BEYOND
SMART CITIES
ENERGY AND ATMOSPHERE - GREEN BUILDING TECHNOLOGY TRAINING PROGRAM
FOR ENERGY AND GREEN BUILDING SPECIALISTS
KRISHNAJI PAWAR,LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
ENERGY SPECIALIST CURRICULUM

BEYOND
SMART CITIES
FUNDAMENTAL COMMISSIONING AND VERIFICATION - CREDIT
FOR ENERGY AND GREEN BUILDING PROFESSIONALS
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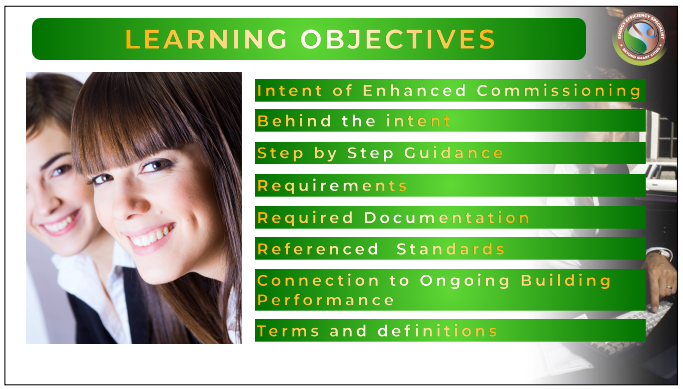
ENERGY EFFICIENCY SPECIALIST CURRICULUM


LEARNING OBJECTIVES
Intent of Enhanced Commissioning
Behind the intent
Step by Step Guidance
Requirements
Required Documentation
Referenced Standards
Connection to Ongoing Building Performance
Terms and definitions

EA- CR(6) - DESIGN

ENHANCED COMMISSIONING

Intent

To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

Potential Technologies & Strategies

Enhanced commissioning is a natural extension of the fundamental commissioning (Cx) process. It provides owners, via the commissioning authority (CxA), further oversight and verification that the building will meet their expectations and requirements beyond the first day of occupancy. Enhanced commissioning gives the CxA the power to act as the owner's advocate by conducting in-depth reviews of the basis of design, design documents, and construction submittals. Training and a postconstruction verification visit are some of the enhancements that contribute to ongoing quality building control and operations

Requirements

Implement, or have in place a contract to implement, the following commissioning process activities in addition to those required under EA Prerequisite Fundamental Commissioning and Verification.

The commissioning authority must do the following:

- ☑ Review contractor submittals.
- ☑ Verify inclusion of systems manual requirements in construction documents.
- ☑ Verify inclusion of operator and occupant training requirements in construction documents.
- ☑ Verify systems manual updates and delivery.
- ☑ Verify operator and occupant training delivery and effectiveness.
- ☑ Verify seasonal testing.
- ☑ Review building operations 10 months after substantial completion.
- ☑ Develop an on-going commissioning plan. include all enhanced commissioning tasks in the OPR and BOD.

IMPLEMENTATION

REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
List of all tasks completed as part of Cx activities	X	X	X
Training outline and participation list	X	X	X
Confirmation of systems manual delivery	X	X	X
Ongoing Cx plan	X	X	X
Inclusion of monitoring and tracking in Cx plan		X	
Inclusion of envelope in Cx plan			X
Verification of additional reviews per Data Center requirements (data centers only)	X	X	

BEHIND THE INTENT

Enhanced commissioning is a natural extension of the fundamental commissioning (Cx) process. It provides owners, via the commissioning authority (CxA), further oversight and verification that the building will meet their expectations and requirements beyond the first day of occupancy. Enhanced commissioning gives the CxA the power to act as the owner's advocate by conducting in-depth reviews of the basis of design, design documents, and construction submittals. Training and a postconstruction verification visit are some of the enhancements that contribute to ongoing quality building control and operations.

The CxA may make additions to the Cx plan to verify that the building operators will have the proper tools to manage the building's equipment efficiently and effectively. Monitoring-based commissioning (MBCx) gives the building owner, operators, and the CxA a continual stream of information that helps them identify operational issues as they occur, thereby saving time, money, and energy consumption over the lifetime of the building.

