



EXISTING BUILDING COMMISSIONING

BEST PRACTICES

Acknowledgments

The Building Commissioning Association is fortunate to have access to numerous commissioning professionals who practice state-of-the-art building commissioning every day. We are grateful for their donated time and intense effort to bring this Existing Building Best Practices update into being. Over the past year, these subject matter experts have authored, touched, interpreted, reviewed, edited and generated comments on the manuscript. Their insight and vast experience in the field reinforce the building industry's recognition of best practices in commissioning. Thank you!

Content and Editorial: EBCx Best Practices Subcommittee

John Villani, Grumman/Butkus Associates
Justin D'Arcy, Grumman/Butkus Associates
Diana Bjornskov, Building Commissioning Association

Content and Editorial: Contributors

David Cohen, Grumman/Butkus Associates
Kevin Coleman, Nexant
Bob Fuls, McKinstry
Lee Gordon, McKinstry
Justin Johnson, McKinstry
Tracey Jumper, Jump-Start Building Commissioning
Kenny Reed, Specialized Engineering Solutions
John Runkle, Intertek
Peter Rylander, AKF Group
Clay Schroeder, Nexant
Jesse Sycuro, BGIS
Jeremy Wolff, McKinstry
Eniola Yussuf, AKF Group

Editorial: BCxA Best Practices Committee

Karl Stum, Summit Building Engineering
Kent Barber, Keithly Barber
Jim Feeney, Grumman/Butkus Associates
A.J. Kindya, Colliers
David Lewis, ClayCorp
Jack Schirpke, Total Mechanical

BCxA Staff Contributors

Liz Fischer, Executive Director
Sheri Adams, Member Relations Manager
Nicole Gardner, Marketing and Events Manager

Contents

Acknowledgments

- Executive Summary 1**
- 1 Planning Phase 4**
 - 1.1 Engage a Commissioning Provider 4
 - 1.2 Screen the Building for EBCx Viability 5
 - 1.3 Define Owner’s EBCx Goals and Objectives 6
 - 1.4 Confirm Scope of Work, Schedule and Budget 6
 - 1.5 Conduct Cursory Walk-Through to Identify General Conditions 7
 - 1.6 Ascertain/Examine/Develop Current Facility Requirements (CFR)..... 7
 - 1.7 Initiate EBCx Plan 9
 - 1.8 Define Roles & Responsibilities..... 9
 - 1.9 Select the Initial EBCx Team..... 12
 - 1.10 Conduct a Kickoff Meeting..... 13
 - 1.11 Deliverables..... 13
- 2 Initial Assessment Phase 14**
 - 2.1 Review Building Documentation..... 14
 - 2.2 Analyze Energy Data (Utility Billings and Interval Data) 14
 - 2.3 Perform Initial Facility Staff Interviews..... 15
 - 2.4 Perform Building Occupant Interviews 15
 - 2.5 Perform Initial Site Walk-Through and BAS Review..... 15
 - 2.6 Update EBCx Plan and Scope 15
 - 2.7 Develop an Initial Assessment EBCx Report 16
 - 2.8 Meet with Owner 16
 - 2.9 Deliverables..... 16
- 3 Investigation Phase 17**
 - 3.1 Update EBCx Tasks 17
 - 3.2 Update EBCx Team..... 18
 - 3.3 Conduct Investigation Phase Kickoff Meeting 18
 - 3.4 Conduct Additional Detailed Documentation Review 18
 - 3.5 Conduct Detailed Site Survey..... 19
 - 3.6 Check Calibrations of BAS-Trended Points 19
 - 3.7 Analyze Facility Performance and Establish Performance Baseline 19

3.8	Functional Testing or Monitoring?	20
3.9	Monitor System and Equipment Performance	20
3.10	Conduct Additional Building Personnel and Occupant Interviews	20
3.11	Review Building Automation Controls System	20
3.12	Develop Functional Test Procedures	21
3.13	Conduct and Evaluate System Functional Testing	21
3.14	Gather Data for Energy Calculations and Implementation	22
3.15	Perform Energy Savings and Cost Calculations	22
3.16	Perform Simple Repairs	23
3.17	Master List of Findings	23
3.18	Update EBCx Report with Investigation Report	24
3.19	Finalize Measurement and Verification Plan	24
3.20	Complete Scope of Work for Implementation and Hand-off Phases	24
3.21	Obtain Owner Acceptance and Decision to Proceed	25
3.22	Deliverables	25
4	Implementation Phase	26
4.1	Implement Facility Improvement Measures	26
4.2	Deliverables	28
5	Hand-off Phase	29
5.1	Update and Deliver Documentation	29
5.2	Train Staff and End Users	30
5.3	Plan for Persistence	31
5.4	Close-Out Project	32
5.5	Deliverables	32
6	Ongoing Commissioning	33
7	Abbreviations	34
8	Definitions	35
9	References	37

EXECUTIVE SUMMARY

The value of best practices in any profession is the certainty, cost-effectiveness and efficiency it brings to practitioners, recipients of services, and other process participants. Commissioning (Cx) best practices, in particular, have a wide range of practice across providers. This document is intended to provide the combined best practices from a wide range of practitioners and has been updated from time to time throughout the life of the document.

This document describes and defines “best” practices for conducting Existing Building Commissioning (EBCx) projects, beyond minimum practices required to satisfy codes and standards. EBCx Best Practices is a useful complement to ASHRAE Guideline 0.2-2015: Commissioning Process for Existing Building Systems and Assemblies, the APPA/BCxA Building Commissioning Handbook, the ASHRAE Commissioning Stakeholders Guide, and other “how-to” commissioning guides.

Best practice deliverables for each phase are listed at the end of their respective chapters. Detailed descriptions and actual examples of many EBCx deliverables are available in The Building Commissioning Handbook, third edition, and ASHRAE Guideline 0.2-2015: Commissioning Process for Existing Building Systems and Assemblies.

Best Practice

Best Practice is the level of rigor and excellence that projects should seek to meet, within reasonable budget limitations, to obtain optimal outcomes in system performance over time. Defining best practice creates a benchmark against which the market can gauge quality and professionalism. This Best Practice allows the BCxA and other organizations to objectively evaluate commissioning initiatives, processes, standards, guidelines, training curricula and certifications, etc. It facilitates improved implementation of high-quality building commissioning processes and promotes appropriate standardization of commissioning.

Definition of Existing Building Commissioning (EBCx)

Existing Building Commissioning (EBCx) is a systematic process for planning, assessing, investigating, analyzing, improving, optimizing and verifying the performance of building systems and assemblies.

Scope and Purpose of EBCx

The scope of EBCx includes existing buildings, systems, and assemblies which may or may not have been previously commissioned. The scope may be limited to specific systems and assemblies, like energy using equipment, or broadened to include other systems such as those that affect comfort such as temperature control or air quality impacting systems, life safety and other mission critical or redundancy equipment in healthcare, industrial process and similar facilities, building envelope elements such as roofs, windows and doors, curtain walls and other building envelope assemblies, or even aesthetics such as landscaping and irrigation.

The purpose of EBCx is most often to address facility conditions such as:

1. A change in building use, ownership or functional requirements.
2. The building uses more energy than it should or has in the past.
3. The building has problems that impact the occupants or functional program.
4. The systems and assemblies are in poor condition, or don't perform properly.
5. An addition or alteration to the building.

EBCx addresses these conditions by following a specifically designed, complete and methodical process. Key process elements include the following, which have a positive impact on building asset management and energy efficiency:

- Comparison of the facility's current functional requirements with the original basis of design.
- Comparison of field verified current performance with the original basis of design and opportunities to optimize performance.
- Implementing measures to address performance deficiencies and take advantage of performance optimization opportunities.
- Identify and leverage new systems, equipment and technology that may not have existed when the building was constructed in order to enhance and optimize performance.

The EBCx objectives are to make the building systems perform interactively to meet the Current Facility Requirements (CFR) and owner project objectives and provide the tools to support ongoing commissioning (OCx), performance tracking and improvement of system performance over time.

As a best practice, it is advisable for most owners to hire an independent third party to provide commissioning services and act directly as the Owner's advocate.

Note: Depending on the size, scope and complexity of the project, and in collaboration with the Owner or representative, Planning and Initial Assessment, or Initial Assessment and Investigation Phases occasionally are combined to minimize cost and/or avoid duplication of effort.

Phases of EBCx¹

EBCx comprises the following sequential phases. Each phase is discussed in a separate section of this document.

1. **Planning.** Initial project documentation gathering and planning meetings that form the basis for developing the EBCx goals, facility requirements, and EBCx Plan.
2. **Initial Assessment.** Initial walk-through of the building to note and confirm current use and occupancy of the building and condition of systems and equipment, document known issues, identify other potential issues, interview building staff and occupants, and prepare an initial EBCx Plan. Confirm EBCx feasibility, gain a preliminary understanding of systems' performance and facility operation and maintenance, and preliminarily assess the potential for energy and functional improvements along with related return on investments.
3. **Investigation.** Field observation and testing of system and equipment operation, interviewing facility staff, reviewing equipment and building documentation, review and confirmation of preventive maintenance plans, evaluating sequences of operation, evaluating building automation system (BAS) performance and trend or logging data of equipment operation, documenting findings and identifying energy conservation measures (ECMs) and facility improvement measures (FIMs), estimating energy impacts and implementation costs, evaluating the source of performance problems (e.g., water leakage) and investigating any applicable rebates or incentives.
4. **Implementation.** Implementation of desired energy conservation measures and facility improvement measures followed by commissioning and verification of results and performance through documented trending and post implementation testing and data measuring. This may include the review of remediation designs and corresponding installation of repairs.

