be in use, such as during overnight or weekend hours. For the years covered in this evaluation, a total of 55 projects were for PC controls, with a total program calculated savings of 4,076,631 kWh. No summer or winter seasonal peak savings were claimed. Of these 55 projects, fifteen projects, with a total program calculated savings of 1,231,670 kWh, were included in the sample for the evaluation.

Table 38 summarizes the results for the PC projects. Based on the sampled sites, the overall realization rate for the PC projects was 41% for energy savings. All of the adjustments were due to quantity adjustments or operation adjustments.

**Table 38 PC Project Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustment /RR (%) | (kW) | Adjustments /RR (%) | (kW) | Adjustments /RR (%) |
| **Program calculated Savings Estimate** | 4,076,631 | 100% | 0.00 | N/A | 0.00 | N/A |
| **Documentation Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | N/A |
| **Technology Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | N/A |
| **Quantity Adjustment** | -272,283 | -7% | 0.00 | N/A | 0.00 | N/A |
| **Operation Adjustment** | -1,819,044 | -45% | 25.06 | N/A | 148.42 | N/A |
| **Heating and Cooling Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | N/A |
| **Evaluation measured Savings** | 1,985,303 | 49% | 25.06 | N/A | 148.42 | N/A |

Quantity adjustments accounted for approximately 9% of the reduction in the evaluation measured savings estimate. Seven projects had savings adjusted upwards, with eight projects having savings adjusted downwards. The primary cause for adjustment was that the number of computers that the software was controlling to turn off was greater or less than the number of controlled computers claimed in the original analysis.

One site had the savings set to zero due to a quantity adjustment. Savings were originally claimed for this site for the installation of software to control a total of 635 computers at a school. The software was installed on these computers; however, at the end of the school year the computers were reimaged and the software package was never reinstalled.

For all seven projects that had the savings increased as a result of a quantity adjustment the increases were due to the facility increasing the number of computers at the facility and purchasing additional licenses for the new computers.

Operational adjustments accounted for the remaining 49% of the reduction in the savings measured in this evaluation. The primary cause for savings reductions due to operational adjustments was due to the wattage per workstation being greatly overestimated in the original analysis compared to the wattages of the workstations observed. Specifically, many of the projects based the savings estimates on a per workstation demand of approximately 65W per computer and 45W per monitor, or 110W total. However, the computers examined during the evaluation typically had lower demands of approximately 50W. The monitors were found to be LCD screens with demands typically in the 25W range.

Several sites had savings reduced because the original analysis included the installation of the software on servers. The servers did have the software installed; however, the software settings were set so as not to turn the servers off. Additionally, some schools were in the process of switching from desktop computers to laptop computers. The laptop computers typically had the software disabled.

It should also be noted that of the fifteen projects evaluated, eight projects were found to be set to turn the computers off late in the evening (typically between 11:00 PM and midnight) to allow updates to be pushed to the computers. These sites were schools or government buildings that typically were not using the computers beyond 5:00-6:00 p.m.

### 4.4.3“Other” Projects

The “other” project category involved all electric projects that did not fit into the compressed air or PC controls categories. The projects completed included:

- Efficient transformers
- Insulated receiving door
- Duct insulation
- Lighting rewiring and occupancy sensor installation
- EMS system additions
- Carbon monoxide control for exhaust fans in a parking garage
- Anti-sweat heater controls
- Condenser coil cleaning
- Steam trap replacement

For the years covered in this evaluation, a total of 27 projects were for Other Projects, with a total program calculated savings of 1,615,101 kWh, 73.5 kW of summer peak seasonal peak savings and 52.2 kW of winter seasonal peak savings. Of these 27 projects, nine projects, with a total calculated savings of 1,095,732 kWh were included in the sample for the evaluation. There are a total of three gas projects with a total of 8,948 CCF savings and 0.00 CCF of summer demand and 40.57 CCF of winter demand.

Table 38 summarizes the results for the Other Projects. Based on the sampled sites, the overall realization rate for these projects was 99%. Adjustments were due to quantity adjustments or operation adjustments.

**Table 39 "Other" Project Results**

| | Energy Savings | | Summer Seasonal Peak Savings | | Winter Seasonal Peak Savings | |
|---|---|---|---|---|---|---|
| | (kWh) | Adjustments /RR (%) | (kW) | Adjustments /RR (%) | (kW) | Adjustments /RR (%) |
| **Program calculated Savings Estimate** | 1,615,101 | 100% | 73.54 | 100% | 52.16 | 100% |
| **Documentation Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Technology Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Quantity Adjustment** | 0 | 0% | 0.00 | 0% | 0.00 | 0% |
| **Operation Adjustment** | -84,683 | -5% | 185.94 | 253% | 231.94 | 445% |
| **Heating and Cooling Adjustment** | 73,486 | 5% | 3.56 | 5% | 3.79 | 7% |
| **Evaluation measured Savings** | 1,603,904 | 99% | 263.03 | 358% | 287.89 | 552% |

Operation adjustments accounted for an approximately 4% reduction in the savings estimate as measured through the evaluation. Due to the wide range of technologies implemented, the individual project-level savings adjustments and the resulting realization rates had were widely varying with no clear or consistent pattern. However, the most common adjustments involved changes to equipment loading or hours of operation compared to the assumptions used in the original analysis. However, this adjustment was counteracted by a 5% increase in savings due to heating and cooling interactive effects adjustments.

Three projects have gas savings. Table 40 summarizes the results for the "Other" gas projects. The overall realization rate for the "Other" gas projects was 87%. All of the adjustments were due to the operation adjustment.

**Table 40 "Other" Gas Project Results**

| | Energy Savings | | Summer Demand Savings | | Winter Demand Savings | |
|---|---|---|---|---|---|---|
| | (CCF) | Adjustments /RR (%) | (CCF) | Adjustments /RR (%) | (CCF) | Adjustments /RR (%) |
| **Program calculated Savings Estimate** | 8,948 | 100% | 0.00 | N/A | 40.57 | 100% |
| **Documentation Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | 0% |
| **Technology Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | 0% |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Quantity Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | 0% |
| **Operation Adjustment** | -1,139 | -13% | 0.00 | N/A | 3.33 | 8% |
| **Heating and Cooling Adjustment** | 0 | 0% | 0.00 | N/A | 0.00 | 106% |
| **Measured Savings** | **7,809** | **87%** | **0.00** | **N/A** | **43.90** | **108%** |

The reduction in savings for the "Other" gas projects is attributed to two of the projects having measured savings of zero. One of the projects was the optimization of a heat recovery unit; however based on the data collected for this project, the unit does not run. It should be noted that this unit is the only source of ventilation for a wing of a school.

The second project was a water treatment system for a boiler. The savings for this project are due to reducing boiler blow down; however the maintenance personnel doesn't trust the boiler blow-down controls and manually opens the blow-down valve for the boiler the same as before the project implementation.

The third project was the repair of the condensate return tank. The project was found to be operating for more hours per year than anticipated in the original analysis. Additionally, the condensate was found to be at a higher temperature than originally anticipated, and the boiler was less efficient than anticipated. All three of these changes increase the measured savings in the evaluation analysis.

### 4.4.4 Persistence of Savings

The persistence of the compressed air projects was a special interest of the program and was investigated as part of the evaluation. As part of the program, many of the customers that completed a leak study received a leak detector and 2 hours of training to help the customer detect and repair future leaks. Of the ten compressed air projects that were evaluated, 6 of the 7 medium, large and certainty projects had a leak audit performed as part of the evaluation process to determine how effective the leak detectors and persistence training are at reducing the number of leaks. Eight of the ten customers filled out a survey regarding their compressed air projects and the compressed air program.

Only one of the surveyed sites reported using the provided leak detector on a regular basis to survey their facility for leaks. The leaks were surveyed as part of the 3rd shift maintenance schedule and the entire facility would be covered over a period of approximately 2 months. This site also had the lowest leak level of any site audit, with approximately 1% of the average compressed air demand being attributed to leaks. At the time of the original project completion, leaks accounted for 18% of the compressed air demand. At a second site, flow meters had been installed and the maintenance manager would periodically check the compressed air demands over the weekend when no equipment was using compressed air to keep a check on the leak rate. However, this was not an official part of his job. Also, he has since left the company and indicated that it was unlikely that periodic checks would continue after he left, as no other staff had been trained in this function. At the time of the original project completion, 36% of the compressed air demand was leaks. During the evaluation, only 8% of the compressed air demand was leaks.

The remaining facilities reported that leaks are repaired when found but there is no formal leak detection program. Some of the customers had indicated they no longer know how to use the leak detector while another customer compared the leak detection process to an "Easter egg hunt".

### 4.4.5 Documentation

The total project list was provided through a data extract of the CL&P and UI project tracking systems for the O&M program. The tracking system included information at both the project and measure level. It included the project number, name, contact information and address, program, and completion date at the project level. The measure level descriptions included the project number and name, measure status, measure description, and measure savings, and dates for status updates. The tracking system included all of the necessary information for project sampling as well as customer contact information. It should be noted that the UI tracking system was not filled out completely and several of the projects did not have measure descriptions.

The documentation for the O&M program was collected as a combination of electronic files and hard copy files collected by evaluation personal from the CL&P office. All of the UI projects were supplied in electronic format.

The actual collection of the hard copy project information was a difficult task. Initial difficulties in locating project files resulted in projects having to be removed from the sample and replaced with backups. However, the documentation for all but three of the projects was able to be located at a later date, which allowed the sites to be reinserted into the sample.

Twelve of the 38 projects sampled had documentation provided in electronic format with eight of the files having calculations in excel. Four projects did not have any calculations in the provided documentation to review. The remaining projects had calculations that were provided in pdf format.

## 4.5 Recommendations

In the evaluation process several recommendations were identified that could increase the ability of the O&M program PA's to achieve more accurate energy savings.

- **Recommendation 5: The Companies should afford greater scrutiny to the large projects that make up a significant portion of the program portfolio. This can be done by additional levels of review to allow additional people to review the project or increased metering requirements by collecting both pre and post data.**

  One of the compressed air projects comprised of 46% of the evaluated O&M program savings and 25% of the entire O&M program savings. Several significant errors were found in the analysis which resulted in a 54% realization rate for the project which was not representative of the remaining compressed air projects.

- **Recommendation 6: Equipment energy specifications should be double-checked, especially for projects where equipment wattages are applied over a large number of installations.**

  Many of the PC projects were penalized due to the PC wattage being significantly lower than the assumed wattages.

