

# **BUILDING COMMISSIONING Commissioning Process Overview**

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***Presentation Provided by:  
The Building Commissioning Association (BCA)***



# What is Building Commissioning?

*“The Commissioning Process is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”*

-- ASHRAE Guideline 0

- The process is performed specifically to ensure that the completed facility operates in accordance with the owner’s documented project requirements and the construction documents.
- It begins in pre-design and continues through design, construction, and occupancy of the facility.

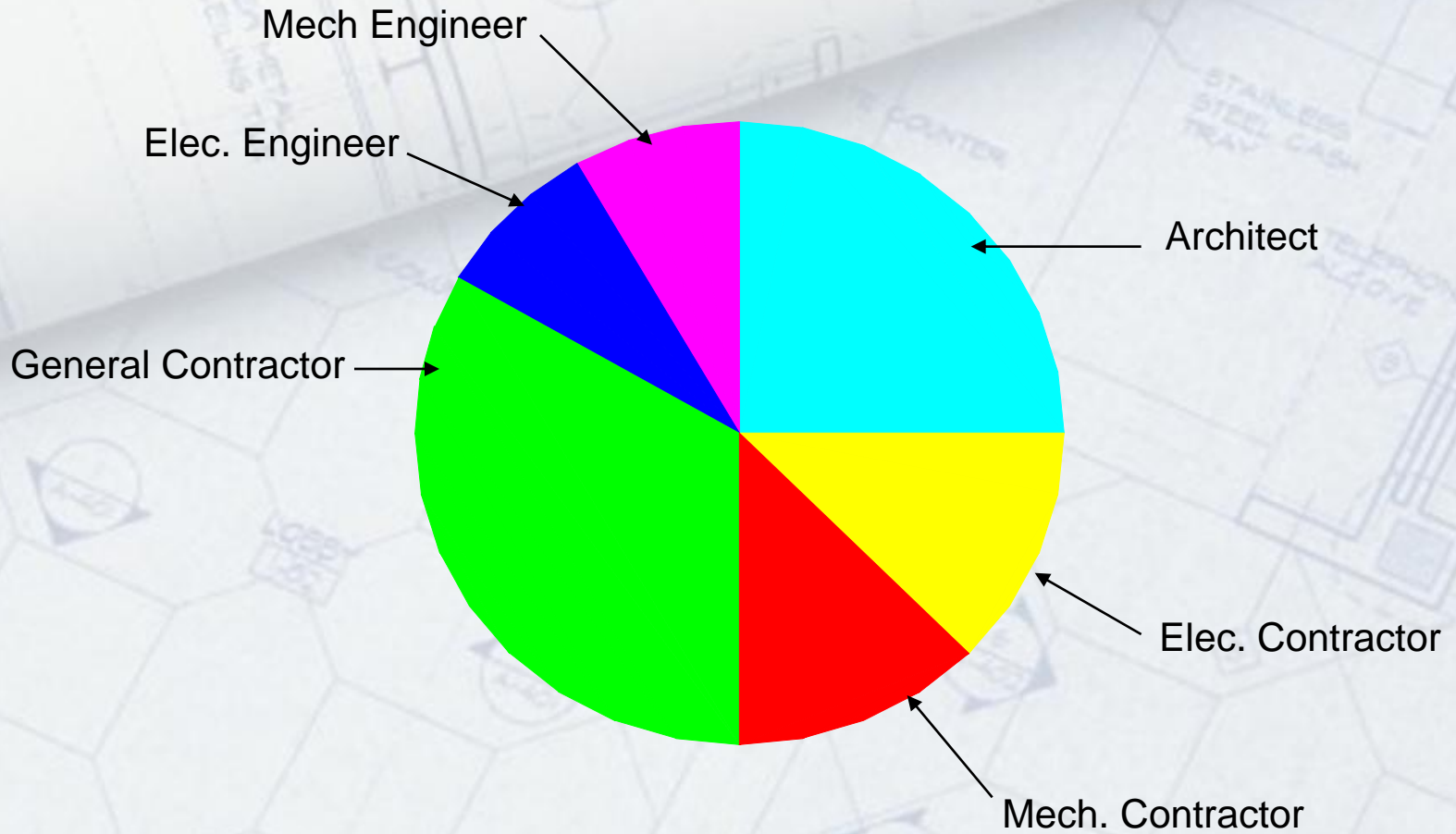


# Why do we need Building Commissioning?

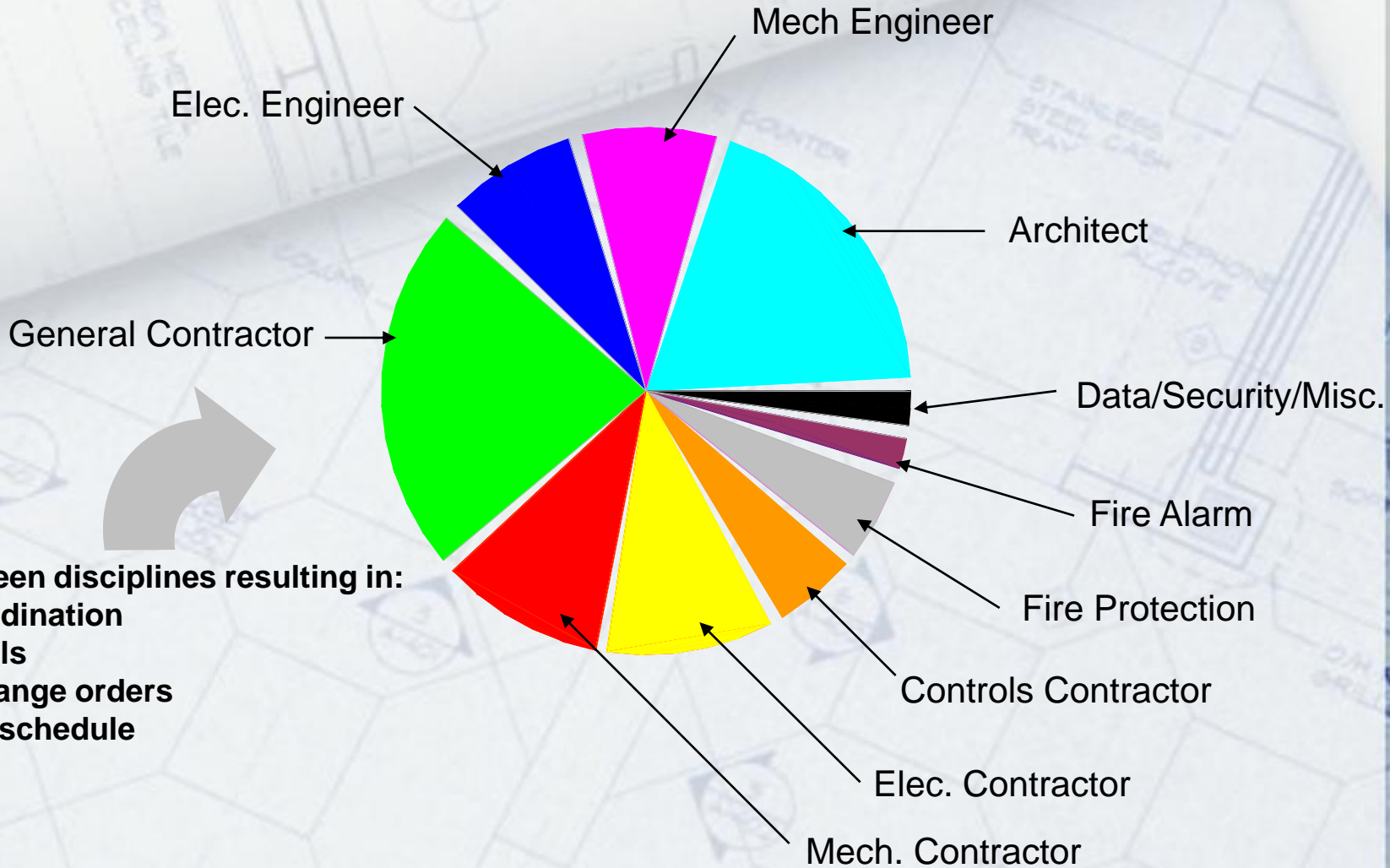
# Why Do I Need It?

- Increased system complexity
- More cost competitive industry
- Systems are not working as expected
- Systems are turned over to owner in less than optimal working order
- Improve facility operations and training

# Typical Project Team Configuration Up to the Mid 1970's



# Typical Project Team Configuration After the Mid 1970's



**Gaps between disciplines resulting in:**

- **Poor coordination**
- **Lost details**
- **Costly change orders**
- **Delays in schedule**

The background of the slide is a light blue-tinted image of architectural blueprints. A section of the blueprints is rolled up at the top right, creating a diagonal shadow. The blueprints show various lines, circles, and text, though it is mostly faded. Some legible text includes "STAIRCASE", "ELEVATORS", and "TELEPHONE".

**Building Commissioning is a process to  
meet the owners expectations!**

**Building Commissioning is not just testing  
at the end of construction!**

