Public Buildings Enhanced Energy Efficiency Program

2.3 Investigation Guidelines

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1.0 Executive Summary

The *Investigation Guidelines* are designed specifically for Providers participating in the Public Buildings Enhanced Energy Efficiency Program (PBEEEP Program). The PBEEEP is designed to be a retrocommissioning/recommissioning and retrofit focused program. The purpose of these Guidelines, and the Documentation Guidelines included in the *Findings Workbook* (*Findings Reference* worksheet), is to promote rigor and consistency in the identification and calculation of energy savings for the Program.

This document is one of several tools made available for Provider use throughout different phases of the Program's recommissioning (RCx) project. Other Program tools include the *Findings Workbook*, which is one of the primary reporting tools during the investigation and implementation verification phases of the project, and the *Implementation Verification Guidelines*, whose purpose is to ensure that Providers gather appropriate evidence to show that measures were implemented and the actual performance is in accordance with the findings and calculations proposed during investigation.

The *Investigation Guidelines* contained in this document define field procedures and calculation methods for measuring and verifying the pre- and post-conditions of typical operational improvements and retrofits. The document is intended to guide Providers through the primary tasks and associated deliverables of the investigation phase, which include:

- Identifying energy savings opportunities and corrective measures,
- Collecting baseline data in support of each measure,
- Calculating energy, demand and cost savings for identified RCx and retrofit measures, and
- Recommending implementation of selected measures based on technical and financial feasibility.

The close of the Investigation Phase is the presentation of measures and the selection of measures for implementation. Following the Implementation Phase, when measures are implemented, the Provider is responsible for verifying that each measure was implemented as intended per the project investigation. Providers will be required to refer to the *Implementation Verification Guidelines* provided by the Program for this verification process.

Although these Guidelines are intended to promote RCx best practices and high levels of rigor, please note that eligible measures and specific process requirements are likely to vary when the local Utility is providing services and/or co-funding opportunities for a project. These variances may include specific rebate applications, data collection requirements, implementation verification requirements, technical review requirements, and financial thresholds that could impact the RCx Provider's scope and the project's financial incentive availability. Prior to the start of work, at the Screening Level, the Provider will be responsible for contacting the applicable Utilities to compile specific co-funding forms and refund requirements.

Please note the *Investigation Guidelines* cannot predict every question or issue uncovered during the investigation. When questions arise, the Provider should immediately consult with Program staff to develop a mutually agreeable approach and solution.

2.0 Investigation Overview

The investigation phase is the second of four primary phases of a project in the Public Buildings Enhanced Energy Efficiency Program (the PBEEEP Program). The phases are: screening, investigation, implementation, and verification of savings/follow-up. After screening for suitability and potential energy savings, selected buildings will move on to the investigation phase. During the investigation, the RCx Provider conducts a rigorous analysis of the building operations. Through observation, targeted functional testing, and analysis of extensive trend and portable logger data, the RCx Provider identifies deficiencies in the operation of the mechanical equipment, lighting, envelope and related controls. The goal is to identify opportunities for operational and maintenance improvements and/or retrofits to reduce energy consumption.

At the outset of the investigation, the RCx Provider shall arrange a kick-off meeting with a Program Representative and appropriate facility staff to discuss any facility access and security issues, and to communicate the desired approach for the investigation process. The Utility Account Representative should be invited to attend this meeting. The Provider may also coordinate with the building staff to invite any primary service contractors (e.g. controls contractor) who may be key to collecting data during the investigation or implementing measures later in the process. This will ensure that all project stakeholders are clear about Program process expectations and team roles. As a reference, the Program provides a sample checklist of topics to cover during the project kick-off meeting (see **Attachment B**). A building walk through should be scheduled following the meeting.

During the investigation, it is especially important that the RCx Provider gather information on the Owner's Operating Requirements so as to be sensitive to building schedules, functions, and processes during the investigation. The Program provides a form for the RCx Provider to reference for collecting this information (see **Attachment C**), which is included as an attachment to the *RCx Investigation Report*.

The RCx Provider should use the building automation system trending or portable data loggers to obtain baseline data that demonstrates the problem or opportunity of a given finding. For retrofit measures, baseline data should align with applicable utility requirements. If retrofit measures are included in a package of measures that includes RCx measures, project-specific data should be gathered for developing the baseline condition.

The RCx Provider will summarize the investigation in the Program's primary reporting tool, the Excel®-based *Findings Workbook.* The *Findings Workbook* contains the *Investigation Summary*, one of the summary spreadsheets built into the workbook. The *Investigation Summary* provides a complete set of measures identified during the investigation and includes findings and measure descriptions, energy savings calculations, estimated costs, and simple payback calculations.

The RCx Provider will submit the *Findings Workbook* for each *building* investigated, along with all supporting calculations and information, to the Program for review. Supporting information includes all calculations and assumptions, trend and portable logger data, functional test results, building simulation parameters and results, site visit reports, and any photographs that were used to identify the problem or opportunity.

Upon approval of the *Findings Workbook* and associated documentation, the RCx Provider presents the results of the investigation in a meeting with the Program Representative, building staff, key contractors and, if applicable, the Utility Account Representative. The RCx Provider assists the Program Representative and building staff in selecting measures for implementation.

The final package of selected measures is presented in the *RCx Investigation Report*. The *RCx Investigation Report* includes the measures selected for implementation, the energy savings and payback calculations, and additional information on recommendations for implementation. The *RCx Investigation Report* and *Findings Workbook* will be used to move the project into the implementation phase.

3.0 Eligible Measures

The Program's purpose is to make sure that energy-consuming equipment, as well as building components that impact energy use (e.g. building envelope; windows), only use as much energy as is necessary to perform their intended functions. To meet this requirement, the Program sets standards for investigating building operations and reporting findings to maximize energy and cost savings in public buildings. Consequently all reasonable RCx (low-cost) and retrofit (capital) measure types within the RCx Provider's scope of work shall be examined after verification by the Program. Additional recommendations for the use of alternate energy are also within the scope of the Program. Providers are encouraged to seek out and analyze any alternate energy solutions that may be beneficial at each site. In the event of a renovation of 50% or more of an existing building or energy system, a minimum of 2% of the building energy requirements must be provided by renewable sources located on-site. Please note that eligible measures will vary depending on the specific Utility. Long payback items (over 15 years) are often ineligible for consideration. Prior to the start of work, the Provider will contact the building's Utility to help ensure that Utility-specific protocols for collecting financial incentives are followed during the investigation and implementation phases of the project.

Typical measures cover the following types of systems

1. HVAC
2. Lighting
3. Domestic Hot Water (DHW)
4. Miscellaneous Pumps (Booster pumps, fountains, etc.)
5. Building Envelope
6. Refrigeration

The goal of the Program is to implement the following types of measures:

1. Fix problems with existing controls
2. Enhance the control and operation of existing equipment
3. Make repairs/upgrades to the existing equipment to make it run more efficiently
4. Replace equipment with higher efficiency equipment
5. Educate the building operation staff on the most efficient manner in which to operate the building.

Most commonly, measures will apply to the following system components and operational situations: lighting, chillers, cooling towers, economizers, air handlers, pumps, simultaneous heating and cooling, and controls.

The RCx Provider should check equipment warranties, in case there are any limitations on system modifications that may be carried out. This is referenced in the Kick off Meeting checklist (see **Attachment B**).

The RCx Provider should consider the impact of any applicable building and/or energy codes when recommending measures. All required codes shall be followed.

