BUILDING COMMISSIONING (Cx) PROCESS

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Webinar Series

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BUILDING STRONG

DEFINING COMMISSIONING (Cx)

DOE Proposed Fossil Fuel rules

- *Commissioning* means a **systematic process** of ensuring, using **appropriate verification and documentation**, during the period beginning on the initial day of the design phase of the facility and ending not earlier than one year after the date of completion of the facility, **that all facility systems perform interactively in accordance with the design documentation and intent of the facility**, the operational needs of the owner of the facility and preparation of operation personnel, and the primary goal of which is to ensure fully functional systems that can be properly operated and maintained during the useful life of the facility.

DEFINITIONS (Cx)

Commissioning Team: These are the individual(s) who through coordinated actions are responsible for implementing the Commissioning Process.

Commissioning Authority (CxA): The commissioning authority is defined as the **representative responsible for ensuring the commissioning process is properly carried out according to contract requirements.** The CxA is identified by the Owner who leads and coordinates the commissioning team to implement the Commissioning Process. The commissioning authority is usually someone on the owner's staff, the owner's design professional, or a commissioning consultant retained by the owner specifically to represent the owner's interests with respect to commissioning.

The Commissioning Specialist (CxS) is defined as the person or persons **responsible for carrying out the "detailed" planning and implementation of the commissioning process.**.The (CxS) as a member of the Commissioning Team provides support to the Commissioning Authority (CxA) by performing discipline specific duties such as design review, equipment installation checkout, start-up, functional performance testing and operator training. There can be more than one CxS on the project. One may be hired by the Contractor and another may be hired by the Corps to assist with its CxA tasks. When there is more than one use the designation CSC and CSG.

DEFINITIONS (Cx)

- *Whole –building or Total Building Commissioning* means a process in which **building systems and their interactions are tested and verified** to work in accordance with OPR and Contract documents.
- The following are several common systems that could be included in the Commissioning plan
  - HVAC
  - Building Envelope
  - Protective systems (Fire Suppression, Lightning Protection)
  - Plumbing (Water distribution, sanitary, storm water)
  - Electrical (Power distribution, lighting)
  - Communications Systems (Telecomm Sound, Video)
  - Alarm Systems (Fault detection, security, Leak Detection)