# History of Commissioning



# History of Building Commissioning

Reference: “eWork and eBusiness in Architecture, Engineering and Construction” by Attila Dikbas & Raimar Schere - 2004

- 1977 – First introduced to the building industry
- Public Works Canada was first to use commissioning
- 1981 – Disney, Inc. issued a full comprehensive commissioning program for design and construction of EPCOT theme park
- 1984 – ASHRAE formed a commissioning guideline committee.
- 1989 – Initial ASHRAE guideline published
- 1993 – First National Conference on Building Commissioning (NCBC) was held.

# History of Building Commissioning Continued

1998 – Building Commissioning Association (BCA) was established.

1998 – US Green Building Council added “Commissioning” to its Leadership in Energy and Environmental Design (LEED) criteria

1999 - The BCA Regions were established. Our region being the Mid-Atlantic Region

2004 – National Capital Chapter received their charter to become a chapter in the MidAtlantic Region

2009 – BCA International: Canada chapter chartered.

# Organizations

## ◎ Some Leading Organizations:

- Building Commissioning Assoc. (BCxA)
  - (*Cx “Best Practices”; PECE, NCBC affiliate*)
- UW – Madison, Dept. of Engineering Prof. Dev’t
- ASHRAE (*Guidelines 0,1*)
- AABC Commissioning Group (ACG)
- Association of Energy Engineers (AEE)

◎ All have defined quality processes, professional development, & certifications.



# Understanding the Basic Commissioning Process

# Purpose of Building Commissioning

It is BCA's premise that:

“ The basic purpose of building commissioning is to provide a quality based process with documented confirmation that building systems are planned, designed, installed, tested, operated and maintained in compliance with the Owner's Project Requirements (OPR).”

