

# State of California Guide to Commissioning

[Logo(s): CCC/CEC/DGS ???]

January, 2006

## Acknowledgements

**The information in this document draws on several existing guides to commissioning:**

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). *Guideline 0-2005, The Commissioning Process* (2005).

California Department of General Services. *Adopting the Commissioning Process for the Successful Procurement of Schools* (January, 2003), prepared by Farnsworth Group.

Collaborative for High Performance Schools (CHPS). *Best Practices Manual* Vol. I “Planning,” and Vol. II “Design,” (2002).

Energy Design Resources. *Building Commissioning Guidelines* (no date).

Efficiency Vermont. *Commissioning for Better Buildings in Vermont – An Owner’s Guidelines* (unpublished), prepared by Portland Energy Conservation, Inc. (PECI).

**Many people contributed their time and expertise to writing and reviewing this guide:**

## About this Guide

**Comment:** Reviewers: This page will be revisited once the guide is complete.

This Guide describes the building commissioning process. You can read it cover-to-cover, or skip around to find just the information you need.

Building commissioning is a quality assurance process that spans the entire design and construction process, helping ensure that the new building's performance meets owner expectations. This Guide is written for building owners and managers, but others involved in the commissioning process will also find it useful.

The Guide answers the following questions:

**Comment:** Reviewers: We suggest using a graphical element to tie each bullet to the chapter in which the info is found (in order from 1 → 6)

- What is building commissioning and why should I use it?
- What are the benefits and costs of commissioning?
- What happens during the commissioning process and how does it relate to design and construction?
- How do I hire a commissioning provider and integrate him/her into my existing team?
- How will the commissioning process help me ensure efficient operations at my facility over the long term?
- How do I get started with commissioning?

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# 1. Introduction

This chapter introduces the building commissioning process. It answers the questions:

- What is building commissioning?
- What are the goals of the commissioning process?
- Why is commissioning important?

## Online Resources

[www.cacx.org](http://www.cacx.org)

**California Commissioning Collaborative**  
Contains a collection of commissioning and energy efficiency case studies

[www.usgbc.org/LEED](http://www.usgbc.org/LEED)

**U.S. Green Building Council**  
LEED (Leadership in Energy and Environmental Design)  
Green Building Rating System

## Publications

*What Can Commissioning Do for Your Building?* Written by PECI (no date).

**Comment:** Reviewers: We suggest listing both online and print resources at the beginning of each chapter. Please suggest whether this section is useful here, and additional resources.

## What is Building Commissioning?

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. Before being awarded this title, however, a ship must pass several milestones. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems and staff have successfully completed a thorough quality assurance process.

Building commissioning takes the same approach to new buildings. When a building is commissioned it undergoes an intensive quality assurance process that begins during design and continues through construction and occupancy and operations. Commissioning ensures that the new building operates as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.

Commissioning can also be performed on existing buildings. This type of commissioning, known as retrocommissioning, identifies operations and maintenance (O&M) measures that solve operational and comfort problems to improve the building's performance.

Recommissioning is another type of commissioning. Recommissioning occurs when a building that has already been commissioned undergoes another commissioning process. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. Recommissioning is required [as a result of Executive Order 20-04 for all State of California](#) buildings over 50,000 square feet in size, every five years. Ideally, a plan for recommissioning is established as part of a new building's original commissioning process.

### **Definition: Building commissioning (Cx)**

Building commissioning, often abbreviated as "Cx," is a quality assurance process that spans the entire design and construction process, helping ensure that the new building's performance meets owner expectations.

### **Note**

For more information on retrocommissioning, consult the full-length *State of California Guide to Retrocommissioning*, a companion to this publication.

### **Cross reference**

A more detailed discussion of recommissioning can be found in *Chapter 5: Strategies for Promoting Efficient Operations over the Long Term*.

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## Goals of the Building Commissioning Process

All forms of building commissioning share the same goal: to produce a building that meets the unique needs of its owner and occupants, operates as efficiently as possible, provides a safe, comfortable work environment, and is operated and maintained by a well-trained staff. The commissioning process is a team effort, usually led by a third-party commissioning provider, who verifies that the building meets the owner's expectations at each stage of the design and construction process.

Commissioning has several specific goals. To meet them, the commissioning provider will:

Document the building's functional and performance requirements. The commissioning provider works with the owner and design team to ensure that the *Owner's Project Requirements (OPR)* document clearly describes the owner's performance and maintainability criteria. Ideally, this occurs during the design phase of the project.

Provide tools and documentation to improve the project team's deliverables. These include *Issues Logs*, which track issues from identification to resolution at each phase of development, and a *Commissioning Report*, which documents the results of inspections and functional performance tests.

Verify and document that systems perform as specified in the OPR. To ensure that the building will perform as expected, the commissioning provider observes equipment start-up, writes and observes functional testing, verifies that control system calibration, and testing, adjusting and balancing have been performed satisfactorily, and documents these activities.

