



## Retro-Commissioning

### Introduction and Suggested Best Practices

ASHRAE defines the *Commissioning Process* as: “A quality-focused process for... verifying and documenting that [a] facility and all of its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the Owner’s Project Requirements”<sup>1</sup>. Stated simply, the Commissioning Process ensures that a building’s equipment and systems are working together efficiently and that the proper procedures are in place to ensure that this continues. While it may seem natural that Commissioning (Cx) should be integrated into the design and construction process of any building, the reality is that less than 5% of buildings are commissioned when built, resulting in inefficiencies that can greatly affect the building’s ongoing performance and energy consumption<sup>2</sup>.

In addition to inefficiencies arising from latent design and construction deficiencies, buildings naturally tend to “drift” from their optimal operating conditions over time. As space is reconfigured, tenants move in and out, ownership changes hands, and new equipment is added, control systems and set points must be continually adjusted to account for these changes. Because of the high degree of interdependency between building systems, seemingly minor operational or maintenance issues have a major impact on overall energy efficiency.

*Retro-Commissioning* (RCx) is the term used to describe the application of the Commissioning Process to existing buildings that may or may not have been commissioned at start-up. RCx is a collaborative process, wherein a qualified RCx firm works alongside building staff to discover and correct issues that may be preventing building equipment and systems from operating at peak efficiency. Lawrence Berkeley National Laboratory recently published a study analyzing the results of RCx projects implemented at 643 buildings representing 99 million square feet of floor space, showing median whole-building energy efficiency improvements of 16%<sup>3</sup>. Buildings that underwent a “comprehensive” Retro-Commissioning realized energy savings nearly double the median—roughly 30%<sup>4</sup>. And since RCx focuses on identifying operational and maintenance efficiencies rather than replacement of equipment, RCx is perhaps the most cost-effective way to reduce a building’s energy consumption, with a typical simple payback of just 1.1 years<sup>5</sup>.

This document is intended to highlight certain Suggested Best Practices in Retro-Commissioning gleaned through research conducted by the Clinton Climate Initiative (CCI). CCI seeks to accelerate the real estate market’s transition towards greater energy efficiency by working with building owners and operators to facilitate projects that reduce energy consumption and GHG emissions. To that end, CCI has developed several additional resources to assist in the development of RCx projects: a Request for Qualifications & Proposals designed to help qualify RCx providers; a phased contracting approach designed to standardize critical aspects of the RCx process by clearly defining the scope of work and deliverables at each step; and several tools to assist with the evaluation of RCx proposals.

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<sup>1</sup> ASHRAE Guideline 0-2005, “The Commissioning Process”

<sup>2</sup> PEI, 1998

<sup>3</sup> Evan Mills. 2009. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions," <http://cx.lbl.gov/2009-assessment.html>

<sup>4</sup> Ibid

<sup>5</sup> Ibid



### **Benefits of Retro-Commissioning (RCx)**

- Captured wasted energy, water, and money
- Extended equipment life
- Identification, quantification, and prioritization of future capital needs
- Lower GHG emissions
- Improved indoor environmental quality and occupant comfort
- Improved O&M staff training and performance
- O&M manuals and procedures updated to reflect the building's current actual use
- Improved Energy Star score
- Increased building value
- Part of the US Green Building Council's LEED EB-O&M rating system

### **Typical Costs and Savings associated with RCx**

- Phase I preliminary building analysis generally costs between \$0.07 and \$0.14 per square foot, and generates savings leading to a typical simple payback of 1 year or less<sup>6</sup>.
- Phase II detailed analysis and Phase III implementation usually costs between \$0.25 and \$0.50 per square foot, and generates savings leading to a typical simple payback of 3 years or less<sup>7</sup>.
- The exact cost depends on the scope of the project and the complexity of the building's systems, and the building's size. It may reduce costs to combine Phase I and Phase II services.
- It is common to achieve O&M-related energy savings of 5–30% through RCx<sup>8</sup>.
- Non-energy benefits (operational cost savings) are extensive and often offset part or all of the Retro-commissioning cost<sup>9</sup>.
- Limited multi-year post-commissioning data indicate that savings often persist for a period of at least five years<sup>10</sup>.