# Approaches

- New Construction (Includes Renovations)
  - Pre-design through occupancy
- Existing Buildings
  - Retro-Commissioning
    - In existing, Un-Commissioned buildings
  - Re-Commissioning
    - In previously Commissioned buildings

# Systems to be Commissioned

The scope of work is usually determined by the owner; however the following systems/equipment are typically included:

- Mechanical Systems
  - HVAC (Heating, Ventilation and Air Conditioning Systems)
  - DDC Controls (Automatic Temperature Controls)
  - Domestic Hot Water
- Electrical Systems
  - Lighting and lighting control
  - Emergency/Standby power
- Specialty Systems
  - Security Systems
  - Voice/Data Systems
  - Building Envelope

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# The Commissioning Process

There are Five Phases of Commissioning

PRE-DESIGN

DESIGN

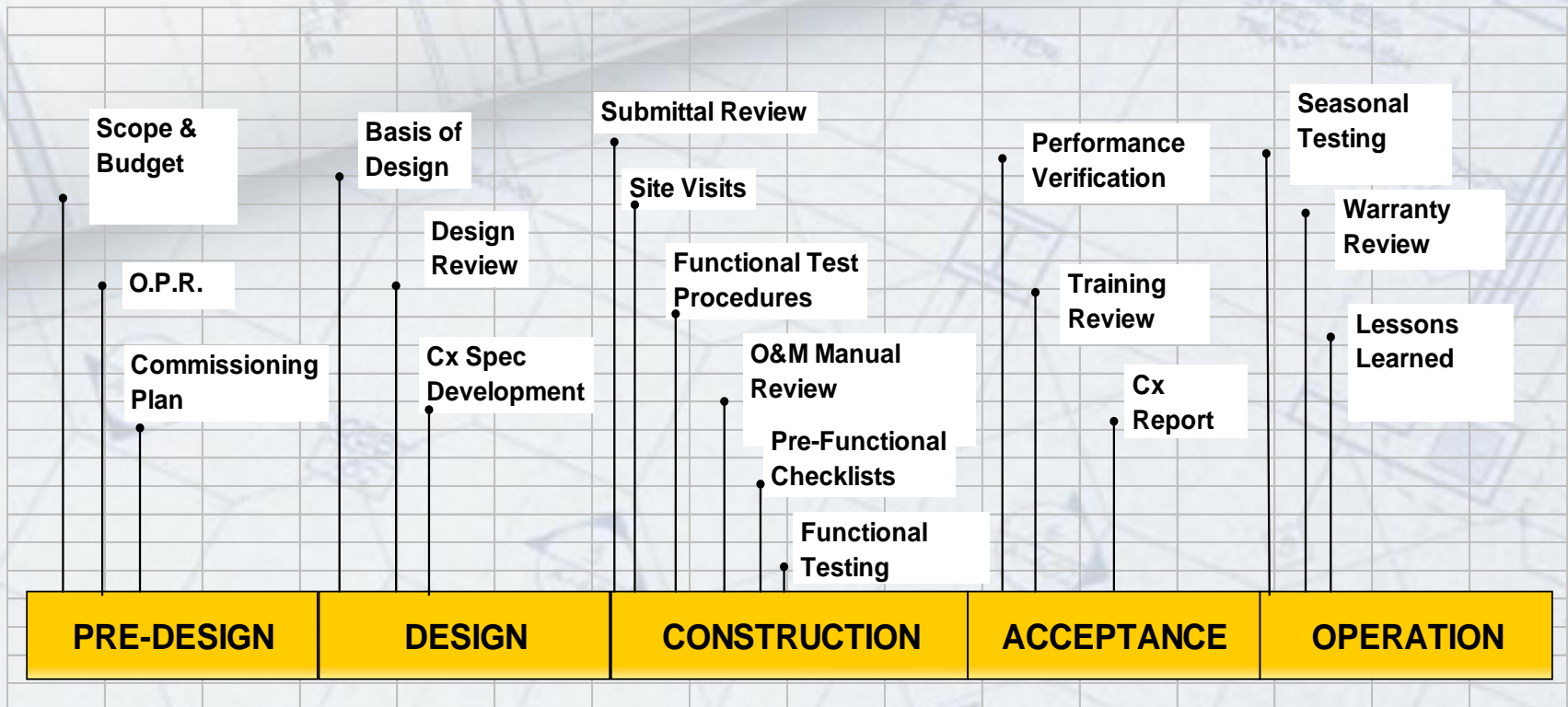
CONSTRUCTION

ACCEPTANCE