¹ Building Commissioning Handbook, third edition. APPA/BCxA 2017. ISBN 1-890956-96-1

5. **Hand-Off.** Systematic transition from a commissioning activity and commissioning team to normal operating practice and the operations and maintenance (O&M) team; puts in place measures to ensure persistence of performance, including updating documentation, revising preventive maintenance requirements, training, and performance tracking, and may include plans for an Ongoing Commissioning Phase.

Note: In many utility-funded EBCx programs Hand-Off is called the “Verification Phase.”

6. **Ongoing Commissioning (OCx).** The continuous process that helps to monitor and ensure effective and efficient building performance over its lifecycle. Energy use, benchmarking, conformance to and continuous revision of the current facility requirements, automated fault detection and diagnostics, and training are all key parts of the ongoing commissioning process. *The Building Commissioning Association’s OCx Best Practices are scheduled for publication in early 2020.*

EBCx Process Overview:



1 PLANNING PHASE

The objective of the Planning Phase is to engage the Commissioning Provider (CxP), document the facility's current operational conditions and requirements, confirm the Owner's project goals and objectives, and plan the process for executing the work for the EBCx program.

The outcomes of the planning phase include clear communication and documentation of the goals and objectives of the EBCx program, and identification of roles and responsibilities of parties involved in the commissioning process.

The Planning Phase includes these activities.

- Engage a Commissioning Provider
- Screen the Building for EBCx Viability
- Define Owner's EBCx Goals and Objectives
- Confirm Scope of Work, Schedule and Budget
- Conduct Cursory Walk-Through to Identify General Conditions
- Ascertain/Examine/Develop Current Facility Requirements (CFR)
- Initiate EBCx Plan
- Define Roles & Responsibilities
- Select the Initial EBCx Team
- Conduct a Kickoff Meeting

1.1 Engage a Commissioning Provider

1.1.1 Qualifications

The required qualifications for a commissioning provider for an EBCx project are:

1. Experience and expertise with the type of building and occupancy the project entails, i.e., vertical market segment. Commercial office, healthcare, K-12, data centers and laboratories are all examples of vertical market segments for which the CxP's experience is an essential qualification. Higher education, while often considered as a single market segment, requires experience for the specific facility types involved in the project.
2. Relevant, documented experience with commissioning the current and expected assemblies, systems, and equipment in the building.
3. Documented experience overseeing the implementation and or/self-performing implementation of the facility improvement measures (FIMs) anticipated for the EBCx project.
4. Proven track record for achieving the performance and energy savings when part of the project objectives.
5. Best practice generally discourages owners self-performing the day-to-day EBCx effort because too frequently they have insufficient expertise and limited time. A CxP with commissioning certification from an accredited agency, such as the Building Commissioning Certification Board, is preferred.

The Qualifications-Based Selection (QBS) process is a professional services best practice for evaluation, scoring, and selection mandated by U.S. Congress through the Brooks Act of 1972. For more information and methodology, refer to the Building Commissioning Handbook, third edition, Appendix 1-1, "How to Hire a Commissioning Team."

1.1.2 Third-Party Contracts – Types and Negotiation

If a CxP is engaged under a third-party contract, a clearly defined scope of work, roles of responsibility, schedule, and CFR must be understood, documented, and agreed upon by all parties and included in the EBCx provider’s contract.

Contracts shall clearly state the method, schedule, and criteria for payment so that the Owner and the CxP can avoid interruptive contract discussions along the way.

Best practices would advocate for the CxP to be retained through a master service agreement or similar contracting vehicle from which task orders can be written. This would enable maximum flexibility for the Owner and CxP to add individual task orders for the EBCx phases and implementation of individual measures.

If a master service agreement approach is not suitable, an alternative approach that still accommodates tailoring of the project resources, is to have the Owner and CxP consider having the CxP provide a firm fixed fee for the Planning and Initial Assessment Phases and a budget estimate for the remaining phases based on mutually agreed assumptions. At the end of the Initial Assessment Phase, the remaining phase fees are negotiated based on findings and planned implementation scope. This provides the CxP risk mitigation (lower cost to the Owner) while providing the Owner a reserve budget.

The scope of work should be flexible to accommodate easily modifying the contract when changes in scope are needed, but clear and detailed enough to easily identify when the scope changes are occurring.

1.2 Screen the Building for EBCx Viability

Determine if facilities under consideration have significant conditions that prevent EBCx from being successful. Many criteria can be applied -- engage the CxP to assist with screening. The screening process shall include a preliminary review of the existing building documentation and data for possible systems to be included in the process. It should be acknowledged, that most existing buildings and facilities will have some challenges that must be overcome in order to implement an EBCx project, and if one waits for the “perfect” project, far fewer EBCx projects would be completed. While the ultimate goal of this task is to screen for EBCx viability and a go/no-go decision, equally as important is recognizing the potential challenges, acknowledging them with the Owner, and discussing how an EBCx project can still proceed in light of these challenges.

Best practice EBCx screening includes evaluating the following characteristics. Sites that are missing one or more these characteristics can still be successful, but optimal results may not be realized. Best practice is to evaluate the potential for optimal success which will allow the Owner and the CxP to set realistic costs and expectations should the project go forward.

1. An engaged Owner with the desire and financial budget to invest in building improvements
2. An engaged building staff who have the interest and time to dedicate to the process. It is critical to have a building operations champion from the Owner’s team as the point person for the rest of the operations staff and end user occupants
3. Available building documentation such as original plans, specifications, as-builts, controls sequence of operations, preventive maintenance plans, and past energy reports
4. For buildings with a building automation controls system (BAS):
 - a. system and sequence of operations documentation
 - b. trending and data archiving features that allow trending all control points at 5-minute intervals for at least 5 days.

- c. an active service contract with the BAS vendor/manufacturer
5. Owner's budget or plan for a budget to take the EBCx project from Planning through Hand-Off.
6. The Owner and CxP shall define the financial cost vs. savings (payback) criteria for ECM measures to be implemented.
7. The Owner and CxP understand and have outlined a realistic project schedule that includes some of the first year of occupancy and testing/validating through all seasons.
8. For energy efficiency projects, an EUI (energy use intensity) that is above the average in its market sector and climate indicating the building has energy-related cost savings potential.
9. The building assemblies, systems and equipment are not in need of extensive repair that would prevent optimization changes. If pervasive repairs are needed, the project starts with or waits for these repairs to be made.
10. The building is currently static from major equipment changes that would interfere with the EBCx effort.

If the building is currently undergoing changes that are not related to EBCx, establishing a baseline is essential. For example, realized energy savings desired to be seen on a utility bill from the implementation of ECMs can be completely overshadowed by an increase in building size or occupancy.

1.3 Define Owner's EBCx Goals and Objectives

The Owner and the stakeholders work with the CxP team to develop and document clear goals and objectives. It is important that the Owners understand what various types of EBCx can and cannot do. For example, if all the facilities manager has been mandated to do is meet ENERGY STAR™ or minimum LEED™ criteria, the EBCx effort will likely be quite different than if the company directive is to reduce energy as much as possible or to reduce the environmental footprint. If the Owner's company has a sustainability initiative, the EBCx program should be interwoven as an integral part of the initiative.

Start with asking why you as a CxP were called to a facility. Was it a symptom? Was it a high utility bill? Why do you think you need EBCx services? These start a line of questions that help determine the initial intent or source of an issue and more expediently lead to defining goals and deliverables.

Example Goals and Objectives:

- Address known issues to correct or enhance safety, preventive maintenance
- Reduce energy use and demand
- Leverage utility incentive programs
- Comply with requirements (company mandates, regulations, codes, lease agreements, rating systems)
- Improve comfort
- Improve systems performance and control
- Resolve failures in building systems

1.4 Confirm Scope of Work, Schedule and Budget

If a third-party consultant is the CxP, a clearly defined scope of work, schedule and CFR need to be understood, documented and agreed upon as part of the CxP's contract. The roles of all the commissioning participants are defined in the agreement.

The EBCx scope of work provided to the CxP in the Request for Proposal or Qualifications (RFP/RFQ), or upon selection and negotiation, includes:

- Project objectives: the CFR or Owner’s Project Requirements (OPR)
- Whether the Owner will provide the CFR, or if the CxP is to be included to develop the CFR with the Owner
- List of building equipment and systems to be included in the EBCx evaluation process
- Condition of all affected equipment and any outstanding repairs
- Special desires or procedures or emphasis on certain spaces, issues, systems or equipment
- Capabilities of the building automation system (BAS) for trending and reporting and whether the CxP will have remote access to the BAS
- A list of documents that will be provided to the CxP, including whether they will be provided electronically or in hard copy or whether they will only be available for visual inspection onsite
- Description of how much support can be expected from the operations staff for answering questions and escorting the CxP, including an after-hours night walk
- Expectations for interim reporting and the final report from the CxP
- The rigor of ECM and FIM cost and energy savings estimates to be provided by the CxP
- The rigor and expectations the Owner has for the CxP to develop the ECM and FIM scope of work, construction design drawings, construction administration overseeing the implementation, and commissioning of the measures
- The method by which the implementation of ECMs and FIMs will be procured such as 1) design/build with the CxP responsible to procure and provide installation services, or 2) implementation as the responsibility of the Owner.
- List of milestones or check-in points when progress will be discussed, work, scope refocused, and new budget or contract modifications made
- Desired schedule
- Potential Measurement and Verification (M&V) Plan
- List of deliverables

A task list for the CxP scope includes the lists of tasks at the beginning of the initial assessment, investigation, implementation, and hand-off, ideally negotiated in phases.

1.5 Conduct Cursory Walk-Through to Identify General Conditions

After or during the screening process, before the EBCx program starts, the CxP performs a cursory walk-through of all major spaces to gain an understanding of the types and condition of spaces, to determine the state of the facility and systems. If a large amount of equipment or components that are likely to be part of the EBCx project need maintenance, a plan for how the corrective repair work that affects equipment operation will be completed by the Owner before the EBCx project starts, or incorporated into the EBCx project scope of work.