For reference see the *Findings Reference* worksheet in the *Findings Workbook* which contains a list of common retrocommissioning measures.

4.0 Findings Workbook

To organize, communicate and track project progress and the selection and implementation of measures, the Program has developed a Microsoft Excel *Findings Workbook* (FWB) as a tool for the RCx Provider and Program team to use. This tool is used during investigation and implementation as a deliverable and to produce associated deliverables required by the Program. The Program requires the RCx Provider to use this workbook, as its intent is to facilitate and streamline reporting and project tracking. The *Findings Workbook* deliverables represent the minimum level of reporting that the RCx Provider must complete. RCx Providers are encouraged to expand upon these tables and provide additional information and narratives in the *RCx Investigation Report* and the *RCx Final Report* as they see fit to clarify entries for the benefit of the Agency and the Program's reviewers. The Provider is required to complete the *Findings Workbook for each building investigation* (i.e., a 10-building campus would require 10 *Findings Workbooks*).

The RCx Provider will use the 'Project Overview' and 'Data Input' worksheets to input all of the necessary data. Other worksheets are linked to the 'Data Input' worksheet and are fully formatted to summarize the data for presentation to the Agency during key meetings. The RCx Provider should only have to make minor formatting adjustments to ensure that each deliverable prints cleanly. Details for each worksheet are provided in the following table. Worksheets requiring input are noted in bold; all of the other worksheets are output only.

Findings Workbook Description of Individual Worksheets:

Worksheet	Phase	Purpose	Contents
Tips	ALL	Help for the *Findings Workbook*	Explanation for data entry, inserting and deleting rows, other edits, measures selected for implementation, and costs per kWh
Project Overview	RCx Investigation & Implementation	Project summary	Summary of the project, including building characteristics, energy consumption, utility rates, and RCx project costs and savings
Progress (optional)	RCx Investigation and Implementation	Project tracking information	Key project milestones and dates of completion
Investigation Checklist	RCx Investigation	Documentation of scope of work by Provider	Main findings categories and types
Findings Reference	RCx Investigation and Implementation	Reference for Investigation Checklist and Data Input Worksheets	Findings Descriptions and Documentation Requirements for each finding are provided here. The worksheet is formatted to print one finding per page.
Equipment List	RCx Investigation	Documentation of project-applicable equipment for the building	Key summary information on equipment: equipment models, quantities, serviced areas and locations, equipment usage and operational hours
Attachments	RCx Investigation and Implementation	Documentation of measure supporting files	Listing of measures and associated support file names with descriptions

Worksheet	Phase	Purpose	Contents
Data Input	RCx Investigation & Implementation	Data input into a central location	All data for each measure
Investigation Summary	RCx Investigation	Report investigation findings to the Program	Findings, measures, benefits, energy and cost savings estimates, estimated costs, estimated Utility co-funding[1] (if applicable), and simple payback.
Implemented Measure Summary	At the end of Implementation	List of implemented measures, including updated cost and savings values	For each measure, updated energy and cost savings, actual implementation costs, Utility co-funding, and updated simple payback
Non-Implemented Measure Summary	At the end of Implementation	List of measures not implemented.	Measures that were not implemented, but may be implemented in the future.

5.0 Deliverables

The RCx Provider will prepare four key program deliverables during the RCx investigation phase: an initial review of their project and trending plan, followed by two submissions of the *Findings Workbook,* and *RCx Investigation Report*. Providers should also expect to communicate periodically with PBEEEP to discuss questions and progress, which will be completed primarily through the invoice progress reports. Each of these is described below.

Please note there are two additional program deliverables during the post-implementation phase: an *Updated Findings Workbook* and *RCx Final Report*. These deliverables are discussed in further detail in the *Implementation Verification Guidelines*.

5.1	Initial Review	Review of trending plan, project approach/plan review, sampling plans, etc.
5.2	Mid Point Review including Preliminary Findings Review	Rigorous review of *Findings Workbook* and associated files(data tracking/reporting .xls workbook); overview of all findings identified to date
5.3	Final *Findings Workbook* submission and Review	Final *Findings Workbook* and associated files (data tracking/reporting .xls workbook)
5.4	Submission of Final Investigation Report	*Investigation Report*

During the Investigation Phase, Providers will use WorkZone® for document management. All program related documentation exchanges and reviews, which includes the Findings Workbook, supporting documentation for energy-related and cost-related calculations, and project management documents will occur in WorkZone. WorkZone is a collaborative, web-based application that will be used throughout

[1] Co-funding is defined in this document as a utility sponsored incentive or rebate. No financial incentives will be provided by the Program directly.

each phase of PBEEEP projects. Providers will have their own secure log-in accounts that will host all PBEEEP project folders for that Provider. A WorkZone guide will be provided to Providers in their individual WorkZone accounts (workspaces).

5.1 Initial Review

Shortly after the Kick-off meeting (2 to 4 weeks is an expected range), the Program will hold an informal meeting with the Provider to review the progress, approach, and format for the investigation process and the documentation of the investigation process. Specific deliverables at the initial review are:

- The trending plan
- The equipment sampling plan
- Summary of any initial observations of opportunities
- Confirmation that Provider is aware of all issues observed during Screening
- Any issues or concerns that arose during the first weeks of the project

5.2 Mid Point Review Including Preliminary List of Findings

At the mid-point of the investigation, the Program requires the Provider to submit the *Findings Workbook* for review. At this time the workbook should contain substantially complete information on those findings related to the investigation to date (heating or cooling season, depending on the start date of the Investigation) and should also include issues that have been identified but not yet investigated fully. All of these findings (those that have been fully investigated and the preliminary findings) will be summarized by the Program in an update memo which will be shared with project stakeholders following the Project Mid-Point Review that the provider has with the program. These communications will help ensure Program expectations are understood and help keep the project stakeholders informed of the progress of the Investigation.

Throughout the investigation, the RCx Provider is encouraged to communicate with project stakeholders about measures that are being identified. This is meant to avoid sinking a significant amount of time into a measure that will not be implemented for various reasons, such as prohibitive implementation costs, measure impact on critical items, or aesthetic-related considerations.

5.3 Findings Workbook and Associated Savings Calculations

Each *Findings Workbook* (FWB) must contain the following information for each finding, as indicated in the FWB template:

- Finding name and assigned number
- Description of finding
- Recommended measure or improvement
- Supporting documentation file name(s)
- Baseline documentation method
- Evidence of implementation method
- Estimated annual electric savings (kWh and $)[2]
- Estimated annual gas savings (therms and $)
- Estimated annual savings of other energy sources (fuel oil, propane, chilled water, hot water, steam, etc) (btus and $)
- Estimated total annual energy cost savings ($)[3]
- Estimated peak demand savings (kW)
- Total estimated implementation cost ($)
- Initial simple payback (years)
- Estimated Utility co-funding ($), if any
- Estimated simple payback with co-funding (years)

[2] The estimated annual electric savings accounts for peak, semi-peak, and off-peak for summer and winter seasons. Detail on how to calculate the annual energy savings for each measure is described in detail in Section 6.4.

[3] The estimated annual savings accounts for interactions between measures. Accounting for interactions is described in detail in Section 6.5.

All calculations or modeling parameters and results must be submitted with the FWB for Program review, together with supporting trend or logged data and analysis. The Program will use this data as the baseline performance to prove implementation and verify savings for those measures that are implemented by the Agency.

