



## Public Buildings Enhanced Energy Efficiency Program

### 2.5 IMPLEMENTATION, VERIFICATION AND HAND-OFF GUIDELINES

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## 1.0 Executive Summary

The *Implementation, Verification and Hand-Off Guidelines* are designed specifically for Providers participating in the Public Buildings Enhanced Energy Efficiency Program (PBEEEP). The purpose of the *Implementation Guidelines* is to promote best practices in the verification of measure implementation and in the persistence of energy savings for each building.

This document is one of several tools made available for Provider use throughout different phases of the Program's retrocommissioning and retrofit (RCx) project. Other Program tools include the *Findings Workbook*, which is the primary reporting tool during investigation, implementation, and verification, the *Screening Guidelines*, which establish a screening process to cost-effectively identify energy savings opportunities in building candidates, and the *Investigation Guidelines*, whose purpose is to promote rigor and consistency in the identification and calculation of energy savings for the Program.

These *Implementation, Verification and Hand-Off Guidelines* were created to guide Providers through the primary tasks and associated deliverables of the implementation, verification and hand-off phases, which include:

- Provider collection of verification data to prove the implementation of measures
- Updates to energy, demand and cost savings for any measure with a revised scope
- Program and utility review and approval of verification data
- Project hand-off to Agency Owner via the *RCx Final Report* and Hand-Off Training

This document is intended to ensure that Providers gather appropriate evidence to show that measures were implemented in accordance with the findings and calculations proposed during the investigation phase. Accurate implementation evidence (i.e. verification) is necessary to ensure that the program and the utility will accept the work performed and approve financial support and co-funding.

Although these *Guidelines* are intended to promote best practices and high levels of rigor, eligible measures and specific process requirements may vary. These variances may include, but are not limited to, specific utility rebate applications, data collection requirements, implementation and verification requirements, and technical review related requirements. Regarding the utility specific requirements, the Provider will be responsible for contacting the applicable utilities to compile specific co-funding forms, policies, and requirements. Program staff will be involved in the process to verify that all utility rebate options were thoroughly investigated and that requirements were completed.

Please note that the *Implementation, Verification and Hand-Off Guidelines* cannot predict every question or issue uncovered during these project phases. When questions arise, the Provider should immediately consult with Program staff to develop a mutually agreeable approach and solution.

## 2.0 Implementation, Verification and Hand-Off Overview

The implementation and verification / hand-off phases are the final phases of a retrocommissioning (RCx) / retrofit project in PBEEEP.

Implementation begins with the Implementation kick-off meeting, which is arranged by the Provider and includes all project participants, including building staff, contractors, and if applicable, a utility representative and Program representative. At the Kick-off meeting the Provider will summarize the approved measures for implementation to inform key stakeholders of the scope of work to occur in the phase, as well as cover phase kick-off related topics (Owner requirements, roles and responsibilities, etc.).

During implementation, at minimum, the Provider checks in monthly with building staff until implementation is complete. The Provider will also be required to notify or update the Program of the check-ins with building staff. Check-in meetings allow the Provider to answer any questions that arise during implementation and provide clarification or advice on measures being implemented. Updates must be communicated to the Program and State Project Manager to provide a documented account of implementation progress. The details of updates are covered in the project administration and management duty requirements provided in the RFP for each project and/or detailed in the contractual agreement.

Once implementation is complete, the Provider conducts a site visit to verify the completion of each measure and to update the *Findings Workbook* with final savings, costs, payback calculations, and any other required information. In support of the updated *Findings Workbook*, for each measure, the Provider must submit verification data, contractor invoices, estimates of in-house labor, updated savings calculations when applicable, and similar information as the utility requires. If feasible, verification data should include trends or functional test results, though other methods, such as copies of invoices, site visit reports, and before/after photos, may be acceptable. The verification plan should be discussed as early as the Investigation Phase with the final approval of the plan to occur at the start of the Verification Phase.

The *Findings Workbook* and verification data are reviewed and approved by Program staff before being submitted to the utility. The Provider is responsible for submitting the Program-approved *Findings Workbook* and verification data in the utility-required format to ensure co-funding is approved for each project. This is covered in greater detail in Section 6.0.