- **Recommendation 7: The customers should be required to make leak detection a regularly occurring part of the facility maintenance. Additionally, the possibility of offering a limited incentive for in-house leak detection and repair should be investigated to encourage persistence of savings for leak reduction.**

  While reviewing the compressed air projects and investigating the persistence of leak repairs it became apparent that many of the companies were not using the provided leak detector on a regular basis. The two companies that were performing leak tests had either made it part of the maintenance program or was driven by a site engineer. The latter has now left the company and leak testing is no longer a focus of the maintenance team.

- **Recommendation 8: Reinstating the distribution of leak detectors under the O&M Services program should be investigated, along with periodic education or training.**

  The compressed air sites that were investigated for the persistence of leaks it was clear that sites that actively searched out and repaired leaks had lower leakage rates than companies who were not actively repairing leaks. Some of the limiting factors appeared to be the lack of leak detection in maintenance plans and the lack of understanding on how to use the leak detector.

# 5. The Business Sustainability Challenge (BSC) Program

## 5.1 Background

The Business Sustainability Challenge (BSC) pilot program was created to educate and train customers to achieve deeper and longer-lasting energy savings through development of a company culture of sustainability.

The objectives of the BSC are:

- To provide technical resources, training and guidance that will assist participating organizations to develop a sustainability strategy; which will include a comprehensive energy management plan and reduction goals.
- To reduce customer costs and environmental impacts associated with energy, waste, resource use and/or carbon emissions
- To improve the economic, social and financial value of participating organizations, thereby maintaining viable and profitable businesses in Connecticut and promoting economic development.

In order to accomplish those objectives, customers entered either Track A or Track B variations of the BSC program, while two entered both tracks.

Track A is operated by United Illuminating and consisted of a one-on-one consultation process. In this track customers are educated through one-on-one meetings with utility staff and industry experts. The one-on-one meetings allow the topics covered and the application of the topics to be flexible and closely aligned with the individual customer's needs and desires.

Track B is administered by CL&P and consisted of a group or curriculum based process. Participants in Track B attended eight monthly meetings in a classroom setting with other participants. For each class, the participant is given "homework" to apply the information from the class to their company. In addition, following completion of the eight monthly meetings, each participant company has a six month period of independent sustainability development. Following the six month period, the program concludes with a reunion of participants to discuss progress and challenges.

It is important to note that the evaluated program no longer exists, having been replaced by a single approach that utilizes portions of each track.

## 5.2 Customer Case Studies

Because the program offers significant technical assistance and has relatively few participants, the evaluation lent itself to a case study approach to learn important details affecting each participant's experience. Notably, a case study approach utilizing semi-structured, in-depth interviews allows researchers to learn not only *what* happened, but also *why* companies responded to their participation in different ways, and what factors most influenced their actions (or lack thereof). These specific factors (e.g., competitive environment, company culture, firm-specific production constraints, and resource availability) are important to understand, so the effectiveness of the program is not misunderstood or underestimated where unique or insurmountable barriers exist. In contrast, other research tools, such as telephone surveys, can provide a broader perspective (across many participants), but are less suited for obtaining project details, seeking clarifications, and learning about important context considerations.

In order to assess the impacts of the BSC program, nine participants responded and were interviewed. The interviewed attempted to identify what steps the customers have taken towards sustainability due to their participation in the BSC study.

Of the companies that were interviewed, two participated in the Track A option, five participated in the Track B option, and two participated in both the Track A and the Track B option. The specific tracks that each company interviewed completed are given in Table 41 below.

**Table 41 BSC Participant Tracks**

| Company | Track A: Consultant | Track B: Classes |
|---|---|---|
| Company A | | X |
| Company B | | X |
| Company C | X | |
| Company D | | X |
| Company E | X | X |
| Company F | | X |
| Company G | X | X |
| Company H | | X |
| Company I | X | |

### 5.2.1 Company A

**Company Sector:** Manufacturing

**BSC Participation Track:** Classes

**Staffing**

Activities related to sustainability and BSC participation are managed by the Environmental Health & Safety (EHS) Director. According to the Director, The EHS team meets monthly and “is like a Green Team." It is comprised of nine staff (with 5 or 6 “core” members), and the Director reports to the Vice President of Operations, who monitors the group’s initiatives. The EHS team focuses on "practical” short-term projects pertaining to technical water, wastewater and energy issues, and not “social issues” (e.g., charitable giving). Company budgets are linked to core operations only; there is no specific "green" funding.

This rural company has water usage constraints, and is also focused on wastewater quality and electricity consumption. Specialized chemical use/reductions staff are focused on improving wastewater quality, and there is a specialized "electric savings team." While the EHS team used to solicit projects ideas from all employees, most ideas now come through the specialized teams to the larger EHS team. There are no broad communications to all staff about EHS achievements. The company is ISO 14000 certified and required to regularly monitor EHS, and no staffing changes are planned.

**Metrics and Tracking**

The company has monitored its electricity, water use, and wastewater quality for a while now, since this is required for ISO 14000 certification. According to the Director, the ISO standard has only general tracking requirements, and companies have flexibility regarding the data that actually comprise the reported metrics. (The ISO reporting also requires ongoing risk assessment of environmental impacts from production.)

For its tracking the company utilizes monthly utility bills, monthly production and inventory reports, chemical usage reports, and daily water usage. After participating in the BSC the company began normalizing electric and water consumption and chemical usage to production units, and learned that while electricity and water usage had been declining prior to BSC, the declines were not as impressive when normalized for business activity. According to the interviewed Director, it was not difficult or controversial to normalize energy and water use for production.

Greenhouse gases are not a major output or concern of the company, and are "being addressed by regional generators via RGGI." The company did calculate (unspecified, indirect) emissions for the first time after BSC and discussed potential alternative energy sources, but this would have introduced unacceptable business process risk and was not pursued.

**Goals**

The company initially aimed for 5 percent annual reductions in water and wastewater, but now just hopes for any decline, since many conservation projects were done prior to BSC and it has become more difficult to obtain additional savings. Going forward the company's goals are only likely to change if there are significant exogenous events (e.g., a local water shortage with new usage restrictions).

**Projects and Staff Behavior**

The company completed a T-8 lighting retrofit project after its BSC participation; this previously planned project was "supported" but not directly caused by BSC. The company is also considering more efficient equipment upgrades that it could not discuss at the time of the interview. The company had not implemented any policies or strategies to change staff behavior, and the "sustainability mindset" is mostly within the small EHS group. Company staff appears to be recycling more, although there is no formal company recycling policy. Future firm-wide communications on sustainability efforts have been considered informally, but nothing has been implemented.

**Overall Value**

The company enrolled for BSC because its existing sustainability processes (driven by ISO 14000) were mature, and it wanted to be exposed to other companies and new "real-world ideas for corporate responsibility." While the BSC classes did expose the company to new business practices and project types and the SCORE assessment tool was fairly informative, the company could not implement many new projects, as they had already been implemented before or were not appropriate for the company's unique processes. In addition, the company has not prioritized any social/community policies or projects, since the benefits are less quantifiable. Lastly, this manufacturer of intermediate (not finished) goods does not have a visible "public personae" that would benefit from positive public relations, and according to the interviewee, did not have significant incentive to consider innovative projects with more risk.

### 5.2.2 Company B

**Company Sector:** Manufacturing

**BSC Participation Track:** Classes

**Staffing**

According the BSC participant that was interviewed; no one at the company is currently managing or focused on resource conservation or sustainability activities. This is primarily because the previous company president that was recruited into the program was subsequently replaced, and the new president views sustainability as "soft money" that will not increase profits relative to other initiatives.

**Metrics and Tracking**

The interviewee tried to learn how to benchmark the company's electricity consumption during the classes using the ENERGY STAR software, and obtained energy bills from facility managers and heating/cooling days from the National Weather Service. The company stopped its benchmarking efforts after the classes ended, however, and now the interviewee just reviews the monthly energy bills for any "major swings" that may not be readily explainable. Other production issues (e.g., materials procurement, transportation costs) get much more management attention than energy and water consumption.

On a technical note, the respondent also noted that another subsidiary company that did not participate in BSC shares its building. This company makes different products and serves different customers, and the two companies have combined electric and gas bills, which would make it difficult to attribute progress on future sustainability initiatives.

**Goals**

The company was encouraged to target 10 percent savings in one or more areas (e.g., electricity and/or water consumption), but no formal or informal goals were ever established.

**Projects and Staff Behavior**

The company has not completed or planned any projects directly attributable to BSC, and has done nothing to modify staff behaviors.

**Overall Value**

The company's previous president chose to participate in BSC in part to reciprocate CL&P's assistance in securing funding for earlier efficiency projects. The company did not have any specific sustainability goals at the time, and the respondent attended the classes "with an open mind" towards potential improvements.

As noted previously, the primary reason the company has dropped its sustainability focus is recent cultural change that focuses on short-term profits (driven by the new president). That said, during their class participation the respondent also perceived that the company was "already in good shape" relative to peer companies, and also noted that defense contractor firms are somewhat limited in the changes they can implement due to product specifications imposed by government clients. While energy consumption is very important to many retail goods providers (e.g. food products), defense contractors win bids based on price and past performance, and are not as driven to (constantly) reduce product costs. Going forward, the company is not likely to prioritize energy efficiency or sustainability unless the top-level management changes.

### 5.2.3 Company C

**Company Sector:** Manufacturing

**BSC Participation Track:** Consultants

**Staffing**

This company's sustainability efforts are led by the interviewee, who was promoted to Facilities Manager in mid-2010. The Facilities Managers leads a committee of nine staff that represents all areas of company (e.g., facilities, executive management, factory workers, and engineers). At the time of the interview the group had only met three times – at the BSC kickoff presentation, at a follow up meeting, and then to create baseline measurements. Since then, company staff has been focused on implementing three key retrofit projects (planned prior to BSC, discussed subsequently) and have not been able to meet to discuss future initiatives or projects. (The consultants were scheduled to present next steps to upper management the week following the interview.) After the large retrofit projects are completed the manager hopes to convene the group quarterly, and future sustainability ideas are expected to come from "these experts" primarily (i.e. not from regular staff). No committee staffing changes are expected.

**Metrics and Tracking**

The company benchmarked its energy consumption at the start of its BSC participation, and the consultant was scheduled to discuss the comprehensive SCORE assessment (which includes financial planning capabilities) with management shortly after the interview was conducted. For the initial baseline benchmarking the company compiled monthly energy bills, conducted (unspecified) equipment metering, and normalized consumption for production.