A second option in this credit is building envelope commissioning (BECx) to test and verify the building's thermal envelope, achieving better building performance and less energy expenditure over its lifetime. Adding envelope commissioning ensures not only that active energy-consuming systems are considered but also that passive load-defining envelope systems are understood and verified. Early introduction of BECx helps meet an owner's requirements for envelope performance through the review of design documents and contractor submittals. Such actions can help prevent problems with envelope design and construction that would be costly or impossible to address after construction. Additional benefits of BECx include improving occupants' comfort through glare control, infiltration testing, and reduced solar heat gain.

Updated referenced standards. Minor text revisions to Option 2. Building Enclosure Commissioning intend to clarify implementation for project teams.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT ONE OR BOTH OPTIONS

Use input from the CxA and the project team and select one or both options. Review the building type, the assumed occupancy type, and the project goals and scope. The team should be familiar with the credit requirements so that any gaps in scope or skill can be addressed (see *Further Explanation, Planning the Cx Process* and *Choosing an Appropriate CxA*).

- Option 1 has two compliance paths.
  - Path 1, Enhanced Commissioning
  - Path 2, Enhanced and Monitoring-Based Commissioning. This is often appropriate for projects that are energy-intensive and will benefit from real-time data and the ability to track trends. The additional first costs may be offset by maintaining the proper energy usage over time.
- Option 2 is beneficial for most projects but especially for those that are envelope dominated, located in an extreme climate or microclimate, or subject to potential leakage or infiltration of contaminants.

STEP 2. UPDATE DOCUMENTS TO INCLUDE ENHANCED CX ACTIVITIES

Project documents should reflect the enhanced commissioning activities included in the project scope.

- Update the owner's project requirements (OPR), basis of design (BOD), and Cx plan (see *Further Explanation, Enhanced Commissioning Plan*).
- The CxA must ensure that the OPR, the BOD, and the Cx plan include all additional commissioning activities that will be conducted throughout the design and construction phases of the project.

Option 1, Path 1. Enhanced Systems Commissioning

STEP 1. DEVELOP SYSTEMS MANUAL SCOPE AND FORMAT

During the design development phase, outline the scope and format for the project systems manual to include all the information necessary to operate, maintain, and recommission all energy-consuming systems within the building.

STEP-BY-STEP GUIDANCE +

- The CxA is responsible for working with the owner to develop and outline the requirements of the systems manual. Include operating staff in preparing the manual if the team is in place during design.
- Information for the systems manual is generally collected during construction and after completion of a project.

The basic scope and format of a systems manual are outlined in ASHRAE Guideline 0–2005, Annex O; the manual usually includes the following:

- Executive summary
- Owner's project requirements
- Basis of design
- System single-line diagrams
- Construction record documents and specifications
- Approved submittals
- As-built drawings
- As-built sequence of operation
- Original setpoints for all systems commissioned
- Recommended schedule for recommissioning
- Recommended schedule for sensor recalibration
- Equipment operations and maintenance manuals
- Equipment preventive maintenance schedules
- Confirmation of completed training for the owner and occupants
- Ongoing system optimization procedures
- Final commissioning report

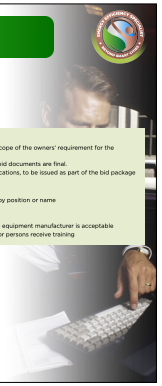
STEP 2. DEVELOP TRAINING REQUIREMENTS

Create training requirements. Verify that they meet the scope of the owners' requirement for the operator training.

- Training requirements must be completed before the bid documents are final.
- Integrate requirements into the commissioning specifications, to be issued as part of the bid package during the construction document phase.

Training requirements include the following:

- List of those who should receive operational training, by position or name
- List of systems that require operator training
- Level of instruction required for each system
- Determination of whether the training provided by the equipment manufacturer is acceptable
- Tracking method to ensure that all required positions or persons receive training



STEP-BY-STEP GUIDANCE +

STEP 3. ENSURE ENHANCED CX SCOPE ITEMS ARE INCLUDED IN CONSTRUCTION DOCUMENTS

Confirm that the following items are included in the construction documents to be issued for bid:

- System manual requirements
- Operator and occupant training requirements

STEP 4. REVIEW CONTRACTOR'S SUBMITTALS

Ensure ongoing compliance with the OPR, BOD, and Cx requirements by reviewing the HVAC&R contractor's submittals.