US Army Corps of Engineers

Total Building Commissioning

COMMISSIONING ORGANIZATION CHART AND ROLES AND RESPONSIBILITES

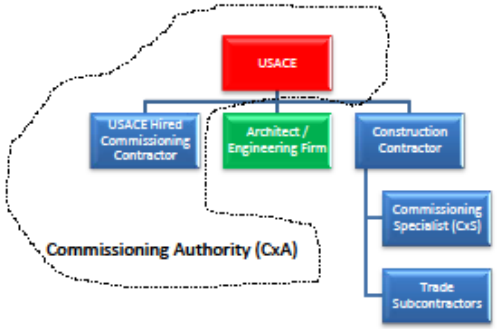

FIGURE 1: Design – Bid – Build (D-B-B) Commissioning Organization Chart

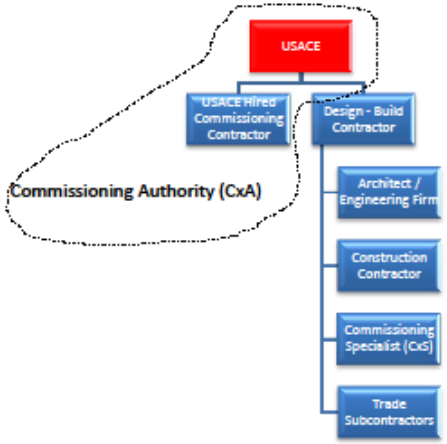

FIGURE 2: Design –Build (D-B) Commissioning Organization Chart

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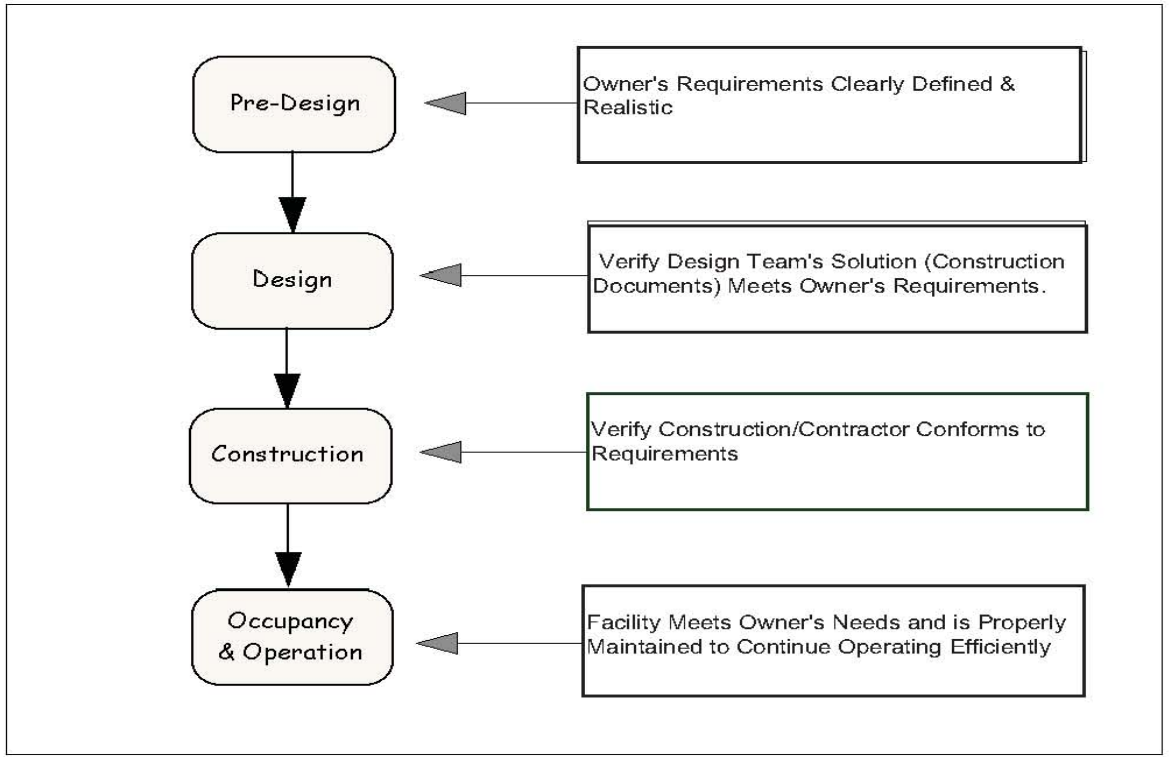
DEFINING COMMISSIONING (Cx)

- Cx is a Quality Assurance Process for Buildings:
  - From **pre-design through design, construction, and building operations**.
  - It involves achieving, **verifying, and documenting** the performance of each system and integrated system.
  - Systems meet the building's operational needs within the capabilities of the documented design and equipment capacities, in accordance with the owner's functional criteria (ASHRAE Guideline 0).

USER INPUT INTO COMMISSIONING

Each phase of the project acquisition process can hold pitfalls that negatively affect the likelihood of a quality outcome



KEYS TO SUCCCESSFUL Cx

- Owner's Project Requirements: Incorporation into Design
- Commissioning Team Composition:
  - Commissioning Authority (CxA)
  - Designer
  - User
  - O&M Staff
  - Corps of Engineers
  - Contractor Team (TAB, Controls, Mech, Elect)
- Verification of OPR by Commissioning Team

KEYS TO SUCCESSFUL Cx(Cont'd)