To help ensure that energy savings and other benefits from retrocommissioning and retrofit persist over time, the Provider creates the *Final Report* as a future resource for the building. The *Final Report* describes the implemented measures and actions taken through the Program, and offers recommendations and best practices for Operations and Maintenance (O&M) to maintain the performance of the improved systems. Program engineers review and approve the *Final Report* before it is provided to the building staff.

The Provider makes a final site visit to the building to conduct a training session that marks the project's end – the hand off phase. The training discusses the investigation process and results, measures that were implemented, and requirements for ongoing maintenance and monitoring. To verify the training was completed, the Provider submits a *Training Completion Form* to the Program, which includes when the training session(s) was/were held, topics covered, and who attended.

## 3.0 Implementation

During the Implementation phase, the Program and Provider focus their efforts on assisting the Agency Owner whenever possible and facilitating and promoting the timely and accurate implementation of measures. The Provider will be working directly with the Owner in providing implementation support.

### **3.1 Measure Selection**

The Agency Owner's selection of measures occurs at the close of the Investigation phase (and is documented in both the Investigation Report and the Findings Workbook). At that time, all findings, measures, and any Program or utility requirements for measure selection are reviewed. During the Implementation Kick-Off meeting the Provider should be prepared to answer any questions and address any concerns from the Agency Owner regarding implementation and should detail out the scope of work to be followed for implementation of measures. For example, the Agency Owner and Provider should discuss any operational constraints that might conflict with one or more measures, and ways of overcoming these obstacles. Additionally, the Provider should attend the Kick-off meeting well-informed of any available utility-sponsored rebates or incentives and prepared to discuss them with the Agency Owner. This is covered further in Section 3.3.

During the meeting, the Provider and Agency Owner should determine the roles and responsibilities of the provider, specifically discussing the extent to which the Provider will directly implement measures versus assuming an auxiliary role of overseer. The Provider's involvement may vary measure-to-measure, and will impact the implementation facilitation, discussed in Section 3.2.

### **3.2 Implementation Facilitation**

Overall implementation will be managed by the Provider. While the Provider ultimately manages implementation, the Agency Owner has flexibility to involve the Provider during implementation in several ways. The Provider may assist on-site staff with implementation or oversee and approve work done by contractor firms. For State Agencies with Project Management and Contracting Authorities independent of Department of Administration, Real Estate and Construction Services (ADMIN/RECS) project management services (as Owner Representative) may be supplied by a third party consultant. The Provider will be required to report to the project management consultant, in addition to the Program, as they would normally report on project administration and management functions to the ADMIN/RECS State Project Manager.

The implementation phase requires a new contract with the Agency. The Agency Owner may opt to amend an existing contract with the Provider, or the Agency Owner may bid out the work via an RFP (competitive bid process). The process will depend on the project and the Agency Owner agency's specific procurement and contracting requirements and policies.

For any work being completed by a contractor, the Provider reviews contractor bids prior to implementation to ensure that the contractor scopes of work for implementation adequately reflect the intent of the recommendations in the *RCx Investigation Report*. The Provider is ultimately the responsible party to oversee and complete 'sign-off' for the work being done by all parties in implementation.

### **3.3 Utility-sponsored Co-funding<sup>1</sup>**

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 and submitting all necessary documentation in order to meet the specific utility requirements for co-funding, including utility rebate applications and forms.

### **3.4 Implementation Check-Ins and Progress Updates**

During implementation, the Provider checks in with the building on a monthly basis at minimum. The check-in format will be discussed at the kick-off meeting and may only require a teleconference with the

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<sup>1</sup> Co-funding is defined in this document as a utility sponsored incentive or rebate.

Provider and the key building staff in attendance. Check-in meetings help the Provider and Program identify and address any issues or barriers that arise during implementation so that the project can move forward unimpeded. Check-ins also help to ensure that projects are on track to meet the Program's requirements. These program required check-ins would be in addition to the contractual project administration and management requirements of the agreement between the Agency Owner and/or State Dept. of Administration and Provider.