- Conduct a submittal review by the CxA concurrently with the design team's review or, at the latest, before final acceptance by the engineer or architect of record.
- The CxA must document all issues discovered during the review process in a log, to be distributed to the project's design and construction teams (see *Further Explanation, Examples, Table 4*).
- The CxA must also confirm that all issues recorded in the log are addressed or resolved by the owner, design, or construction teams.
- Establish the submittal review process at the commissioning kickoff meeting included in the fundamental commissioning steps.

STEP 5. VERIFY TRAINING

Confirm that the training program has been completed according to the owner's requirements for all commissioned equipment.

STEP-BY-STEP GUIDANCE +

- Training is required to ensure that the building's operating staff is fully knowledgeable about operating the equipment and systems. Typically, it is provided by the equipment manufacturer, general contractor, or subcontractors.
- A good training program covers all new HVAC&R equipment and associated controls as well as monitoring equipment and software (if Option 1, Path 2 is pursued).
- It is recommended that the training cover all operating scenarios to help the building engineering team understand the most effective and efficient way to operate the building.

As outlined in ASHRAE Guideline 0–2005, a robust training program will address the following:

- Emergency instructions and procedures
- Operation instructions and procedures
- Troubleshooting procedures
- Maintenance and inspection procedures
- Repair procedures
- Upkeep of the systems manual and associated maintenance documentation logs

STEP 6. DELIVER POSTCONSTRUCTION DOCUMENTS

Complete and deliver the necessary operating documents and reports to the owner before building occupancy to ensure a smooth transition from construction to operation. The project CxA must confirm delivery, and the final package must include the following:

- Up-to-date systems manual, including operations and maintenance manuals for all commissioned equipment
- Documentation of operator training on all commissioned systems
- Completed functional performance test reports
- Up-to-date issues log detailing closed and open issues
- Updated Cx plan that outlines commissioning completed to date, plan for seasonal testing, plan for 10-month operational review, and plan for addressing open issues identified after the initial round of commissioning.

STEP 7. PERFORM SEASONAL TESTING, IF REQUIRED

Determine whether seasonal testing will be necessary, based on the project schedule.

- Both projects that reach substantial completion during peak heating or cooling months and projects that are occupied and operational before all equipment has been installed must create Cx plans and complete all necessary tests.
- The project CxA must be involved in seasonal testing, even if it occurs after the project is completed.

The results of seasonal testing and the issues log must be included in the final commissioning report (preferred) or issued as an addendum to the owner.

STEP 8. REVIEW BUILDING OPERATIONS 10 MONTHS AFTER SUBSTANTIAL COMPLETION

Perform the 10-month review of building operations after substantial completion to ensure that the building is being operated according to the owners' requirements. The 10-month review may include the following:

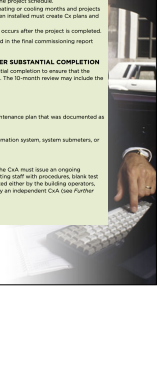
- Interviews with the operations and maintenance staff
- Interviews with occupants
- Status of outstanding commissioning-related issues
- Comparison of current operations with the operations and maintenance plan that was documented as part of EA Prerequisite Fundamental Commissioning
- Follow-up functional performance testing, when required
- Trends in building operations, as indicated by the building automation system, system submeters, or whole-building utility meters

STEP 9. DEVELOP ONGOING CX PLAN

Before or as part of the 10-month review of building operations, the CxA must issue an ongoing commissioning plan. The plan should provide the building's operating staff with procedures, blank test scripts, and a schedule for ongoing Cx activities. It may be executed either by the building operators, in addition to their normal preventive maintenance activities, or by an independent CxA (see *Further Explanation, Ongoing Commissioning Basics*).

The plan must include the following:

- Definition of the ongoing commissioning process



STEP-BY-STEP GUIDANCE +

- Defined roles and responsibilities
- Recommended schedule for recommissioning as-built systems
- Continuous documentation and updating of building operating plan and current facility requirements throughout the building's lifetime
- Blank testing materials, including functional performance tests for all commissioned as-built systems in the building, as well as an issues log
- Direction for testing new and retrofitted equipment

Option 1, Path 2. Enhanced and Monitoring-Based Commissioning

STEP 1. ACHIEVE OPTION 1, PATH 1

Ensure that the requirements for Path 1 have been met.