1.6 Ascertain/Examine/Develop Current Facility Requirements (CFR)

Review and, if required, update the CFR which defines the current operational needs.

For buildings that have undergone new construction commissioning (NCCx), the CFR is the evolution of the Owner’s Project Requirements (OPR) established during the original commissioning process. The EBCx Plan addresses the CFR in sufficient detail to document and verify that those requirements are being met relative to systems and equipment that could affect the outcome of the EBCx meeting its objectives.

If the building use has changed from the original design, or if a current CFR does not exist, the CxP with input from the Owner, develops a detailed CFR including items such as temperature, humidity, operating

hours, filtration, sound, vibration, energy efficiency objectives, etc. The CFR notes integrated requirements such as controls, fire & life safety, personnel training, warranty review, service contract review and security systems. Recommended sections to be contained in the CFR Specific are outlined in ASHRAE Guideline 0-2019: The Commissioning Process, and indicated in the following section.

Develop a customized and project specific Facility Guide. A Facility Guide, as defined by ASHRAE is: “A basic building systems description and operating plan with general procedures and confirmed facility operating conditions, set points, schedules, and operating procedures for use by facility operations to properly operate the facility.” The Facility Guide information is used as a component of the CFR to document how systems and equipment operate to support the operational needs of the building’s intended function(s).

1.6.1 Conduct a CFR Workshop or Questionnaire

The procedures and methods for the CFR workshop are similar to the Owner’s Project Requirements (OPR) workshop for new construction, well defined in ASHRAE Guideline 0-2019: The Commissioning Process. The CFR workshop is typically facilitated by the Commissioning Provider (CxP), who determines the primary concerns of the project team. The workshop is organized to encourage identification of all requirements, interaction and discussion among all team members, and group consensus of priorities for the CFR. This is accomplished through the presentation of multiple questions in an ordered structure.

The CFR typically includes:

- User-Occupant Requirements
- Owner-Directed Requirements
- Specific Facility Requirements
- Sustainability Requirements
- Equipment and System Maintainability Requirements
- Capabilities of Operators and Maintenance Team
- Regulatory Requirements
- Ongoing Commissioning (OCx) Requirements
- Financial Requirements and Investment Criteria
- Building-wide and zonal/space information

It is the responsibility of the CxP to take the individual requirements developed by the project team and translate them into physical properties that can be measured, designed, and documented. The CFR is a living document, and shall be modified as intent changes, which may occur as new information is brought to light through the EBCx process.

After several iterations and reviews of the CFR by the project team, the requirements must be approved by the Owner.

Best practice can also be accomplished at sites where multiple stakeholders are involved, but don’t have the time to participate in CFR workshops through the use of a template or questionnaire. The CxP utilizes a template and queries stakeholders who are willing and fills in as much of the CFR as possible and leaves blanks and questions for other CFR elements. This document is distributed to the other stakeholders with assignments for filling in needed data for areas they have expertise in or are concerned about. Version control and iterations of review and data gathering are managed by the CxP.

1.7 Initiate EBCx Plan

Develop an EBCx Plan that documents goals, roles, responsibilities, the EBCx process, communication protocols, major activities and tasks and the overall EBCx project schedule. The Plan should give thoughtful consideration to the level of involvement of all Stakeholders and how communication with key Owner constituencies will be handled to ensure consensus and success. The Plan is a working document that evolves throughout the EBCx process.

Example outline:

- Project Scope. Specific areas of focus including systems, operations and assemblies
- Specific issues to look into and address including prioritization
- Project schedule and budget, and Owner’s financial metrics to determine the viability of ECMs and FIMs
- Expected benefits including savings or operational improvements
- Team members’ roles and responsibilities
- Phase-by-phase planning
 - Known areas that do not conform to the CFR
 - Data gathering approach
 - System testing plan including a how testing will be scheduled to minimize disruption to the building operations and occupancy
 - ECM and FIM procurement and implementation strategy
 - Measurement and Verification (M&V) requirements and approach
 - Measure persistence plan and transition to ongoing commissioning (if applicable)

It is critical to establish a budget and define the financial metrics for the program. Financial resources, the Owner’s budget and funding sequence are discussed during the Planning Phase. When using outside resources, the costs associated with individual tasks must be estimated to establish what level of funding will be required.

1.8 Define Roles & Responsibilities

In general, the CxP is the overall lead who plans, directs and coordinates the commissioning team and the EBCx process. The role of the CxP is to help develop the project plan and guide the team through the process of troubleshooting and identifying issues, sequencing commissioning activities, and bringing in the right internal and third party implementation team members with appropriate level of communications, technical skills and knowledge at the right time to meet project performance goals.

The entire Owner’s team (property or facility manager, representatives of the occupants, user groups, and operations staff) is engaged in the process from the beginning to ensure the perspectives of stakeholders and building systems requirements are met. The roles and responsibilities of all EBCx participants are defined during this phase. Determine availability of internal resources or possibility of sourcing for external resources.

At-a-Glance summary of CxP and Owner EBCx activities by phase:

Cx Provider Responsibilities	Owner Activities
Planning Phase	
<ul style="list-style-type: none"> Meet with Owner to define project Update the Current Facility Requirements (CFR) 	<ul style="list-style-type: none"> Hire CxP to help update the CFR Contribute, review, & approve the CFR Develop initial budget
DELIVER TO OWNER: Updated CFR	
Initial Assessment Phase	
<ul style="list-style-type: none"> Review building documentation Develop initial EBCx Plan Analyze energy data Perform initial walk-through Conduct staff interviews Document findings Meet with Owner to focus work for investigation 	<ul style="list-style-type: none"> Approve EBCx budget Review & approve EBCx Plan & scope
DELIVER TO OWNER: Initial EBCx Plan & Scope	
Investigation Phase	
<ul style="list-style-type: none"> Run & analyze trends & monitoring Conduct deeper field inspections Conduct functional testing Document findings Estimate savings & implementation costs Review findings with Owner, select findings to implement Update EBCx Plan for implementation & handoff 	<ul style="list-style-type: none"> Attend commissioning meetings Coordinate O&M staff involvement Manage occupant impact/issues
DELIVER TO OWNER: List of findings, Final EBCx Plan, initial cost & savings estimate	
Implementation Phase	
<ul style="list-style-type: none"> Complete additional investigation & engineering Engage subcontractors, as needed Implement selected findings Verify performance of ECMs & FIMs Adjust energy savings estimates & costs 	<ul style="list-style-type: none"> Review and/or approve energy savings estimates
DELIVER TO OWNER: Adjusted Cost & Savings Estimates	
Hand-Off Phase	
<ul style="list-style-type: none"> Facilitate training of building staff Update sequences of operation Update Systems Manual Update preventive maintenance procedures Implement performance tracking Develop ongoing commissioning (OCx) recommendations 	<ul style="list-style-type: none"> Support facility staff training Support OCx Plan execution
DELIVER TO OWNER: Updated Facility Guide, Final Cx Report, OCx recommendations	

1.8.1 Commissioning Team: Individual Roles and Responsibilities

The individual roles and responsibilities of each team member in a typical EBCx project are listed below. Additional detail can be found in the BCxA/APPA Building Commissioning Handbook, third edition, the ASHRAE/BCxA Commissioning Stakeholders Guide, and ASHRAE Standards and Guidelines listed in this document's references.

CxP Lead

The CxP is the technical lead for any EBCx project. EBCx projects need to be led by a person with technical and managerial expertise as described in the CxP task description list below. This person may be a qualified third-party consultant or qualified in-house staff.

The overall role of the CxP is to:

- Screen building to confirm EBCx viability.
- Manage the EBCx process and schedule.
- Facilitate the development or updating of current facilities requirement.
- Develop the EBCx plan.
- Hold project team or stakeholders' meetings as necessary.
- Gather and review documentation.
- Administer initial site assessments (interviews, inspections, and analysis).
- Oversee trending and development of trend analysis plan and execution.
- Oversee development of the functional testing plan and execution.
- Keep a master finding and improvement list.
- Oversee or conduct the energy and cost calculations.
- Provide expertise to develop written scopes of work, plans and specification or criteria for documenting the work required for implementing the ECMs and FIMs.
- Work with facilities staff to see that the improvements are successfully implemented, commissioned and verified.
- Oversee training of the operations staff and end users (if applicable).
- See that the sequence of controls and Facility Guide are updated.
- Prepare written documentation and write the final report.

Owner/Property Manager

The Owner, facility manager or project manager/engineer is the party referred to as the "Owner." They:

- Assist in developing the CFR.
- Provide overall project supervision.
- Ensure the participation of building personnel.
- Review and approve the choice of improvements to implement.

Facility Managers

- Assist in developing the CFR.
- Ensure participation of building personnel and service contractors as needed.
- Provide input into the CxP's assessment.
- Direct and oversee the gathering of documentation.
- Work with the building operator to manage assignments.
- Coordinate input and communication with end users.

Building Operator/Engineer(s)

Best practice involves the building operators assisting actively in the RCx process (documentation gathering, discussion of improvement ideas and viability, verification support, etc.). Specifically, they:

- Assist in developing the CFR.
- Assist in gathering building documentation.
- Escort the CxP in the building.
- Calibrate sensors and actuators, perform needed deferred maintenance before EBCx begins.
- Discuss ideas and findings with the CxP.
- Provide input into the CxP's site assessment.
- Help CxP understand in detail how building systems and equipment function.
- Verify sequences of control and set points.
- Assist with installation and removal of portable logging equipment.
- Execute requested BAS trend logs.
- Assist with manual functional tests and measurements.
- May work with CxP to implement, commission and verify selected ECMs and FIMs.
- Perform simple repairs and improvements.
- Escort, as necessary, the CxP in areas that require it.