### **3.5 Documentation Management and Project Tracking**

During the Implementation 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 (i.e. Training Form) will occur in WorkZone. Additionally, Providers will utilize the project tracker function in WorkZone to report on and update key milestones in the schedule and progress on deliverables. WorkZone is a collaborative, web-based application that will be used throughout 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).

## **4.0 Verification**

The purpose of verification is for the Provider to gather evidence demonstrating that measures were implemented as recommended by the Program and as described in the *Findings Workbook* and associated calculations.

If the scope of any measure changes during implementation, the Provider must follow the change control process of the contracting authority for the project. There may be additional program requirements depending on the level and type of change. The Program will require a technical review and approval for the revised measure, similar to the Investigation *Findings Workbook* review, before implementation can proceed. If the scope of any measure changes during Implementation, the Provider documents this with updates to the *Findings Workbook* and associated documentation to reflect the actual measure description and energy savings.

The preferred verification method is to collect trend data. The Program should be contacted if the Provider intends to use a non-preferred method of verification, as described in the *Investigation Guidelines* Attachment E: Documentation Guidelines. If the implemented measure scope differed from the assumptions in the original savings calculations, the Provider should gather additional trend data to update the measure savings and payback realized during the verification phase. See Section 5.3 for additional information regarding updated savings calculation requirements.

### **4.1 Verification Planning Meetings**

The Verification Planning Meeting provides clarity between the Program and the Provider on expected outcomes of the verification process. As the Owner completes the final steps of implementation, the Provider and a Program representative hold the Verification Planning Meeting over the phone to discuss and establish the appropriate verification method (trending, functional test, etc.) and supporting data (invoices, updated savings calculations, etc.) required for each measure based on the guidelines provided below in Section 5.2. Any changes to verification method as a result of this meeting should be recorded in the *Findings Workbook* under the "Evidence of Implementation: Results" column.

During the Verification Planning Meeting, the Program and Provider should discuss a time line for the verification site visit and Provider's subsequent submittal of verification data to the Program. Typically, the Provider will need approximately two weeks after the site visit to organize the submittal and recalculate any new measure savings.

## 4.2 Verification Site Visits

The Provider coordinates a site visit at the building to collect data. The Provider is responsible for informing the building staff in advance of the site visit date and any requirements for a successful site visit (such as access to key areas of the building). If the Provider is able to verify any measure remotely, this should be relayed to the building staff so they are informed of the process.

## 5.0 Verification Deliverables

The following sections describe the steps necessary for the Provider to make an accurate submittal of verification data to the Program. Providers will exchange Verification Phase documentation, covered in the following sections, using WorkZone (see Section 3.5).

### 5.1 Updated *Findings Workbook*

The updated *Findings Workbook* is the key output of the verification site visit. The Provider should fill out the following information in the Post-Implementation section of the *Findings Workbook* for all measures implemented:

- Updated Measure Description
- Site Visit Date
- Implementer
- Evidence of Implementation: Results
- Ongoing Maintenance of Measure
- Updated peak demand savings (kW and \$)
- Updated annual electric savings (kWh)
- Updated annual gas savings (therms)
- Contractor and/or Provider Cost

These fields are defined further in the *Findings Workbook Guide* instructions.

### 5.2 Evidence of Verification

Along with the updated *Findings Workbook*, the Provider must submit supporting evidence demonstrating that each measure was implemented successfully. The verification method should align with the process agreed upon during the Verification Planning Meeting discussed in Section 4.1. The verification data should indicate whether or not the measure has been implemented properly, provide enough data to update the calculations in the event of a change in scope, and verify any baseline assumptions that have a significant impact on the savings. Measure-specific guidelines and examples for implementation verification are included in *Investigation Guidelines Attachment E: Documentation Guidelines*.