### **What kinds of buildings can benefit from RCx?**

Any building of any type can benefit from RCx. In an RCx project each building system is inspected and tested to discover opportunities for operational improvements and necessary repairs. RCx will discover any deficiency caused by:

- Deferred maintenance
- Incorrect or inadequate system design
- Construction deficiencies
- Inoperable or incorrect design control sequences
- Malfunctioning systems or components
- Air and water balance deficiencies

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<sup>6</sup> Based on CCI research and industry surveys

<sup>7</sup> Ibid

<sup>8</sup> Ibid

<sup>9</sup> Evan Mills. 2009. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions," <http://cx.lbl.gov/2009-assessment.html>

<sup>10</sup> Ibid



### **Common Energy Conservation Measures Implemented in RCx**

- Optimization of control systems and revision of controls schedules
- Elimination of simultaneous heating/cooling situations
- Identification of economizer opportunities
- Control systems calibration and set-point adjustments
- Building lighting systems' repair, cleaning, retro-fit or upgrades
- Optimization of day-lighting and building lighting systems operations
- Air and hydronic balance and associated mechanical systems repairs and adjustments
- Adjustment of diffusers and registers per Test, Adjust and Balance (TAB) analyses
- HVAC equipment water usage investigations and tests
- Adjustment and of outside air dampers/intakes to provide proper design flow rates
- Building envelope component cleaning, caulking, shading and pressure adjustments
- Electrical systems' corrections of grounding faults, circuit identifications and bolted connections tightening torques
- Plumbing systems' repairs and set-points or sequences adjustments
- Plumbing upgrade recommendations
- Grey water opportunities to reduce potable water/sewage usage
- Eliminating select deferred maintenance issues

### **Recommended Deliverables from an RCx Project**

- Comprehensive Final Retro-Commissioning Report and Issues Log
- ASHRAE required documentation (or equivalent) for Level I and II energy audits
- Energy Star Reports
- Training Plan and Schedule
- Capital Budgeting Plan for future systems and equipment upgrades and replacement when appropriate and necessary
- Updated Operations & Maintenance documents, including:
  - Building Operations Plan
  - Systems Narrative
  - Sequence of Operations
  - Trends and Charts of Building Systems' Operations
  - Preventative Maintenance Plan
  - Ongoing Cx Plan



## Suggested Best Practices in RCx

### 1. “Technical” Retro-Commissioning rather than “Process” Retro-Commissioning

- The “Technical” Retro-Commissioning Agent must have a thorough understanding of the engineering principles involved in the project design, detailed knowledge of the construction methods used in building the systems, and a deep understanding of both the system controls and the testing and balancing process. The Technical Retro-Commissioning Agent physically tests, observes, and verifies that **all** systems are actually operating optimally.
- In the previously cited 2009 LBNL study, projects employing a comprehensive approach to commissioning (“Technical RCx”) attained nearly twice the overall median level of savings (30%), and 5-times the savings of projects with a constrained approach.
- The Technical Retro-Commissioning Agent monitors the procedures followed by the various contractors, observes all testing, and when the final report is completed, the Technical Retro-Commissioning Agent verifies all readings to ensure the system is operating properly before project hand-off. Many times the Technical Retro-Commissioning Agent can perform many of these tasks, greatly reducing cost.
- The role of the Retro-Commissioning Agent (RCxA) in a “Process” Retro-Commissioning project is to collect documentation of the field tests performed by the various contracting trades. The “Process” Retro-Commissioning Agent does not necessarily need to possess detailed technical knowledge of the project—the “Process” Retro-Commissioning Agent’s area of expertise is the commissioning process itself.

The following Table may help to clarify the differences between these two RCx approaches:

Question	Technical RCx	Process RCx
Who does the site inspections and fills out the RCx Check Sheets?	The RCxA – true Third Party Validation	The contractors – true First Party Validation
Are sampling strategies utilized?	No – 100% of components are tested	Yes – 10% of components are tested
Is a separate control point-to-point test utilized?	Yes – by RCxA – 100% Third Party Validation	No – done by Controls Contractor – First Party Validation
How are functional tests verified?	RCxA verifies each control loop through documented data trends	RCxA observes system operating or observes contractor start-up. No additional documentation is provided
Who is responsible to verify that issues are actually resolved?	RCxA manages Issues Log to complete resolution	Contractor manages Issues Log and resolution of identified issues – RCxA has no responsibility



**2. RCx firms must be qualified to perform “Technical” Retro-Commissioning**

- There are many firms that offer RCx services, but Owners should verify that any firms being considered for a project are able to provide “technical” RCx services as distinct from “process” RCx.
- The attached RFQ&P covers the questions that an owner/operator should address when assessing a firm’s ability to provide a thorough technical RCx project.
- The National Environmental Balancing Bureau (NEBB) certifies firms in “technical” Retro-Commissioning, but firms need not necessarily be NEBB certified in order to deliver a technically sound RCx project.