The observations and findings from the RCx investigation will be communicated to the Owner and Program via the FWB's *Investigation Summary*, one of the spreadsheet summary outputs of the FWB. In a meeting with project stakeholders, the RCx Provider will use the Investigation Summary to present the RCx investigation results and assist the Owner with selecting measures for implementation. At the meeting, Utility co-funding and/or financing based upon the simple payback and implementation cost estimates from the investigation will be addressed.

Measures that do not lead to energy savings, but result in non-energy benefits (IAQ, reduced maintenance, etc), should still be included in the FWB if their investigation was specifically requested by the program or the agency.

5.4 RCx Investigation Report

The *RCx Investigation Report* is generated by the RCx Provider after measures are selected for implementation. At a minimum, the *RCx Investigation Report* includes all of the data presented in the *Investigation Summary*, as well as recommendations for implementation for each measure selected. To assist the RCx Provider, the Program provides a template for the *RCx Investigation Report*, including the cover page, table of contents, and text narrative to help guide the report (see **Attachment D** for more information). The required narrative for the *RCx Investigation Report* should describe the baseline building systems, the investigation process and results, and implementation recommendations to help the Agency take the next steps to implement identified measures.

To facilitate implementation, the RCx Provider assists the Agency with estimating costs for implementation of each measure and includes these costs in the *RCx Investigation Report.* Once the investigation phase is complete, a scope of work will be required to determine the efforts and costs associated with initiating and completing the implementation phase. The RCx Provider may be asked to perform design work and/or detailed specs for each selected measure. In the *RCx Investigation Report*, the RCx Provider should also be clear about the format for submitting evidence that the measure has been properly implemented, i.e., trending, functional testing, site visit reports, and/or before/after photographs. See the Finding Descriptions (*Findings Workbook*, *Findings Reference* worksheet) for information on calculating savings and documenting implementation of the common RCx and retrofit finding types.

5.5 Utility-sponsored Co-funding

Utility-sponsored rebates or incentives might be available for some of the findings discovered during the Investigation. Each Utility will likely have specific requirements and/or additional application forms to qualify for their incentive offerings. Where these co-funding opportunities are applicable, the Provider is responsible for developing all documentation and providing necessary information in meeting the specific Utility requirements for co-funding, including Utility rebate applications and forms. In some cases the utility may have a limited number of standard rebate offerings. This will be particularly true for smaller coops and municipal utilities. If a utility does not have a standard rebate for a particular recommendation, a "custom rebate" may be developed. Note that energy utilities in MN are now required to save 1.5 percent of their sales annually, so all utilities are more likely to partner to provide co-funding and other programs for these projects.

6.0 Required Documentation for Measures

Documentation for the individual findings (problems) and corresponding measures (fixes) must be detailed in the *Findings Workbook*. The RCx Documentation Guidelines (*Findings Workbook*, *Findings Reference*) give further detail on satisfying data requirements for the Program. Backup documentation

external to the *Findings Workbook* is also required, including savings calculations, and RCx Providers should identify the file names for all supporting documentation in the 'Data Input' worksheet found in the *Findings Workbook*.

6.1 Guidelines for Documenting RCx and Retrofit Measures

Quality, consistent documentation of measures is a critical aspect of the Program. Not only does it measure the overall success of the Program, but it also adds to the industry's body of knowledge about the benefits and cost-effectiveness of retrocommissioning. For this reason, the RCx Documentation Guidelines (*Findings Workbook*, *Findings Reference* worksheet) were developed to define field procedures and calculation methods for measuring and verifying the pre- and post-conditions for measures commonly implemented through the Program. RCx Providers are required to follow these guidelines and work with the Program to ensure that measures are properly documented and savings are verified.

A variety of measures may be implemented under Program; with each type of measure, there may be different documentation requirements for:

- **How the issue was found** (a description of how the problem was detected must be input into the field "Finding Method" in the *Findings Workbook*);
- **How the savings are determined**; and
- **What evidence of implementation must be provided** (the method for providing evidence of implementation and the results of implementing this method are reported in the *Findings Workbook*).

The RCx Documentation Guidelines present the requirements for each of these steps for potential RCx measures. In all, the RCx Providers must demonstrate to the Program that the measures they identify during RCx Investigation are practical and cost-effective. Providers must also collect **baseline data** in support of each measure. Before approving the *Findings Workbook* and associated calculations, the Program staff will review all **savings calculations** to verify assumptions, appropriateness of the calculation, and reasonableness of the result. This will include a review of the implementation cost estimates and the RCx Provider's Implementation Assistance cost estimates. Once measures are implemented, the RCx Provider is responsible for verifying that measures have been properly installed and must provide **evidence of implementation**.

The "Recommendations for Implementation" section of the *Findings Workbook* (Data Input tab) shall indicate a reasonable method to implement the measure that ensures the highest level of persistence that can reasonably be accepted by the Agency and operations staff. For instance, if a measure identifies that the chilled water reset strategy had the improper setting in the BAS user screen, the simple measure would be to recommend that the setting be fixed. However, it is quite likely that the improper values will be input again. Improved methods would be to recommend that these inputs are password protected or have some type of separate input screen along with the proper set points indicated so that these would not be accidentally overridden. A more extreme measure would be to hard code this, although this may not be acceptable to the building operator.

The following section provides further detail on each of these steps, as it is laid out in the RCx Documentation Guidelines.

6.2 RCx and Retrofit Finding Descriptions and Documentation Guidelines

The RCx Findings Descriptions and Documentation Guidelines (*Findings Workbook*, *Findings Reference* worksheet**)** contain guidelines for problem identification, baseline documentation, calculation, and implementation verification, for 53 Finding Types. The most current version of the RCx Findings Descriptions and Documentation Guidelines is a reference file located in the *Findings Workbook* (Version 2.0 or later) in the *Findings Reference* worksheet. The following information is provided for each Finding:

Finding Type

The title of each page of the RCx Finding Description table lists categories of findings likely to be discovered and corrected through the Program. The typical RCx findings are organized into the following major categories.

a. Equipment Scheduling and Enabling
b. Economizer/Outside Air Loads
c. Controls Problems
d. Controls (Setpoint Changes)
e. Controls (Reset Schedules)
f. Equipment Efficiency Improvements / Load Reduction
g. Variable Frequency Drives (VFD)
h. Retrofits
    - Motors
    - Primary HVAC equipment
    - HVAC system design
    - Lighting
    - Building envelope
    - Alternative energy
i. Maintenance Related Problems

RCx Providers are encouraged to identify all problems or system operational enhancements even if they are not explicitly described in the *Guidelines*. Presumably, these findings will fit into one of the existing categories, and the information within the category will be sufficient to provide documentation guidance for the measure. If questions or issues arise concerning other findings, the Program will work with the RCx Provider and the Utility to define the documentation requirements.

Finding Examples

Specific examples are given of each finding type. Keep in mind that the examples provided do not include all possible findings in each category. Any questions that arise regarding the classification of a finding type should be communicated to the Program.

Method for Finding the Problem

Methods for finding problems are described. For most measures, trending or data logging may be used to both find the problem and collect the baseline data.

Calculating Energy, Demand, and Cost Savings

Examples and guidelines are given for the accepted savings calculations methods. Savings for some of the measures are independent of weather and depend only on kW and hours of operation. For measures that

depend on weather, calculations of savings most often involve bins of hourly temperature data or approved simulation models. If there is potential demand reduction, the Program requires an estimate of the measure's monthly impact on peak demand.

