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## The Commissioning Process: A Step-by-Step Guide

WHITE PAPER

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A solid understanding of the commissioning (Cx) process — what it is and how it works — can provide a range of benefits for building owners and facility managers. Commissioning is a process designed to optimize the built environment for energy efficiency, leading to reduced energy costs and enhanced building performance. It is also a way to verify that a new building's processes operate according to the owner's project requirements (OPR).

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) defines Cx as “a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems and assemblies meets defined objectives and criteria.” Cx is the integration of the planning, delivery, verification and risk management of a building's functions. It is not another layer or step in the design-build process; rather, it is a means to produce buildings that do everything they are supposed to do throughout the building's life cycle.

### What Commissioning Does

One easy way to illustrate the effects of commissioning is to compare a building to a human body. Both have an outer layer of skin that protects the inner functions from the elements. Both have an electrical system, a heating and cooling system, a frame to support their weight, and even a plumbing system — as well as a distinctive personality expressed by their appearance.

Now, imagine a person's body could be commissioned to function at optimal levels. It would have no health problems. It would never get sick. It would have perfect vision and perfect hearing, and it would perform any physical task with athleticism. Cx plays the combined roles of personal trainer and doctor for your building, producing an alpha structure that far outperforms its non-commissioned counterparts.

According to the National Institute of Building Sciences' “Whole Building Design Guide,” one of the main benefits of implementing Cx is cost savings. Cx produces a monetary and emotional return on investment with reduced energy costs and peace of mind in the form of reduced change orders, reduced contractor claims, reduced contractor callbacks, avoided project delays, improved project scheduling, improved documentation development and improved communications to keep the project team focused on properly turning over a facility.

Other benefits include a more comfortable environment for building occupants, improved air quality, increased reliability and uptime, reduced maintenance and longer life cycles for building equipment. Cx can be implemented with many systems across a range of projects and at any stage of a facility's life cycle.

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### Types of Commissioning

There are four primary types of Cx:

**New construction commissioning** — This begins when the building is just an idea, a drawing or a schematic and is typically just called “commissioning.” It is a systematic process of verifying and documenting that a facility and all of its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner’s project requirements (OPR). Ideally, the commissioning process begins in predesign, continues into the warranty period for a minimum of one year after construction, and involves the proper preparation of operations personnel.

**Re-commissioning** — Also known as ongoing Cx, the Cx process is repeated after a project has been commissioned previously. This may be preferred option as system performance drifts and/or technologies change and advance over time, making it possible to restore the efficiency of a previously commissioned building and potentially enhance optimization further.

**Retro-commissioning** — When the Cx process begins after a building has already been built but has not been put through the commissioning process, a building’s systems are tested and tuned to perform optimally for the current facility requirements. Low-cost and no-cost improvements such as energy conservation measures or reliability enhancements are also recommended, implemented and then commissioned to ensure proper performance.

**Monitoring-based commissioning** — Known as MBCx, this process involves innovative commissioning techniques combined with new technology to integrate energy management, utility and building automation data with analytical and diagnostic algorithms that identify actual energy savings and performance enhancement opportunities in real time and ongoing. MBCx seeks to resolve performance issues as they surface and continually refine facilities so that greater than design performance (i.e. technical potential) is achieved over time.

Commissioning first gained prominence in the late 1970s and early 1980s. The Walt Disney Co. included commissioning in the design, construction and startup of Epcot Center in 1981. In 1984, the University of Wisconsin-Madison began to offer classes in commissioning, and in 1989, the University of Michigan established a commissioning group as part of its institution. And in 1994, Executive Order 12902 established that a commissioning program is required for all federal agency buildings. Commissioning has become an integral piece of sustainable building practice, and some level of functional commissioning is required for a building to attain LEED certification from the U.S. Green Building Council.

### Implementing Commissioning

The Building Commissioning Association (BCA) publishes a series of best practices to aid the successful implementation of Cx for design-build, retro-commissioning or recommissioning projects. The BCA is a nonprofit organization with the stated purpose of “creating and supporting the highest standards for the commissioning profession” and a charge to “champion industry standards, policies and building codes that meet the future as challenges arise.” The material that follows is derived from the BCA’s publication, “New Construction Building Commissioning Best Practice.”

The commissioning authority (CxA) leads the Cx process like a coach leads a sports team, so the selection of a CxA is a critical decision. When evaluating who to hire as the CxA for your project, consider:

- Previous experience as a CxA on similar projects.
- Ability to serve as your advocate independent of the desires and opinions of the design or construction team; the CxA should understand the owner’s goals.
- Communication and interpersonal skills — a CxA should be able to point out inconsistencies and make suggestions for improvement with diplomacy and without confrontation. A CxA should be able to communicate effectively to work cohesively with the project team to help build trust and create an environment where creative ideas and problem solving are welcomed and encouraged.
- Field experience in construction, O&M, testing and troubleshooting building systems.
- Credentials, background and education, company focus, client testimonials, and local presence for accessibility.

Cx is most effective when it begins in the predesign phase. A building owner or the owner’s representative should assemble the commissioning team and begin to define the OPR. The commissioning team includes the owner or an owner’s representative, a commissioning authority (CxA), the design team, operations and maintenance (O&M) personnel, the construction team, and, preferably, someone to speak for the occupants who will use the building once it’s complete.