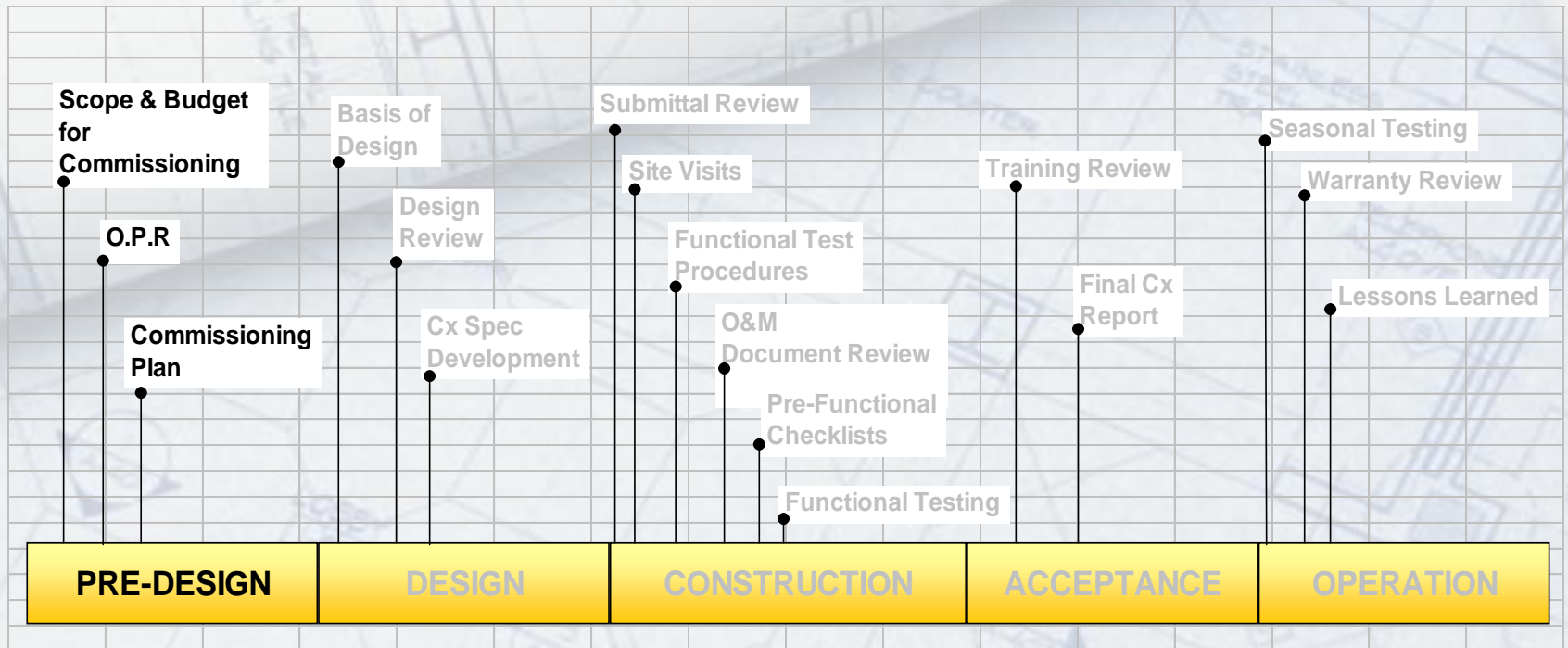
OPERATION

There are several tasks integrated into every phase

# Commissioning Process Overview



# Commissioning Process Overview



# Commissioning: Pre-Design Phase

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Owner Selects CxA
- Create a Scope & Budget for Commissioning with the Owner
- Review/Document Owner's Project Requirements (OPR)
- CxA Creates Commissioning Plan

# What is the OPR?

- The Owner's Project Requirements is a written document that details the functional requirements for a project
- The Owners expectation of how the building will be used and operated.

# Why is the OPR important?

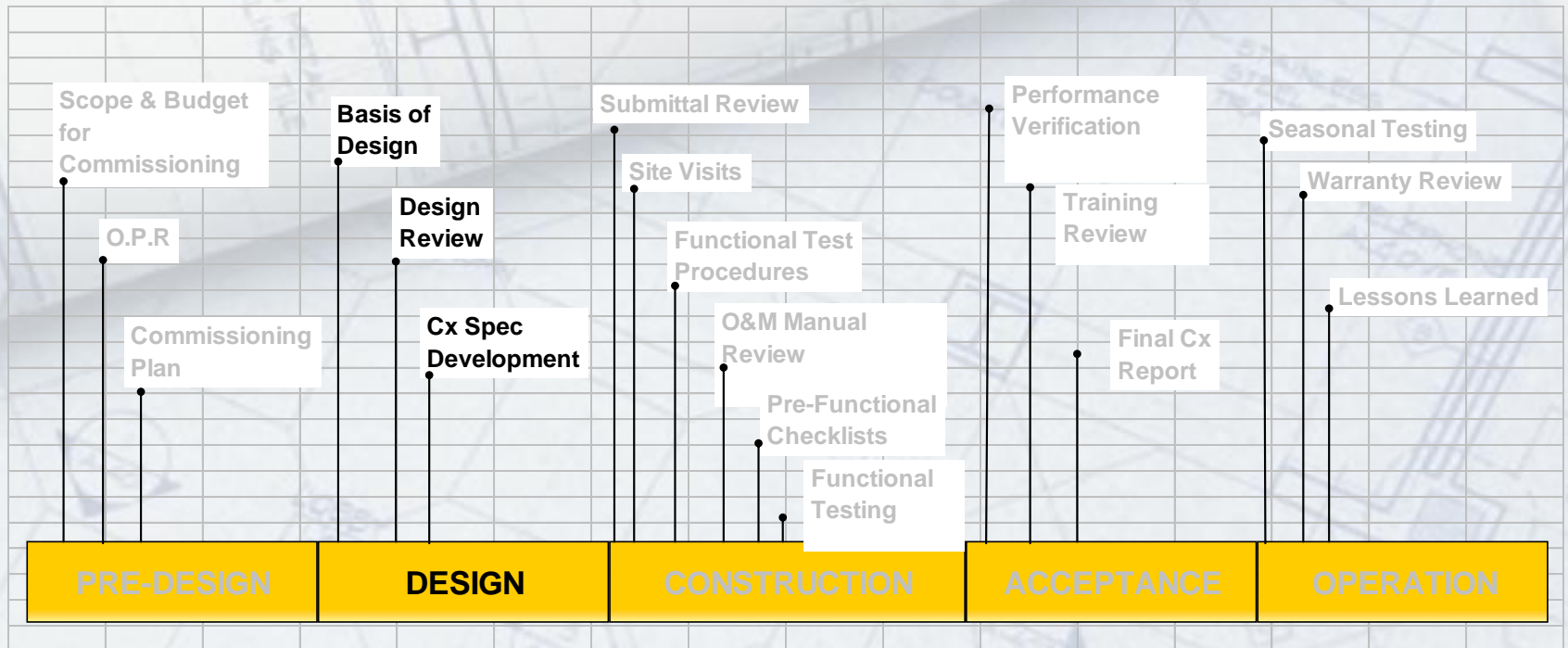
- The OPR is the opportunity for the Owner to set a documented quality expectation for the project
- The OPR will serve as the basis for evaluating whether the Design and Construction has been completed to the Owner's satisfaction