- Commissioning Plan:
  - Specific Roles and Responsibilities
  - Owner's Project Requirements Identified
  - Construction Checklists
  - Test Protocols
  - Documenting Corrective Actions
- Communications
  - Commissioning Meetings
  - Issues Log
- Owner Buy-In and Support
  - Investment of Time Up-Front

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KEYS TO SUCCESSFUL Cx(Cont'd)

- Good Performance Benchmarking
- Documents Control
- Well Developed Project Specific Construction Specifications
- Functional Performance Verification by Commissioning Team
- Proper Training of O&M Staff

COMMISSIONING (Cx) PROCESSES

- Commissioning Processes includes:
  - Documenting the Owner's Needs
  - Documenting Design Teams Reasoning and Decisions
  - Conducting Quality Peer Reviews
  - Defining, Specifying, Planning and Verifying the Functional Testing of the Building Systems
  - Increased Coordination and Integration of Construction Trades
  - Preparing and Enhancing Building Documentation
  - Improving the Operation and Maintenance Training Process

COMMISSIONING Processes (Cx)

- Post Construction and Pre Occupancy
  - Systems start up, testing and troubleshooting
  - Systems balancing and Integration
  - Building Systems Operation
  - Building Systems verification of Owners Requirements and Design Specifications compliance
  - Systems training
- Turn over an Operable building that meets the customer requirements and Contract Documents.
  - The result should be fully functional systems that can be properly operated and maintained throughout the life of the building. (ASHRAE, 2004)
- Post occupancy inspection (seasonal fluctuations)

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SYSTEMS TO BE COMMISSIONED (at a minimum)

- HVAC Systems & Associated Controls
- Interior & Exterior Lighting & Daylighting Controls
- Domestic Hot Water Systems
- Renewable Energy Systems (wind, solar, etc.)
- Electrical Sub-Metering Systems
- Building Envelope (Building Air Tightness Test)
  - Envelope not required for LEED commissioning – separate Army testing requirement – currently not required to be included in Commissioning Agent (CxA) activities and documents.

COMISSIONING GUIDANCE DOCUMENTS

- ER 1110-345-723, Systems Commissioning Procedures
- ER 25-345-1, Systems Operation and Maintenance Documentation
- ER 414-345-38, Transfer and Warranty
- U.S. Green Building Council (USGBC) LEED Reference Guide for Green Building Design and Construction 2009 Edition
- ASHRAE Guideline 0-2005, The Commissioning Process
- ASHRAE Guideline 1.1-1996 The HVAC Commissioning Process (supersedes ASHRAE guideline 1-1989)
- ASHRAE Guideline 189.1-2011 Standard for the Design of High Performance Green Buildings, Section 10 Construction and Plans for Operations
- Memorandum, DASA (I,E&E), 27 Oct 10, Sustainable Design and Development Policy Update (Environmental and Energy Performance)

ARMY COMMISSIONING REQUIREMENT

By Memo dated 27 Oct 2010 ASA (IE&E) has identified the need for commissioning, "Facility construction projects will use **total building commissioning practices,** tailored to the size and complexity of the building and its system components in order to ensure that design requirements/ specifications are met during construction. **Performance of building components and systems will be verified** at a minimum of one year after beneficial occupancy. Enhanced commissioning process activities must be planned, budgeted, and specified to be completed for the building envelope, storm water management systems, water treatment systems, and information technology systems.

