RETRO-COMMISSIONING (RCX)

A Whitepaper

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Retro-Commissioning: A Whitepaper

BACKGROUND

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. Before being awarded this title, however, a ship must pass several milestones. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems, and staff have successfully completed a thorough quality assurance process.

Building commissioning takes the same approach to new buildings. When a building is initially commissioned it undergoes an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.[i]

APPLICATIONS

Retro-commissioning (RCx) is the application of the commissioning process to existing buildings. Retro-commissioning is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, retro-commissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retro-commissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

Although retro-commissioning can identify building improvements that require capital (i.e., retrofits and equipment upgrades), it is a phase of building improvement process which identifies and provides a baseline for improvements.

Definitions

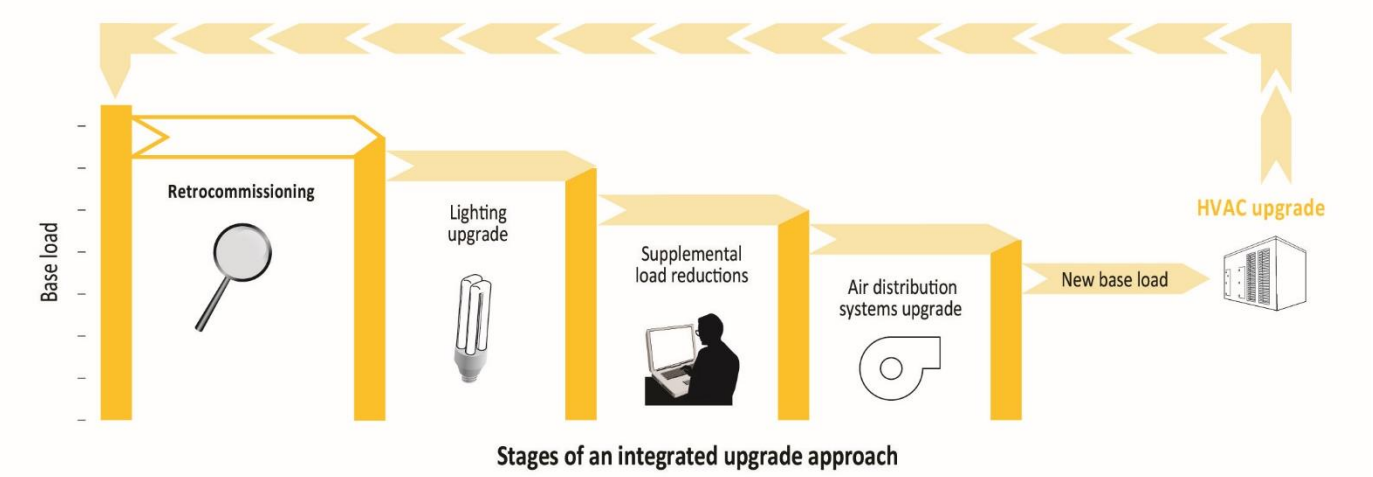
Commissioning: A systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. The process evaluates building equipment, subsystems, operation, and maintenance (O&M) procedures, and performance of all building components to ensure that they function efficiently, and as designed, as a system. Single instance commissioning typically occurs with a newly constructed building or major building addition and is applied from project inception to initial occupancy.

Retro-commissioning (RCx): Retro-commissioning is a form of commissioning that is applied to buildings that have either not been commissioned or have been previously commissioned but have since been modified or reprogrammed without additional commissioning. It basically baselines the building again looking at all elements of the building improving the overall operation and maintenance of the building. This may be needed when buildings are adapted, additions are made, and/or considerable time has passed. Retro-commissioning may resolve problems that occurred during design or constructions and bring the building back to its original or desired performance. RCx is the starting point for the building improvement process.

Recommissioning: Recommissioning is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. Ideally, a plan for recommissioning is established as part of a new building's original commissioning process or an existing building's retro-commissioning process. Because recommissioning is used when the building has been commissioned previously, the process tends to be faster and simpler than in retro-commissioning. Recommissioning typically involves both testing and repairs.