Generally, the preferred method of verification is **post-implementation trend data**. The trend data should be analyzed and presented in a manner that clearly indicates the results of the measure implementation. Wherever possible, the format of the verification data should align with the baseline data submitted. Trend data should show system functioning in each operating mode and over a sufficient range of operating conditions to demonstrate that the measure has been implemented and the system is functioning as expected. Measures related to controls resets must use this method wherever possible. Refer to Section 5.4 for guidelines on best practices for representing trend data and graphs.

If the preferred trend data collection is not used for verification, there are other acceptable methods available. However, the Program should be contacted in advance, preferably during the Verification Planning Meeting, if the non-preferred methods will be used. Other acceptable methods in order of preference are:

- Functional performance test (FPT), **documented** with a form. A blank template functional test form, including instructions and an example is provided as Attachment A. Examples of functional test forms for many RCx measures are available on-line<sup>2</sup>.
- Screen shots of system operation at multiple operating conditions. Screen shots should show both output (commanded state) and input (status feedback) whenever available.

For measures with savings of less than 25,000 kWh or measures that cannot be readily trended by any means (e.g., leakage):

- Screen shots of control logic that show all relevant operating conditions.
- Before and after photos of visual measures (e.g. lighting or air leakage). Make sure that camera's date / time are set correctly.

The Program may grant exceptions when there are significant data acquisition problems (e.g., the Agency Owner's chiller cannot be shut down to setup the logger). These circumstances must be documented and, in these cases, conservative values should be used as a proxy for the trended value. The Program must be notified in advance about the circumstances preventing the collection of verification data. This should be addressed at the *Verification Planning Meeting*.

In addition, it is required that the Provider collect data on all implementation costs so that accurate payback values can be calculated (reference 5.3 below for details). Copies of itemized invoices for each measure must be submitted, indicating installation date, installer company info, installed equipment/procedure, and cost. If in-house labor was used for implementation of a measure, an estimate of the number of in-house hours utilized must also be provided and documented in the *Findings Workbook*.

See Section 6.3 of the *Investigation Guidelines* for additional general measurement guidelines related to verification.

### 5.3 Updated Savings Calculations

The final project savings reported to the Program should accurately represent the true savings achieved. Therefore, the calculations performed during the RCx investigation should be updated post-implementation if significant changes from the investigation phase findings are realized. The *Findings Workbook* contains a post-implementation section in the 'Data Input' tab to record any modifications to the engineering calculation or model used to estimate savings. If no changes are made to the calculations, then the original savings estimate should be transferred to the post-implementation savings section in the workbook.

Circumstances where the savings calculations should be updated are:

- To include interactive effects among the implemented measures.
- To reflect the actual scope of the implementation of the measure (e.g., four pump impellers were trimmed instead of three; economizer upper limit set to 65°F rather than a two degree differential from return and temperature).
- To correct or update major assumptions made during the investigation calculations that have a large impact on final savings. (e.g., the addition of a VFD was expected to reduce pump speed to minimum during low load conditions, but actual post-implementation speed was only reduced by 30%).

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<sup>2</sup> Example functional test forms can be found at the Functional Testing and Design Guides website at [www.ftguide.org](http://www.ftguide.org).

If utility co-funding is included in the project, the utility requirements may vary from this guidance and should be confirmed in advance of verification activities. In the event of differing requirements between the Program and the utility, the most stringent requirements should be followed. Any differences in savings between the investigation-phase calculations and the post-implementation calculations must be documented. Preferably, the Provider highlights or annotates the modifications within the calculation spreadsheet or model input summary page as part of the documentation.

## 5.4 Trend Data Analysis and Graphical Representation

Trend data should be presented in a format that is intuitive and can be quickly and easily understood by the reviewer (“trend data” includes both BAS trend data and data logger data). Raw trend data should be provided with the supporting calculations / verification data; however an analysis of the data should also be included and charts should be developed wherever possible that clearly indicate the message(s) being delivered by the data.

### *Analysis*

Typically, raw trend data must be analyzed before it can be utilized for calculations and presentation. Analysis techniques include:

- Filter the data as necessary to isolate only the useful data. E.g., filter data based on equipment on / off or occupied / unoccupied periods.
- Line up date / time stamps if necessary, utilizing a program such as *Universal Translator*<sup>3</sup>.
- Clearly distinguish between baseline data and post-implementation data.