USACE Commissioning Guidance

- **ECB No. 2006-2 19 May 2006 "Sustainable Design and Development (SDD)"** Starting with the FY08 program, all vertical MCA climate controlled projects are required to be capable of achieving the USGBC's LEED silver certification
  - FUNDAMENTAL COMMISSIONING IS A PREREQUISITE FOR LEED CERTIFICATION
- **(ECB) 2010-14, 28 Jun 2010, "Improving Building Performance through Enhanced Requirements for Energy Performance and Selected LEED Credits"**
  - EA credit 3 Enhanced Commissioning is selected LEED credit required to be pursued
- **ECB No. 2011-1, 19 Jan 2011 (superseded ECB 2010-14 above)**

  In addition to the prerequisites, the following LEED-NC/NR credits shall be included in all MCA projects where applicable

  (f) EA 3 Enhanced Commissioning
- **Memorandum of Understanding (MOU), 06 Mar 06, revised 01 Dec 08,** ***Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings*** Commissioning. Employ commissioning practices tailored to the size and complexity of the building and its system components in order to **verify performance of building components and systems** and help ensure that design requirements are met. This should include an experienced commissioning provider, inclusion of commissioning requirements in construction documents, a commissioning plan, verification of the installation and performance of systems to be commissioned, and a commissioning report.

Commissioning Tasks

LEED FUNDAMENTAL Commissioning Guidance

- Designate independent Cx with experience with at least 2 similar bdlg projects
- Document Owners Project requirements (OPR)
- Develop Basis of design
- Incorporate Commissioning requirement into the construction documents
- Develop and implement a commissioning plan
- Verify the installation and performance of commissioned systems
- Complete a summary commissioning report

LEED Commissioning Guidance Enhanced (tasks beyond Fundamental)

- An **independent, experienced commissioning authority** (CxA) needs to be designated to lead, review and oversee commissioning efforts, prior to the construction documents phase of the project.
- The CxA conduct at least 1 commissioning **design review** of the owner's project requirements basis of design, and design documents **prior to the mid-construction documents** phase and back-check the review comments in the subsequent design submission.
- CxA **reviews the contractor's submittals** applicable to systems being commissioned. At the same time, the submittals should also be reviewed by the architect or engineer of record.
- CxA provides a **systems manual** for future operating staff so they can operate key systems optimally.
- **Training** for building operating personnel and occupants is provided and verified by the CxA.
- CxA **reviews the building's operations within 10 months** after completion and develops a plan for resolving outstanding commissioning-related issues.

DESIGN PHASE
(Section 6 of ASHRAE Guideline 1.1)

- Owner's Project Requirements (OPR's) are translated into construction documents (see Paragraph 5.2.2 of 1.1)
- Create Basis of Design Document (BOD) (6.2.2)
- Develop Commissioning Plan since not done in Pre-design phase (Paragraph 5.2.4 of Guideline 0) Annex G of Guideline 0 is an example
- Commissioning Plan is expanded to include details of Construction Phase and Occupancy and Operations Phase activities relative to HVAC&R systems (6.2.3)

DESIGN PHASE
(Section 6 of ASHRAE Guideline 1.1)

- Put Cx requirements in the Construction Documents 6.2.4 of 1.1
- Develop Construction Checklists Annex M of 1.1 for examples
- The format for Systems Manual shall be clearly stated in the Construction Documents Annex O of 1.1 is a sample format
- Training Requirements shall be provided in the Construction Documents Annex P of 1.1 has recommendations
- Design Review of Construction Documents 6.2.8 of 1.1

Develop Test Procedures (7.2.9)

- The following should be accomplished prior to the start of any Cx process OPR test:

1. Verify control system operation (know as Performance Verification Test [PVT]) 7.2.9.3.b
2. TAB Verification

- Examples of HVAC&R OPR test verification objectives (7.2.9.5), include: comfort, indoor air quality, environmental goals, energy efficiency, and support of other systems

Schedule Construction Phase Cx Process Activities (7.2.8)

- Order of HVAC&R Testing
- Pipe and duct leak testing, flushing of piping, and TAB
- HVAC&R equipment installation & start-ups
- Site utilities testing
- BAS control system testing
- Testing, Adjusting, & Balancing (TAB)
- Cx Tests
- Test verification

Develop Test Data Records

- Trend logs
- Detailed responses to input changes, including response times if they are critical
- Flows, temperatures, pressures, volumes, capacities, etc. to confirm equipment and system capabilities
- When conducting a comfort test, ensure the status of all affected equipment is recorded along with the space and outdoor conditions