USAGE IN THE BUILDING UPGRADE PROCESS

"Retro-commissioning is the first stage in the building upgrade process. The staged approach accounts for the interactions among all the energy flows in a building (example figure shown) and produces a systematic method for planning upgrades that increases energy savings. When the staged approach is adopted and performed sequentially, each stage includes changes that will affect the upgrades performed in subsequent stages, thus setting up the overall process for the greatest possible energy and cost savings. In this staged approach, retro-commissioning comes first, because it provides an understanding of how closely the building comes to operating as intended. It also helps to identify improper equipment performance, what equipment or systems need to be replaced, opportunities for saving energy and money, and strategies for improving performance of the various building systems."[ii]



Stages of an integrated upgrade approach

TIMING

In existing buildings that have never been commissioned before, retro-commissioning can take place anytime – unless the facility and/or major equipment are programmed for replacement in the immediate future. In that case, it is best to wait and commission the facility as part of the construction effort.

In existing buildings that have been previously commissioned, recommissioning is usually recommended at about the 3–5-year point since the previous commissioning.

The most proactive programs commission their buildings continuously (ongoing commissioning or monitor-based commissioning), using and trending data from their building management systems, installed meters and sensors, and even utility data. In these cases, commissioning never really stops, as analysis is conducted continually to detect impending failures, abnormalities, and efficiency opportunities.

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COMMON REASONS FOR RETRO-COMMISSIONING

There are a few situations that indicate building systems must be checked and tuned:

- **Recent occupancy change:** HVAC and lighting needs vary significantly according to the type of occupancy. For instance, if space previously used for a store is converted to an office area, increased ventilation rates will be needed due to the higher occupancy.
- **Increasing energy consumption**: If the electricity and gas bills of a building have been constantly increasing with no evident explanation, retro-commissioning can be an effective way to identify and address the cause.
- **Increasing occupant complaints**: These are typically the result of poor lighting, noisy HVAC systems, poor water pressure, excessive temperatures, and moisture extremes.

COMMON PROBLEMS IDENTIFIED BY RETRO-COMMISSIONING

Retro-commissioning identifies a variety of problems which are typically driving energy costs up, but which may or may not be causing occupant discomfort.

- Outside air dampers stuck in the always open or always closed position
- Adjustable speed drives that no longer adjust properly
- Unconnected flexible ductwork
- Belts and valves that are malfunctioning
- Control systems components that do not properly respond to their prescribed control sequences
- Incorrect sequences of operation
- Energy management systems that have not been updated to reflect system modifications
- Changed facility uses that affect personnel loading and partition configuration changes that cause suboptimal air flow
- Thermostats and controls sensors that are improperly placed, out of calibration or permanently overridden
- Equipment problems due to long-term storage of equipment, such as breakdown of dielectrics, degraded fluids, failed batteries, leaking seals, and flattened bearings
- Systems that are simultaneously heating and cooling the same spaces

TYPICAL ACTIVITIES

The most significant energy-saving opportunities are usually found in optimizing building controls, but other common RCx measures include:

- Optimizing chiller and boiler operations to better match building load conditions
- Reducing ventilation in over-ventilated areas
- Ensuring ventilation dampers open and close properly
- Decreasing supply air pressure set point and system rebalancing
- Aligning zone temperature set-points to match the building's actual operating schedule

- Improving scheduling of lighting and HVAC equipment
- Enabling or enhancing economizer controls
- Optimum start function with warm up and cool down
- AHU supply fan static pressure optimization and reset
- Adding BAS control scheme to electric unit heaters and reheats
- Improve airflow management and setpoints in data centers
- Improve and validate demand-based ventilation systems
- Confirm sequence of operations for EMS equipment

BENEFITS

Building owners, managers, staff, and tenants all benefit from the retro-commissioning process:

- **O&M improvements:** Reduced O&M costs, fewer service calls, increased O&M training and improved documentation.
- **Occupant comfort:** Occupant complaints are reduced, thanks to the improvement in building controls, as well as improvements in lighting levels, temperature, and humidity.
- **Equipment service life:** When equipment operates optimally, its service life is extended. This allows building owners to delay capital expenditures that are due to equipment replacements.
- **Indoor air quality (IAQ):** Poor HVAC operation can lead to the accumulation of air pollutants or excessive humidity. In turn, humidity stimulates the reproduction of mold and dust mites, both of which can cause allergic reactions or trigger asthma attacks.
- **Improved productivity:** Retro-commissioning can help eliminate issues such as noise or lamp flicker, which may distract occupants and reduce productivity in office environments.
- **Improved safety:** This applies to lighting improvements in particular, where improved visibility and uniform lighting reduce the chance of an accident.
- **Maintenance savings:** Improved system performance and reliability. RCx identifies equipment issues, which, once corrective actions are taken, can result in maintenance savings.