The OPR communicates the owner’s expectations, goals and success criteria with measurable benchmarks to the rest of the team. It should be developed during the predesign phase with the input and guidance of the CxA, who will help the owner objectively incorporate input from the design team, construction team, O&M personnel and the building’s occupants. The CxA also defines the scope of Cx for the project as part of the Cx plan and incorporates this information into the project’s overall schedule and budget.

During the design phase, the CxA verifies the design development is consistent with the OPR. The CxA’s objectives are to communicate the Cx requirements to the project team members, perform an independent review of the design documentation, verify that Cx is included in

## The Commissioning Process: A Step-by-Step Guide

construction documents, and facilitate cooperation among the project team members. The CxA creates a Cx plan to document the Cx process, roles and responsibilities, systems commissioned, and Cx schedule, and communicates the Cx plan to the contractor during a commissioning kickoff meeting.

During the construction phase, the CxA verifies that equipment and systems are properly installed and integrated per the design to meet the OPR by performing installation site observations, witnessing system startups and third-party evaluations such as testing and balancing (TAB) or InterNational Electrical Testing Association (NETA) testing, and verifying prefunctional checklists completed by the contractor.

As the building nears substantial completion, the acceptance phase of commissioning begins. The CxA works with the project team to complete functional performance testing, integrated systems testing, and training to verify successful turnover to O&M personnel, optimize building performance and evaluate project success. The CxA works with facility maintenance personnel to develop a commissioning manual for ongoing maintenance.

Finally, during the occupancy phase, the commissioning authority makes periodic trips to the project site to perform any deferred or seasonal testing. A review of the entire facility is conducted 10 months into the warranty period and a final commissioning record is developed.

This outline represents a typical approach to commissioning a new facility. An appropriately planned and executed process should be adapted suit project scale, complexity, criticality and unique client needs regarding level of assurance required. Variants of the process exist for specialty industries such as mission critical, health care, pharmaceutical and others; they should be considered when scoping commissioning and selecting a CxA.

### Systems Commissioned

The types of systems that can be commissioned include but are not limited to:

- Mechanical
  - HVAC
  - Chilled water
  - Hot water
  - Steam
  - Piping
  - Plumbing

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- Electrical
  - Generators
  - Switchgear/transformers
  - UPS systems
  - Grounding/bonding
  - Lighting and lighting control
  - Photovoltaic
  - Electrical metering
- Fire & Life Safety
  - Fire suppression
  - Fire alarm
- Integrated Systems
  - Building automation
  - Direct digital controls (DDC)
  - SCADA
- Specialty Systems
  - Security
  - Voice/data
  - Automated manufacturing
  - Airport baggage handling
  - Nurse call
  - Wastewater treatment
  - Fuel cells
  - Renewable energy
  - Vertical and horizontal transport
  - Combined heat and power (CHP)
- Building Envelope
  - Wall assemblies
  - Fenestrations (windows and doors)
  - Roof construction
  - Waterproofing

### Conclusion

In the end, the building owner, facility manager and design team can be confident that the systems installed and spaces created will function according to their original design intent. Over the life of the building, its performance will be optimized to save energy and reduce costs. Other benefits, defined by the “Whole Building Design Guide,” can include a safe and healthful facility, well-trained O&M personnel, and better building systems documentation. Owners may also

## The Commissioning Process: A Step-by-Step Guide

achieve savings of \$4 in the first five years of building occupancy for every \$1 spent on commissioning, according to the guide. The cost of not commissioning may well be even higher.

To circle back to the analogy comparing the commissioning process to the human body, the commissioning process is like an apple a day and a personal trainer. It helps keep the building in tip-top shape, so that it performs at its optimum level.

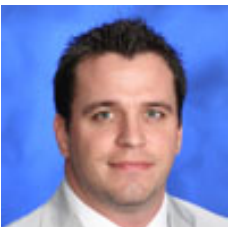
### Additional Resources

- The Building Commissioning Association (BCxA), [www.bcxa.org](http://www.bcxa.org)
- Associated Air Balance Council (AABC) Commissioning Group, [www.commissioning.org](http://www.commissioning.org)
- Association of Energy Engineers (AEE), [www.aeecenter.org](http://www.aeecenter.org)
- The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), [www.ashrae.org](http://www.ashrae.org), and ASHRAE Guideline 0, <https://www.ashrae.org/education--certification/instructor-led-courses/commissioning-process--guideline-0>
- The National Institute of Building Sciences “Whole Building Design Guide,” [www.wbdg.org](http://www.wbdg.org)
- The U.S. Green Building Council (USGBC), [www.usgbc.org](http://www.usgbc.org)
- The National Association of Energy Service Companies (NAESCO), [www.naesco.org](http://www.naesco.org)
- The U.S. Department of Energy (DOE), [www.energy.gov](http://www.energy.gov)

### About the Authors



**Brian Lindstrom, PE, DCEP**, is the commissioning practice leader at Burns & McDonnell. He has commissioned more than 14 million square feet of complex and critical facilities valued at more than \$6 billion and been responsible for retro-commissioning more than 10 million square feet of existing space worldwide. He is a registered professional engineer, certified data center energy practitioner and earned his bachelor’s degree in mechanical engineering from Kansas State University.



**Brian Schwartz, CxA, CCP, LEED AP BD+C**, is a manager of commissioning and has developed automation solutions and performed the necessary commissioning and training activities to demonstrate the systems’ performance. His experience has given him exceptional strengths working in a team environment and providing effective project documentation. He earned his bachelor’s degree in industrial engineering from the University of Minnesota-Duluth.