Occupancy & Operations Phase

- Verify Seasonal Testing of Facility Systems and Assemblies
- Complete Final Cx Process Report

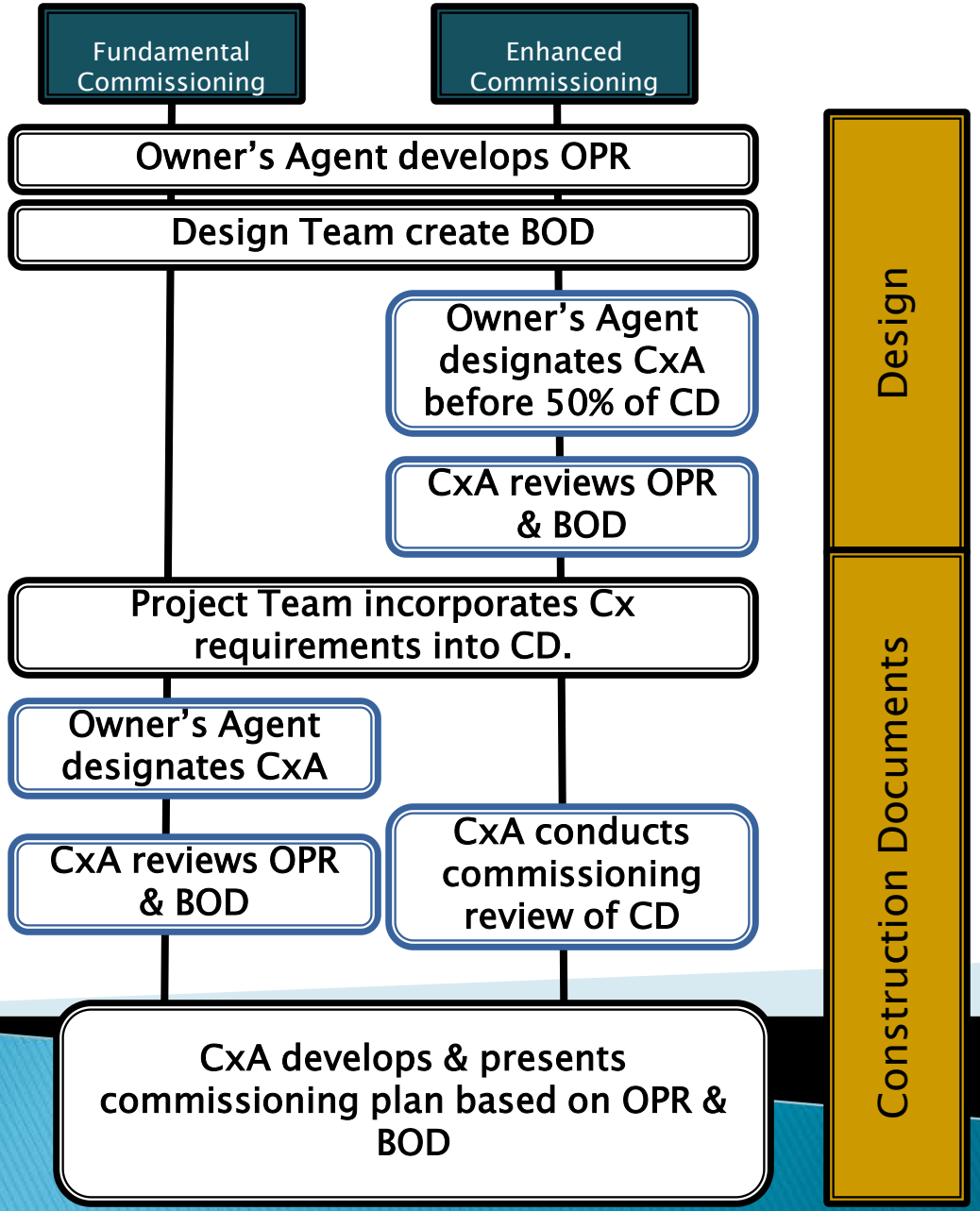
- Ensure the involvement by the CxA in reviewing building operation 10 months after substantial completion with O&M staff and occupants. Include a plan for resolving outstanding issues