Company staff spent "several months" measuring consumption for the initial benchmarking, and will establish a new baseline and detailed tracking metrics after all the new projects are installed. The manager does want to see "additional progress" going forward, and noted that production processes (rather than equipment) may receive more company attention in the future. Currently, the company is simply tracking monthly utility bills (electric and gas), and the manager sometimes monitors real-time electricity demand (the consultant told them how to do this).

**Goals**

The company has not established any formal goals, but does "have a vision to build on its recent investments" after learning how the new equipment operates.

**Projects and Staff Behavior**

The company has been focused on implementing the short-term projects planned prior to BSC, and future projects may include water and wastewater reduction projects. In the current economic environment, however, the company attention has been most focused on reducing electricity and gas consumption. The company has not done anything to modify employee behaviors or adopt new company sustainability policies.

**Overall Value**

The company was in the process of planning three large projects when it was recruited into the BSC program, and "was not starting from scratch." Specifically, these three projects were: a new HVAC system (7 new 30-ton packaged units), a boiler replacement (to achieve 85 percent efficiency) and an Energy Management System (EMS).

According to the interviewee, high-level management "takes the BSC very seriously", but has had to focus on the three retrofit projects in the short-term. The company is considering obtaining Cradle-to-Cradle certification (i.e. how makers purchase materials) and the BSC complements this. While the company does have budget constraints, funding should be forthcoming for future efficiency and/or conservation projects, and the manager expected to leverage the consultant's high level of expertise and engagement. Lastly, the manager was very pleased with the positive public relations the company was receiving from its current projects (because it had strategically leveraged UL funding), implying that positive public relations could also be a driver of future BSC-inspired projects.

### 5.2.4 Company D

**Company Sector:** Manufacturing

**BSC Participation Track:** Classes

**Staffing**

The interviewee became the company's Continuous Improvement (CI) manager after another staff person was able to assume their previous role as Facilities Manager. At the time of the interview, the new CI role was still evolving and not entirely defined, but the respondent expected to assume more responsibilities and affect company culture change over time.

The manager "has the President's ear" and the company leadership team is "somewhat engaged", although energy efficiency and sustainability is still not a high focus for some company managers. Like many other firms, "the company was focused on survival" in the last year, and "green" activities took lower priority to other initiatives. The manager described their CI activities as being "mostly ad-hoc" (not strategic), and the main forum for discussing BSC-related topics is the quarterly facilities/health & safety meeting, where recycling and coolant usage are frequent topics. Going forward, the manager doesn't think the company can reduce its gas consumption by much, and the company does not use much water.

The interviewee is likely to continue leading the firm's (expected) sustainability initiatives, and hopes that a more formal green team will be established. The manager continues to track energy efficiency best practices through the International Facilities Management Association, and set up a workshop in Connecticut for Dutch company representatives to present their activities.

**Metrics and Tracking**

The company was tracking its energy consumption in spreadsheets before the BSC, and added water during the classes (the class covering the EPA water assessment tool was described as a "good class"). The manager learned that the ENERGY STAR Tracker 1.0 tool can track greenhouse gases (GHGs), energy use and progress towards goals, but instead uses an internal tracking tool that he obtained after attending a previous CL&P presentation. The company is not tracking GHGs but would use the EPA tool "when regulatory pressure increases." A consultant currently tracks VOCs for the paint shop, and the manager may use him for GHG tracking in the future.

The company has had problems normalizing energy and water data to output and/or labor hours, because it is a "job shop" with a very variable product mix, so the company continues to track absolute seasonal usage. The manager would also like to know how to easily measure its trash and recycling volumes, to see the impacts of the new recycling program.

**Goals**

Although the company was encouraged to target 10 percent savings in one or more areas (e.g., electricity and/or water consumption); no formal or informal goals have been established.

**Projects and Staff Behavior**

At the time of the interview the company had not implemented any efficiency projects that are attributable to the BSC. However, the company had implemented and educated employees about a new single stream recycling program, which was directly "caused by" the BSC according to the manager. The company has also started to write about efficiency and sustainability efforts in the company newsletter, whether or not the efforts were caused by BSC (e.g., the company has also implemented coolant recycling, although this change was required by the Connecticut Department of Environmental Protection). As a result, employees are starting to ask more questions about the company's sustainability efforts and plans, particularly as employees continue to implement energy efficiency in their own homes.

**Overall Value**

In the year before signing up for BSC the company had been tracking its energy use and had installed a VSD air compressor and replaced 2 rooftop 15-ton HVAC units with high efficiency units. The company signed up for the BSC relatively late, at the urging of their account manager, to see if there was additional ways to leverage available Connecticut Efficiency funding.

Since then the company has been primarily focused on immediate business pressures and "keeping people hired", but continues to track electric and gas consumption and advises employees "don't be fuelish" (a new company slogan). The most important benefit of the program so far as been the realization that the company needs to communicate its (emerging) sustainability efforts to its employees in order to gain long-term traction.

Regarding the BSC classes, the manager noted that a few speakers "were not that great", but that the teambuilding speaker was particularly good (though the topic was less important than the technical measurement tools topics). In particular, the

SCORE, presented to the company by a consultant, was described as a "nebulous academic exercise," resulting in few practical project opportunities. The manager was also disappointed that a class reunion had not been organized, so they could stay informed of other participants' progress, and potentially for an EPA software users group.

### 5.2.5Company E

**Company Sector:** Retail Food and Beverage Production

**BSC Participation Track:** Classes and Consultants

**Staffing**

Sustainability tracking and planning is primarily done by the Facilities Operations Supervisor (the interviewee) with assistance from one of the plant managers. There is a green team comprised of corporate management staff, and the company was in the process of establishing green teams among hourly staff at each of the three production plants (the interviewee is the leader for one of the plants).

Sustainability topics related to BSC (e.g., greenhouse gases) and projects status are often discussed at the weekly management team meeting. Most projects ideas and conceptual planning, however, are generated by the interviewee and the plant manager, who have frequent email communications. According to the interviewee, the two are able to respond to new industry trends and news articles quickly, and the informal process is working well. The hourly staff are also starting of offer project suggestions pertaining to production process (e.g., air leaks, excessively heated glue) and "are generating some good ideas." The two sustainability leaders always respond to employee suggestions to keep staff engaged.

Sustainability staffing is not expected to change going forward, and the primary challenge for the respondent is finding time to focus on BSC activities, manage facilities and do environmental compliance work.

**Metrics and Tracking**

At the outset of the BSC the company started baseline benchmarking by compiling various utility reports for the prior 18 months. The manager developed several spreadsheets to track energy use, water use, trash volumes and recycling volumes, and he continues to obtain monthly accounts reports. The company had not yet normalized energy and water usage, and was considering electricity/water per man-hour or machine-hour, or per 1,000 production units. GHG savings are based on (purchased) energy savings, which are derived from the company's on-site solar panels.

The company does not do any peer-company comparisons (due to the very unique product produced), and the three company production plants compete informally to reduce resource use. The plants also trade conservation ideas; one plant started composting recently, while another facility shared information about their use of VFDs.

**Goals**

The company's informal goals are "to get 0 to 10 percent waste" and to reduce water use generally. According to the interviewee, these goals are always in mind, although no goals have been formally adopted. In general, the company wants to lower its carbon footprint, use fewer natural resources and receive positive public relations; these directives come down directly from the company President.

**Projects and Staff Behavior**

At the time of the interview the company had not installed any new equipment as a direct result of its BSC participation. However the BSC "reinforced serious consideration" of other planned projects, including: full HVAC upgrades, real-time energy monitoring (e.g. for summer cooling), and on-site geothermal generation. The company was also continuing to study recycling specialized bags for product transport, LED lighting and facilities daylighting. After BSC, the company looked at rainwater harvesting, but found it would not save much water, and zero-water plantings were considered "too ugly" to pursue.

On the behavioral front, the company has installed a cafeteria video display with recycling messages, and production employees and each corporate department have also received in-person training. "Recycling bins are everywhere", and the quarterly newsletter (and email blasts) describe new green projects.

**Overall Value**

The company was recruited into the BSC because it had started or completed many efficiency projects (e.g., solar panels, VSD air compressors, re-lamping, sink aerators, motion sensors, efficient boiler retrofit, new water wells), and could potentially be a rich source of information sharing.

According to the interviewee, the BSC classes "really showed the way" for making future progress, and subsequent interactions with other committed peers regarding specific project ideas have been particularly useful. The BSC consultant continues to be engaged with the company's planning and is also a good technical resource; the manager regularly receives emails about new courses to take, and other staff are now going to seminars similar to BSC to "spread the sustainability culture." Lastly, the manager also perceived that employees' awareness of energy efficiency opportunities in their own homes was increasing.

### 5.2.6 Company F

**Company Sector:** Manufacturing

**BSC Participation Track:** Classes

**Staffing**

Activities related to sustainability and BSC participation are managed by the Green Team and people from the quality control department. The Green Team is part of the company's organizational chart and they participate in the business' quarterly meeting. The Green Team also meets every three weeks independent of the rest of the organization.

The Green Team is planning on 18-month to 2-year rolling transitions for Green Team staff members. They do this for the Green Team to ensure that it doesn't become a static position within the company. The purpose of rolling transitions is that the company wants new visions and new people to affect their Green Team decisions. While the company understands that this approach does have negatives, they believe that 18-months or 2-years is the right amount of time.

The company's goal is to be more efficient and include "LEAN" principles. The Green Team participated in a LEAN protocols session with a company that specializes in training companies in LEAN approaches. Through this they developed certain LEAN principles (e.g., energy efficiency).

**Metrics and Tracking**

The company benchmarked its energy and water consumption at the onset of the BSC program. They used a simple Excel program, identified in the monthly sustainability seminar they attended. The spreadsheet captures kWh, gallons of water, and CFUs of gas. They identified reduction goal and tracked the metrics throughout the following year. Since the firm owns their facility, they are able to get full system metrics in addition to monthly energy bills. In addition to tracking kWh, gallons of water, and CFUs of gas, the company concurrently tracked labor hours and dollars of sales, to determine overall company efficiency.

They also compared their consumption with other companies as part of the BSC classes. The companies reviewed their consumption with the other firms, and it was reportedly, "helpful to see what others were doing."

**Goals**

The company set a goal of 10 percent energy reduction (kWh), but had "less defined" goals for gas and water. Within the first year they met their 10 percent kWh reduction goal. They plan to continue improving, but do not believe that they will be able to make the same level of change in subsequent years – they "are striving to maintain positive improvements every day." It is unknown if the firm has set new savings goals.