PROJECT SAVINGS

Existing buildings can achieve energy savings between 5 and 15%, as evidenced by the following industry statistics:

An old but oft repeated statistic from the Energy Star Building Manual by the US Environmental Protection Agency estimates that a retro-commissioning project has an average cost of $.44 per square foot (adjusted for inflation), while achieving energy savings of 15% and a payback period of just 0.7 years.[iii]

Other studies show that commissioned buildings typically save 10 to 20 percent of utility costs compared to similar non-commissioned buildings, with properly optimized HVAC and control systems often leading to the greatest energy savings.[iv]

A 2020 study of three decades of commissioning shows the median primary energy savings in existing buildings ranged from 5 percent for those conducted under utility programs, 9 percent for monitoring-based commissioning utility programs (i.e., augmented with submetering and diagnostics), and 14 percent for projects outside of utility programs. [v]

PROCESS

The retro-commissioning process has multiple steps with specific physical deliverables, along with ongoing monitoring activities to satisfy utility rebate requirements. Steps 1 – 4 are part of the Retro-Commissioning process, with Steps 5 and 6 being separate line items and processes.

Step 1: Proposal

Includes documentation of which facilities and equipment will be reviewed and a cost estimate for the initial assessment

Step 2: Approval

Customer approval to initiate the RCx process along with budget approval for the initial assessment

Step 3: Implementation

A physical review of the site and equipment as identified in the proposal, including review of utility bills as provided by customer

Step 4: Report

- Assessment Findings: log of issues identified
- Corrective Actions Summary: list of activities to be undertaken to address identified issues
- Repair & Correction Cost Estimates: anticipated costs for fixing equipment and correcting issues
- Energy Analysis: projected energy savings resulting from corrective actions
- Financial Analysis: a summary of anticipated costs, projected savings

Step 5: Corrective Actions

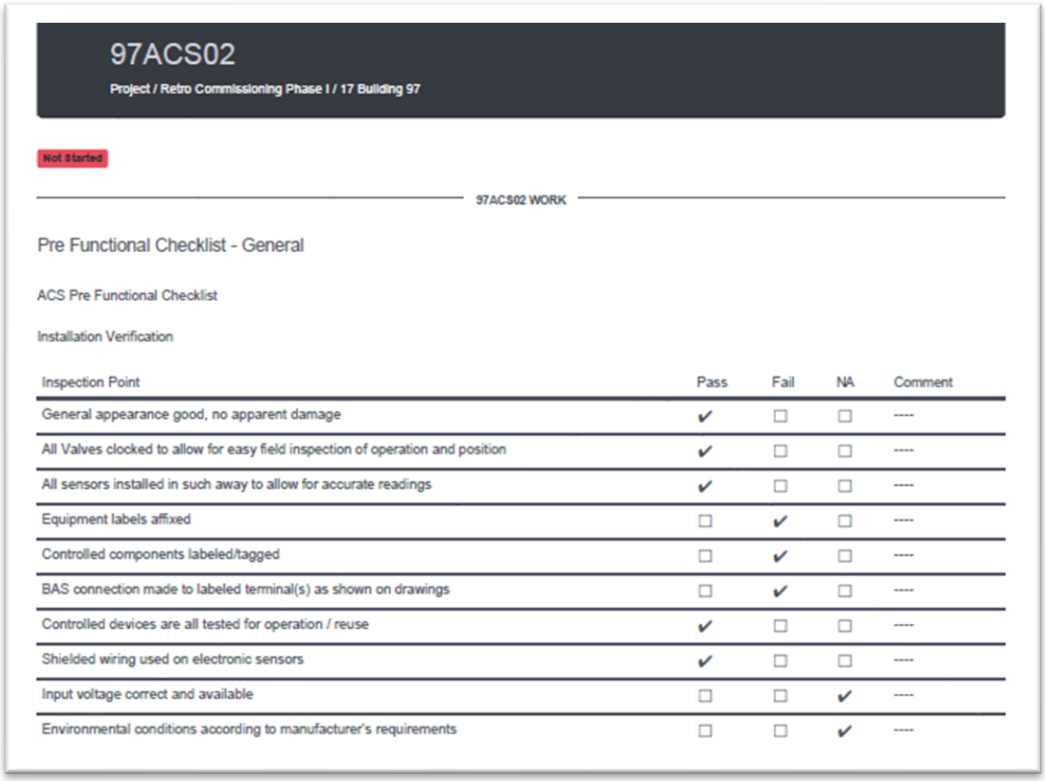
The repairs and corrective actions identified in the RCx Report. (This step is not part of the RCx process, but it is required to qualify for any utility rebate programs).