### *Charts*

Develop charts that include the filtered trend data and graphically represent the data in a truthful and concise format. Charts should be able to stand on their own with no further explanation beyond what is included in the charts. The following guidelines can be used when developing charts:

- Title the chart appropriately.
- For the horizontal and vertical axes:
  - Label each axis appropriately, including units.
  - Scale the axis appropriately for the data being presented (minimum, maximum, and interval). Set the interval to a relevant value. E.g., don’t use a 5-day interval for three months of trend data – a 7-day (one week) interval may be easier to view and understand.
  - Ensure that the axis labels are easy to read (font size, alignment, rotation).
  - Use a secondary vertical axis where appropriate when charting multiple data sets.
- Use lightweight gridlines and a white plot area background.
- Use either time-series (date / time on the horizontal axis) or x-y scatter plots where appropriate. Scatter plots may be more appropriate for some data, and for developing correlations.
- Annotate the graphs with notes, using text boxes and arrows pointing at the data points. Annotations can be used in lieu of a legend. They also can be used to highlight changes in equipment operation, and to note differences between baseline and post-implementation operation.

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<sup>3</sup> Available for free at [www.utoonline.org](http://www.utoonline.org)

- Include both baseline and post-implementation data and graphical representation on one chart, if possible / applicable. Presenting the information on one chart makes it easier to see that a measure has been implemented.
- Use different colors for emphasis. However, ensure that the message being conveyed by the chart is still clear when printed black and white (for example by using different data point shapes or line styles).

These are only a few of the main recommendations for graphical representation of data. As a general rule, maximize ink and minimize junk. For additional techniques, we recommend consulting other resources<sup>4</sup>.

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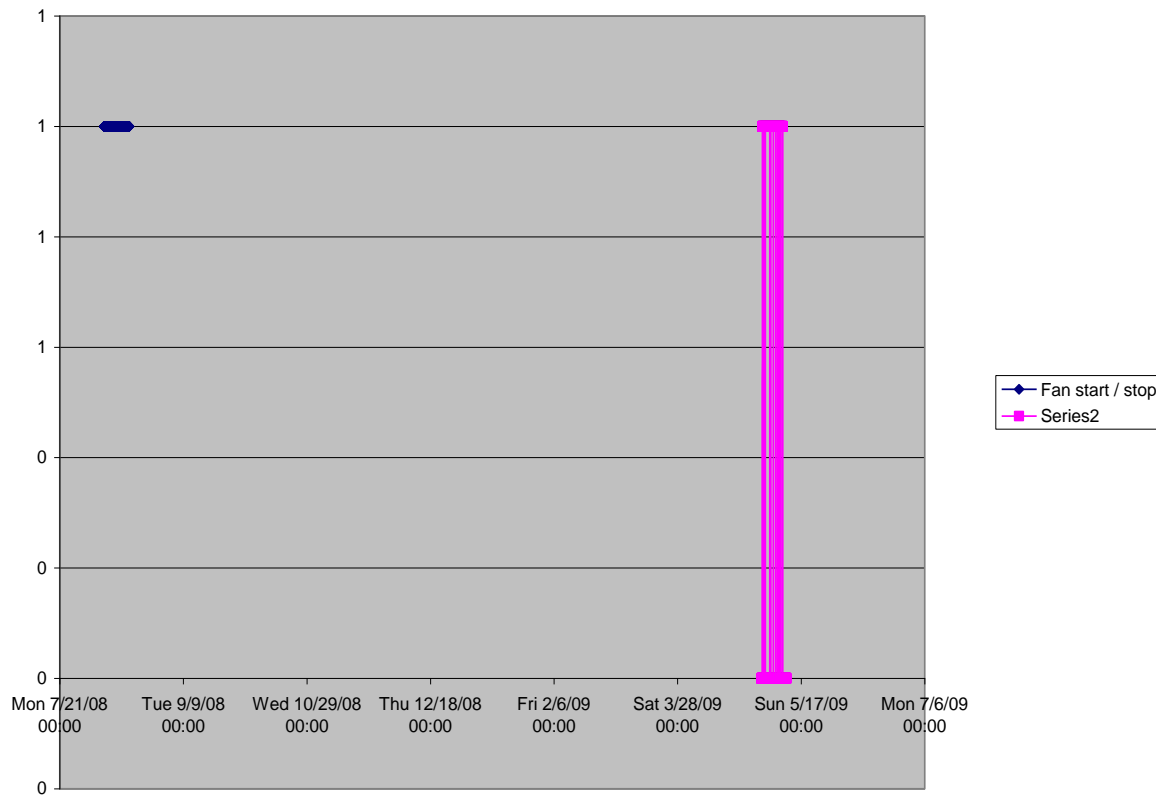
<sup>4</sup> Edward R. Tufte. (2001). *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press LLC.