Contractors and Manufacturer's Representatives

The controls service contractor reviews programming code remotely or onsite and communicates the actual sequences of control to the CxP. They also weigh in on recommendations of the CxP for viability and cost before measures are finally recommended or selected for implementation. They may assist in BAS sensor and actuator calibrations and install equipment and programming and graphics for selected measures. Service contractors for larger equipment like chillers and boilers assist, in like manner, as the controls contractor.

Design Engineers and Architects

When the CxP does not act as the designer/engineer for measures warranting engineering or architectural expertise, a suitable engineer or architect is employed and managed by the CxP.

Tenant Representatives and Energy Managers

Other team members may include a tenant representative and the Owner energy coordinator, who assist in developing the CFR and reviewing the CxP recommendations. Tenant representatives are critical to gathering end user input to the actual issues the occupant deal with throughout their space, and to the successful implementation of measures that directly affect the occupants. Tenant representatives should be responsible to facilitate EBCx project communications with occupants.

1.9 Select the Initial EBCx Team

The specific individuals of the EBCx team listed above are identified and engaged into the project prior to the kickoff meeting.

Architectural or engineering designers are not typically part of the EBCx team unless the building is a hospital or critical environment facility where codes and regulations require their engagement (and/or licensure "stamp"). Regardless of who is included on the team the CxP is responsible for leading and organizing the team throughout all commissioning phases of the project.

1.10 Conduct a Kickoff Meeting

Conduct an EBCx kickoff meeting including all key decision makers and stakeholders to establish the lines of communication, procedures, and party roles for implementing the EBCx project. The kickoff meeting includes the CxP, the Owner or representative, facility/project manager, operations manager, and an individual representing the building occupants. For projects with a BAS, the controls service contractor should also attend this meeting. Discuss the level of effort each party will need to put forth in order to achieve the established goals.

Commissioning Coordination

Throughout the entire EBCx process the commissioning team meets periodically to discuss commissioning status, system performance, and issues identified. Stakeholder participation in these status meetings is critical to solicit additional input and build consensus, as well as to help address any simple repairs or adjustments that need to be made.

1.11 Deliverables

Deliverables of the planning phase include:

- EBCx RFP /RFQ
- EBCx contract
- Documented project goals and objectives
- Cx Team identified and engaged
- CFR
- Existing Owner documentation including existing drawings, submittals, as-built information, completed maintenance and repairs, preventative maintenance records, and previous reports and documentation
- EBCx scope
- EBCx work schedule

2 INITIAL ASSESSMENT PHASE

The objective of the initial assessment phase is to gain a preliminary understanding of how and why the building systems and equipment are currently operated and maintained, understand areas of performance concerns, determine how much potential there might be for improvement, and where to focus later Investigation Phase efforts.

Initial Assessment Phase tasks include these activities:

- Review Building Documentation
- Analyze Energy Data
- Perform Initial Facility Staff Interviews
- Perform Building Occupant Interviews, when appropriate
- Perform Initial Site Walk-Through and BAS Review
- Update EBCx Plan and Scope
- Develop an Initial Assessment EBCx Report
- Meet with Owner

For many CxPs and utility-sponsored programs, the Initial Assessment phase tasks are encompassed in the Planning and Investigation Phases and not conducted as a separate phase. Fundamentally, most projects go through some type of initial feasibility assessment for the Owner and CxP to determine the viability of the project.

2.1 Review Building Documentation

Make a cursory review existing building documentation, such as building plans and specifications, control drawings, O&M manuals and maintenance documentation records, as well as other reports and documentation like TAB reports and energy studies, to increase understanding of the building and determine availability of documentation for the EBCx Investigation process. Note what documentation is missing that may be needed for the project. For important or complex systems, if no one-line diagrams exist, the CxP should create them with hand sketches or drawing programs to assist in system evaluation and measure feasibility.

2.2 Analyze Energy Data (Utility Billings and Interval Data)

For EBCx projects that include energy savings/demand reduction components to meet the Owner's fiscal payback metrics, the CxP evaluates the facility's energy use from monthly utility bills and determines the facility's annual energy use intensity (EUI) and compares the EUI to the facilities industry peer group. Ideally, several years of energy data are evaluated in order to establish a trend. The monthly data are plotted in graphs and multiple years overlaid for comparison, creating load profiles. Identify whether energy use is increasing year over year for the same month. Monthly outside air temperature or cooling and heating degree days are also used to normalize or account for variations in the monthly and annual energy use.

Demand data are also evaluated through graphing and inordinately large use during unoccupied periods and too early of starts and too late of equipment shut down are identified. Peak demand spikes are also identified and documented for further evaluation during the Investigation Phase.

During the Initial Assessment, this is a quick analysis (overall energy use intensity (EUI)) versus deep dive/interval data analysis). This is one way of sizing up a project that shows the savings potential. A more thorough analysis in the later investigation phase will help reveal measures (e.g., comparing usage to occupancy, schedule).

2.3 Perform Initial Facility Staff Interviews

Interview key O&M (manager, operations and maintenance) personnel to learn from their extensive knowledge and experiences working in the building daily, to establish a baseline knowledge of current issues and operational problem areas, systems or equipment, building and equipment time of day schedules and areas of required investigation. Note if there are planned replacements or renovations that would disrupt potential EBCx scope items. Also note all operator overrides and ask why they are being used.

2.4 Perform Building Occupant Interviews

When the EBCx objectives explicitly include improving comfort, interview selected building occupants to increase knowledge of occupant and space issues, and discuss requirements and expectations that are not being met. Update the CFR with new information, if appropriate. Typical interview topics include issues related to temperature and humidity control, drafts, air quality, lighting, acoustics, safety, security, productivity, and health. Projects that are focused primarily or exclusively on energy efficiency may not warrant occupant interviews.

2.5 Perform Initial Site Walk-Through and BAS Review

The CxP and facility staff assigned to the project conduct a walk-through of all major spaces to gain an understanding of the layout of the building; types and condition of spaces; occupancy levels; lighting and controls; location of equipment rooms; location of documentation; the building automation system, its age and what it controls; and general condition of equipment. Elements of the initial site walk-through, relative to equipment observation, include general condition evaluation of the systems and equipment to be included in the EBCx project. Additionally, document any components that are beyond their service life and require capital replacement rather than inclusion in the EBCx project. Note any planned replacements or renovations that would disrupt potential EBCx scope activities.

1. Review BAS graphic screens for major systems and equipment to understand the systems operation and information available
2. Obtain and review the written sequences of operation
3. Document potential ECM/FIM improvements and questions
4. Determine BAS trending and reporting capabilities
5. Determine if remote access to the BAS is feasible

In addition, the review lists the energy using equipment that is not controlled by the BAS or is overridden to manual operation.

Start to Document Findings. Documentation is a constant task and its importance cannot be overstated. Detailed notes from the walk through and BAS review are recorded, along with all ECMs/FIMs that are initially identified. Documentation includes starting a Master List of Findings that will be presented to the Owner as part of the reporting in this phase and further investigated and vetted for feasibility in the investigation phase.

2.6 Update EBCx Plan and Scope

Updates are made to the EBCx plan and scope including scope changes related to areas found to be either more or less important than others. Other elements to focus on when updating the EBCx plan are based on information obtained from the facility staff and building occupant interviews. These elements might include additional details for the trending and monitoring plan, calibration and testing plan, M&V activities, savings and implementation costs and methods, and updated outlines of the Implementation and Hand-Off Phases.

2.7 Develop an Initial Assessment EBCx Report

Based on the findings from the Initial Assessment Phase, prepare an Initial Assessment Findings Report. The primary objective of this report is to convey to the Owner if the EBCx project is likely to meet the Owner's fiscal metrics in terms of costs and return on investment (ROI) criteria and if the CxP recommends the project to proceed. The report includes the findings from the CxP's walk-through, document evaluation and staff and occupant interviews, a list of ECM and FIMs identified; the measures' estimated order of magnitude costs for implementation and energy savings potential for each measure; and any available utility incentives if applicable. Other items can include the updated EBCx Plan, CFR, utility analysis, initial Master List of Findings. The CxP presents the findings and Initial Assessment EBCx Report to the Owner for review.

2.8 Meet with Owner

The meeting is arranged to discuss the results of the initial assessment and to define or update the goals of the EBCx project. The Owner provides input on which findings they are most interested in pursuing and for which there may be problems implementing. Operations staff are involved in this input. They also make recommendations for adjustments to the EBCx Plan or scope. Specifically, the meeting should:

- Review:
 - EBCx Plan, including roles and responsibilities
 - Outcome from the facility staff and building occupant interviews
 - Findings from the initial planning assessment and Master List of Findings
 - EBCx project financial summary for measure costs vs. savings potential (capital, energy, maintenance)
 - Investigation Phase scope
 - Scheduling of testing and facility access
- Discuss training requirements
- Additional meetings are scheduled throughout the investigation to further coordinate testing, sub-contractor support, schedule, identified issues, and gain feedback on early identified FIMs

The difference between an energy audit, condition assessment and Initial Assessment is that during the Initial Assessment the CxP has the ability to walk around and take quick, cursory measurements/ tests (pre-tests) and do some quick-type metering and analysis. This is a good time to focus on goals that may be beyond energy, like maintenance improvements, troubleshooting, and even improving safety. The CxP's testing abilities and beyond-energy (total package/measures) eye make Cx more comprehensive than a condition assessment or energy audit alone.

2.9 Deliverables

- Initial Assessment EBCx report
- Updated EBCx Plan

3 INVESTIGATION PHASE

The objective of the investigation phase is to further evaluate systems and equipment in detail to verify proper operation and identify specific energy conservation measures (ECMs) and facility improvement measures (FIMs). The findings, recommendations, and subsequent analysis are presented to the Owner for further prioritization and selection of measures for implementation. The current operation and performance are documented and compared to the CFR.