Step 6: M & V

Ongoing measurement and verification process which demonstrates energy savings over time that is achieved from the implementation of corrective actions. (This step is not part of the RCx process, but it is required to qualify for any utility rebate programs).

REPORTING EXAMPLES

Physical deliverables within the retro-commissioning project include highly specific reporting and data analysis, such as a pre-functional checklist, functional checklist, and visual documentation



97ACS02

Project / Retro Commissioning Phase I / 17 Building 97

Not Started

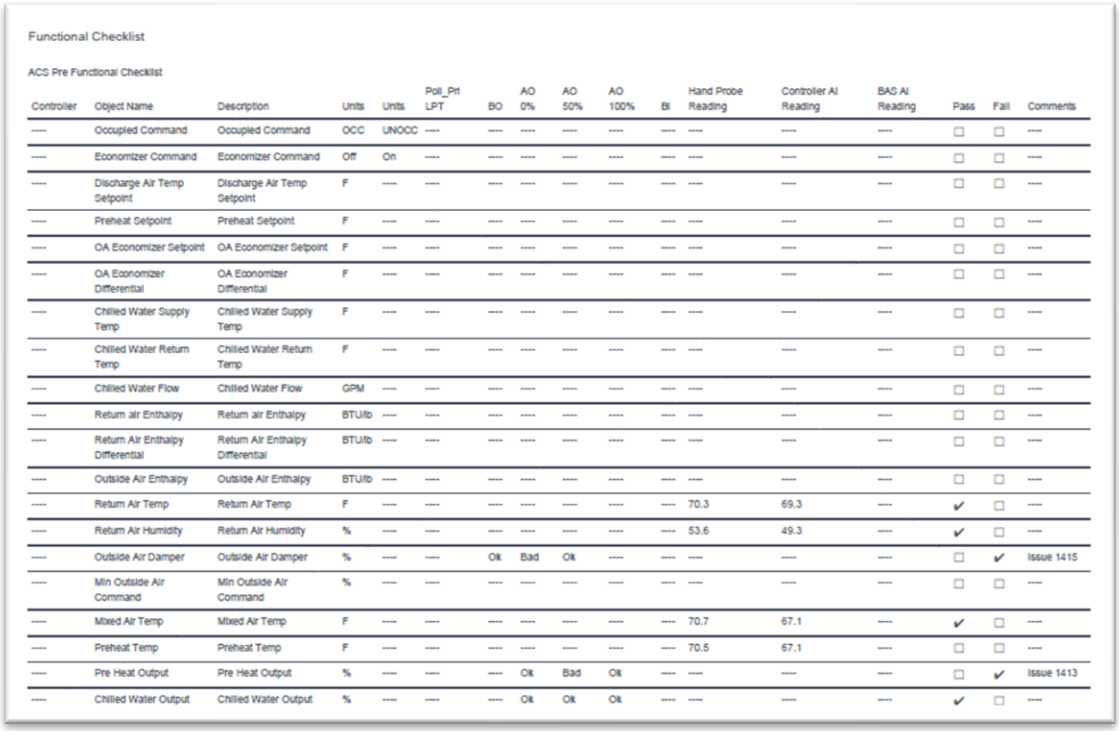
97ACS02 WORK

Pre Functional Checklist - General

ACS Pre Functional Checklist

Installation Verification

Inspection Point	Pass	Fail	NA	Comment
General appearance good, no apparent damage	✔	☐	☐	----
All Valves clocked to allow for easy field inspection of operation and position	✔	☐	☐	----
All sensors installed in such away to allow for accurate readings	✔	☐	☐	----
Equipment labels affixed	☐	✔	☐	----
Controlled components labeled/tagged	☐	✔	☐	----
BAS connection made to labeled terminal(s) as shown on drawings	☐	✔	☐	----
Controlled devices are all tested for operation / reuse	✔	☐	☐	----
Shielded wiring used on electronic sensors	✔	☐	☐	----
Input voltage correct and available	☐	☐	✔	----
Environmental conditions according to manufacturer's requirements	☐	☐	✔	----