# The Commissioning Plan

The Cx Plan is a living document that outlines the organization, schedule, allocation of resources and document requirements of the commissioning process.

- OPR
  - Basis of Design
  - Communication / Roles & Responsibilities
  - Cx Specifications
  - Pre-Functional & Functional Checklists
  - Performance Verification Procedures
- Issues Log
- Report

# Commissioning Process Overview



# Commissioning: Design Phase

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Basis of Design Review
- Review of Design Plans & Specs
- Provide Cx Specifications to be included in the construction documents
- Update Commissioning (Cx) Plan

# Basis of Design

- A more detailed / defined OPR. Design Professional must read the OPR before starting BOD
- OPR gives the direction – BOD will indicate how it will be accomplished
- BOD shall include: Occupancy schedule, codes, guidelines, equipment types, systems descriptions, special requirements, etc.
- See ASHRAE Guideline 1.1-2007

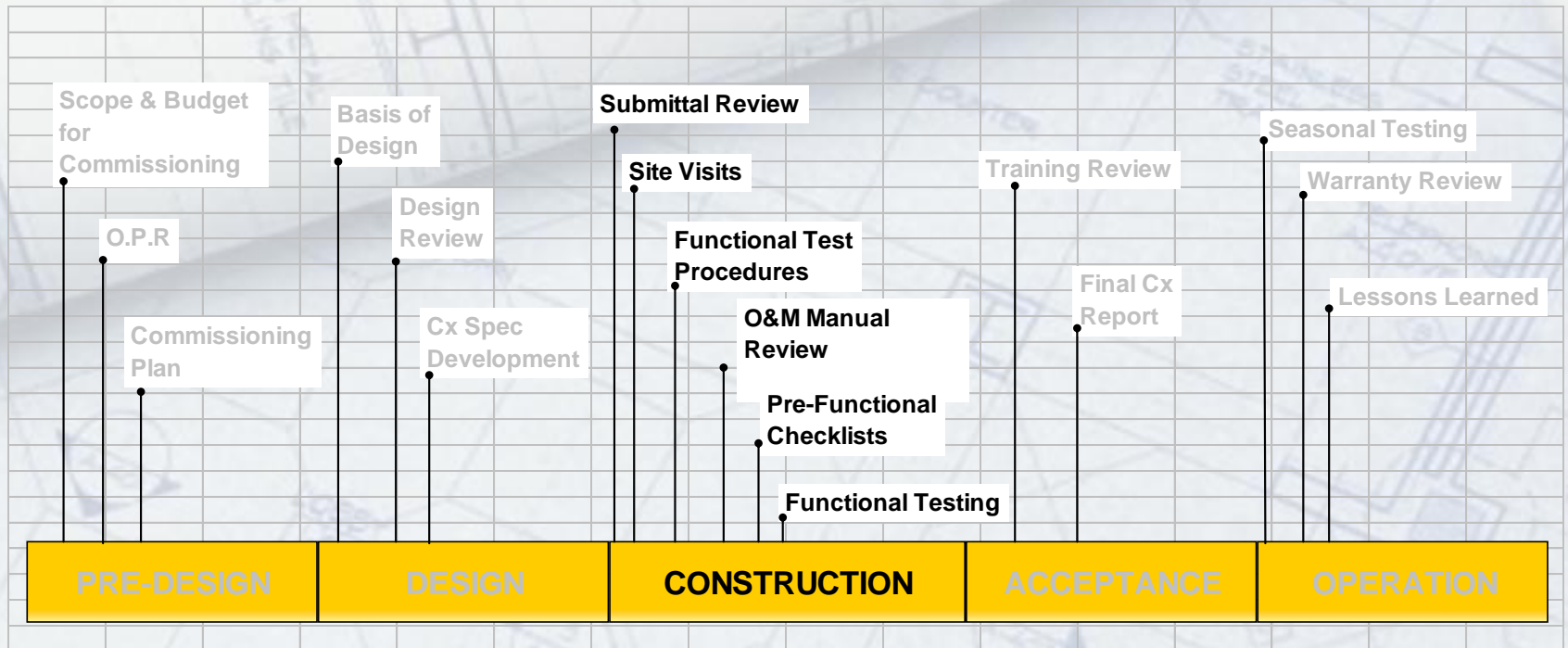
# Review of Design Documents

- Commissioning Review is not Peer Review or Code Compliance Review
- Review to determine if design info provides sufficient clarity and consistency by which systems can be commissioned and maintained.
- Depth of reviews