Data Collection Methods

Acceptable methods for establishing a baseline and for verifying implementation of the measures are described. The allowable methods are separated into the order of preference. The preferred method generally involves trending or logging of actual system performance. Trending is the preferred method as it gives a true indication of system performance over a range of operating conditions (occupied / unoccupied, warm-up / shutdown, cool / warm OA temps, etc). However, other methods are also acceptable, as indicated in columns C and D. If any of these other methods are used, contact the Program in advance of collecting the data for approval. For findings / measures in the 'Controls (Reset Schedules)' category, note that trend data is the only acceptable method for baseline and implementation verification.

For visual spot verification that actual system performance matches that indicated by the EMS, provide brief documentation of observations. E.g., "On 5/14/08, toilet exhaust fan EF-1 was visually observed to be off when commanded to be off at the EMS. Same exhaust fan was visually observed to be on when commanded to be on at the EMS."

Note that other data beyond that indicated in the table may need to be trended / measured for the savings calculations. For example, besides trending equipment status (on/off), the kW power draw of the equipment would need to be spot measured (for constant load equipment) to calculate savings.

Trend data may be collected using data loggers or the trending capabilities of the building's EMS. See section 6.3 for general measurement guidelines.

See the *Implementation Verification Guidelines* for additional information on the data that will be needed after implementation to be sure that you have collected all necessary baseline data. If, during the verification process, it is found that some improvements have not been made correctly, the implementer (building staff or contractor) will be expected to perform repairs or complete the process.

6.3 Measurement Guidelines

Baseline data for energy savings calculations can be gathered through trending, spot measurements, data logging, manufacturer's data, or a combination of these methods. Following the kick off meeting and initial walk through the provider will meet with the Program's engineer for the project and present the trending plan and any updates to their project plan. The following guidelines apply to collection of baseline data and, where applicable as indicated in the RCx Documentation Guidelines, data to be used for evidence of implementation. See the *Implementation Verification Guidelines* for additional general implementation verification guidelines.

6.3.1 Trending

For trending and data logging, collect a minimum of one week of fifteen minute interval data for non-temperature dependent data, and two weeks of data for temperature-dependent data. Data should be collected during operating conditions that are applicable to the measure (season, outside air temperatures, operating / occupancy schedules). Site reference data, such as outside air temperature must be collected.

It can take substantial time to set up trends and to download the data, this is why it is important to prepare a trend plan in advance of the data collection period. Ideally one or two sample trends will be set up at the time of the first visit to a building.

If it is not possible to collect trend data for implementation evidence during applicable operating conditions (e.g., if the outside air temperature is too high to verify proper economizer operation) then another method should be used for verification of measure implementation. Refer to the *Findings Workbook*, *Findings Reference* worksheet for acceptable alternate methods.

Trended or logged data used for implementation verification should be the same type as the baseline data.

To gather time-series data, RCx Providers may use the building automation system to trend data or may install portable data loggers. In all instances, the data collection method used must provide accurate values. This means that the accuracy of EMS and data logger sensors must be verified. The following table shows the preferred format for trend data collection:

Data Format and Availability	ASCII; Importable to Microsoft Excel Available as .txt, .csv or .xls files for the Program management team
Duration	Minimum of one week of data, two weeks preferred
Sampling rate	One to 15 minutes (Use a shorter interval when a data logger can sample and average separately. Some energy management systems may only be able to trend relatively few parameters simultaneously, and the shorter the sampling interval, the fewer points that can be trended.)
Averaging/Archiving Rate	Five to 30 minutes or less. For fast acting controls, or evaluation of control loop stability, short interval data may be required.
Typical points	A complete list of points is provided in Section 3.0 of the Investigation Guidelines for Trend Data Collection (Section 2.3.1 of the PBEEEP Guidelines).

The Program recognizes that there may be instances where collecting time-series data for a measure may be inappropriate or unfeasible, and may accept alternate proof that a measure is appropriate. Other forms of proof include trending using a lower sampling rate (when the BAS cannot support intervals of fifteen minute or less), functional test results, written observations or site reports, and photographs. To ensure baseline data will meet the Program's EM&V needs for implemented measures, the Program will expect close communication about the methodology used for collecting baseline data during the investigation.

For measures that are estimated to save less than 25,000 kWh/yr (for other fuel types $2,000 per year or 3% of annual energy cost whichever is less) spot measurements and nominal schedules may be used; the sources of all such measurements must be provided with screen shots, photos, etc.

6.3.2 Power Measurements

Energy savings estimates will be based on baseline data collected during the investigation. For collection of electricity data to be used in these calculations, power can be measured directly or estimated based on measurements of voltage, current, and power factor. Whether for a spot measurement or trending, the following guidelines apply, in order of preference:

1. Trend or log RMS power directly.
2. For constant load equipment, spot measure RMS power. For variable load equipment associated with savings initially estimated at less than 25,000 kWh/year, spot measure RMS power. Record location, time, and date of spot measurements.
3. Trend or log voltage and current and apply a power factor to calculate power (see following section on power factor).
4. Trend or log current, spot measure voltage, and apply a power factor to calculate power. Voltage may be spot measured at the motor control center or electrical panel related to each piece of equipment being trended (see following section on power factor).

5. For equipment with available part load efficiency curves, this data may be used as a surrogate for actual trending of power data if a trend data-based load profile is available. Verify and perform the following:

    a. Actual operation of the equipment is consistent with the assumptions in the data.
    b. The load data covers the relevant range of operating conditions.
    c. Supply the data as part of the analysis. A reference may be used if DOE-2 or a similar readily available data source is used.
    d. Spot measure the power, along with relevant operating data, to establish the consistency of the curve fit with actual operating conditions. If a discrepancy is found, apply a correction factor to the curve fit.

6. Use nominal manufacturer's values for equipment with a constant nominal load (e.g., non-dimmed lighting, resistance heaters). Perform the following:

    a. Spot measure random samples of the installed equipment, to ensure that the installed equipment meets the specifications. Measuring groups of identical equipment at an electrical panel is preferred over measuring individual pieces of equipment.
    b. Determine, from inspection or spot power measurements, any variable adjustments that impact load, e.g., ballast factors.

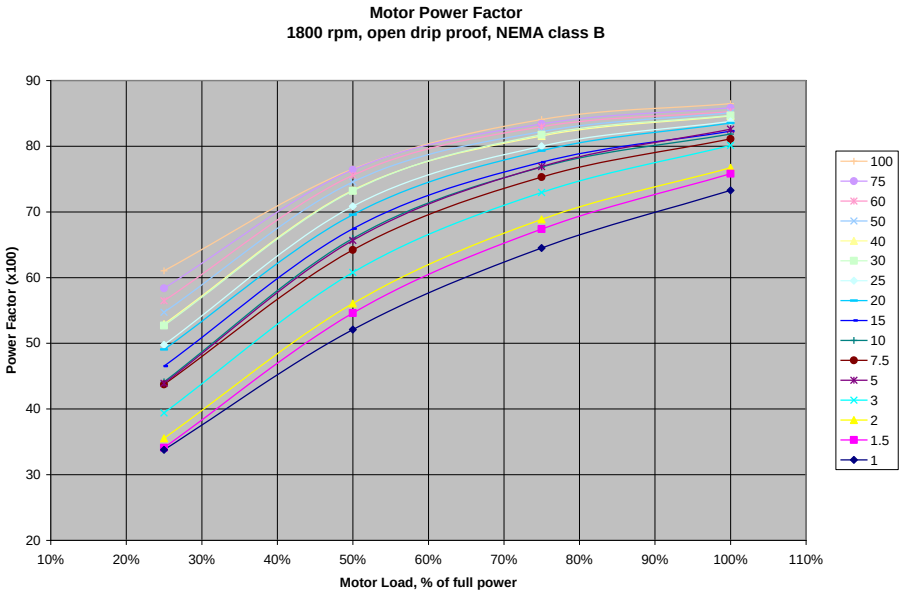
For spot measurements, record the location, time, and date of measurements. For spot measurements of voltage on three phase power, measure the voltage of all three legs and use the average in the energy use calculations.