STEP 2. UPDATE CX PLAN TO INCLUDE MONITORING-BASED COMMISSIONING (MBCX) REQUIREMENTS

During the design development phase, incorporate the MBCx requirements and activities into the project's Cx plan (see *Further Explanation, Monitoring-Based Commissioning Basics*).

- Define analysis procedures, including frequency during year one.
- Outline the evaluation process and determine the procedure for handling system conflicts, usage profiles, and out-of-sequence operations.
- Include preventive planning and maintenance procedures necessary to meet performance goals.
- Determine measurement requirements and decide whether predictive algorithms can be used in conjunction with metered points.

STEP 3. CONFIRM THAT MBCX IS FULLY INCORPORATED INTO ENHANCED CX

Ensure that requirements for MBCx are included in all commissioning documents. Items to look for may include the following:

- Owner's requirements, such as specific trends to track, reflected accurately in the engineer's BOD
- Metering and monitoring required for MBCx, included in the BOD
- Single-line or riser diagrams for location of building and system meters
- Controls sequences for specification of appropriate monitoring points
- Cx specifications for contractors and building operators
- Submittal reviews of meters, energy analysis software, and drawings of controls for compliance with the owner's MBCx metering and monitoring requirements
- Creation and completion of prefunctional tests for MBCx-related equipment, such as meters and energy analysis software programs, by the CxA and contractors
- MBCx operator education regarding measurement techniques, energy analysis software tools, fault detection and fault resolution, all incorporated into training requirements

STEP 4. IMPLEMENT MBCX PLAN

Execute, concurrently whenever possible, MBCx monitoring and analysis with the functional performance testing completed for EA Prerequisite Fundamental Commissioning.

The equipment and tools required for MBCx must be installed, and the electrical and controls contractor should submit construction checklists for review by the CxA. The benefits of implementing MBCx functional testing after construction but before occupancy include the following:

- More robust documentation of functional performance tests
- Verification that the energy meters and monitoring points have been properly installed and programmed
- CxA oversight of monitoring procedures and energy analysis, to ensure that the owner's requirements for ongoing monitoring are executed correctly
- Verification that energy analysis software tools, if installed, are appropriately identifying faults and producing the correct reports

It is recommended that the CxA confirm execution of the MBCx commissioning plan during the 10-month review. Confirmation of execution includes the following:

- Review of metering and trend logs

STEP-BY-STEP GUIDANCE +

- Review of the issues log showing results of the MBCx
- Confirmation of issue resolution
- Confirmation of ongoing operator training
- Updating of the systems manual with any modifications or new settings that differ from design, with explanations for the changes
- See *Further Explanation, Bridging the Gap between LEED BD+C and LEED O+M.*

Option 2. Envelope Commissioning

Incorporate envelope commissioning into the Cx plan by extending the requirements of EA Prerequisite Fundamental Commissioning and Verification to cover the building's thermal envelope and completing EA Credit Enhanced Commissioning (Option 1, Path 1) as it relates to the building envelope. It is not necessary to complete the enhanced commissioning for building systems to meet the requirements of this option. However, doing so will help to ensure a better-performing building.

Ensure that the building envelope is fully accounted for in all commissioning documents and testing procedures (see *Further Explanation, Building Envelope Commissioning Basics*).

REQUIREMENTS

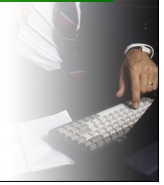
Implement, or have in place a contract to implement, the following commissioning process activities in addition to those required under EA Prerequisite Fundamental Commissioning and Verification.

Commissioning Authority Qualifications:

- ☑ The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;
- ☑ The CxA may be a qualified employee of the owner, an independent consultant , or an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team.

REQUIREMENTS +

Path 1: Enhanced Commissioning (3 points)
Complete the following commissioning process (CxP) activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies according to ASHRAE Guideline 0–2013 and ASHRAE Guideline 1.1–2007 for HVAC&R systems as they relate to energy, water, indoor environmental quality, and durability.