# Commissioning Specifications

- Indicates to the contractor to follow the commissioning plan.
- The specifications will refer to other specification sections & to industry guidelines.
- Specifies equipment and systems to be commissioned
- The Performance testing requirements & special test methods required.
- Type of training / O&M manuals

# Commissioning Process Overview



# Commissioning: Construction Phase

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Pre-Comm Meeting
- Review Contractors Submittals
- Pre-Functional Checklists
- Create Functional Testing & Performance Verification Procedures
- Update Commissioning Plan
- Post Submittals Comm Meeting
- Site Visits and / or Construction Observations

# Commissioning: Construction Phase, cont.

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Observe Functional Testing & Performance Verification
- Document issues with an Issues Log
- Deficiency correction and retesting
- Review Systems/O&M Manuals

# Checklists & Forms

- Pre-Functional: Checklists created by the CxA to verify that equipment, systems and components are installed per design; equipment ready for operation.
- Checklists can be equipment or systems based

# Checklists & Forms

- Functional Testing: Checklists to validate that equipment, systems and components operate.
- Operation may or may not equate to verifying performance

# Checklists & Forms

- Performance Verification: Procedures established to verify that systems perform in accordance with design.
- Deferred seasonal testing often required for HVAC systems

Condensing Boiler

Sections 15501,15513

B - \_\_\_\_\_

Service:

Checklist Item	CA	CM	MC	ATC	TAB	O	EC	MFR
<b>Documentation</b>								
Submittal Approved								
Factory Test Report submitted								
Field Test Reports								
O&M Info								
<b>Boiler Start-Up Report (15513 ¶3.61)</b>								
<b>Burner Start-Up Report (15501 ¶1.91)</b>								
<i>Mfr start-up services complete (15501 ¶1.91, 15513 ¶3.61)</i>								
<i>Mfr training complete (15513 ¶3.81)</i>								
<i>Training Video (15050 ¶3.81 E)</i>								
<b>Installation – General</b>								
Housekeeping pad installed								
Piping installed per diagrams & details								
Maintenance access & clearances provided								
Relief valve set & piped to drain								
Temp/pressure gauges installed (1)								
Wells installed for BAS sensors								
<b>Installation – Control</b>								
Operating aquastat properly adjusted								
Hi-Limit aquastat properly adjusted								
Low water cut-off properly adjusted								
BAS interface (15513 ¶2.34 B)								
<b>Electrical</b>								
Power to blower								
Power to burner control cabinet								
Emergency shut-off switch installed (2)								
<b>Fuel System</b>								
Gas piping pressure tested and leak free								
Gas train install & vented per specs								
Adequate gas pressure at gas train inlet verified by mfr's rep.								
<b>Combustion Venting</b>								
Vent provided per contract								
Inlet provided per contract (3)								
<b>Testing &amp; Balancing</b>								
Water flow balanced to design								
Balancing Report Submitted								

Comments:

1. Installation/connection detail not found in contract documents – refer to diagram on M3.1.
2. Not found in contract documents.
3. Intake not specified.

Ventilation Energy Recovery Unit: ERU – \_\_\_\_\_

1. Performance verification shall start with the ERU OFF in the unoccupied mode.
2. Command unit to occupied mode.
3. Verify night dehumidification.
4. Verify occupied mode of operations.
5. Verify safeties.

1. **UNOCCUPIED:** Supply and exhaust fans are off; outdoor air (face & by-pass) damper(s) closed, exhaust damper closed; re-circ damper open, EMS water control valve closed (2-way) or in by-pass (3-way); Mfr's head pressure control valve closed or in bypass.

	Owner's Rep. Initials:	Date	
Unoccupied Mode		Pass	Fail
ERU off, output off			
Supply fan off, input off, alarm - normal			
Exhaust fan off, input off, alarm-normal			
Outdoor air and exhaust air dampers closed; re-circ damper open (via visual verification)			
Water valves closed or in by-pass			

Comments/Notes:

2. **OCCUPIED MODE:** OA & Exh dampers open; supply & exhaust fans start after dprs end-switches make. Re-circ dpr closes. ERU supply/exhaust fans are running. Outdoor damper and exhaust air dampers are open and exhaust air bypass damper is closed.