The following figures show examples of both insufficient and preferred trend data presentation.

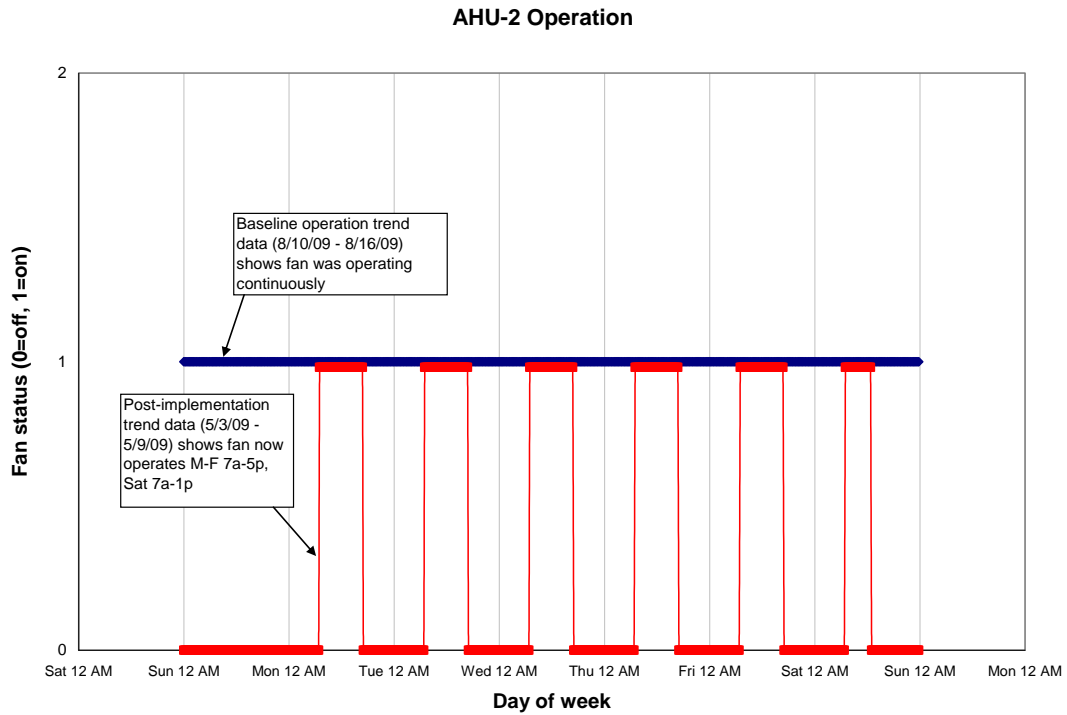
**Figure 1.** Insufficient representation I (Raw trend data must be analyzed)