Wherever trending or spot measurements of power are used as a means of implementation verification, perform the same method of power measurement for both the baseline data collection and implementation verification.

6.3.3 Power Factor

Provide justification for the power factor value used in the calculations, e.g., measured values, motor manufacturer's curves, lighting cut sheets. Constant power factors may be used for constant load equipment or for measures with estimated savings of less than 25,000 kWh/year.

The following chart shows power factor as a function of motor load and motor horsepower, for motors typically used in HVAC systems (1800 rpm, open drip proof, NEMA class B). These values may be used in power calculations when voltage and current are being measured / trended and the actual power factor cannot be readily measured.



Source: *MotorMaster+ version 4.00.06 motor database.* Developed for the U.S. Department of Energy by the Washington State University Energy Program, 2007.

The following table includes power factor correction values that may be used when the measured voltage deviates from the nameplate voltage.

Power Factor Correction Values		
Motor Load	**Voltage Difference from Nameplate Value**	
	- 4%	**+ 4%**
100%	+ 0.6%	- 1.0%
75%	+ 1.4%	- 2.0%
50%	+ 3.2%	- 3.6%
25%	+ 6.5%	- 6.9%

Source: *Effects of Reduced Voltage on the Operation and Efficiency of Electric Loads, Volume 2.* Electric Power Research Institute (EPRI), 1981.

6.3.4 Sampling

For large numbers of similar equipment with similar operating characteristics, sampling may be used. This equipment should meet the following criteria:

- Components and control sequences for each piece of equipment are similar.
- Operating conditions for each piece of equipment are the same, e.g., outside air temperature, chilled and heating water supply temperatures, operating hours, occupancies served.
- Samples must be designed to be representative: e.g. if there are VAVs on three floors, the sample should include each floor as well as all space types (such as both offices and meeting rooms).
- For air handlers, supply fan motors do not exceed 15 HP.

Group equipment with similar operating parameters into use-groups. All equipment over 15 HP must be trended individually, regardless of the total number of units.

Number of Units	Minimum Number to Sample	Incremental Rate	Example
10 or less	All units	100%	
11 to 50	10 units	25% of units in excess of 10	If there are 30 units, sample size is 15 (100% of 10 +25% of 20)
51 to 100	20 units	20% of units in excess of 10	If there are 80 units, sample size is 24 (100% of 10 + 20% of 70)
Over 100	25 units	20%	If there are 140 units, sample size is 28 (20% of 140). Note that for 100 to 130 units the sample size is 25.

Samples should be representative to the rest of the population in the use-group. Provide supporting documentation, including a diagram of the various use-groups and a written description of the use-groups and their operational parameters. If substantial variation in performance is seen in the sample, the sample size must be increased. Contact the Program if you have questions. As an example, the air handlers listed in the following table can be grouped as indicated:

Air Handlers	**Quantity**	**Type**	**Occupancy Served**	**Operating Schedule**	**Use-Group Sample Size**
AH-1 – AH-11	11	VAV, CHW coil, HW coil, economizer section (serves perimeter zones)	Offices, conference rooms	8-5 M-F	10
AH-12 – AH-13	2	VAV, CHW coil, economizer section (serves interior zones)	Offices, conference rooms	8-5 M-F	2
AH-14 – AH-15	2	VAV, CHW coil, economizer section (serves interior zones)	Conference rooms	Intermittent from 8-5 M-F	2
AH-16 – AH-18	3	VAV, CHW coil, HW coil, economizer section (serves perimeter zones)	Retail space	7-10 M-Sat,12-7 Sun	3
AH-19 – AH-25	7	CV, CHW coil, HW coil, economizer section (serves perimeter zones)	Retail space	7-10 M-Sat,12-7 Sun	7

6.3.5 Equipment Runtimes

For schedule-based equipment (e.g., lighting), trend run times for measures that are estimated to save more than 25,000 kWh/yr. For measures with less savings, nominal schedules may be used in conjunction with spot measurements. For other fuel types, spot measurements may be used when savings are less than $2,000 per year/3% of annual energy cost, whichever is less. The schedule must be verified and documented.

For equipment that operates based upon demand, trend run times if the trending can cover typical annual operational characteristics (e.g. air compressor). If the trending cannot cover typical annual operational

characteristics (e.g. chiller operation), estimate run times with bin engineering calculations or a building simulation.

For runtimes obtained by trending of EMS data, there should be verification that the EMS data is correct. Status feedback data (AI/DI points) is preferable to Enable/Disable command data (AO/DO points).

6.3.6 Correlations

Correlations are used to estimate system characteristics based on factors known to affect performance, e.g., chiller load as a function of outside air temperature (load profile). Include the development procedure for any correlations used in the calculations. Correlations should be based on measured / trended data whenever possible.

Assumed load factors / nominal equipment efficiencies may be used for measures with a savings estimate of less than 25,000 kWh/year.

Short term trend data may or may not be adequate to collect loads that can be used to extrapolate energy savings. The following are recommended methods, in order of preference, to develop correlations:

a. Use trended data to create correlations between loads and relevant variables, e.g., fan speed as a function of outside air temperature. If these correlations are developed using inadequate data, i.e., if the data was not obtained during relevant operating conditions or over a sufficient range of the expected outside air temperatures, collect additional data later, prior to implementation, and update the savings calculations accordingly.
b. Perform load calculations / simulations using software to establish annual load profiles.

6.4 Determining Energy Cost Savings

Energy cost savings can be calculated in the *Findings Workbook* using either the provided utility rate schedule or an average rate approved through PBEEEP.

6.4.1 Using appropriate utility rates to calculate energy cost savings:

The RCx Provider should model the energy cost savings using the appropriate time of use utility rates in the Utility Rates table to correctly account for variances in energy and demand charges. This results in more accurate cost savings when a measure's energy savings are not distributed across all time of use periods.

Utility rates are entered in by the Program and locked for editing in the *Findings Workbook*. If questions regarding the use of utility rates and calculating energy cost savings come up, the Provider should contact PBEEEP for assistance.

6.4.2 Savings Calculation Guidelines Method

Energy savings may be estimated using either spreadsheet calculations or building simulations (energy modeling). Use standard calculation methods (e.g., bin methods) and/or engineering software (DOE-2.2). Spreadsheet calculations using bin data should include hours of operation, load, and temperature by location, in table format. Monthly average data may be used in appropriate calculations when the monthly calculation has been calibrated to the trended data. Note that there may be small differences (less than 10%) between savings calculated using the *Findings Workbook* and those generated by a utility's calculator (excluding any interaction effects).

The guidelines for determining energy, cost and demand savings are as follows:

1. For spreadsheet calculations, the annual energy savings is calculated by applying the operating profile (the times of day and year when the equipment is operating) to the energy savings profile

(calculated savings as a function of the time of day and year) to generate the resulting energy savings.