The EBCx process is intended to be iterative and flexible; therefore, some implementation may occur during the Investigation Phase and, conversely, further investigation may occur during the Implementation Phase.

Investigation Phase tasks include these activities:

- Update EBCx Tasks
- Update EBCx Team
- Conduct Investigation Phase Kickoff Meeting
- Conduct Additional Detailed Documentation Review
- Conduct Detailed Site Survey
- Check Calibrations of BAS-Trended Points
- Analyze Facility and System Performance and Establish Performance Baseline
- Conduct Additional Building Personnel and Occupant Interviews
- Review Building Automation Controls System
- Develop Test Procedures
- Conduct and Evaluate System Functional Testing
- Gather Data for Energy Calculations and Implementation
- Identify sources of performance problems
- Perform Energy Savings and Cost Calculations
- Perform Simple Repairs
- Master List of Findings (Perform Issues and Opportunities Analysis)
- Update EBCx Report with Investigation Report
- Finalize Measurement and Verification Plan
- Complete Scope of Work for Implementation and Hand-off Phases
- Obtain Owner Acceptance and Decision to Proceed

While many tasks and steps in the investigation phase appear to repeat steps from the initial assessment phase, these tasks are done in a more thorough manner during the investigation phase.

3.1 Update EBCx Tasks

At the beginning of this phase, update the EBCx Plan with any refocusing or rescoping needed as identified in the Initial Assessment. Add detail or create a trending and testing plan for in-depth evaluation of systems. This is often identified as a stand-alone investigation plan or an investigation phase section within the EBCx Plan. It should:

- Specifically define the testing and trending that will be implemented during this phase
- Identify baseline energy measurements or sub-metering that needs to be performed for energy savings calculations, ongoing tracking or fault detection
- Identify:

- Scope and intent of testing procedures
- Scheduling of and support required to execute testing
- Monitoring and trends that may need to be set up in advance
- Anticipated changes to the system that may affect occupant comfort or daily workflows
- Occupant or operator interviews or additional surveys that need to take place

3.2 Update EBCx Team

During the investigation phase all team members involved throughout the scheduling and execution of activities are identified, including operations staff who have specific knowledge of the facility and certain systems to help guide the investigation process.

Members involved with this stage include:

- Commissioning provider
- Owner representative(s)
- Facility manager
- O&M staff
- Service contractors
- *And may include* facility users and occupants

3.3 Conduct Investigation Phase Kickoff Meeting

Discuss results of Planning and Initial Assessment Phases and the updated EBCx Plan. Specifically cover:

- Investigation Phase scope
- Roles and responsibilities
- Scheduling of testing and facility access
- Training requirements
- Concerns

Additional meetings are scheduled to coordinate testing, subcontractor support, project schedule, identify issues, and gain feedback on early-identified FIMs.

3.4 Conduct Additional Detailed Documentation Review

Review building drawings and documentation to understand the building energy usage and initial basis of design, and evaluate the system integration. The review process includes the evaluation of all old and new drawings, specifications, test and balance reports, applicable construction equipment submittals and operations & maintenance manuals, any previous commissioning or energy reports and service or test records. Particular attention is given to reviewing existing written sequences of operation and control drawings.

Besides learning the building systems and performance criteria from the building documentation, part of the rationale behind this step is to try and understand how and why the building was originally designed the way that it was, what modifications have taken place, coupled with the current knowledge of how the building is being used. Having the historical understanding of how and why the building was originally designed will enable and provide direction for building energy savings measures.

3.5 Conduct Detailed Site Survey

The site survey is based on a detailed assessment focusing on original areas of concern and items discovered during occupant interviews, drawing review, and review of additional building documentation.

The detailed site review includes examination of physical condition and review of system performance. The condition review evaluates appearance, physical damage, whether equipment is in need of maintenance, new features, or changes of use. Performance based evaluation includes how system and components are operated compared to CFR requirements or expected or good practice.

During investigation planning, discuss how to define simple repairs. Best practice is to define it as 1) requiring materials less than a specified dollar amount from which the Owner (typically the building operations staff) can spend out of the operations resources/budget not requiring approvals, and 2) time to repair over 30 minutes. Of course, other arrangements can be made, but this is a good way to define what can be included in scope.

Conduct a night walk if not already completed during the initial assessment. This helps to identify equipment that is operating that may not need to be, based on the time of day or potential temperature setbacks. Equipment that cannot be turned off completely should be evaluated to operate at a lower speed or reduced set point.

3.6 Check Calibrations of BAS-Trended Points

Verify accuracy of sensors, valves and actuators and statuses to ensure precision of BAS screen shots and trend data. At minimum, perform this on all devices that will impact control and BAS points and devices are calibrated by O&M staff, the service contractor, or the CxP. As a best practice, calibration is completed prior to initiating trends.

3.7 Analyze Facility Performance and Establish Performance Baseline

Energy performance monitoring and ongoing tracking establish baselines and correlations of proper performance:

Establish an energy baseline early in the EBCx project and track that progress as items are identified and implemented. The more the baseline identified extends from the building level down into the individual equipment level energy use (i.e., chiller or pump power), the more accurate the baseline comparison and future savings calculations will be. Building-level energy baselines should include kWh and therms per day, per month and eventually per year, all correlated to outside air temperature and converted to EUI per square foot and compared to peer buildings. Equipment baselines should be established for large energy using equipment like chillers, cooling towers, larger pumps and large air handlers and also correlated to outside air temperature.

Analyzing trend data occurs through spreadsheet or cloud-based software analysis. The goal of trend monitoring is to allow for identification of improper operation, lack of schedule control, or other operational issues inconsistent with meeting the CFR or the system/equipment operating at optimal efficiency. Analyzing the trend monitoring data can assist in determining if the system is meeting the CFR.

Energy, non-energy and other system performance data establishes baseline benchmarks for facility performance. Available facility performance baseline data may include utility billing data, sub-metering data, work orders, comfort complaint logs, indoor air quality parameters, occupant satisfaction survey results, BAS trend data and/or standalone data logger data.

Performance measurements and tracking can be further expanded and enhanced as part of an ongoing commissioning program.

The electrical kW 15-minute interval demand data analyzed in the Initial Assessment Phase is further evaluated in this phase. Solutions and improvements to excessive energy or demand are developed and added to the Master List of Findings.

Throughout the EBCx process the CxP shall work with the Owner and/or BAS service contractor to update and accurately reflect the as-programmed sequences of operations. This shall be done in two ways through the EBCx process.

- The CxP shall, in the implementation phase, prepare a Facility Guide that describes the sequence of operations for the projects systems and equipment.
- Additionally, as part of the implementation phase the BAS service contractor shall prepare and submit an updated as-built controls submittal, which reflects all of the actual programmed sequences of operations for the systems and equipment within the scope of the EBCx project.

3.8 Functional Testing or Monitoring?

Best practice does not dictate which method (manual functional testing or trending/monitoring) are most appropriate. This issue depends on the capabilities of the BAS, the particular equipment and sequences involved and how much current operations can be interrupted with functional testing, etc. It is best practice for the CxP to systematically evaluate each system and equipment and the likely control loops and features to be investigated and decide which method will be used for each issue. This is documented in the investigation phase portion of the EBCx Plan.

3.9 Monitor System and Equipment Performance

Develop a diagnostic monitoring plan (monitoring that will identify poor performance and potential improvements). Diagnostic monitoring methods include BAS trending, portable data logger trending, and energy and weather data collection. Establish a trend monitoring plan early in the Investigation Phase. The initial assessment phase should have confirmed the capacity of the BAS to trend and archive data at what intervals which will guide what points are put into trend.

The CxP, facility staff or the controls service contractor set up trends and data loggers. Trending intervals should be small enough to capture the issues being evaluated. Some control loops can be evaluated at 15 minute intervals while others require two to five minute intervals.

The CxP views the trend and monitored data graphically or tabularly to identify issues and improvement opportunities and highlight particular problems that may require more rigorous and focused investigation.

3.10 Conduct Additional Building Personnel and Occupant Interviews

Interview the Owner's facility management, maintenance personnel and occupants (as appropriate—see also Initial Assessment Phase interview activities) to understand and confirm the current use and operation of the building and its systems. A formal interview process should be used to systematically identify potential problem issues, uncover potential improvement opportunities, confirm the CFR and to develop consensus on the commissioning process goals.

3.11 Review Building Automation Controls System

Conduct a thorough and detailed review of the building automation system. This can be one of the most time consuming—yet critical—tasks during the investigation phase, and is focused on establishing current sequences of operation, identifying accurate graphics, and evaluating unit alarms/settings.

The CxP shall work with the Owner and BAS service contractor to accurately identify and document the programmed controls sequences for the systems and equipment within the scope of the EBCx project. This should be accomplished by:

- reviewing written control sequences (ideally the as-built version),
- interviewing knowledgeable facility staff and controls service contractors,
- reviewing the program code,
- direct observation of trend data, and
- direct observation and testing.

Review building automation system graphic screens, alarm logs, and schedules as applicable for each piece of equipment. This includes complete review of set points or reset parameters. Run override and “in-hand” reports and confirm that each is required. Identify ways to remove all overrides and equipment that is in-hand while still managing the issue that caused them to have to be overridden originally. Identify wasted energy use.

If feasible, take screen shots for each system and piece of equipment to document the as-found condition and operation of the systems. This information is critical for later aspects of the project during measurement and verification.

Document identified problems and recommendations for improvements to the sequences of operation, resets and time of day schedules in the Master List of Findings log.