Baseline		Post-implementation	
Date / Time	Fan start / stop	Date / Time	Fan start / stop
Fri 8/8/08 00:00	1	Fri 5/1/09 00:00	0
Fri 8/8/08 00:15	1	Fri 5/1/09 00:15	0
Fri 8/8/08 00:30	1	Fri 5/1/09 00:30	0
Fri 8/8/08 00:45	1	Fri 5/1/09 00:45	0
Fri 8/8/08 01:00	1	Fri 5/1/09 01:00	0
Fri 8/8/08 01:15	1	Fri 5/1/09 01:15	0
Fri 8/8/08 01:30	1	Fri 5/1/09 01:30	0
Fri 8/8/08 01:45	1	Fri 5/1/09 01:45	0
Fri 8/8/08 02:00	1	Fri 5/1/09 02:00	0
Fri 8/8/08 02:15	1	Fri 5/1/09 02:15	0
Fri 8/8/08 02:30	1	Fri 5/1/09 02:30	0
Fri 8/8/08 02:45	1	Fri 5/1/09 02:45	0
Fri 8/8/08 03:00	1	Fri 5/1/09 03:00	0
Fri 8/8/08 03:15	1	Fri 5/1/09 03:15	0

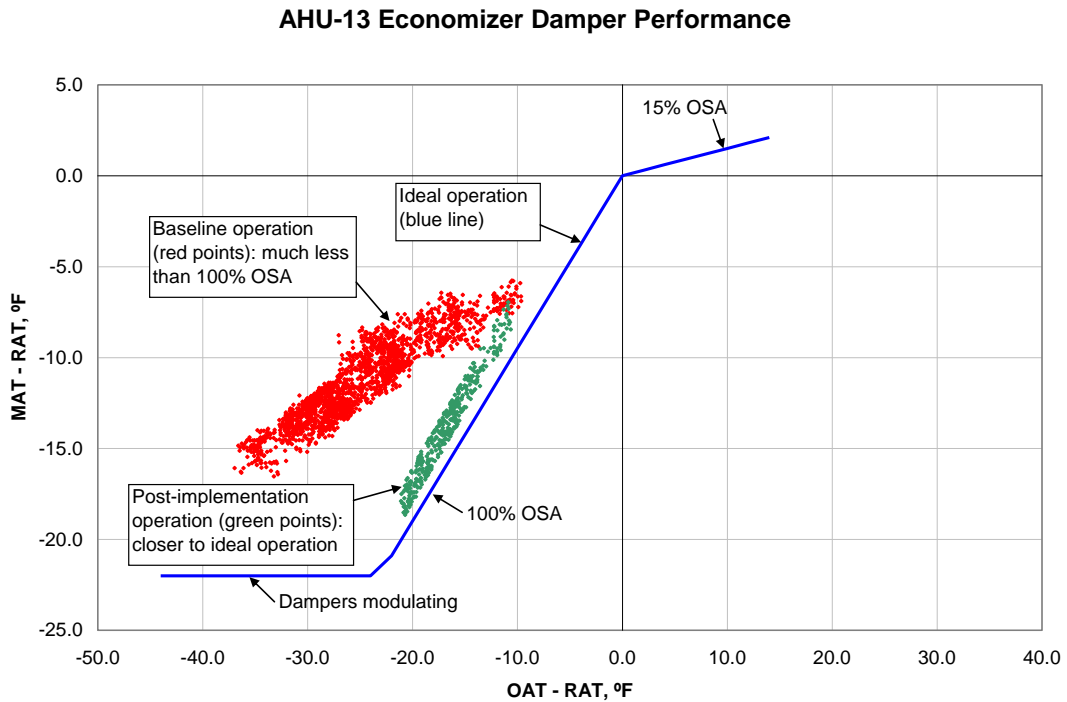
**Figure 2.** Insufficient representation II (Charts must be properly labeled and scaled)



**Figure 3.** Preferred representation I (Pre and post data displayed on the same chart with annotations, labels and easy-to-read scale)



**Figure 4.** Preferred representation II (Pre and post data displayed on the same chart with annotations, labels and easy-to-read scale)



## 6.0 Verification Review

All verification data must be reviewed and approved by the Program and if applicable, the utility. The Provider is responsible for ensuring that all utility reviews are completed.

### 6.1 Program Review

Prior to submitting the Provider's verification data to the utility, the Program conducts a cursory review of the documentation for completeness, clarity, and consistency with the guidelines set during the Verification Planning Meeting. The Program should use this time to explain why savings changed for any measure in the "Close Out Notes" column of the *Findings Workbook*.