	Owner's Rep. Initials:	Date	
Occupied Mode		Pass	Fail
ERU on, output on			
Supply fan on, input on, alarm - normal			
Exhaust fan on, input on, alarm-normal			
Outdoor air and exhaust air damper open (via visual verification)			
Exhaust air bypass damper closed (via visual verification)			
HX F&B damper full open to HX (via visual verification)			
Condensing unit enabled, input on			
Heating coil control valve modulation (via visual verification)			

Comments/Notes:

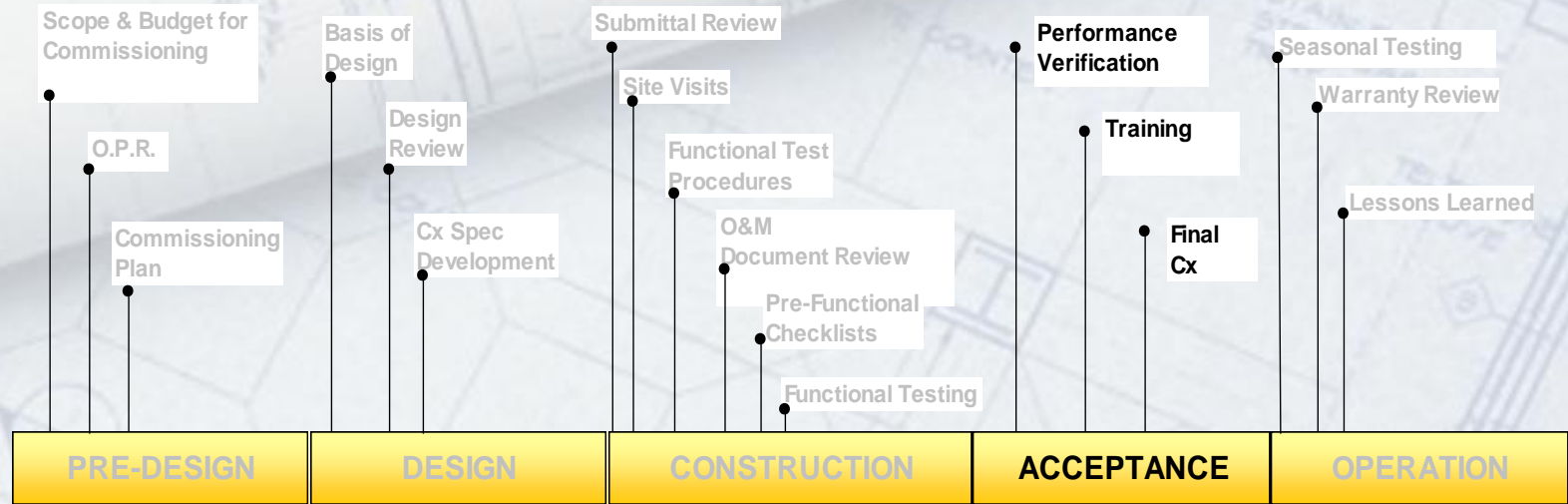
5. **Winter Defrost Mode:** Perform this portion on the FPT when the outdoor air temperature is below 25°F.

	Owner's Rep. Initials:	Date	
Winter Defrost Mode		Pass	Fail
Outside temperature below 25°F			

# O&M Manuals

- Review
- Reference and Training tool

# Commissioning Process Overview



# Commissioning: Acceptance Phase

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Systems Performance Verification
- Training of operations & maintenance staff
- Make adjustments for occupancy period
- Summary Report

# Performance Verification

- Most systems, other than HVAC, performance verified via functional testing.
- HVAC performance verifications requires completion of testing and balancing and building operating under automatic control.

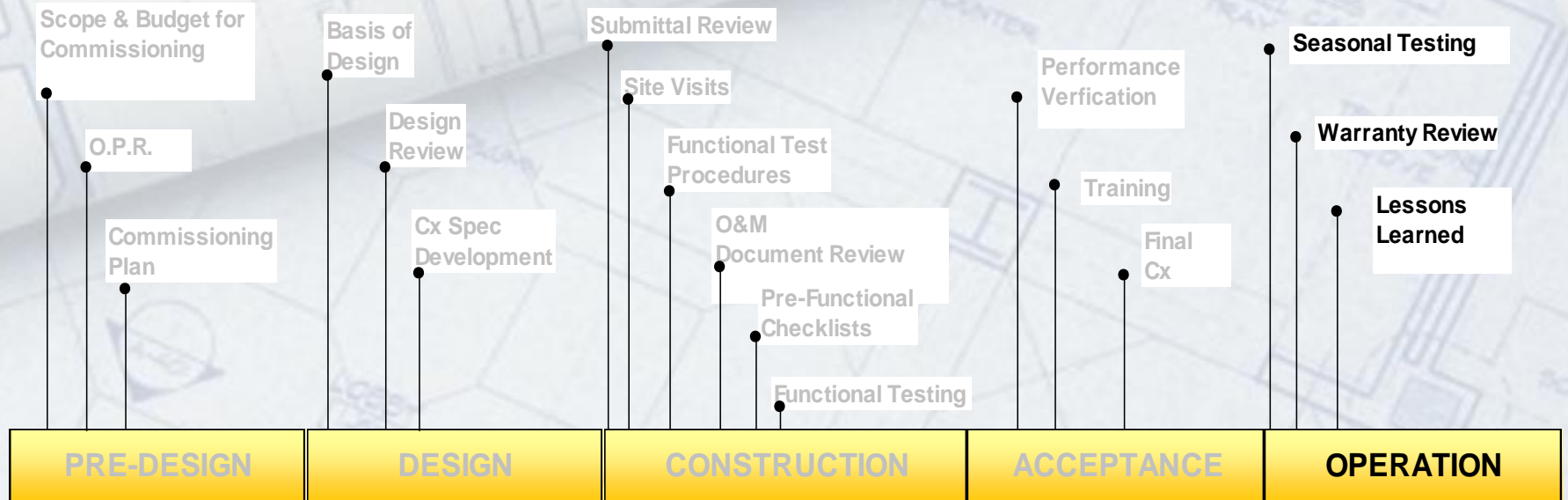
# Training

- CxA shall review training schedule, materials, content and attendance
- Confirm that the operation staff has an understanding of the “Systems” operations not just the equipment
- Who should attend?
- Design Engineer and CxA involvement