LEED Fundamental vs. Enhanced

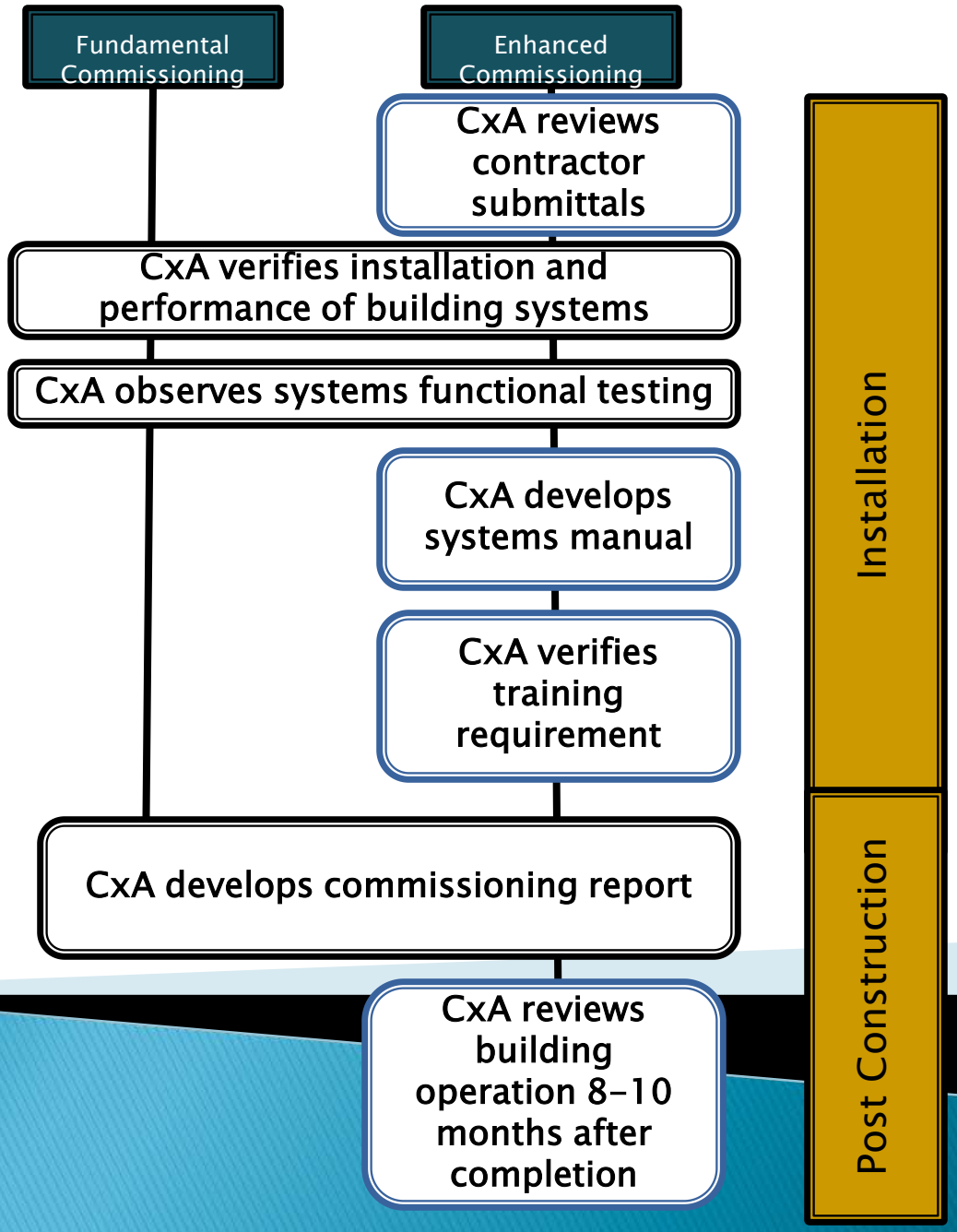
All MILCON Projects Fundamental Commissioning.