2. For spreadsheet calculations, the annual energy dollar savings is calculated by multiplying the resulting energy savings (generated in #1 above) by the corresponding energy charge for that period.

3. For reporting peak demand savings in the *Findings Workbook*, enter the average demand savings during the peak demand reduction period. Note that this may differ from the monthly peak demand savings used to calculate demand cost savings.

4. The Program focus is on kWh savings, so that is the emphasis in the *Findings Workbook*. The workbook is **not** set up to have different demand savings each month. However, the demand dollar savings can significantly affect the cost-effectiveness of the measure and should be calculated on a monthly basis **outside** the workbook. The total annual cost savings can be entered directly into the appropriate cell in the workbook (labeled "Estimated Annual kW Savings ($)"). The total annual dollar savings is the sum of the annual energy (kWh) dollar savings and the annual demand (kW) dollar savings.

5. If a building simulation is used, the rate structure may be entered directly into the model. Also, the annual dollar savings from the model can be entered directly into the *Findings Workbook*. When this is done the energy savings profile does not need to be populated. For entering the estimated peak demand savings in the *Findings Workbook*, the proper DOE output needs to be used.

Documentation

Present savings calculations in a manner that is clear and easy to follow. Submit actual spreadsheets as attachments listed in the Findings Work Book that can be audited, not pdf files. In general, all calculations shall be self documented, or reference another document that summarizes assumptions. Verbal documentation is **inadequate**, as is documentation included in emails or memos**.** The following steps should be taken to document savings calculations:

- **Include trend data with calculations**. Trend data should be presented in a manner that is easy to follow, typically with Date / Time stamps in the first column. Include charts based on trend data that graphically summarize the data.
- **Document and justify each input assumption used in the calculations**. Examples include energy cost, boiler efficiency, annual operating hours, and chiller staging changeover temperature. If an assumption deviates from a measured value that is used for the basis, clearly indicate the rationale.
- **Include binned assumptions for savings and occupancy**. For bin calculations, include the binned weather hours for the project's climate zone in a table; the total binned weather hours shall be 8,760 hours/year. Clearly indicate the equipment operating schedule, and account for this schedule in the binned weather hours for use in the calculations. The bases for the binning shall be clearly indicated. The load and savings calculations should be next to the binned weather data.
- **Provide justification for input values that vary as a function of another parameter**. Examples include a chart of VFD efficiency as a function of speed, obtained from previous research; or chiller efficiency as a function of cooling load, obtained from chiller manufacturer.
- **Show each equation used, including any constants, and all intermediate calculations**. For spreadsheet calculations, use additional columns where necessary for intermediate calculations.
- **Include units for each input and output value**, e.g., $ / kWh, Btu/h, % efficiency.
- **Include one-line system diagrams of relevant systems**, e.g., chilled water system piping schematic.
- **Provide the following documentation for relevant equipment**:
    - Nameplate information for major pieces of equipment.

- HP of all relevant motors (fans, pumps, etc.).
- For pumps and fans over 20 HP, nameplate information that indicates the design head and flow.

The Program will grant exceptions where it may be impractical to obtain the data (e.g., the nameplate cannot be read or the motor is not readily accessible). These circumstances must be fully documented and, in these cases, a conservative value should be used as a proxy for the nominal value.

Additional supporting documentation that could be provided as support for the savings calculations includes:

- Equipment cut sheets, for atypical equipment or to document data used in the calculations.
- Photos, clearly labeled with relevant information. Make sure that date / time on camera is correct.
- Copy of maintenance logs that document operating conditions, spot measurements, repeat problems, etc.
- Reference to occupant complaints relayed during the investigation work.
- Reference to historical equipment repair/replacement invoices.
- Reference to original design intent and/or current owner's operating requirements.
- Point to point checks.
- Equipment calibration certification/documentation.

Review

Savings calculations will be reviewed by the Program for reasonableness, accuracy and soundness. The Program may adjust (derate) the savings estimates for calculations that contain a high degree of uncertainty. Instances where a derating factor may be applied include:

- Correlations are based on very limited trend data
- Interactive effects have not been accounted for
- System characteristics used in the calculations are based on assumed values, not trended / verified
- Non-preferred types of baseline data and post-implementation verification data are used

The amount of deration applied will be based on the degree of uncertainty in the calculations.

6.5 Accounting for Interactions

The energy and demand savings from combinations of measures is usually different than the sum of savings from individually evaluated measures due to the fact that the savings of some measures may interact with each other. The calculations should take into effect the interactions between all measures (retrocommissioning and retrofit) expected to be selected for implementation. If all of those assumed measures are not selected for implementation, the calculations must be updated to account for the revised interactions between actual selected measures.

The savings from each measure should be calculated independently as the 'Estimated Annual Savings without Interactions.' To take into account the interaction between measures, the 'Estimated Annual Savings without Interactions' is multiplied by an 'Interaction Factor' to calculate the 'Estimated Annual Savings.' Any measure-related interactions or impacts with other building systems should be accounted for in the original savings calculations, e.g., reduced chiller energy use as a result of a lighting control measure that lowers lighting power usage (and, therefore, the cooling load) should be accounted for in the measure savings calculations.

The interaction factor should be estimated based on engineering judgment and the operational characteristics of the measures expected to be implemented. Interaction factors can be estimated specifically per measure, or a default of 0.85 may be used. Interaction factors may range from 0.7 to 1.0, depending on characteristics such as systems affected, climate zone, and ratio of internal to external load.

Program engineers reviewing the calculations will evaluate the reasonableness of the factor, or how interactive effects are handled. If building simulations are utilized, interactive effects will be included implicitly in model outputs, and an interaction factor of 1.0 should be used. For all measures with interaction factors other than 0.85 for spreadsheet calculations and 1.0 for building simulations, provide justification for the interaction factors used.

An example of a measure that would have an interaction factor less than 1.0 is restoring operation of economizer dampers, if there is a separate measure related to increasing chiller efficiency through condenser water temperature reset. If the chiller efficiencies used in the economizer damper savings calculations were the baseline efficiencies used in the condenser water temperature reset measure, then the realized savings related to the economizer dampers would be less if both measures were implemented, since the chiller efficiency would be higher.

Even when the Agency has not chosen the package of measures to implement yet, accounting for interactions is important because this simple payback calculation must be sufficiently accurate to determine which measures will be implemented. After measures are implemented, calculate 'Updated Annual Savings' for the Implementation Summary Table, including interactions of the selected group of measures. If a group of "interactive" measures is not implemented as originally planned, then the interaction factors need to be adjusted accordingly.

6.6 Guidelines for Modeling Energy Savings

While the collection of empirical data is the preferred method, energy modeling can provide a powerful and robust means of estimating energy savings associated with proposed measures. Not only do energy models allow for interaction of building systems with loads and weather conditions, they also simulate the potential interactive effects between proposed measures when packages of measures are run together. When the energy model accounts for measure interaction, a value of 1 should be used in the *Findings Workbook*. As an additional benefit, energy models can properly apply the utility rate structure to calculate energy costs.

However, it can be challenging to simulate improper or sub-optimal operation using a simulation program. Therefore, the Program has established that energy modeling can be used as a tool to estimate energy and cost savings for a project within the Program, provided the following criteria are adhered to:

- Energy models must be developed using the DOE-2.2 or later building energy simulation program
- All input, building description language (BDL), and output files are submitted for review

The following inputs (at a minimum) are included in the report (presented in the following tables, with examples). This information must be provided separately from the DOE2.2 input files to facilitate review by the Program.