# Commissioning Report

- Must be presented to the owner within reasonable time and must include:
  - Executive Summary
  - Basis of Design Review
  - Testing Results Summary
  - Deficiency List & History
  - Outstanding Issues
  - Deferred Testing Identified

# Building Systems Commissioning



# Commissioning: Operation Phase

PRE-DESIGN

DESIGN

CONSTRUCTION

ACCEPTANCE

OPERATION

- Seasonal Testing
- Warranty Review (10 months after acceptance)
- Lessons Learned Meeting

# Warranty Review Services

- CxA verifies that the contractor provides all equipment warranties to the owner
- Verify the start of warranty (usually starts upon beneficial usage)
- Check with Operations / logs that equipment being maintained in accordance with manufacturers recommendations
- Owner's RFP needs to define CxA scope
- Project Specifications needs to identify contractor's role in warranty period.

# LEED Commissioning

## **Energy and atmosphere prerequisite 1 (EAP 1)**

### Requires

- OPR
- Basis of Design
- Commissioning Plan
- Commissioning Specifications
- Performance Verification Documentation (Functional Performance Tests)
- Commissioning Report

## **Energy and Atmosphere Credit 3 (EAC3)**

- All of the Above
- Design Review (at 50% Completion)
- Review Contractor Submittals
- Develop a Systems Manual for Staff
- Verify Training and Completion
- Review Building Operation 10 Months After Completion

# Benefits of Commissioning

- Reduce Change Orders
- Verification that Systems Operate as Intended
- Energy Savings and Performance
- Health, Safety and IAQ
- Less Contractor Call Backs

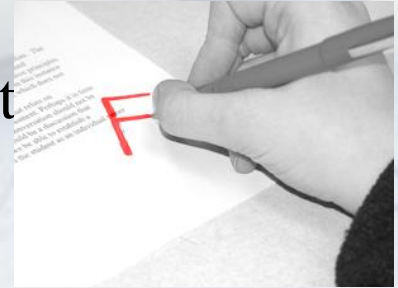
# Objections to Commissioning

“Haven’t I already paid for a quality building in my design and construction fees?”

- Designer’s (A/E) services typically do not include field verification of the operation of building systems
- Construction Manager’s services typically do not include verification that the installed systems meet design intent (OPR).

# Misconceptions

The CxA is not a peer review to point out the Design Professional mistakes. He is not a fault finder or accuser but is a team builder that will use the Cx process for everyone's benefit.



The CxA is not a referee between the Design Professional and the Construction Team.



The CxA is not “the hammer” that pounds on the contractors.



# Commissioning Economics

- Commissioning service fees are a function of the building systems complexity and extent of services required by the owner
- Commissioning services are selected by task and phase.

# Cost of Commissioning

Estimated Commissioning Authority Costs to Owner for Construction and Occupancy/Operation Phases:

## Commissioned Systems Cost

## Total Commissioning

HVAC and Controls (a)

2.0 to 3.0% of mechanical

Electrical System (b)  
electrical

1.0 to 2.0% of

HVAC, Controls and Light Electrical

0.5 to 1.5% of construction

Sources:

(a) Wilkinson, R. (2000). Establishing Commissioning Fees, ASHRAE Journal 42 (4):41-47.

(b) PECEI (2000). The National Conference on Building Commissioning Proceedings, Portland Energy Conservation Inc. OR.

Printed in New Building Commissioning, 2003 ASHRAE Applications Handbook, 42.10

# VALUE OF COMMISSIONING

2009 Study by LBNL (Mills), funded by DOE, with support from NEEA, PECI, NYSERDA...

***“These findings demonstrate that commissioning is arguably the **single-most cost-effective strategy** for reducing **energy, costs, and greenhouse gas emissions** in buildings today”***

*- LBNL Study Conclusion Statement, “Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions”*

# Evan Mills. 2009. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions"

## Key findings:

- Median commissioning costs: \$0.30 and \$1.16 per square foot for existing buildings and new construction, respectively (and 0.4% of total construction costs for new buildings)
- Median whole-building energy savings: 16% and 13%
- Median payback times: 1.1 and 4.2 years
- Median benefit-cost ratios: 4.5 and 1.1
- Considerable reductions in greenhouse-gas emissions were achieved, at a negative cost of -\$110 and -\$25/tonne CO<sub>2</sub>-equivalent.

# Evan Mills. 2009. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions"

## Key findings (continued):

- Non-energy benefits are extensive and often offset part or all of the commissioning cost.
- Limited multi-year post-commissioning data indicate that savings often persistent for a period of at least five years.
- Uniformly applying our median whole-building energy-savings value to the stock of U.S. non-residential buildings yields an energy-savings potential of \$30 billion by the year 2030, and annual greenhouse gas emissions reductions of about 340 megatons of CO<sub>2</sub> each year. An industry equipped to deliver these benefits would have a sales volume of \$4 billion per year and support approximately 24,000 jobs.

# Questions?

**For additional information on the BCA  
[www.bcxa.org](http://www.bcxa.org)**