FY11 4th Qtr Mandate: Enhanced Commissioning

OPR = Owners Project Requirements
BOD = Basis of Design
CxA = Commissioning Authority



Fundamental vs. Enhanced



USACE PROCESSES ~ LEED EA CR 3

USGBC LEED EA PR1 Fundamental Commissioning of Building Energy Systems and EA 3 Enhanced Commissioning (tasks in bold)	**USACE Processes**	**REFERENCES: Corps Engineering Regulations or SOPs or document**
Designate independent Cx with experience with at least 2 similar bdlg projects	USACE is oversight contractor for Army client (owner)	UFC-4-030-01
Document Owners Project requirements (OPR)	Charrettes	1391
Develop Basis of design	Design	Design Analysis
Incorporate Commissioning requirement into the construction documents	Design	UFGS 23 08 00 and 23 09 23
Conduct Commissioning design review prior to mid-construction documents	ITR and BCOE review Dr. Checks	ER1110-1-12 ch 4 ER-415-1-11 1 Sep 1994
Develop and implement a commissioning g plan	Design and Construction Management	Commissioning 23 09 23 ASHARAE 0 and ASHRAE 1.1
Submittal review concurrent with DOR	**Resident engineer plus Arch and DOR**	**ER-415-1-10 15 Apr 1997**
Verify the installation and performance of commissioned systems	CQC three phase inspection	UFGS 23 0923
Develop Systems manual	Project team and/or CxS	ER-25-345-131 Jan 91 UFGS 23 09 23 and UFGS01 78 23
Training verification	Project Team and/or CxS	See above
Complete a summary commissioning report		UFGS 23 08 00 Paragraph 3.3.
Operations within 8 to 10 months after substantial completion	USACE Warranty Inspections at 4 months and 10 months	ER 414-345-38 Transfer and Warranty UFGS 01 78 02

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CORPS CONSTRUCTION PROCESS

- NTP
- Preconstruction Conference
- Schedule review (coordinated with Customer)
- Submittals
- Three Phase QA/QC Inspection
  - Preparatory Inspection
  - Initial Inspection
  - Follow Up Inspection
- Attend Progress Meetings

ASHRAE 189.1

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New for FY13- Compliance with ASHRAE 189.1 standard (Army)

It Covers :

- Sustainable Sites
- Water Use Efficiency
- Energy Efficiency
- Indoor Environmental Quality
- Impact on the Atmosphere, Materials and Resources

and……

- **Construction and Operations Plans**

Construction and Operation Highlights

- Acceptance Testing / Commissioning
- IAQ Construction Management Plan
- Plans for Operation
  - High-performance building operation
  - Maintenance
  - Service life
  - Transportation management

Where does Commissioning fit?

In Section 10 of AHRAE 189.1, requirements for construction and operation plans — including the commissioning process, building acceptance testing, measurement and verification, and reporting of energy use, water use and indoor air quality — are also specified to assist building owners in achieving high performance operation.

Why and How

- **Benefits**
  Energy 30% savings over Standard 90.1-2007
  Water About 40% savings over U.S. EPAct 1992

- **Compliance** Mandatory plus prescriptive is a Simple option, very few calculations OR Mandatory Plus Performance has more options, but more effort
  - However, for Construction and Plans for Operations there are no prescriptive or performance options, just the standard.