While the company did rely on rebates, they still absorbed some upfront cost. They have a dedicated building management fund that paid for the upgrades made to their building. The budget spent on retrofits has produced a return on investment.

**Projects and Staff Behavior**

The company installed mostly lighting equipment. This rolled into more energy efficient “means and methods”, as simple as installing sensors and timers, so areas were not using energy around the clock. The company received some incentives for lighting measures.

In addition to lighting equipment, they installed phase metering on various (unspecified) equipment, and HVAC enhancements (e.g., economizer mode, bringing in more outside air, VFDs) to reduce annual electricity consumption by more than 10 percent (a detailed figure was not given). This company also completed a comprehensive vacuum system survey, as recommended through BSC, to detect air leaks, estimated at 15 percent of system capacity. They received a small financial incentive for some of the equipment, including VFDs.

In order to affect staff behavior, they created battery return stations. They have a goal to always put out twice as much in recycling as trash, and have worked with the local trash company to get that company to recycle skids and other materials from their operations. The firm faced typical challenges, such as authorizing expenditure for something that is not visually prominent, and difficulties affecting the engrained practices of staff members (e.g., throwing used batteries away instead of recycling them).

**Overall Value**

The most valuable part of the program for this business was the instruction in benchmarking. Their view is that without benchmarking their pre-existing usage, they would be unable to ensure that they reached their goals for energy savings. They also hope that this process has produced a sense of pride within their workforce and that employees feel that they are all members of a sustainable team. Finally, their business has benefited from better efficiencies for system performance.

This company is very much a niche manufacturer, so sometimes the recommendations they received did not match their day-to-day activities or they were simply unable to make compromises.

They noted that that, while they had applied for various grants based on meeting their goals, they did not win those grants and therefore they were not able to implement those plans.

### 5.2.7 Company G

**Company Sector:** Manufacturing

**BSC Participation Track:** Classes and Consultants

**Staffing**

At the time of the interview, the company was considering consolidating and closing one of their two facilities at this location, so attention to BSC was a low priority.

The interviewee, who is in charge of corporate communications, is considered the primary person at this business regarding their participation in the BSC program. They also have a “Green Team,” but at the time of the interview the interviewee indicated they were not “fully practicing.” According to the interviewee the “Green Team doesn’t have a big influence.”

**Metrics and Tracking**

This business conducted benchmarking in 2008, and continues to collect monthly data regarding their energy usage and associated costs. According to the interviewee, they have reduced their costs in the past few years as the result of changing energy suppliers and reductions in the number of work shifts (from three down to two).

They track electricity, gas, water, and sewer use, relying on monthly bills for the information. They do not track greenhouse gas emissions, but were working with UI on developing a method at the time of the interview.

**Goals**

This business aims to continually improve their efficiency. They did have a 10 percent reduction goal, which they reportedly met. They claim to be unable to meet 10 percent reduction annually, as they are nearing a plateau for what they can, and are willing, to do to conserve energy.

With respect to the BSC, lots of the information that was presented to the company was things they were "already on board with." They have completed a lot of the "low hanging fruit," and state that the "triple bottom line contains things [they] are never going to do."

**Projects and Staff Behavior**

The firm installed lighting motion sensors after their BSC participation (with rebates from UI), but also eliminated one of three work shifts (due to economic recession), and the interviewee did not know if their 10 percent annual electricity savings was due to these or other factors.

In the 10,000 square feet of office space at their location, they re-wired the lighting so that there is a night setting when there is fewer lights are on. This is not automatic; a human has to initiate the night setting.

Through the BSC program, the business was encouraged to have their building audited. The auditor was thorough. The recommendations were divided up between physical changes and recommendations for behavioral changes, but the physical changes were perceived as easier.

The "Green Team" is also charged with handling staff behavior. The interviewee met with various departments and spoke with them about their energy usage. Within each department, the goal is to make people aware of what they are trying to do, but at the time of the interview, the Green Team hadn't been around long enough to see results. Additionally, they have posters up that show how the electric rates are changing and how that affects their business. The hope with this is to raise awareness.

**Overall Value**

The company found the seminars over the past couple years to be a highlight of the program. The ten-month monthly meetings were also well received. The company viewed this as an opportunity to see what other companies are doing with respect to energy efficiency.

The main benefits experienced by the company have been cost savings related to reductions in energy usage, and raising awareness among staff. The interviewee preferred the in-person meetings instead of webinars, stating emphatically, “webinars don’t work for me!”

This company was unable to take full advantage of the behavioral aspects of the BSC program, as the interviewee – who was the only interface between the program and the company – is not in human resources or management, and thus had limited capacity to affect behavior. They anticipated that the program was to reduce energy and keep the environment clean and safe, and did not anticipate the behavioral aspects. As noted by the interviewee, this “comes down to the goals of the companies involved.”

The firm had also requested help (from undisclosed sources) to set up systems for measuring their carbon footprint (in September 2011), but this had not happened at the time of the interview.

Lastly, at the time of the interview, the EDC had recently “let go” their company’s representative, whom the company believed to be the best around. The interviewee was, “very dissatisfied with the EDC about that decision,” and claimed it, “says volumes about local commitment and the BSC program, more than any written plan or audit.”

### 5.2.8 Company H

**Company Sector:** Printing and Paper Products

**BSC Participation Track:** Classes

**Staffing**

The “Green Team” is comprised of the Vice President of Operations (the interviewee) and his supervisor, as well as the maintenance department and their supervisors. They started with a larger Green Team, but found it difficult to keep people involved, as the company has been very busy and employees didn’t want to stay after work (despite offerings of dinner). Without employee input, it is essentially just the supervisors asking, “what can we do for sustainability?”

The supervisors are motivated due, at least in part, to the way their compensation is calculated. There is a bonus program for reducing waste, downtime, electric bill, etc. Moreover, these supervisors are reported to be interested in being more efficient in general.

**Metrics and Tracking**

This company conducted a quasi-benchmarking process as part of their LEAN efforts. They also conducted benchmarking with the BSC, and reported that it went well and was very helpful.

They also track their energy through the ENERGY STAR Challenge for Industry. Tracking is done through the ENERGY STAR website. The interviewee enters information from the firm’s energy bill (electricity and gas consumption) into the ENERGY STAR website. Then the interviewee enters the output of goods and the website tracks production vs consumption, based on square inches of material produced. The firm reports that they were the first company to complete the challenge. Carbon is not tracked in this system, and the company does not track it independently.

**Goals**

The company was asked if they were interested in participating in the BSC program. At the time, they had already done a lot to improve their electricity and natural gas usage, and waste production, before being approached. Some of these retrofits were done independently and some were completed through utility programs. The firm received $2,000 for air conditioning retrofits, but also relies on a compensation structure that encourages efficiency and discourages waste; supervisors at the firm receive bonuses for reducing waste, reducing “downtime”, and reducing their department’s energy usage. The company believed that the program might help, especially with tracking their accomplishments.

They set a goal of reducing electricity usage by 10 percent in 3-5 years, and set an informal goal to further reduce material waste.

**Projects and Staff Behavior**

The company realized a 23 percent decline in electric energy intensity over two years by installing energy efficient air conditioning (AC), process heat outside during the summer months and installing lighting sensors in offices. They received $2,000 in incentives for the AC replacements (which cost a total of $15,000). The company also installed AC unit communications to prevent simultaneous start up and, therefore, demand spiking. This company also reduced winter gas usage from about $9,000/month to $800/month by utilizing an air compressor for building heating on weekends, and reported a 50 percent drop in their monthly energy bill. The company also reduced production waste from 15 percent to 6 percent.

In addition to the energy efficiency retrofits mentioned above, they trained staff on recycling and on not using Styrofoam. They installed network printers throughout their offices, use electric hand dryers instead of paper towels, and implement a shut down procedure for the weekend. At the time of the interview they were looking at turning the majority of the power to the building off during weekends, as well.

**Overall Value**

The company is saving a lot of money through energy efficiency and waste management practices. In addition, staff is happier and they have a nicer work environment. The program also, “brought our staff closer together” as they use recycling money to hold cook outs for the staff.

According to the interviewee, some of the things that were brought up in the BSC were very small and insignificant, or too difficult, such as carpooling, biking to work, and harnessing rainwater. The staff live all over the state (and even in other states), so carpooling and biking are too difficult. The interviewee mentioned that harnessing rainwater might be helpful in the future, but that it is not on their radar at this point.

The interviewee also noted that the BSC should focus a bit more attention on LEAN manufacturing. They acknowledged that there was a class on this topic, but suggest that it has significant ties to sustainability – the elimination of waste means more sustainable.

### 5.2.9 Company I

**Company Sector:** Distribution

**BSC Participation Track:** Consultant

**Staffing**

The interviewee, a self-described “worker bee”, is charged with building maintenance for the company. The company also has a task force within the marketing department that was helping with the sustainability activities of the company. Prior to the BSC, the company’s efforts started with marketing. The interviewee is part of the initiative team, and plays a large roll in the sustainability of the building. The initiative team is comprised of full time employees, managers of their departments – marketing and sales.

According to the interviewee, the initiative team holds sporadic meetings, distributes fliers, and ensures that there is “green” on everything. The company is a distributer, and they stock and sell products from green manufacturers. The company also has auditors coming in all the time, and the interviewee is in charge of keeping the records – he has two years of utility bills at his desk.

**Metrics and Tracking**

For benchmarking, the company reviewed two years of data. According to the interviewee, this process was not difficult because they keep all of their records. Benchmarking consisted of putting the billing data in a spreadsheet, and staff from the BSC entered the data into the software program. BSC programming helped the company understand how to document a good baseline for the utility bills before they started the program.

When UI asked the company to participate, it was, reportedly, a “win-win” for the company. The BSC program paid for tracking software (the Sustainable Real Estate Manager), and the interviewee reported that the software keeps track of the business’ utilities better than any simple excel spreadsheet. The tool provided by the program allows the business to run a variety of reports. The tool includes information on how efficient the business was in the past, how efficient it is currently, and if the company is meeting their goals.

The company is tracking carbon for sustainability reasons. They are tracking electricity and gas because both play into the company’s carbon emissions, and energy consumption is more directly related to the economic situation of the company.

**Goals**

The main goal of the company is to achieve a 75 Energy Star Rating. The firm decided on this goal because there is a comparison with other companies, and they wanted to be at or above the level of competitors. The interviewee maintains all the information, and the company set goals from that. BSC program administrators directed the company to this program, and program incentives paid for the initial cost (one year or the first run). The company is continuing to use the system.