If extensive changes or corrections are needed, the Program may use a *Technical Review Memo* to record observations and required changes. Once approved by the Program, the data is sent to the utility via an FTP site or web portal.

### 6.2 Utility Review

The extent of the utility review will vary depending on the utility's requirements. The Program and utility reviewers should define in advance a system for communicating during the review that enables the utility to request additional data from the Provider if necessary. The utility may communicate directly with the Provider, so long as requests are logged and addressed in a timely manner.

## 7.0 Hand-Off

After implementation, it is essential that the Agency Owner and building staff have the resources they need to maintain and monitor the implemented measures. The Hand-Off phase consists of one key deliverable, the *RCx Final Report*, and one key meeting with the Agency Owner, the Hand-Off Training. These events encourage best practices around new systems and control sequences, which ultimately help ensure the persistence of energy savings.

### 7.1 RCx Final Report

The *RCx Final Report* contains recommendations for O&M practices that will maintain the performance of the improved systems; it is therefore critical to long-term persistence of savings. The *Report* is a resource to current and future operators and should be made part of the permanent record of recommended O&M practices at the building. The *Final Report* is based on the *Investigation Report* and includes an additional narrative on implementation.

For each measure that was implemented, the *Report* includes, but is not limited to:

- Finding description (as-found condition, problem, or opportunity)
- Measure description (improvement, repair, retrofit, or installation)
- Utility-approved energy savings of each implemented measure (\$, kWh, and therm)
- New or improved sequences of operation
- Requirements for ongoing maintenance and monitoring of the measures
- Contact information for the Provider, in-house staff, and contractors responsible for implementation

To complete this task, the Provider must develop and submit the *RCx Final Report* for review and approval by the Program approximately two weeks after the utility has approved the final project savings. Once the *Final Report* is approved, the Provider supplies both an electronic copy and a hard copy to the

Agency Owner and building staff. The Provider is also responsible for adding any RCx documentation to the building's O&M files, as indicated in the *RCx Final Report*.

## 7.2 Hand-Off Training

The Provider conducts an on-site training to discuss the new O&M documentation and implemented measures with the Agency Owner and appropriate building operations personnel (or subcontractors). During the training, the Provider should review the investigation process and results, answer any questions regarding new systems and controls sequences, and discuss best practices for ongoing maintenance and monitoring. To the extent possible, the training should incorporate hands-on activities and the attendees should have the opportunity to inspect, in-person, the retro-commissioned or new equipment and systems.

The training should be scheduled after measures are implemented and should last approximately 2-4 hours. The Program should be notified of the date and time of the training in advance. To verify that the training was complete, the Provider submits a *Training Completion Form* to the Program. Training materials used by the Provider should also be submitted to the Program as part of the final document hand off and will be included in the project file.

## 7.3 Example Hand-Off Training Outline

The Provider is responsible for developing the training outline and materials. To prepare, the Provider should assess the level of knowledge of building operators and design the training accordingly. As a reference, the Program provides the following sample outline for the training:

- Background on the energy use of this particular building
  - Compare the pre and post implementation Energy Utilization Index (kWh/SF/year)
  - Compare the pre and post implementation benchmarking score, and compare to other, similar types of buildings if possible
  - Describe Operating Schedules and Agency Owner's operating requirements
- RCx investigation process used in this building
  - Describe the methods used to identify problems and deficiencies
  - Review findings from the *Findings Workbook*
- Implementation process in this building
  - Describe the measures that were implemented and by whom
  - Review savings from the *Findings Workbook*
  - Describe improved performance that the measures will create (show trends if available)
  - Walk around the building to look at any physical changes or step through the new control sequences at the operator workstation
- O&M Requirements
  - Describe the O&M requirements needed to keep these improvements working
  - Describe how the staff can be aware of energy efficiency opportunities and look for additional savings potential
  - Describe how to identify if improvements are not working correctly (For example, a VFD operating outside of design intent, once installed, constantly running at 100% and always in operation)

The Provider should prepare materials to hand out at the training session as is necessary.

## **Attachment A: *Functional Test Form***



Functional Test Form