3.12 Develop Functional Test Procedures

Develop functional performance test (FPT) procedures for the systems identified in the project scope. Test plans for energy efficiency focused projects should confirm actual system operation to identify improvements and to test or confirm ideas for improvements. Projects that include requirements for confirmation of proper operation, should test non-energy efficiency features like temperature and humidity control, alarms, failure and standby modes, etc. and other performance requirements of the Owner set forth in the CFR. The level of written detail and repeatability of the test procedures should match the requirements of the Owner, any utility program or regulatory authority, but should not be excessive which takes resources away from more in-depth investigation.

For building enclosure commissioning (BECx) performance evaluations, development of the functional performance testing plan needs to occur in the Planning Phase and executed in the Investigative Phase.

3.13 Conduct and Evaluate System Functional Testing

Perform system testing to evaluate the building systems performance. In addition, anomalies or issues identified in earlier Investigation Phase are considered for further evaluation during system testing to determine root causes and possible solutions. The EBCx test procedures, are used to 1) validate that all components are functioning or what needs to be repaired/replaced; 2) validate the actual sequence of operations for systems and equipment, which is often found to be different than the original as-built sequences; 3) identify opportunities to improve the systems and equipment through energy savings measures or FIMs.

Schedule tests with facility staff so that day-to-day operations are not disrupted. For systems that are critical or cannot be modified regardless of time of day, functional testing may be limited to detailed trend observations through the BAS. Testing may need to be deferred based on climate conditions or occupancy.

The system functional test plans typically contain a modified and scaled down version of a NCCx functional performance test procedure and only focus on those elements that are part of the project objectives and scope. For example, on an air handling system, the test procedure would validate that all valves and dampers actually open and close without restriction and perform per the sequence of operations. Additional, testing may include measurement of the differential pressure drop across heating and cooling coils to evaluate if they are dirty. EBCx test procedure typically do NOT, include a test of system and equipment safety devices or standby functions. This is due to the typical goal and purpose of EBCx project to save energy, and the validation of safety devices will add project cost but not energy savings. However, for older buildings, systems and equipment, validation of safety devices may be a secondary goal of the Owner and should be discussed.

Aside from individual equipment testing, system testing (often initiated through the BAS) is done to observe the whole building or system or multiple pieces of equipment functioning in different modes of operation. An example of this may include commanding all VAV units to heating mode and running a report through the BAS to identify positions of all heating valves and airflow readings compared to set point.

3.14 Gather Data for Energy Calculations and Implementation

Gather data for savings calculations and detailed implementation recommendations. This includes documenting submittal and equipment schedule data and nameplate data as well as actual measurements or readings of fan KW, amperage, motor speeds, airflows, motor size, coil temperature differences, and equipment run times.

Many CxP firms and/or Owners will not allow people to open live electrical panels which is often necessary to obtain electrical power measurements or to install data loggers; CxPs need to outline and electrical data measurement plan with the Owner for the project and how these measurements or data logger installations can be achieved. Many Owners have licensed electricians on staff or on call through a service trade contractor. Through proper planning, communication and execution, electrical measurements and data can safely be obtained.

NOTE: for many utility sponsored/incentivized EBCx programs, 3-phase power measurements including power factor must be actually measured for all energy savings measures that exceed a certain electrical energy savings threshold.

Don't rely only on an occupancy schedule or a BAS trend that conveys only an "enable" or "commanded" status for determining when the equipment is running. Rely on BAS feedback signals or data loggers that can sense either vibration or measure electrical in order to log when a piece of equipment is actually running. This kind of data gathering and measuring is critical for making sure energy calculations more accurately project savings.

3.15 Perform Energy Savings and Cost Calculations

Energy savings are estimated for potential facility improvements. Complete savings calculations as most appropriate and as described in the EBCx Plan. Best practice does not spend excessive time in improving savings accuracy at the expense of other important activities. However, custom weather bin spreadsheet, hourly computer simulation, or basic engineering calculations, local weather data, or even real-time weather data that coincides with trend data used for calculations can be helpful to ensure accuracy of calculation estimates. Stack or adjust individual measure energy savings calculations so they account for interactive effects of other measures so savings are not double counted.

Include rough budgetary implementation cost estimates in the Master List of Findings during the Investigation Phase, with firm contractor quotes to be obtained during the Implementation Phase after specific measures have been selected for implementation.

Factors that impact calculation methodology rigor may include utility program requirements if applicable, Owner expectations, and the level of investment required for measure implementation.

Energy calculations are based on the best information available and cover:

- 1. List parameters, values, correlations and approximations used, and why they were used. At this point most data should be measured. However, even measurements still may be approximate.*
- 2. During the investigation phase, the accuracy of energy calculations should be increased from that achieved during the initial assessment phase in accordance with the agreements and expectations given in the CxP's scope and the EBCx Plan.*
- 3. Know the format required for calculations. This is usually Owner or utility-requested, or driven by M&V requirements. Energy modeling can have greater cost implications than spreadsheet calculations. On the other hand, energy modeling could be more accurate, especially for custom measures, but some utilities requires spreadsheet calculations.*
- 4. Make sure energy savings are conservative (projected lower than expected), so that in reality savings are more achievable than you project. Similarly, make sure costs are projected a little high (so that you hit your cost projections when unexpected costs are factored in).*

3.16 Perform Simple Repairs

If appropriate and agreed upon by the Owner and CxP, perform — or work with O&M staff and the Owner's on-call service trade contractors to perform — simple repairs or improvements identified during the Investigation Phase monitoring and testing.

3.17 Master List of Findings

Create, update and prioritize Master List of Findings and recommendations to include possible ECMs and FIMs based on the findings from CFR/discussions and iterations with Owner's team, and from the steps above.

*As conditions are found and isolated, the Owner team may change the way they prioritize the findings. This can be critical if findings involve safety items or large cost items or code issues that should be implemented first, versus energy measures if that is what original goals were. If the data confirms the Owner's suspected issues, the value of Cx now is that you have **conclusive** data, measurements, trends.*

The following information on each ECM and FIM is desirable so that the Owner has sufficient information to make an informed decision when selecting the ECMs or FIMs for implementation:

1. Description of Finding
2. The Solution/ Measure Description
3. Benefits
4. Drawbacks/Risks
5. Implementation Cost
6. Energy, maintenance, operational savings, including trade-offs for system conversions based on CFR-stated methodology (details on estimated electric, fossil and demand savings may be desired)
7. Payback and Return on Investment (ROI) analysis; and
8. Commissioning Team recommendation for implementation

The Master List of Findings includes updates to previous findings and descriptions identified during previous phases.

Often the Master List of Findings is dedicated to no/low cost measure but can also be inclusive of capital improvements. Systems that do not meet the CFR, are identified and their feasibility evaluated on a similar basis as other recommendations and findings. “Non-measures” can be as valuable to present as any other facility improvement measure.

The CxP meets with the Owner and goes through the Master List of Findings and clarifies any questions the Owner may have. The Owner corrects any data given in the findings and identifies concerns they have with any measures. During that meeting or later, the Owner identifies which measures they intend to have implemented and gives each a priority. During this meeting the Owner determines who will be responsible for leading the implementation efforts, and if they will be performed in house or completed by outside contractors and vendors.

3.18 Update EBCx Report with Investigation Report

Update the EBCx Report with the summary findings and analysis from the investigation phase. This report provides the Owner with a full debrief of the opportunities for improvement and how the conclusions were reached. The report includes all major elements throughout the investigation phase such as:

- Summary documentation of changes made during the Investigation Phase.
- List of all findings and recommendations.
- List of the measure selected for implementation.
- Complete monitoring and test results or investigation documents such as test scripts and checklists.

3.19 Finalize Measurement and Verification Plan

For ECMs being implemented, evaluate methods of measuring system performance and verifying proper implementation to best demonstrate the success of the ECMs. Each ECM shall have a verification methodology appropriate to the size and complexity of the measure (and interests of the Owner), incorporated into a measurement and verification (M&V) Plan. The M&V plan provides a protocol to verify the performance of the measure/system and confirm that the predicted energy savings have been achieved upon the completion of implementation. Ongoing BAS trending, portable data loggers, spot measurements, and functional testing may be utilized pre and/or post implementation as part of the M&V process. Best practice does not dictate the required M&V rigor, since the appropriate rigor is based on the Owner’s interests for accuracy and any utility program requirements. Some Owners prioritize their expenditures in finding and implementing energy savings rather than in quantifying exact energy savings beyond the rough estimates from the initial assessment phase.

SIDEBAR: A thorough M&V plan is a significant effort and should be developed upon Owner request or a program requirement. The M&V plan can be written and reviewed by the CxP. It is important the M&V plan is developed around the existing or planned data collection infrastructure as part of the EBCx Project.

3.20 Complete Scope of Work for Implementation and Hand-off Phases

After findings and recommendations are approved to proceed, the CxP writes and develops a detailed scope of work for the implementation and handoff phases.

Best practice will utilize scopes of work (SOW) appropriate for the measure and may require varying degrees of documentation and design support. The CxP and the EBCx plan clearly outline to the Owner what is “included” and what will be additional project costs. Examples of varying level of scope of work documentation include the following:

- **Simple SOW:** These include written setpoint changes and sequence of operations changes for optimization strategies such as reset schedules, economizer, and night time setbacks. Simple SOW may also include replacement in kind for failed components.
- **Medium SOW:** This might include the replacement of fail components or replacement of components to a newer model where sizing and performance calculations are required. This could include the replacement of a failed or poorly performing control valve where the control valve needs to be calculated.
- **Complex SOW:** Complex measures often include the requirement of design documentation, permits and often bidding the SOW out to contractors due to the measure cost being above a certain threshold.