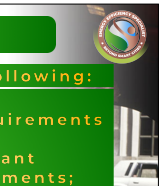


REQUIREMENTS +

The commissioning authority must do the following:

- ☑ Review contractor submittals.
- ☑ Verify the inclusion of system manual requirements in construction documents.
- ☑ Verify the inclusion of operator and occupant training requirements in construction documents; verify system manual updates and delivery.
- ☑ Verify operator and occupant training, delivery, and effectiveness.
- ☑ Verify seasonal testing.
- ☑ Review building operations 10 months after substantial completion.
- ☑ Develop an ongoing commissioning plan.

Include all enhanced commissioning tasks in the OPR and BOD.



REQUIREMENTS +

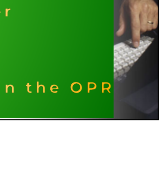
Path 2: Enhanced and Monitoring-Based Commissioning (4 points)

Achieve Path 1. AND
Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems.

Include the procedures and measurement points in the commissioning plan. Address the following:

- roles and responsibilities;
- measurement requirements (meters, points, metering systems, data access);
- the points to be tracked, with frequency and duration for trend monitoring;
- the limits of acceptable values for tracked points and metered values (where appropriate, predictive algorithms may be used to compare ideal values with actual values);
- the elements used to evaluate performance, including conflict between systems, out-of-sequence operation of systems components, and energy and water usage profiles;
- an action plan for identifying and correcting operational errors and deficiencies;
- training to prevent errors;
- planning for repairs needed to maintain performance; and
- the frequency of analyses in the first year of occupancy (at least quarterly).

Update the systems manual with any modifications or new settings, and give the reason for any modifications from the original design.



REQUIREMENTS +

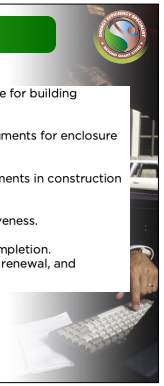
Option 2. Building Enclosure Commissioning (2 points)
Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's enclosure in addition to mechanical and electrical systems and assemblies.

Complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2013 and ASTM E2947-16: Standard Guide for Building Enclosure Commissioning, as they relate to energy, air and water tightness, indoor environmental quality, and durability.

REQUIREMENTS +

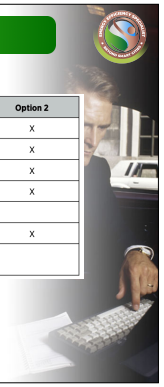
The qualified independent member of the design or construction team responsible for building enclosure commissioning must complete the following:

- Review contractor submittals.
- Verify inclusion of systems manual requirements in construction documents for enclosure systems.
- For specialty enclosure systems with controls and automation:
  - Verify inclusion of operator and occupant training requirements in construction documents.
  - Verify systems manual updates and delivery.
  - Verify operator and occupant training delivery and effectiveness.
  - Verify seasonal testing.
  - Review building operations 10 months after substantial completion.
- Develop an on-going enclosure commissioning plan for maintenance, renewal, and revitalization cycles.



REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
List of all tasks completed as part of Cx activities	X	X	X
Training outline and participation list	X	X	X
Confirmation of systems manual delivery	X	X	X
Ongoing Cx plan	X	X	X
Inclusion of monitoring and tracking in Cx plan		X	
Inclusion of envelope in Cx plan			X
Verification of additional reviews per Data Center requirements (data centers only)	X	X	



REFERENCED STANDARDS

- ASHRAE Guideline 0 - 2013 , The Commissioning Process
- ASHRAE Guideline 1.1 2007 , HVAC & R Technical Requirements for the Commissioning Process
- ASTM E2947 – 16: Standard Guide for Building Enclosure Commissioning
- ASTM E 2813 12 : Standard Practice for Building Enclosure Commissioning

CONNECTION TO ONGOING BUILDING PERFORMANCE

LEED O+M EA credit Energy Performance : Enhanced building commissioning expands the fundamental commissioning process to provide further oversight and verification of mechanical systems, which ensures ongoing building quality control and operations and may help improve the project's energy performance score. Monitoring-based commissioning is a powerful strategy for tracking building performance in real time. Building enclosure commissioning provides quality assurance for enclosure systems design and installation and provides the foundation for energy efficiency throughout the building life cycle.

TERMS AND DEFINITIONS

- Operations and maintenance (O&M) plan a plan that speciies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system
- Owner's project requirements (OPR) a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project
- Systems manual provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.

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