While the BSC program administrator suggested some other goals, the interviewee says that the company needs to be "realistic." They "have done a lot to get there [try to improve]," but were unsuccessful in reaching their goals to date. They are still looking to improve.

The company signed a paper saying they would do everything they could to improve their energy sustainability. A vendor working for UI conducted audits and explained the availability and usefulness of potential retrofits. The company followed through and implemented the changes with the expertise of the consultant and UI.

**Projects and Staff Behavior**

The company reduced natural gas for heating by 13 percent in one year by instructing staff to keep doors closed, installing seals on doors and docks, and repairing building cracks. The company also reduced their energy usage by 5 percent in one year by completing a comprehensive T8 lighting retrofit project, installing office lighting sensors, and charging and running more equipment during off-peak periods. In the process, the company also reduced carbon emissions by 1.8 percent.

According to the interviewee, recommendations from BSC were responsible for their retrofits. Some of the recommendations required capital investment, but the company also took advantage of incentives. The company also did some of the retrofits without incentives. They also recycle everything they can – which comes at an expense. They try to reduce the amount of waste going to a landfill.

Regarding staff behavior, every year the company hosts a health/green fair. Representatives from UI talk about CFLs, sell them at reduced cost, and encourage participation in audit programming.

**Overall Value**

The most useful outcome of the business' participation in the BSC program was gaining knowledge. They were also able to engage UI and hear their ideas for further improvements. The main benefit of the program is the measured reduction in the company's energy use.

Additionally, staff is more conscious of energy and saving energy. The interviewee noted the importance of this given the economic situation at the time of the interview. They also noted that, "it has not only helped [the business], but we have passed the info to our staff."

The company does not want to pioneer new technologies, but has increased confidence with UI recommendations as the result of their experience with the BSC program.

## 5.3 Summary and Conclusions

A total of nine customers were interviewed as part of the evaluation. Due to the limited data set, care must be taken when drawing conclusions, however, general conclusions can be made.

For the purposes of this section, the impacts of the BSC program were broken down into four distinct areas:

- Sustainability staffing
- Establishing metrics

- Setting goals based on the established metrics
- Establishing procedures, protocols, or completing projects to make progress or achieve the goals

### 5.3.1 Sustainability staffing

Based on the customer interviews completed, since participating in the BSC program participants are allocating staff to towards the goal of sustainability. Of the nine companies interviewed, five have established an "official" sustainability group or "green" team. Of the four that do not have an established sustainability group, three have more "informal" sustainability groups or roles for individuals. One site has a staff member that plans the sustainability activities for the company, however the role is informal. Two other sites incorporated the sustainability efforts into existing roles and meeting structures. One of these sites has a corporate green team that serves multiple plants. At this specific site, sustainability was incorporated into the existing weekly management meetings, with close coordination with the corporate team. One site had originally established a green team; however, it was abandoned when the company changed management.

### 5.3.2 Establishing metrics

The participants in the BSC program are tracking energy usage or other metrics associated with their facility. All of the companies interviewed, with the exception of the one company that changed ownership, track data for the purposes of benchmarking their facility. To track their progress, most of the participating companies review and record their monthly utility bills. Most were already doing some form of monthly tracking (in spreadsheets) prior to participation in BSC. One company indicated that on occasion electric and/or water usages are tracked daily, in addition to the monthly tracking. However, the daily tracking was mostly for ad-hoc observation and not systematic evaluation.

However, the BSC participants are less likely to have determined or established *meaningful* metrics for their facility. Of the companies interviewed, only three of the companies indicated that they normalize their usage or other metrics compared to production or other variables. The remaining companies predominantly compared annual and monthly usages to historical usage values with no normalization.

The primary reason that companies have not normalized the usage data is difficulty in determining what variables would be useful for correlation. Specifically, one company would like to start normalizing energy and water consumption, but is unsure whether to base this on labor hours, machine hours or product volumes. A different company also wants to normalize consumption to production but has a very variable product mix that changes monthly and didn't know how to account for this in the normalization.

### 5.3.3 Setting goals based on the established metrics

The impacts of the BSC program are much more mixed for the customer goals. Specifically, almost all of the participants had adopted formal or informal sustainability goals, with five companies establishing formal goals. Two of these companies had established the goals to reduce electricity consumption by (at least) 10 percent in the first year after participation. A third company also aimed to reduce electric consumption by 10 percent over three to five years. One company that is primarily focused on water and wastewater reductions, initially aimed for 5 percent annual reductions in both, but currently just hopes for any reductions, since they have found it very difficult to attain savings.

Three companies had more informal goals. Two companies are aware that the BSC encourages 10 percent reductions in one or more resource categories (e.g., electricity, water, greenhouse gases, waste), and aim for these targets informally (e.g., "we keep it in mind"). Another company strives to reduce water use "generally", but specifically hopes to reduce waste materials up to 10 percent at some point in the future.

However, the impacts of the customers setting goals become less meaningful when examined in combination with the lack of success in customers establishing meaningful metrics. Of the customers that had established goals, only two (Company H and Company I) had goals that were based on normalized energy, water, or waste values. The goals for the other companies were tied to unadjusted utility usage data. For two companies, the company had already achieved the goal of a 10% reduction in energy usage. However, in both cases, the production at these facilities was lower than in prior years. One customer specifically noted that the reduction was likely more due to the reduced production and fewer shifts than any other factor. Neither of these companies had set new goals.

### 5.3.4 Establishing procedures, protocols, or completing projects to make progress or achieve the goals

Due to participation in the BSC program, many participants are establishing procedures or protocols, or completing projects to make progress toward their goals. About half of the interviewed companies had implemented sustainability projects after their BSC participation, which the interviewees characterized as being "directly caused" by the BSC.

Three of the companies have completed traditional energy efficiency projects involving the installation of efficient equipment. These projects tended to focus on lighting and HVAC improvements, however, one customer improved the efficiency of process related equipment.

In addition, five companies have implemented non-traditional energy efficiency or sustainability measures, such as educating employees, implementing policies or activities to modify staff behaviors.

All five of the companies have increased efforts in the areas of recycling and waste reduction. These efforts have been primarily been aimed towards recycling of non-production materials, two customers have also focused on production waste as well. A detailed breakdown of the recycling and waste reduction actions by company are given in Table 42 below.

**Table 42 Recycling/Waste Reduction Measures**

| Company | Action |
|---|---|
| Company D | • Implemented a single stream recycling program |
| Company E | • Increased the number of recycling bins<br>• Increase the signage to promote recycling<br>• Promote recycling through messages on screens in cafeteria |
| Company F | • Install signage for recycling |

| | |
|---|---|
| | • Set up battery return stations<br>• Recycle shipping skids from production materials |
| Company H | • Train employees on recycling<br>• Switched from Styrofoam cups to mugs<br>• Separate paper and cardboard for recycling or to send to the waste-energy plant<br>• Removed paper towels from bathrooms and installed hand dryers |
| Company I | • Set up recycling program for production waste, including shrink wrap<br>• Re-use pallets from production |

Four of the five companies have also increased efforts in the areas of employee training, education, or information. Although these efforts have primarily involved education for use in the workplace, two customers have expanded this to include information to be used by employees at home. A detailed breakdown of the employee training and education actions by company are given in Table 43 below.

**Table 43 Employee Training/Education Actions**

| Company | Action |
|---|---|
| Company D | • Regular newsletters to notify employees on the status of sustainability projects<br>• Make green team staff available to discuss home projects with employees |
| Company E | • Send email blasts to employees to encourage sustainability and inform them of current efforts |
| Company H | • Train people to shut down computers and other equipment over lunch, breaks, etc. |
| Company I | • Train employees and post signs to remind employees to shut shipping doors to reduce HVAC energy usage<br>• Have annual “Green Fair” with UI representative to promote CFLS and home energy audits |

In addition, one company (Company H) has converted from individual printers to network printers to reduce the number of electronic equipment that operates and reduce the “phantom” loads.

## 5.4 Recommendations

During the evaluation process several recommendations were identified that could help the BSC program better serve the participants and guide them to identify both energy savings and sustainability measures and guide the participants to projects to improve their facility.

- **Recommendation 9: The Companies should work with customers to develop a staffing plan to ensure sustainability groups or green teams are “official” positions.**

  While all but one of the companies did have staff allocated towards sustainability, only approximately half of the companies had an “official” group. The other companies incorporated sustainability into existing meetings or included sustainability as an “unofficial” duty for a staff member.

- **Recommendation 10: Work with customers on a one-on-one basis to develop meaningful metrics.**

  Few of the companies had progressed beyond reviewing utility bills to developing meaningful metrics. Several specifically mentioned difficulties in developing meaningful metrics. This process is complex in nature and will be unique to each customer. By working with customers on a one-on-one basis, companies will be more likely to be able to determine what metrics will be meaningful for them.

- **Recommendation 11: While participants are very interested in the broad range of sustainability issues, the program appears to focus on electricity use only in developing savings metrics. To better serve these participants, the Companies should Increase focus on non-utility metrics, such as recycling volumes, trash volumes, and water usage.**

  Two customers indicated a desire to develop metrics regarding trash and recycling volumes. Both indicated that they did not know how to proceed with this task. Therefore, we are recommending that trash and recycling metrics be expanded in the program.

- **Recommendation 12: The Companies should hold periodic meetings open to all BSC participants, to review successes, challenges, and tools.**

  Several customers indicated a frustration with the lack of meetings after the completion of the course.

# 6. Appendix A – Sample Selection Detail

## Introduction

### How Strata Boundaries Were Determined

The Michaels' team considered two standard methods for determining strata boundaries. The first—and the one we chose for this project—was based on finding natural breaks in the distribution of ex ante savings among projects. The second method is based on sorting projects in ascending order based on kWh savings and stratifying the projects into groups of roughly equal total ex ante savings. This is the approach we generally take when the universe of projects is large (e.g. more than a few hundred projects) or the "natural breaks" approach does not sufficiently reduce the sampling variation.

It is our standard practice in impact evaluation to use a benchmark coefficient of variation (CV) value of 0.5 when determining sample size. That is, while we conduct stratification in order to reduce the variation in the sampling universe, we set the minimum value of the CV for determining sample size at 0.5, rather than basing the sample size computation on the weighted average CV among the strata. Because ex ante savings is simply an estimate of savings and ex post savings (i.e., actual savings) often varies greatly from the ex ante value, it is more efficient with respect to time and budget to potentially "oversample" by a small margin than to attempt to optimize sample size by "over-stratifying" the sampling universe in order to drive the CV to a very low level only to have to conduct additional sampling and on-site evaluation later in order to meet required levels of confidence and precision. Thus, while it may appear on the surface that we drew a larger-than-necessary sample, in fact, we drew a sample that we were confident would provide the necessary level of confidence and precision, while minimizing the risk to our client and our client's ratepayers that additional time and resources would be required to conduct additional sampling and on-site evaluations.