Commissioning

- All Projects – Acceptance Testing-
  - Before permit -Acceptance representative designated he/she must review construction documents to verify relevant sensor location devices and control sequences are properly document (design commissioning)
  - Before Building occupation- acceptance testing that include sign off from all parties and system manuals must be provided to operating staff.

Additional Commissioning

- Projects greater than 5,000 SF- a more detailed commissioning process on top of above acceptance testing- similar to enhanced commissioning requirement in LEED and ASHRAE guideline 0
  - Designate Commissioning authority (CX)
  - Cx lead OPR documentation and review construction documents through design phase
  - BOD must reflect OPR
  - Commissioning to verify performance in accordance with OPR
  - Train owner personnel

Systems requiring commissioning in ASHRAE 189.1

* bolded items required for LEED commissioning

- **HVAC**
- IAQ
- Refrigeration
- Building envelope
- **Lighting controls**
- Shading controls
- Irrigation
- Pumping
- Domestic and process water and pumping
- **Water heating**
- **Renewable energy system**
- Water measurement devises
- And energy measurement devices

POSITIVE IMPACTS AND BENEFITS OF CX (Cont'd)

- Lower Operating and Maintenance Costs
- Project that Benefits from a Collaborative Effort of Diverse Participants
- Reduced Contractor Callbacks (Warranty Calls)
- Improved Maintainability of Equipment & Systems
- Fully Functional Facility Meeting all Owner Project Requirements (OPR)

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COSTS of CX

- Costs depend on size and complexity of building systems
- Estimates provide an expected range
  - LBNL study established a median cost of $1.16 for new construction This cost was ~0.4 % of the overall cost of construction
  - RS Means estimates commission to cost 1-1.25% of total project costs
  - 2004 GSA study estimated the incremental increase for Enhanced commissioning above fundamental commissioning of $0.10 to $0.15
- Commissioning costs typically pay for themselves in less than a year by correcting deficiencies

http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf

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EXAMPLE- Lawrence Berkeley National Land Molecular Foundry

- 6 story 94,500 sf $67 M dollar research facility
- Commissioning identified 48 deficiencies were discovered in the Construction Phase
- Measure implemented were
  - modification of controls sequence, setpoints, and start stop operations.
  - Calibrate terminal unit damper position feedback.
  - Calibrate lighting occupancy sensors
  - Bring air compressor operation into spec
- Cost saving s $93,369/yrs. Cost for commissioning $39,932.
- Simple payback 0.4 yrs

www.cacx.org/resources/commissioning.php?sort=building

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Commissioning Agent Costs

Total building commissioning costs for commissioning agent services can range from 0.5% to 1.5% of total construction costs (according to U.S. Department of Energy's Rebuild America Program, written by the Portland Energy Conservation, Inc. (PECI)). The National Association of State Facilities Administrators (NASFA) recommends budgeting 1.25 to 2.25% of the total construction costs for total building commissioning agent services. GSA's commissioning practice is expected to cost approximately 0.5% of the construction budget for federal buildings and border stations. More complex projects such as courthouses could run 0.8 – 1% of the construction budget, and even more complex facilities such as laboratories can exceed 1%. Factors influencing commissioning costs include facility type, phasing 24/7 operations, the depth and breadth of commissioning services, the level of commissioning desired, and the systems and assemblies chosen to be commissioned. http://www.gsa.gov/portal/content/101961

Other Training Opportunities

PROSPECT #327 HVAC SYSTEMS COMMISIONING – 5 day
Half lecture , half hands on commissioning with operating boiler, chiller, and VAV air handling unit and boxes

AEE Certified Building Commissioning Preparatory– 5 day
Lecture series by industry professionals in Total Building commissioning. Beyond the process, specialists teach in TAB (whole day) in building envelope, and electrical commissioning. Use calculations and real examples of commissioning deficiencies

ASHRAE Live or web enhanced seminar – 3 of 6 hours
Covers the commissioning process