Functional Checklist

ACS Pre Functional Checklist

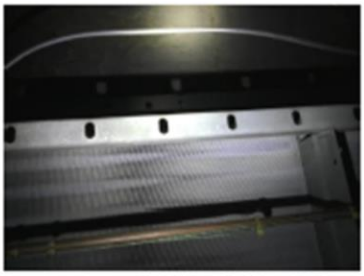
Controller	Object Name	Description	Units	Units	Poll_Prl LPT	BO	AO 0%	AO 50%	AO 100%	BI	Hand Probe Reading	Controller AI Reading	BAS AI Reading	Pass	Fail	Comments
----	Occupied Command	Occupied Command	OCC	UNOCC	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Economizer Command	Economizer Command	Off	On	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Discharge Air Temp Setpoint	Discharge Air Temp Setpoint	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Preheat Setpoint	Preheat Setpoint	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	OA Economizer Setpoint	OA Economizer Setpoint	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	OA Economizer Differential	OA Economizer Differential	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Chilled Water Supply Temp	Chilled Water Supply Temp	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Chilled Water Return Temp	Chilled Water Return Temp	F	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Chilled Water Flow	Chilled Water Flow	GPM	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Return air Enthalpy	Return air Enthalpy	BTU/lb	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Return Air Enthalpy Differential	Return Air Enthalpy Differential	BTU/lb	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Outside Air Enthalpy	Outside Air Enthalpy	BTU/lb	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Return Air Temp	Return Air Temp	F	----	----	----	----	----	----	----	70.3	69.3	----	✔	☐	----
----	Return Air Humidity	Return Air Humidity	%	----	----	----	----	----	----	----	53.6	49.3	----	✔	☐	----
----	Outside Air Damper	Outside Air Damper	%	----	----	Ok	Bad	Ok	----	----	----	----	----	☐	✔	Issue 1415
----	Min Outside Air Command	Min Outside Air Command	%	----	----	----	----	----	----	----	----	----	----	☐	☐	----
----	Mixed Air Temp	Mixed Air Temp	F	----	----	----	----	----	----	----	70.7	67.1	----	✔	☐	----
----	Preheat Temp	Preheat Temp	F	----	----	----	----	----	----	----	70.5	67.1	----	☐	☐	----
----	Pre Heat Output	Pre Heat Output	%	----	----	----	Ok	Bad	Ok	----	----	----	----	☐	✔	Issue 1413
----	Chilled Water Output	Chilled Water Output	%	----	----	----	Ok	Ok	Ok	----	----	----	----	✔	☐	----

ISSUE-1409

Project / Retro Commissioning Phase I / 17 Building 97 / 97ACS02

LTD sensor is after the cooling coil and is not next tO the cooling coil fins.It only has one pass.

Status	Open
Entered	10/27/2021 1:40:33 PM
Entered By	XXXXX XXXXXXX
Category	Client Owned
Assigned To	XXXXX XXXXXXX
Respondent Status	Open
Due Date	11/3/2021 12:00:00 AM



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REBATE PROGRAMS

Rebate programs vary based on the specific utility company. Customers should reach out to their specific utility company or check the utility company website for rebate program guidelines and requirements.

SOURCES

CM3 Building Solutions: Retro-Commissioning Services Team

[i] Haasl, T., and K. Heinemeier. 2006. "California Commissioning Guide: New Buildings" and "California Commissioning Guide: Existing Buildings". California Commissioning Collaborative.

[ii] EnergyStar.Gov, October 2007. “Building Upgrade Manual Retrocommissioning.”

[iii] Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. “The Cost-Effectiveness of Commercial-Buildings Commissioning,” Lawrence Berkeley National Laboratory.

[iv] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. July 2014 “Commissioning of Federal Facilities.”

[v] ScienceDirect, Energy and Buildings, Volume 227, November 2020. “Building commissioning costs and savings across three decades and 1500 North American buildings PG&E, Facility Improvements: Retro-commissioning, RCx Fact Sheet.