Table 44 shows the distribution of ex ante kWh for the three measure groups (Air, Other, and PC) and the strata that each decile of projects would have been assigned to. For example, in Air measures, there is a natural break in ex ante kWh between the 50th and 60th percentile, as well as between the 70th and 80th percentile. We used this information to set strata boundaries for Air measures at 40,000 kWh and 100,000 kWh in order to define the Small, Medium, and Large strata. In addition, we further analyzed the largest strata to determine projects to be designated as Certainty sites. The same approach was taken for the other two measure types.

**Table 44: Distribution of kWh Savings by for Air, Other, and PC Measures**

| | Air | | Other | | PC | |
|---|---|---|---|---|---|---|
| Percentile | kWh | Strata | kWh | Strata | kWh | Strata |
| 10 | 0 | Small | 0 | Small | 2,162 | Small |
| 20 | 0 | Small | 0 | Small | 4,690 | Small |
| 30 | 4,580 | Small | 781 | Small | 38,215 | Small |
| 40 | 25,934 | Small | 2,278 | Small | 51,230 | Small |
| 50 | 33,085 | Small | 8,974 | Small | 58,156 | Small |
| 60 | 64,442 | Medium | 22,626 | Large | 67,982 | Medium |
| 70 | 86,504 | Medium | 29,979 | Large | 76,498 | Medium |
| 80 | 178,411 | Large | 48,034 | Lg./Cert | 111,446 | Large |
| 90 | 263,202 | Lg./Cert. | 377,660 | Cert | 179,720 | Large |

Source: Analysis by Evergreen Economics of data provided by CL&P and UI

## How Sample Size Was Determined

Sample size was determined using the standard formula for estimating a population mean and included the finite population correction Figure 1. For Air measures the CV, based on the stratification shown in Table 44, was 0.46, slightly below the 0.50 benchmark, thus there was no compelling reason to further stratify the sampling universe. In fact, while our standard approach is to stratify the sampling universe in order to achieve a weighted average CV across all strata that is less than or equal to 0.50, we generally still use 0.50 as the CV for determining sample size. This represents best practices in impact evaluation of energy efficiency programs and is recommended in the California Protocols. Nevertheless, because of the large certainly strata, we used the weighted average CV (0.46) to determine sample size for Air measures.

We followed the same approaches for Other and PC measures. The end result is that we achieved the optimal sample size that balanced information from the empirical distribution of the respective installed measure and the inherent uncertainty associated with ex ante savings—which we believe was particularly great in this program.

**Figure 1: Sample Size Formula for a Population Mean**

Basic Sample Size : $n_o = \left(\frac{z \times cv}{D}\right)$ Finite Population Correction : $n = \frac{n_o}{1 + n_o/N}$

Where :

N = Population size

z = Critical value for confidence level (90%)

D = Desired relative precision

cv = Coefficient of Variation ($s/\bar{x}$)

**How Sample Quotas Were Allocated by Strata**

Sample quotas were set for each strata of each measure type through the following steps:

1. Subtract the count of certainty projects from total sample size to derive "probability sample size"
2. Divide probability sample size by number of strata (excluding certainty strata)
3. If the quotient derived in step 2s…
   a. Is a whole number, allocate this number of sample points to each strata
   b. Is not a whole number, allocate sample points to each strata that is equal to the integer portion of the quotient and the remainder to the one or more strata with the greatest ex ante kWh or uncertainty.

These steps represent the standard approach for allocating sample quota across strata.

# 7. Appendix B - O&M Sample Project and Measure Breakdown

| Project | Project Strata | Measure | Summer Demand Reduction (kW) | Winter Demand Reduction (kW) | Yearly Savings (kWh) | Peak Day (CCF/day) | Energy Savings (CCF) |
|---|---|---|---|---|---|---|---|
| CE06M003 | Air Certainty | Compressed Air Leak Repair | 56.40 | 56.40 | 354,654 | 0.0 | 0 |
| CE07M006 | Other Certainty | Transformer | 43.78 | 43.78 | 431,394 | 0.0 | 0 |
| CE09M005 | Air Large | Compressed Air Leak Repair | 51.67 | 51.67 | 237,348 | 0.0 | 0 |
| CE09M007 | Air Large | Compressed Air Leak Repair | 10.00 | 10.00 | 120,949 | 0.0 | 0 |
| | | Pressure Reduction | 4.00 | 4.00 | 13,906 | 0.0 | 0 |
| | | Compressor Scheduling | 0.00 | 0.00 | 29,496 | 0.0 | 0 |
| EA06M011 | Air Large | Compressed Air Leak Repair | 1.40 | 1.40 | 85,760 | 0.0 | 0 |
| EA07M010 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 76,200 | 0.0 | 0 |
| EA09M004 | Air Medium | Compressed Air Leak Repair | 10.09 | 10.09 | 62,147 | 0.0 | 0 |
| EA09M015 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 57,934 | 0.0 | 0 |
| EA09M018 | Air Small | Compressed Air Leak Repair | 7.40 | 7.40 | 26,295 | 0.0 | 0 |
| WE06M038 | PC Large | PC Power Management Software | 0.00 | 0.00 | 175,437 | 0.0 | 0 |
| WE07M005 | PC Small | PC Power Management Software | 0.00 | 0.00 | 35,075 | 0.0 | 0 |
| WE07M015 | PC Large | PC Power Management Software | 0.00 | 0.00 | 164,016 | 0.0 | 0 |
| WE07M019 | Other small | Receiving Door | 0.00 | 0.00 | 156 | 0.0 | 0 |
| WE07M022 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 58,156 | 0.0 | 0 |
| WE07M029 | PC Small | PC Power Management Software | 0.00 | 0.00 | 3,474 | 0.0 | 0 |
| WE07M034 | PC Small | PC Power Management Software | 0.00 | 0.00 | 1,930 | 0.0 | 0 |
| WE07M039 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 56,472 | 0.0 | 0 |
| WE07M041 | PC Large | PC Power Management Software | 0.00 | 0.00 | 48,048 | 0.0 | 0 |
| WE07M047 | PC Large | PC Power Management Software | 0.00 | 0.00 | 214,032 | 0.0 | 0 |
| WE07M049 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 75,192 | 0.0 | 0 |
| WE07M053 | PC Medium | PC Power Management Software | 0.00 | 0.00 | 77,688 | 0.0 | 0 |
| WE07M056 | PC Small | PC Power Management Software | 0.00 | 0.00 | 1,872 | 0.0 | 0 |
| WE07M060 | Air Large | Compressed Air Leak Repair | 49.00 | 49.00 | 232,748 | 0.0 | 0 |
| WE07M064 | Air Certainty | Leaks, Compressor Sequiencing, Dryers, Pressure Reduciton, Drains, etc. | 214.00 | 214.00 | 2,191,048 | 0.0 | 0 |
| | | VFD Compressor | 35.00 | 35.00 | 261,602 | 0.0 | 0 |
| | | Blower | 1.07 | 1.07 | 19,875 | 0.0 | 0 |
| | | Solenoid Valves tied to Occupancy Sensors | 52.89 | 52.89 | 396,085 | 0.0 | 0 |
| | | Solenoid Valves | 69.92 | 69.92 | 218,150 | 0.0 | 0 |
| WE08M008 | Other small | Duct Insulation | 0.00 | 0.00 | 8,974 | 0.0 | 0 |
| WE08M012 | Other Certainty | Lighting Rewiring and Sensors | 9.49 | 6.98 | 114,371 | 0.0 | 0 |
| | | Lighting Rewiring and Sensors | 0.28 | 0.21 | 3,027 | 0.0 | 0 |
| WE09M030 | Other Certainty | EMS | 0.00 | 0.00 | 375,255 | 0.0 | 0 |
| | | EMS | 0.00 | 0.00 | 8,206 | 0.0 | 0 |
| | | EMS | 0.00 | 0.00 | 28,858 | 0.0 | 0 |
| WE09M037 | Other Large | CO Control for Garage Exhaust Fans | 1.19 | 1.19 | 23,962 | 0.0 | 0 |
| WE10M004 | PC Large | PC Power Management Software | 0.00 | 0.00 | 186,144 | 0.0 | 0 |
| WE10M009 | Other Large | Anti Sweat Door Heaters for Freezers | 0.00 | 0.00 | 38,127 | 0.0 | 0 |
| CE09G002 | Gas Certainty | Magnetic Water Conditioning | 0.00 | 0.00 | 0.00 | 0.8 | 888 |
| EA08G007 | Gas Certainty | RCx Measures | 0.00 | 0.00 | 0.00 | 0.0 | 1,377 |
| WE09G061 | Gas Certainty | Condensate Receiver Improvements | 0.00 | 0.00 | 0.00 | 39.8 | 6,683 |
| AmGo | Other Large | Compressed Air Leak Repair | 0.00 | 0.00 | 30,727 | 0.0 | 0 |
| B1uK | Other Large | Condenser Coil Cleaning | 0.00 | 0.00 | 32,675 | 0.0 | 0 |
| Akiu | Air Medium | Steam Trap Replacement | 10.80 | 10.80 | 65,016 | 0.0 | 0 |
| Aio7 | Air Small | Compressed Air Leak Repair | 25.00 | 25.00 | 12,110 | 0.0 | 0 |
| EA07M001 | Air Small | Pressure Reduction | 6.30 | 6.30 | 39,938 | 0.0 | 0 |
| EA06M004 | Air Certainty | Compressed Air Leak Repair | 162.70 | 162.70 | 640,000 | 0.0 | 0 |
| Total | | | 822.38 | 819.80 | 7,334,529 | 40.6 | 8,948 |