Description of Schedules and General Information

Item	Sample Inputs
Floor Area	16,800 ft2
Building Type	Office
Occupancy, Lighting, Plug Loads, HVAC – All Areas	9 a.m. to 5 p.m. (M-F); 7 a.m. to 6 p.m. (M-F) Reduced schedules weekends and holidays

Description of Lighting, Equipment, and Envelope Assumptions

Item	Sample Inputs
Lighting (W/ft^2)	
Conference	1.5
Mechanical	1.3
Bath	1
Lobby	1.8
Break	1.4
Open Office	1.3
Office	1.5
Gift	3.7
Hall	0.7
Active Storage	0.3
Lighting Control	
Occupancy Sensors	None
Daylight Dimming Control	None
Equipment (W/ft^2)	
Office/Admin EPD	1.5
Other EPD	Varies by space
Envelope	
Wall Insulation R-value	R-13 (0.089)
Roof Insulation R-Value	R-30 (0.034)
Floor U-Value	N/A
Glazing U-Value (E,W)	0.57
Glazing U-Value (N)	0.57
Glazing U-Value (S)	0.57
Glazing SHGC (E,W)	0.39
Glazing SHGC (N)	0.49
Glazing SHGC (S)	0.39
Window Shading	No Shading
Window to Wall Ratio	10-20%

HVAC Systems

Item	Sample Inputs
System Type	VAV
Fan Control	Inlet Guide Vanes
Supply Air Temperature Reset	Based on OA
Outdoor Air Minimum Flow	0.3
Demand Control Ventilation	None
Outdoor Air Economizing	Based on OA temp up to 75 F
Natural Ventilation	None

Building models should be calibrated to within 10% of the monthly utility data using utility data covering a recent period of at least one year (12 months). Spot and short-term measurements of key building system components should also be used wherever possible to further calibrate the model. At a minimum, the trend data collected for identifying the finding and creating the baseline operating condition (e.g., heating and cooling loads and the HVAC system's responses to these loads) should be used in calibrating the model. Typical spot and short-term measurements for use in model calibration may include lighting and HVAC equipment operating schedules, lighting fixture power, space temperatures, supply duct static pressures and temperatures, fan and pump operation (preferably power) and motor power.

The model should be calibrated, whenever possible, using a weather file based on actual weather from a nearby weather site from the same time period, while analysis of the measures should be performed with TMY2 data.

Any variables adjusted in the model for the purposes of calibration need to be documented and submitted as part of the *Findings Workbook*. This information will include:

- The KEYWORD that was used for the calibration. KEYWORDS are parameters used by the modeling program that define system characteristics. E.g., VFD minimum speed may be labeled as MIN-SPEED, and may default to 0.2.
- The baseline (un-calibrated model) input value used for the KEYWORD.
- The calibrated model input value used for the KEYWORD.
- The reasoning behind the adjustment of this KEYWORD value.

Similarly, the KEYWORDS used in the measure analysis should also be similarly documented. This information will also be submitted along with the *Findings Workbook*, and will include:

- The measure number and name.
- The KEYWORD(s) that was used to simulate the measure.
- The baseline input value(s) used for the KEYWORD(s).
- The input value(s) used for the KEYWORD(s) to simulate the measure.
- The source of the value used to simulate the measure.

6.7 Implementation Cost Guidelines

In order to secure financing of selected retrocommissioning and retrofit measures, the Program Representative will use the RCx Provider's cost estimates to 1) determine if a project is technically and economically feasible, and 2) calculate cash flow. Therefore, accurate cost estimates are critical.

Guidelines for implementation costs include:

- **Provide backup documentation.** Provide backup documentation for each measure's cost estimate(s), submitted with the *Findings Workbook*. At a minimum, this documentation should include material costs, labor hours and estimated hourly rates.
- **Base costs on Agency's expectations.** When estimating implementation costs, consideration should be given to the building owner's expectations for the quality of work carried out – whether they require 'premium quality,' 'standard,' etc. Costs should include only those items that directly contribute to the energy savings, not the 'optional extras' (unless those optional extras are standard procedure and considered essential by the Agency.) Costs should also take into consideration any special project requirements, such as compliance with the Davis-Bacon Act or use of preferred suppliers or contractors.
- **In-house labor.** If a measure is intended to be implemented by in-house staff, then the labor cost should be documented independently in the supporting calculations and included in the *Findings Workbook.*
- **Include implementation assistance as a separate cost.** Keep the costs for your implementation assistance separate from other implementation costs, and enter the assistance cost for each measure in the appropriate cell in the *Findings Workbook*. If the assistance cost is greater than 15% of the measure cost, then provide a task breakdown. The RCx Provider should check to ensure that tasks in the project Scope of Work are not duplicated in the implementation assistance.

  During the investigation, the RCx Provider should consult with the Program Representative on the level of additional assistance desired or warranted for each potential measure. Additional implementation assistance may include preparing detailed scopes of work, writing detailed control sequences and schematics, working with in-house staff to implement and optimize measures, or providing full turn-key implementation services. As appropriate, total estimated costs should detail out contractor costs and RCx Provider implementation assistance costs in the *Findings Workbook.*
- **Be accurate.** Since Agencies typically base decisions to implement measures on payback, it is important that the cost estimates provided with the *Findings Workbook* be as accurate as possible.

Attachment A: Glossary of Acronyms and Key Terms

Acronym/Term	Definition
FWB	Findings Workbook
IST	Implementation Summary Table, a worksheet within the Findings Workbook
NST	Non-implemented Summary Table
PLF	Preliminary List of Findings
Owner	State Building Operations Personnel
Program	State and/or Program Administrator

Attachment B: Checklists

Topics for RCx Investigation Kick-Off Meeting (sample)

- ☐ Introductions to appropriate building staff, including key contact for day-to-day work
- ☐ Overview of RCx Provider approach to investigation process
- ☐ Deliverables and expected schedule
- ☐ Owner's (current) operating requirements
- ☐ Information on BAS (type, interface, trendability, in-house expertise, controls firm, etc.)
- ☐ Building entrance procedures
- ☐ Keys or access cards
- ☐ Identification requirements
- ☐ Parking permits
- ☐ Off-limits areas, or areas needing escort or prior notification to enter
- ☐ Permission to take photographs
- ☐ Permission to use electronic devices such as laptops, flash drives, cell phones, etc.
- ☐ Document checkout / copying procedures
- ☐ Building walk through
- ☐ Set up sample trends

Operations and Maintenance Topics and Tasks (sample)

- ☐ Analyze electricity utility usage / demand data (provided by the Program), at least two years of monthly data and one year of interval data. Obtain any additional utility data needed or desired for analysis from the utility or Owner.
- ☐ Review current maintenance protocols to establish the level of capability on site.
- ☐ Review historical equipment repairs / replacement costs to identify any recurring issues.
- ☐ Review history of occupant complaints.
- ☐ Review major equipment operating logs.
- ☐ Review equipment warranties, to determine if there are any limitations on modifications that may be carried out.
- ☐ Review any equipment that was installed or upgraded using utility program incentives.