SIDEBAR: Although adding a new variable frequency drive on a constant speed piece of equipment is thought of as a simple measure, the SOW often requires full design drawings, specifications, and permits to handle the complexity of where the source of power comes from, where the VFD is to be located, if a local disconnect will still be required, if and how equipment and life safety circuits are to be tied into the VFD, how arc flash labels will be handled, what the method of procedure (MOP) is to tie in the new VFD.

The Owner's operations staff reviews and approves the scope and identifies areas of work to include design, additional investigation, implementation support, performance verification, and setup of performance-based monitoring.

Additional EBCx scope items for implementation and handoff to consider include further development and updates to the M&V Plan, additional ongoing commissioning activities, and updates of the Facility Guide or preventive maintenance plans.

3.21 Obtain Owner Acceptance and Decision to Proceed

Review the EBCx Report with the Owner and obtain the Owner's written approval to proceed as documented in the updated scope of work.

At this point the project is either a true improvement project (i.e., contracted and/or engineered work that can be completed without a design team and/or engineer's stamp) or a major renovation project (requires a design team), or a combination of the two, in which case it may be best to defer to the new construction commissioning (NCCx) process, starting with the CFR as OPR and design reviews.

3.22 Deliverables

- Updated EBCx Report, including the addition of the Investigation Report data and analyses
- Updated EBCx Plan
- Owner-reviewed/approved/finalized Master List of Findings
- Updated CFR (based on information/requirements resulting from findings)
- Scopes of Work for Implementation
- Implementation Plan (best practice is to have a plan ready to go at the end of the Investigation Phase)

4 IMPLEMENTATION PHASE

The objectives of the implementation phase are to implement the approved ECMs and FIMs and confirm they are operating correctly.

Implementation Phase Cx tasks include these activities:

- Prepare an Implementation Plan
- Implement Selected FIMs
- Verify Successful FIM Implementation
- Adjust Energy Savings Estimates and Measure Costs
- Review and comment on remediation designs by a design professional
- Execute Measurement and Verification Plan and Metering (If in Scope)
- Update EBCx Documentation/Prepare Implementation Phase Summary Report
- Plan for Ongoing Commissioning
- Obtain Owner Acceptance and Written Decision to Proceed

4.1 Implement Facility Improvement Measures

4.1.1 Prepare an Implementation Plan

Prepare an Implementation Plan to guide the implementation process and provide details on steps to be followed to complete the implementation of the selected ECMs and FIMs. This plan typically indicates which improvements will be made during the Implementation Phase and which ones will be deferred with a timetable for planned implementation as capital improvement projects, with the ultimate goal of having the systems perform efficiently to meet the CFR. An important part of the implementation plan includes creating a verification plan for each individual measure. The plan includes what verification method will be used, and what a successful result will look like. The CxP assists in generating an RFP for the selected ECMs and FIMS, and reviews contractor pricing in response to the RFP. The RFP includes scope of work, timetable, warranty, and commissioning responsibilities.

4.1.2 Implement Selected FIMs

Review the contractor's submittals for compliance with the scope of work and CFR. Upon contractor selection, the CxP coordinates a project kickoff meeting with the contractor, CxP and Owner. As defined by the Implementation Plan, the selected improvements to the systems and operations are then undertaken and completed. The CxP facilitates project implementation meetings on a regular basis and provide updates to the Owner regarding the implementation progress of each FIM. CxP supports the implementation contractor by responding to RFIs and implementation questions and assist the Owner in scheduling all on-site activities and when measures will go-live, if not immediately.

4.1.3 Verify Successful FIM Implementation

The CxP shall work with the project team to document and record the results and outcome of the implemented ECMs and FIMS. Verification of the implementation shall be done using a combination of methods including: performing focused functional performance testing (FPT) of the implemented ECMs and FIMS, using a formal FPT procedure; analyzing utility bill data, analyzing BAS or data logger trend data or reports; or other data collected to demonstrate that the desired outcomes and improvements successfully achieve the anticipated outcomes.

If the verification analysis of testing or trending does not show that the improvements were successful, the CxP shall work with the project team to analyze the system/equipment and determine the cause for the discrepancy, document the deficiencies found, and prepare a corrective action plan. The CxP and project team shall then, with the approval of the Owner, implement the corrective actions and repeat the verification process/testing until the implemented ECMs/FIMs are deemed working as intended or as well as can be achieved. Verification shall be thorough enough and completed in sufficient modes to provide high confidence of proper operation.

Similar to the NCCx process, the CxP shall “commission”, through a documented form of functional performance testing, the implementation of measures and generate a deficiency log to track all implementation issues. The CxP and the contractor further modify or refine their improvement measures to meet the CFR and scope of work.

As necessary, create a plan for future testing of deferred capital improvement projects identified, based on seasonal conditions.

*It is important for the Owner and project team to understand that this is **existing building** commissioning, meaning that EBCx projects most often are working with existing and aged equipment. Achieving peak performance, or the equipment’s original rated performance when new is a lofty goal and may not be achievable. However, the verification process shall include scope to commission and optimize the implemented ECM/FIMs to achieve as high a performance as can be achieved.*

4.1.4 Adjust Energy Savings Estimates and Measure Costs

Through the verification of ECM and FIM implementation, performance measurements and post implementation trend data shall be collected and compared to the pre-implementation data and energy savings calculations. Based on the actual post implementation performance, the energy savings calculations shall be updated to as closely as reasonable to reflect the actual trended and measured data. This may yield an increase or decrease in achieved savings which shall be shared with the Owner.

4.1.5 Execute Measurement and Verification Plan and Metering (If in Scope)

Implement the M&V Plan developed during the Investigation Phase to evaluate project success and final energy savings as a result of the project.

4.1.6 Update EBCx Documentation/Prepare Implementation Phase Summary Report

Based on the actual installed measures the CxP shall prepare documentation for each measure implemented including the following for inclusion in the implementation phase summary report:

- Prepared scope of work (SOW) documentation
- Submittals
- RFIs
- As-built documentation, including sequence of operations
- Installation, Operations and Maintenance Manuals
- Facility Guide
- Warranties (if applicable)
- Pre and post trend data and energy savings calculations
- Preventative and routine maintenance procedures

The implementation report is often referred to as the EBCx report, and may be delivered at the end of the project. Not all EBCx projects deliver a separate implementation report.

4.1.7 Plan for Ongoing Commissioning

Plans like remote monitoring, are made to continue elements of the commissioning and M&V verification process on an ongoing basis to help the improvements persist over time. Certain steps may be repeated at regular intervals to facilitate this. Best practice includes CxP's six and 10-month review of the newly implemented ECMs and FIMS to validate the improvements function as expected.

4.1.8 Obtain Owner Acceptance and Written Decision to Proceed

4.2 Deliverables

- Updated CFR
- Updated Master List of Findings with implementation status
- Updated EBCx Report, including the addition of the Implementation Report
- Updated Facility Guide material

5 HAND-OFF PHASE

The objective of the hand-off phase is to ensure that facility staff and occupants have the understanding and documentation necessary to properly operate and maintain the changes and improvements made during the EBCx process, so the performance improvements persist over time. Tasks include updating and delivering key documentation, training staff, and planning for future ongoing commissioning (OCx) or monitoring-based commissioning efforts (MBCx). Clear, accurate, and easily accessible documentation is key to ensuring the persistence of EBCx improvements.

Hand-Off Phase tasks include these activities:

- Update and Deliver Documentation
- Train Staff and End Users
- Plan for Persistence
- Close-Out Project

5.1 Update and Deliver Documentation

During the Hand-Off Phase, the following are updated and delivered to the Owner.

Sequences of Operation. Document sequences directly impacted by the EBCx process. Update or rewrite sequences for all key systems and equipment, including setpoints and reset schedules.

Final EBCx Report. Prepare the report as a record of the EBCx activities and measures implemented for the Owner. This will become an important document for the building and an invaluable resource to current and future building operators. The final report typically includes:

- Planning Phase report and documentation
- Initial Assessment Phase report and documentation
- Investigation Phase report and documentation
- Implementation Phase report and documentation
- As-built and updated BAS sequence of operations
- Updated O&M documentation
- One-line and system diagrams
- Facility Guide

O&M Manuals and As-Built Documentation. Update O&M manuals and as-built documentation as required. If the Owner has acceptable, up-to-date O&M manuals, then O&M manuals only need to be modified to include any changes to equipment or operations that were made as part of the EBCx project. If current manuals are nonexistent or inadequate to support effective O&M of the existing equipment, the Owner should consider including a task in the EBCx scope to create or improve them. This would ideally include digitizing into a file/folder structure all O&M and site documentation such as drawings, specifications, submittals, TAB reports, control drawings, sequences, energy studies, warranties, PM plans, etc. This would include all site data, not just that generated in the EBCx process.

Preventive maintenance procedures. Update preventative maintenance procedures as required to ensure systems continue to operate efficiently.

One-line schematic diagrams of major systems. Create or update one-line diagrams of systems impacted by the EBCx. Accurate one-line diagrams will help facility staff troubleshoot issues and maintain optimum performance.

Facility Guide. The CxP shall create a Facility Guide for the systems and equipment within the scope of the EBCx project. The Facility Guide referred to in this EBCx Best Practices document, and what is sometimes referred to as a systems manual in the industry, would be what ASHRAE defines as the “Facility Guide: a basic building systems description and operating plan with general procedures and confirmed facility operating conditions, set points, schedules, and operating procedures for use by facility operations to properly operate the facility. A well-organized and accurate Facility Guide will greatly enhance the building personnel’s ability to operate the building effectively by providing all of the relevant information in a single location.

5.2 Train Staff and End Users

Training should be pervasive throughout the commissioning process. At the hand-off phase, conduct formal training to ensure operations staff understand the EBCx findings and implemented changes. Training activities ensure that operators understand the theory behind the implemented changes (“why”) as well as how to control and maintain the changes (“how”).