# 8. Appendix C—RCx Project and Measure Breakdown

| Project | Measure | Summer Demand Reduction (kW) | Winter Demand Reduction (kW) | Energy Savings (kWh) | Peak Day (CCF/day) | Energy Savings (CCF) |
|---|---|---|---|---|---|---|
| CE07M017/ CE08G049 | Chiller Plant CHWP Optimizaton | 0.5 | - | 41,205 | - | - |
| | AHU-2 Occupant Control(G) | - | - | 43,012 | - | - |
| | (HRU-1) Control optimization (G) | - | - | 87,480 | - | - |
| | Multi-Purpose Room AHU-3 CO2 (G) | - | - | 17,255 | - | - |
| | AHU-1 and 5 VAV Unit optimization (G) | 3.5 | - | 98,721 | - | - |
| | (FCU) Operation | - | - | 52,508 | - | - |
| | CF-1 / Pump optimization | - | - | 49,901 | - | - |
| | occupancy control for gym AHU4 | 6.3 | 6.0 | 109,672 | - | - |
| | HVAC Improvements | - | - | - | 22.9 | 8,350 |
| EA07M003 | Optimize SCHWP | - | - | 29,187 | - | - |
| | Heat Recovery and HP Optimization | - | - | 101,726 | - | - |
| | Schedule Optimization | - | - | 8,574 | - | - |
| | Optimize VFD exhaust fans on OAT | 2.8 | 2.8 | 16,002 | - | - |
| | Kitchen Exhaust control | - | - | 14,976 | - | - |
| | Old Gym Occ Control | 2.0 | 1.5 | 10,573 | - | - |
| | Old Gym Occ Control | - | - | 18,110 | - | - |
| | New Gym Occ Control | - | - | 9,185 | - | - |
| | New Gym Occ Control | 2.4 | 1.8 | 20,390 | - | - |
| | Optimize Auditorium Schedule | - | - | 18,913 | - | - |
| | Emergency Light Control | - | - | 22,607 | - | - |
| | Corridor Lighting Optimization | 4.1 | 0.9 | 25,343 | - | - |
| WE06M026 | Reduce Hot Water VFD Pump Speeds | 19.0 | 16.0 | 143,297 | - | - |
| | Eliminate Cooling Tower Sump Heaters | - | 21.5 | 76,132 | - | - |
| | Condenser Water Pump Speed Optimization | 10.0 | - | 184,464 | - | - |
| | Supply and Return Fan Syncronization | - | - | 55,739 | - | - |
| | Preheat Coil Pressure Drop Reduction | - | 3.7 | 17,493 | - | - |
| | Increase Size of Mixed Air Damper | 2.8 | 2.8 | 12,187 | - | - |
| | Reduce Filter Press Drop in AHU-1 | 14.7 | 14.7 | 129,071 | - | - |
| | Decrease Reheating on AHU-2 | - | - | 368,678 | - | - |
| | Static Press Setback on AHU-1,-2,-9,-10 | 79.0 | 60.0 | 346,008 | - | - |
| | Remove b.draft dampers on exh. fans | 2.4 | 2.4 | 20,955 | - | - |
| | Install b.draft dampers on garage exh. fans | - | - | 108,916 | - | - |
| | Retrofit Lighting in Helmsley corridors | 26.3 | 21.6 | 203,596 | - | - |
| | Install time cntrl of heat trace sys in Café | - | - | 10,906 | - | - |
| | Control of snow melt sys from BMS | - | - | 14,013 | - | - |
| | De-energize generator heating element | 1.0 | 1.0 | 8,760 | - | - |
| | Replace Nash water seal air compress | 9.5 | 9.5 | 63,363 | - | - |
| | Install speed drive on H20 booster pump | 2.7 | 2.7 | 24,482 | - | - |
| EA08M010/ EA09G081 | Opti RTUs VAV Control and Econo | - | - | 68,822 | - | - |
| | 0 | - | - | 68,821 | - | - |
| | | - | - | - | 708.0 | 2,746 |
| CE07M016 | Chiller Plant Optimization and Control | 0.8 | - | 84,227 | - | - |
| | Optimize (7) seven Air handling units VFD op | - | 20.3 | 181,156 | - | - |
| | Optimize unit RAHU-5 serving administration | - | 3.4 | 42,844 | - | - |
| | Optimize unit RAHU-4 serving classrooms | - | 7.1 | 40,718 | - | - |
| | Heating Plant Optimization and Control | - | 1.5 | 23,869 | - | - |
| | Occupancy control for lighting in the gymnasi | 4.3 | 3.9 | 28,885 | - | - |
| | Occupancy control for lighting in the auditori | 3.7 | 3.1 | 50,894 | - | - |
| EA08M003 | Optimize chiller plant sequence | 207.0 | - | 227,811 | - | - |
| | Optimize operation of H20side Econo | - | 26.0 | 215,052 | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| CE07M019 | Chiller optimization | - | - | 35,212 | - | - |
| | Auditorium HVAC OCC | 9.0 | - | 55,091 | - | - |
| | ERU optimization | - | - | 72,654 | - | - |
| | Optimize AHU-6 | 6.5 | - | 19,485 | - | - |
| | Optimize AHU 7 and 8 | 39.2 | - | 135,203 | - | - |
| | Optimize AHU 9 | - | - | 7,745 | - | - |
| | Classroom FC unit optimization | 12.2 | - | 40,806 | - | - |
| | HW sys Optimization | - | - | 13,928 | - | - |
| | Day light control | 0.5 | 0.4 | 8,797 | - | - |
| | Gym HVAC OCC control | 3.9 | 1.4 | 46,890 | - | - |
| WE06M021 | Static Pressure Reset Control Opt. | 8.5 | 8.5 | 65,357 | - | - |
| | Condenser Water Temperature Reset | - | - | 88,752 | - | - |
| WE07M001 | Static Pressure Reset Control Opt. | 11.7 | 11.7 | 90,317 | - | - |
| | Condenser Water Temperature Reset | - | - | 88,752 | - | - |
| WE06M022 | Static Pressure Reset Control Opt. | 6.3 | 6.3 | 48,265 | - | - |
| | Condenser Water Temperature Reset | - | - | 88,752 | - | - |
| WE06M023 | Static Pressure Reset Control Opt. | 7.0 | 7.0 | 53,789 | - | - |
| | Condenser Water Temperature Reset | - | - | 88,752 | - | - |
| WE07M002 | Static Pressure Reset Control Opt. | 7.2 | 7.2 | 55,604 | - | - |
| | Condenser Water Temperature Reset | - | - | 88,752 | - | - |
| WE06M028/ WE09G058 | Simutaneous Htg and Cooling | 8.3 | - | 4,161 | - | - |
| | CDS Water Reset | 1.6 | - | 43,238 | - | - |
| | Unit Htr MAU-2 | 4.1 | 4.0 | 16,806 | - | - |
| | Boiler Room Ventilation | 1.6 | - | 23,580 | - | - |
| | AHU Optimization | 0.5 | 3.4 | 89,818 | - | - |
| | Unit Heater control | - | - | 34 | - | - |
| | Lab hood velocity control | 2.6 | 1.2 | 10,269 | - | - |
| | Lighting and Night lighting | 12.7 | 11.1 | 47,106 | - | - |
| | | - | - | - | 220.9 | 34,430 |
| WE06M027/ WE08G031 | Reduce Hot Water Reset Range | - | - | 2,735 | - | - |
| | Optimize Chilled Water Pump Speed | 1.2 | - | 6,682 | - | - |
| | AHU System Optimization | 36.1 | 8.3 | 76,294 | - | - |
| | LandS Auditorium Occ. Control | 7.5 | 6.4 | 22,058 | - | - |
| | Day-lighting Control of Light Spline | 12.8 | 12.8 | 30,653 | - | - |
| | Emergency light control - halls and | - | - | 83,730 | - | - |
| | | - | - | 60,238 | - | - |
| | | - | - | - | - | 31,661 |
| CE07M018 | CHWP Optimization | - | - | 36,830 | - | - |
| | AHU-2 Occupant Contro | - | - | 5,838 | - | - |
| | ERU-1 Control Optimization | - | 2.3 | 11,019 | - | - |
| | Media Center RTU-4 Control optimization | - | 4.9 | 10,878 | - | - |
| | Combustion Air Units CAU-1 & 2 operation | - | 3.3 | 37,232 | - | - |
| | Energy Recovery Unit (ERU-1, 2 & 3) Control O | - | - | 17,934 | - | - |
| | CF-1 / Pump optimization | - | 7.5 | 45,314 | - | - |
| | Gym HVAC and light control for AHU-4 | 1.3 | 9.5 | 39,608 | - | - |
| | HVAC and light control for AHU-5 | 0.7 | 0.8 | 37,065 | - | - |
| EA08M007 | Optimize chiller and VFD pumping * | 3.8 | 9.2 | 26,208 | - | - |
| | duel enthalpy RTU - 1, 4, 5 and 6 | 25.2 | 3.7 | 49,237 | - | - |
| | optimuize control on HTX 1,2 and 3 | - | - | 83,841 | - | - |
| | occupancy control Gym units | 5.8 | 5.8 | 39,118 | - | - |
| | occupancy control Auditorium units | 6.2 | 6.2 | 59,132 | - | - |
| EA07M006 | Mead-lighting occupancy control corridors | 1.0 | 1.0 | 24,582 | - | - |
| | Mead-lighting occupancy control corridors | 1.0 | 1.0 | 14,915 | - | - |
| Total | | 650.4 | 378.9 | 5,865,555 | 951.8 | 77,187.0 |

## 9. Appendix C—Peak Demand Definitions

Per the requirements of this evaluation, four values for electric demand reductions and two values for gas demand reductions are presented for each project. The six demand values are:

- Summer Peak—This is the average demand reduction during the summer 1:00-5:00 PM period during non-holiday weekdays in June, July, and August
- Winter Peak—This is the average demand reduction during the winter 5:00-7:00 PM period during non-holiday weekdays in December and January
- Summer Seasonal Peak—This is the average demand reduction during the summer hours that the ISO New England Real-time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the Summer Season, including June, July, and August
- Winter Seasonal Peak—This is the average demand reduction during the winter hours that the ISO New England Real-time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the Winter Season, including December and January
- Peak Day—This is the daily CCF reduction for the average coldest day per year for the past 30 years.
- Extreme Peak Day—This is the daily CCF reduction for the coldest day in the past 30 years.

### Summer Seasonal Peak

For the purposes of this evaluation, all peak demand reductions were calculated using an 8760 hour approach, with the expected demand reductions being calculated for each hour of the year. Using this approach, the summer and winter peak demand reductions can be easily determined by averaging the non-holiday weekday peak hours as defined previously.

However, the determination of the seasonal peak is determined on the hourly system load, and if that system load is greater than or equal to 90% of the expected 50/50 peak load forecast. Therefore, the times and dates for this condition can not be so easily defined. However, it has been shown that system load is found to be related to both the time of day, as well as weather conditions.