Attachment C: Owner's Operating Requirements Data Collection Table (sample)

Item	Area A i.e., office	Area B i.e., conference	Area C i.e., computer
Temperature requirements and limitations			
Humidity requirements and limitations			
Pressure relationship requirements and limitations			
Filtration requirements and limitations			
Air change requirements and limitations			
Sound and noise level requirements and limitations			
Normal operating schedule for occupancy and/or protection			
Process and office equipment status during evening/night hours			
Process and office equipment status during holiday hours			
Process and office equipment status during scheduled maintenance shutdowns			
Normal schedule for building cleaning crews			

Attachment D: RCx Investigation Report Outline

The Program provides a template for the *RCx Investigation Report* and includes the following elements:

1. Program Cover (provided), customize for the facility
2. Table of Contents (provided, update as necessary)
3. Report Contents (see Outline below)

The RCx Provider should consider the following outline as the minimum content required and include any additional information gathered during the RCx investigation process that they feel may assist the Owner in selecting and implementing the retrofit and operational improvement measures.

Introduction

Introduces the Report to the Owner with information about the RCx Provider and Company/Building involved in the project.

1.0 Project Overview

Copy and Paste from *Findings Workbook*, "Project Overview" worksheet.

2.0 Measures Selected for Implementation

An overview, recommendations for implementation, and evidence of proper implementation are outlined for each measure selected by the Agency. This section can include pictures, graphs and tables to support the data collected through investigation. An example of this section is provided in the following pages.

3.0 Next Steps

Description of the next steps in the Program for the Agency to anticipate, including the date they are expected to implement the selected measures.

Appendix A: Investigation Summary Table (copied from the *Findings Workbook*)

PBEEEP State Government

Rev. 2.0 (12/16/2010)

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Summary page for the owner's reference. * Print on lega

Investigation Findings and Measures							Energy Savings Estimates				
#	Investigation Finding	Description of Finding	Measure	Implementer	Recommendations for Implementation	Evidence of Implementation: Method	#	Investigation Finding	Annual Electric Savings (kWh with interactions)	Peak Demand Savings (kW with interactions)	GHG Avoided in U.S. Tons (C02e)
1							1		0	0	0
2							2		0	0	0
3							3		0	0	0
4							4		0	0	0
5							5		0	0	0
6							6		0	0	0
7							7		0	0	0
								Investigation Totals	0	0	0

Cost Savings Estimates			Implementation Cost Estimates			Paybacks and Utility Co-Funding Estimate		
Estimated Annual kWh Savings ($)	Estimated Annual Demand Savings ($)	Estimated Annual Total Savings ($)	Contractor Cost ($)	PBEEEP Provider Cost for Implementation Assistance ($)	Total Estimated Implementation Cost ($)	Initial Simple Payback (years)	Utility Co-Funding - Estimated Total ($)	Simple Payback with Utility Co-Funding (years)
$0		$0			$0		$0	
$0		$0			$0		$0	
$0		$0			$0		$0	
$0		$0			$0		$0	
$0		$0			$0		$0	
$0		$0			$0		$0	
$0		$0			$0		$0	
$0	$0	$0	$0	$0	$0	#DIV/0!	$0	#DIV/0!

Appendix B: Owner's Operating Requirements

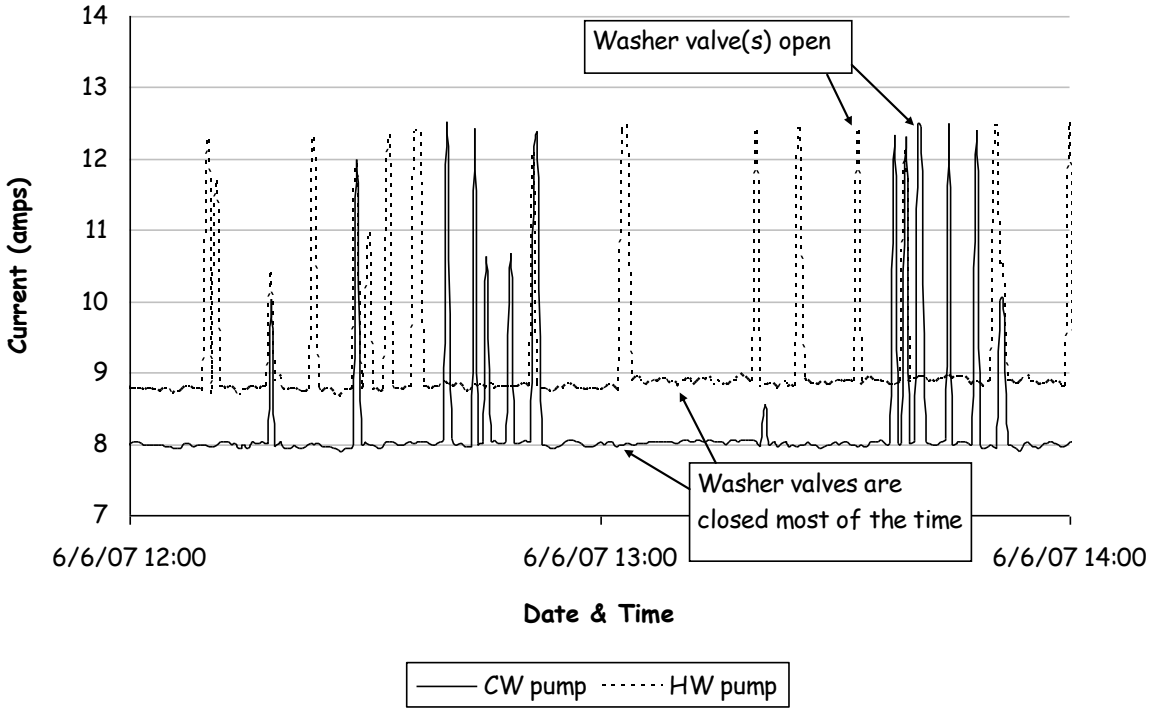
Item	Area A i.e., office	Area B i.e., conference
Temperature requirements and limitations		
Humidity requirements and limitations		
Pressure relationship requirements and limitations		
Filtration requirements and limitations		
Air change requirements and limitations		
Sound and noise level requirements and limitations		
Normal operating schedule for occupancy and/or protection		
Process and office equipment status during evening/night hours		
Process and office equipment status during holiday hours		
Process and office equipment status during scheduled maintenance shutdowns		
Normal schedule for building cleaning crews		

An example of Section 2.0 in the RCx Investigation Report:

2.1 *Measure 7: Add VFDs to Laundry Hot and Cold Water Pumps*

Overview

Hot and cold water is provided to each of the three washing machines by two circulating pumps. As the hot and cold water valves on each washer open, water is supplied to the unit and each pump operates near full load. When water is not needed by the washers, pressure builds up in the piping (pushing each pump back up on its curve) until a pressure relief valve opens and allows water to circulate through the respective storage tank.



Recommendations for Implementation

The recommendation is to control the laundry hot/cold water pumps using VFDs to maintain system pressure rather than allow each pump to ride its curve. In order to implement the proposed control strategy, a differential pressure sensor needs to be installed across the device with the highest pressure drop (i.e. load furthest from the pump), and a VFD must be installed on each pump to maintain the differential pressure needed to provide the design flow rate to this load. As each washer calls for hot or cold water and the control valves open and close, pressure within the circulating loop will vary. The VFD will modulate system flow as necessary to maintain the differential pressure set point.

Evidence of Proper Implementation

The recommended method for verifying that this measure has been implemented properly is by spot measuring the motor current draw at the idle state (all washer valves are closed) and the full flow state (at least one washer valve is open) for both pumps and recording the VFD speeds at these conditions.