Training may also include the end users for ECMs and FIMs that impact or are directly controlled by the end user occupants, examples of these include upgraded thermostats or lighting controls in which the occupants will directly control and adjust.

Conduct Formal Training Sessions. Provide focused training on the EBCx process outcomes, the implemented measures, system optimization techniques and strategies for persistence and continuous improvement. Training relies on the systems sequences of operation, the operations guide and the O&M manuals as the primary sources of information.

If end user training is deemed required, an end user-specific training document specifically focused on what they need to know is to be prepared. For example, end users should not be given the systems operations guide as their training materials when all they need is to learn how to operate a new thermostat.

SIDEBAR: What’s in a best practices training?

Prepare: Qualify what backgrounds and which staffers have the qualifications that apply to the system(s). Who is actually checking systems on a daily basis? Who is responding, who is receiving that call (Property manager? Service company?)

- *Ensure that the right staff attend*
- *Create agendas*
- *Provide a Sign in/Sign Out sheet*
- *Include maintenance in training for O&M*
- *Train for activities that are common sense and meet needs of the staff*
- *Train on system, start to finish (follow air in building methodically to how it enters the space, e.g., hitting every damper, heating/cooling /mixing/coil/filter component along the way, and reviewing components involved in different modes like economizer and dehumidification)*
- *Visit top 5 or 10 things to check the equipment and/or the BAS on a regular basis.*
- *Review who gets the calls to:*
 - *Adjust the setpoints*
 - *Respond to comfort issues*
 - *Respond to HVAC issues*
 - *Respond to controls issues*
 - *Respond to warranty issues versus repair*

Verify Training Effectiveness. Ensure that operators have sufficient knowledge of the systems and EBCx changes to maintain optimum building operation. Verify that the training has accomplished these objectives through the use of quizzes, training evaluations by the trainees, or field observations of the training.

This is often accomplished by the CxP and the operations staff working on the BAS or at the system/equipment and reviewing how the system operates, key setpoints, and the sequence of operations with the CxP asking the operator questions to confirm their understanding and knowledge, or asking them where in the project documentation to find the information.

5.3 Plan for Persistence

The CxP creates a written plan for facility staff to follow to maintain performance. Without intentional changes to existing processes, the improvements from the EBCx activities are likely to erode over time. Planning is therefore required to maintain building performance at the commissioned state. Ideally, the facility transitions to an ongoing or monitoring-based commissioning model.

5.3.1 Include Operational Parameter Checks

The persistence plan shall include frequencies for recalibrating sensors and actuators, descriptions and frequencies for running override and in-alarm reports, verification of time of day schedules, and setpoints, standard trend logs and their interpretations, descriptions and component or control loop functional tests and their periodic frequency, how to evaluate available energy and demand data over time and the use of any “smart”, “energy” or diagnostic alerts or alarms that were programmed into the BAS as part of the EBCx program. The CxP and EBCx project team shall review, train and confirm the operations staff knows how to and plans for routine operational parameter checks.

5.3.2 Implement Performance Tracking

The CxP shall implement performance tracking trending and data collection analysis strategies from which the CxP, or Owner, or other designated staff can review and periodically confirm the operational performance of measures persist. The strategy for performance tracking shall be reviewed and determined by the Owner. Due to limited operational staff and/or expertise, the CxP is often retained beyond the implementation and handoff phases of the EBCx project to perform these periodic operational performance checks.

A cost-effective way to implement performance tracking and ensure persistence of the EBCx improvements is to institute an Ongoing Commissioning (OCx) or Monitoring-Based Commissioning (MBCx) process. The BCxA OCx Best Practices document, currently in preparation and scheduled for completion in early 2020, will outline the OCx process. At that time, updates will be made within this EBCx document to incorporate pre-OCx planning tasks and correlate with OCx procedures.

If OCx is implemented in conjunction with the EBCx project or at the conclusion of the project, the CxP shall work with the OCx software implementation team to establish performance metrics for the systems and equipment as well as fault algorithms that measure, detect and verify the performance and persistence of the implemented measures as well as other features and control loops.

OCx/MBCx should be discussed at the inception of the EBCx project and, if desired, incorporated into the entire EBCx process. A combined EBCx/OCx project has many advantages when deployed together — do not wait to start until the Hand-Off Phase.

5.4 Close-Out Project

Hold a Lessons Learned Meeting with the Owner's building operating personnel and other Commissioning Team members to help sustain the EBCx performance benefits, increase their knowledge, and expand their ability to identify and address improvement measures

5.5 Deliverables

- Updated CFR
- Training agenda, including sign in/out sheets, O&M maintenance info, Notes/Pics from training and contact info for the system responders
- EBCx Report, including the addition of the Lessons-Learned Report
- Plan for Persistence
- Facility Guide
- OCx Plan (if applicable)

6 ONGOING COMMISSIONING

The objective of ongoing commissioning is to create a bridge between EBCx project conclusion and ongoing building and systems performance . The BCxA is preparing a companion document, “Ongoing Commissioning Best Practices,” that describes the best practices necessary to develop and sustain building performance over a building’s lifecycle.

The OCx Best Practices document is scheduled for completion in early 2020. At that time, this Existing Building Commissioning Best Practices will be updated to provide guidance on preparation for ongoing commissioning that takes place throughout the more finite EBCx process.

7 ABBREVIATIONS

ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BAS	Building Automation System
BCxA	Building Commissioning Association
BECx	Building Enclosure Commissioning
BMCS	Building Management Control System
CFR	Current Facility Requirements
CMMS	Computerized Maintenance Management System
Cx	Commissioning
CxP	Commissioning Provider
EBCx	Existing Building Commissioning (<i>includes “retrocommissioning” or RCx</i>)
ECM	Energy Conservation Measure
EMIS	Energy Management Information System
EUI	Energy Use Intensity
FDD	Fault Detection and Diagnostics
FIM	Facility Improvement Measure
FPT	Functional Performance Test
KPI	Key Performance Indicator
M&V	Measurement and Verification
MBCx	Monitoring-Based Commissioning
NCCx	New Construction Commissioning
O&M	Operations and Maintenance
OCx	Ongoing Commissioning
OPR	Owner’s Project Requirements
QBS	Qualifications-Based Selection
ROI	Return on Investment
RFP	Request for Proposal
RFQ	Request for Qualifications
SOW	Scope of Work
TAB	Test and Balance

8 DEFINITIONS

Phrase	Meaning
Commissioning (Cx)	A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner’s Project Requirements (OPR). Followed in EBCx by Current Facility Requirements (CFR)
Commissioning (Cx) Provider	<p>Firm or individual who, through coordinated actions, is responsible for implementing the Cx Process.</p> <p>Third-Party Commissioning Providers are commissioning consultants hired directly by the building owner and not responsible to, or affiliated with, any other member of the design and construction team.</p>
Commissioning Team	The key members of each party involved with the project designated to provide insight and carry out tasks necessary for a successful commissioning project. Team members may include the commissioning lead, building owner or owner’s representative, building staff, design professionals, contractors or manufacturer’s representatives, testing specialists, and the rating system coordinator. The team may also consist of a group of commissioning system specialists in such areas as building enclosure, lighting controls, fire protection and more.
Current Facility Requirements	A written document that describes the current functional requirements of a facility and the expectations of how it should be used and operated. This may include goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information to meet the requirements of occupants, users, and Owner(s) of the facility.
Existing-Building Commissioning (EBCx)	A quality-focused process for attaining the CFR of an existing building and/or its systems and assemblies. The process focuses on planning, investigating, implementing, verifying, and documenting that the facility and/or its systems and assemblies are operated and maintained to meet the CFR, with a program in place to maintain the enhancements for the remaining life of the facility.
EBCx Commissioning Plan	A document that outlines the organization, goals, schedule, allocation of resources, and documentation requirements of the Cx Process.
Facility Guide	A basic building systems description and operating plan with general procedures and confirmed facility operating conditions, setpoints, schedules, and operating procedures to properly operate the facility.
Functional Performance Test Protocol	A written collection of tests that, when executed in the test process, allow verification of the performance of a system or assembly.

Phrase	Meaning
Master List of Findings	A summary list of findings generated during the investigation process. For each finding, the list contains fields such as: finding description, type of equipment, recommended improvement, estimated energy savings and costs, simple payback, recommendations, and status of implementation. Also known as the Findings Log.
Measurement and Verification (M&V) Plan	A plan for gathering relevant data over time to evaluate performance and benefits.
Ongoing Commissioning (OCx) Process	A continuation of the Cx Process after the Hand-Off Phase to verify that a facility continues to meet current and evolving CFR (OPR for new construction). OCx Process Activities occur throughout the life of the facility; some of these will be close to continuous in implementation and others will be either scheduled or unscheduled (as needed).
Owner	“Owner” can refer to different actors who represent financial and performance decisionmakers regarding the building facilities.
Sequence of Operations	A narrative describing how the mechanical, electrical, energy management, and control systems are intended to operate during start-up and other modes of operation.
Test Procedure	A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.
Training Plan	A written document that details, ideally, the expectations, schedule, budget, and deliverables of Cx Process Activities related to training of project operations and maintenance personnel, users, and occupants.
Verification	The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the CFR.

9 REFERENCES

Building Commissioning Handbook, third edition (2017): Building Commissioning Association/APPA: Chapter 4, EBCx and Appendix 1-1, “How to Hire a Commissioning Team”

ASHRAE Standard 202-2018: Commissioning Process for Buildings and Systems

ASHRAE Guideline 0.2-2015: Commissioning Process for Existing Building Systems and Assemblies

ASHRAE Guideline 1.2-2019: Technical Requirements for the Commissioning Process for Existing HVAC&R Systems and Assemblies

ASHRAE/BCxA Commissioning Stakeholders Guide (including QBS section)