The Total Heat Index and Weighted Heat Index are forecast variables used by ISO New England to relate system load and weather conditions. Both attempt to account for temperature and humidity levels. In addition, WHI includes a "history" component to account for weather conditions in the previous two day. THI and WHI are calculated as:

$$THI = 0.5 \times DBT + 0.3 \times DPT + 15$$, where

THI = Total Heat Index

DBT = Dry Bulb Temperature (°F)

DPT = Dew Point Temperature (°F)

and

$WHI = 0.59 \times THI_{di\text{-}hi} + 0.29 \times THI_{d(i\text{-}1)\text{-}hi} + 0.12 \times THI_{d(i\text{-}2)\text{-}hi}$, where

$WHI$ = Weighted Heat Index

$THI_{di\text{-}hi}$ = Total Heat Index for current day and hour

$THI_{d(i\text{-}1)\text{-}hi}$ = Total Heat Index for previous day at the same hour

$THI_{d(i\text{-}2)\text{-}hi}$ = Total Heat Index for two days prior at the same hour

For this evaluation, in order to determine the summer seasonal peak hours, the non-holiday weekday hourly system load profile from the ISO New England Hourly Zonal (SMD) report, was correlated to both Total Heat Index (THI) and Weighted Heat Index (WHI), where the THI and WHI were based on Hartford (Brainerd), CT weather conditions. The resulting plot, showing only temperatures 75°F and above, is given in Figure 2 below.

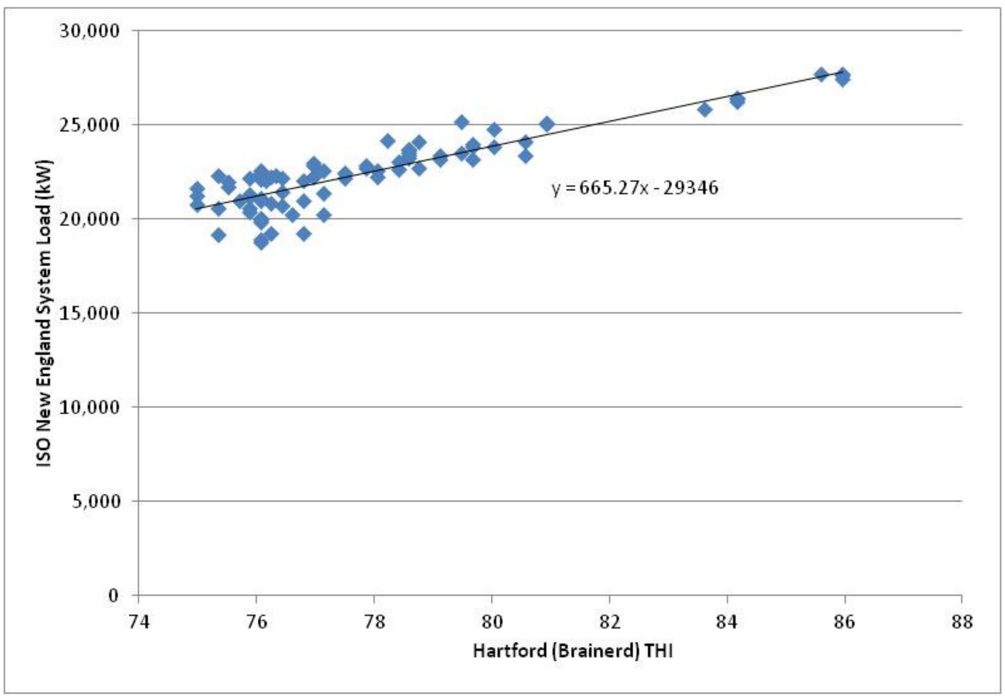


Figure 2 System Load as a function of THI

Based on the 2011 CELT report, the expected 50/50 system peak load for the summer condition was expected to be 27,550 kW. Therefore, 90% of the 50/50 system peak load for the summer condition is met when the system load was 24,975 kW or greater. Based on the WHI relationship developed above, this is expected to be met when the THI conditions are 81.6°F or greater. Therefore, hours used to determine the peak for the purposes of this evaluation were the hours when the THI was at or greater than 81.6°F for Hartford (Brainerd) for the TMY3 file utilized.

A similar approach was taken to correlate to WHI; however, the WHI correlation did not affect the hours selected, and therefore was not included.

### Winter Seasonal Peak

To determine the winter seasonal peak demand reductions a similar approach was taken as given above. However, several changes were made to the analysis. First, based on the 2011 CELT report, the expected 50/50 system peak load for the winter condition was expected to be 22,085 kW. Therefore, 90% of the 50/50 system peak load for the winter load condition is met when the system load was 19,877 kW or greater.

Second, for the winter condition, humidity is not expected to significantly affect the system load; therefore, the system load is correlated to dry bulb temperature.

Finally, based on a review of the data, the system load varied significantly based on the time of day. Therefore, the decision was made to produce separate correlations for each hour considered.

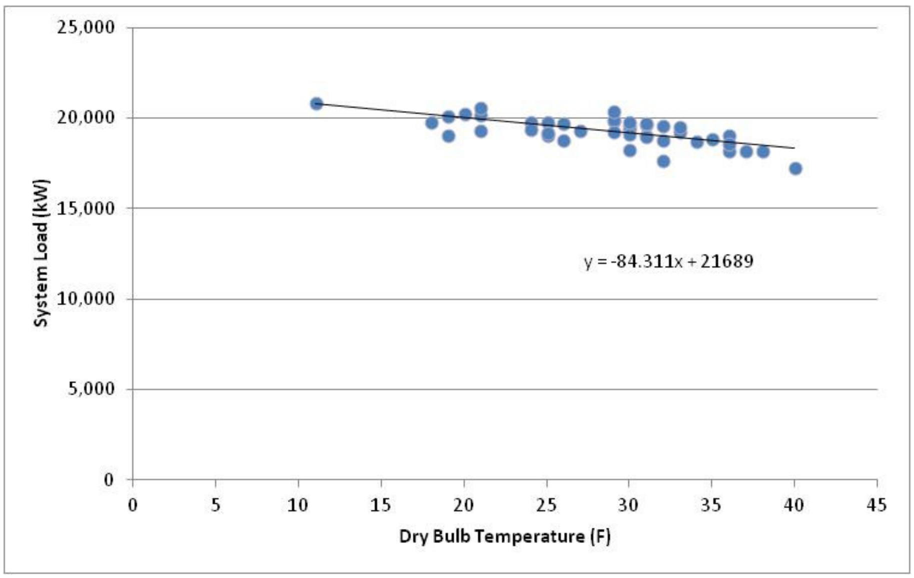


Figure 3 System Load as a function of Dry Bulb Temperature for Hour 18

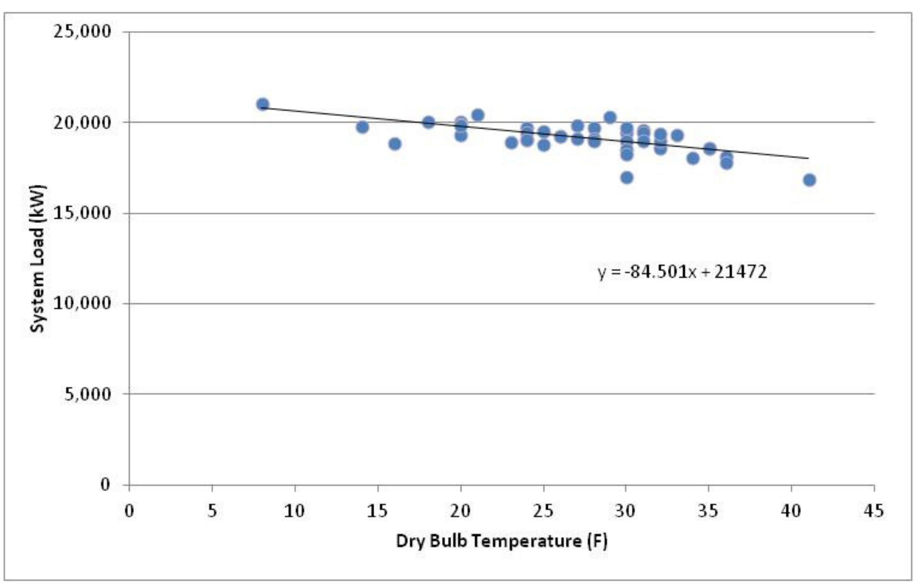


Figure 4 System Load as a function of Dry Bulb Temperature for Hour 19

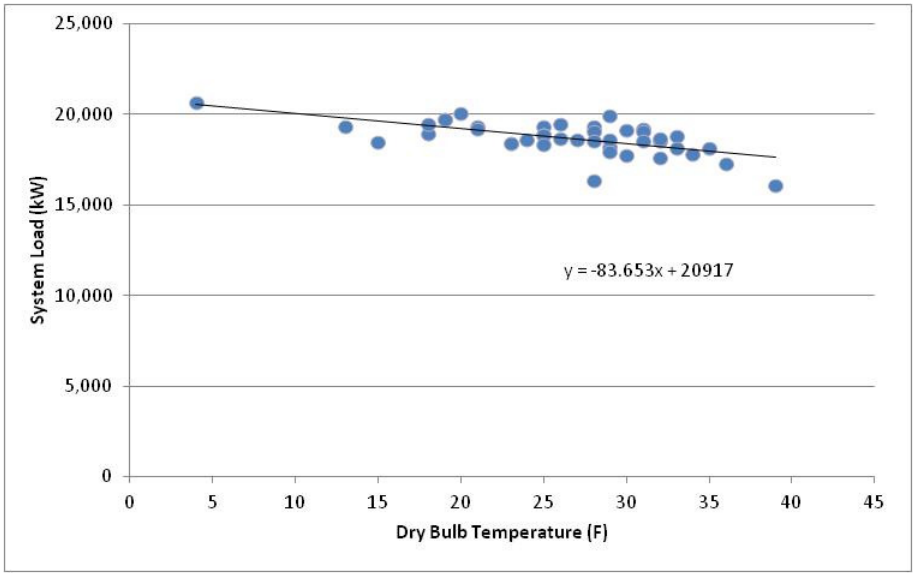


Figure 5 System Load as a function of Dry Bulb Temperature for Hour 20

Based on this analysis, the peak load condition is expected to be met when the temperature is at or below the temperatures given for each hour listed in the table below.

**Table 45 Winter Peak Temperature Conditions**

| Hour | Starting Time | Ending Time | Dry Bulb Temperature (F) |
|---|---|---|---|
| Hour 16 | 5:00 | 6:00 | 20.4°F |
| Hour 17 | 6:00 | 7:00 | 17.7°F |
| Hour 18 | 7:00 | 8:00 | 5.0°F |

# 10. Appendix D—Final Site Reports