**3. Every Retro-Commissioning project should include the following “Scope of Activities” at a minimum:**

**Analysis**

<b>Phase I – Preliminary Audit</b>	<p>Analyses equivalent to ASHRAE Level I building energy audit guidelines, and initial Energy Star benchmarking</p> <p>Equipment and System Assessment for general operating condition and overall performance</p> <p>Energy Star benchmarking and goal-setting</p> <p>Review of building systems’ operations and present operating parameters</p> <p>Assess metering infrastructure and develop a preliminary Measurement &amp; Verification plan</p> <p>Preliminary recommendations for corrections including “no-cost” items and estimated costs, savings, ROIs and simple paybacks for other opportunities identified</p>
<b>Phase II – Detailed Audit</b>	<p>Analyses equivalent to ASHRAE Level II building energy audit guidelines</p> <p>Analyses of operational issues to determine the underlying causes and what measures that can be taken to optimize the operation of the various building systems</p> <p>Energy Star benchmarking</p> <p>Clear financial analyses of proposed Energy Conservation Measures with firm costs and energy savings, factoring in incentives/programs from local utilities</p> <p>Assistance with refinement of O&amp;M documents and databases</p>



<b>Phases III and IV – RCx Implementation and M&amp;V</b>	<p>Repair of system faults, adjustments of operating parameters, calibration of sensors and elimination of deferred maintenance issues as approved by the Owner</p> <p>Construction of corrections as approved by the Owner</p> <p>Building Systems’ Functional Testing and Commissioning of corrections</p> <p>Mid- and long-term capital budgeting assistance</p> <p>Measurement and verification of completed systems</p> <p>Appropriate training of O&amp;M Staff according to Scope of Activities conducted during the RCx process.</p>
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**4. Capacity-building and training, both internal and external**

- The RCx process should be a collaborative effort, and should involve both building staff and existing contractors.
- The building staff knows the building better than anyone—they know what the day to day “pains” are, and what systems are problematic. The RCx firm should work with building staff from project kick-off throughout the entire RCx process so the building staff takes ownership of the project, understands why changes are being proposed, and gains new perspective on ways to handle equipment malfunctions and other day to day issues.
- The RCx firm should also work with relevant existing service contractors to develop them as reliable sources for service of each of the critical systems included in the work. These service contractors, as well as the building staff should be included in the low cost and implementation phases of the Retro-Commissioning process wherever possible in order to enhance their ability to provide effective long term support for the optimized facilities. By including existing/preferred vendors in the RCx process, the vendors also get an introduction to the *cultural* changes that are occurring within the building operations team.
- Following RCx implementation, proper training is absolutely critical to ensuring the continued performance of the building. The RCx firm should provide training on all systems, not just those that were adjusted during the RCx project.

**5. Robust Measurement & Verification**

- Measurement & Verification is absolutely critical to ensuring the continued efficient performance of the building. The owner should articulate to the RCx firm what level of detail of measurement is desired as part of project kick-off. The owner should also communicate which metrics should be tracked, (energy, CO2, GHG, water), and with what frequency (continuous, periodic).
- The RCx firm should then assess the ability of the current building systems to provide that information and develop a plan for installation of additional metering, sensors, and/or software as necessary.



- Measurement and Verification infrastructure should be installed early on in the RCx process (Phase II) so that results can be documented in real time in Phase III implementation.
- Energy and water savings should be measured and verified consistent with the Efficiency Valuation Organization's International Performance Measurement & Verification Protocol (IMPVP).
- The IPMVP provides standard measurement and verification terminology and defines four Measurement and Verification (M&V) options to quantify energy and water savings (Options A, B, C or D).
- The appropriate IPMVP option regarding the scope of M&V services should be decided based upon the complexity of the energy conservation measures implemented, the costs for the M&V services, building owner staff expertise, and other practical considerations.
- Option C is the most comprehensive, and applies to multifaceted energy efficiency projects that affect many systems within a building. Under Option C, savings are determined by taking short-term or continuous measurements at the whole building level throughout the post-RCx period to ensure that the building is continuing to perform as desired.
- The owner may choose to have a separate third party provide the M&V, or to have the implementing RCx firm provide M&V services. Owners may also choose to handle the M&V in-house.

#### **6. Minimize Up-front Costs**

- Negotiate a "Paid from Savings" approach with the RCx provider and maximize the use of any available incentives or rebates.
- Many utilities offer generous rebates and incentives for both the investigation and implementation phases of RCx projects.
- These incentives can in some cases cover nearly the entire cost of the project.

#### **7. LEED EB-O&M**

- In addition to the above, at the owner's request a Retro-Commissioning project can produce analysis and output to assist the owner in meeting LEED EB-O&M credit requirements regarding retro-commissioning investigation and implementation, building energy performance, indoor environmental quality, enhanced metering, and water efficiency. It is possible to attain as many as 31 LEED Credits through RCx, nearly enough for Certification under LEED EB-O&M<sup>11</sup>.

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<sup>11</sup> According to CCI analysis