Verify that the building owner and manager receive adequate and accurate system documentation, and staff training. The commissioning provider ensures that these requirements are included in the specifications, tracks

### **Definition: Commissioning Provider**

The person responsible for leading the commissioning process and planning, scheduling and coordinating the commissioning activities.

### **Definition: Owner's Project Requirements**

A written document that details the owner's functional requirements for a project and expectations for how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

**Comment:** Reviewers: All bullets below will be cross-referenced to the appropriate chapters.

their delivery, and may oversee the work of training providers in developing curriculum and conducting training sessions.

Bring a holistic perspective to the design and construction process that integrates and enhances its traditionally separate functions. The commissioning process brings project team members together on a regular basis and encourages the group to work together to solve problems.

## ***Why is Commissioning Important?***

In today's complex buildings, systems are highly interactive. Increased system interactivity, together with the nearly universal presence of control systems, results in a trickle-down effect on building operations: small problems can have big effects on performance.

No matter how carefully a building is designed, if the systems, equipment and materials are not installed and operating as intended, the building will not perform well.

Now more than ever, efficient operations require subsystems and components that work efficiently and reliably, and a building staff with the knowledge and resources to maintain them. But in today's construction environment, project team members are more cost-conscious than ever, and seldom is there adequate budget allocated to quality assurance processes.

The result of this conflict? Poorly performing buildings, in which:

- System and equipment problems result in higher than necessary utility bills;
- Unexpected or excessive equipment repair and replacement cost the owner money and eat up staff time;
- Poor indoor environmental quality causes employee absenteeism, tenant complaints and turnover, and, in the most severe cases, leads to lawsuits and expensive retrofits.

Building commissioning is a proven solution to the problem of poor building performance. As a process, rather than a set of prescriptive measures, building commissioning adapts to meet the unique needs of each building's owner, design team and future occupants. Commissioning:

- Brings the owner's needs and project requirements to the forefront at each phase of the project to ensure that the finished product will meet

expectations.

- Improves the building's overall performance by optimizing energy-efficient design features, and directly addressing issues like equipment performance testing and system integration.
- Verifies that building staff members are well-trained and in possession of the documentation they need to operate and maintain the building's systems and equipment after turnover.

# Commissioning and LEED

## ***What is LEED™?***

LEED stands for Leadership in Energy and Environmental Design, a green building rating system developed by the U.S. Green Building Council (USGBC).

LEED helps owners, architects, engineers and contractors evaluate a facility's "environmental performance from a whole building perspective over a building's life cycle" and provides "a definitive standard for what constitutes a 'green building.'"

Construction projects using the LEED system can receive one of four ratings: Certified; Silver; Gold; and Platinum.

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## ***What is the LEED rating system?***

The LEED guidelines specify the criteria that define environmentally superior buildings in each of six categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design process

In order to be LEED certified, a project must meet all the "prerequisite" requirements in each category. Projects then earn "points" by selecting more advanced criteria from various categories. The more points a project earns, the higher its LEED rating. This point system allows projects a great deal of flexibility in producing a LEED certified building. Upon completion, a certification package is created that documents the measures that were implemented, and the USGBC evaluates the submission and grants a LEED Rating along with a plaque and recognition on the USGBC website.

## ***What are the LEED commissioning requirements?***

All buildings seeking LEED certification must implement a commissioning process that meets the LEED rating system guidelines. The LEED guidelines also identify more advanced commissioning tasks that may be incorporated to earn an "additional point." Many of the measures that will be incorporated to achieve the level of energy efficiency required for a LEED rating are sophisticated and interdependent. Therefore, commissioning would be advisable even if it weren't required, to ensure that the building performs as well in reality as it did on paper.

Projects undertaking LEED certification should consult the most recent version of the *LEED Green Building Rating System* for detailed information. More information about the LEED rating system can be found on the U.S. Green Building Council's website at [www.usgbc.org](http://www.usgbc.org).

## 2. Benefits and Costs of Commissioning New Buildings

The benefits of starting commissioning early in a new building project are numerous. They include both energy savings and other, significant non-energy benefits. This chapter discusses what a building owner or manager should expect in benefits as well as costs.

This chapter answers the questions:

- How does commissioning reduce a building's energy use?
- What cost savings can an owner expect?
- What are the other benefits of commissioning?
- How much does commissioning cost?

### Online Resources

### Publications

"The Cost effectiveness of Commercial-Buildings Commissioning" (2004). Evan Mills, Lawrence Berkeley National Laboratory.

## Energy Savings

**More and more building owners want to reduce energy use in their facilities. Building commissioning ensures that the building's systems and equipment, as well as any special energy efficient features, are installed and working correctly.**

Once a building owner makes energy efficiency a priority, the commissioning provider will ensure that the delivered building realizes the owner's goals. When a new building operates as efficiently as possible while meeting the owner's expectations, commissioning has been successful.

The commissioning provider employs several strategies to reduce a building's energy use. Early in the design phase, the provider raises the team's awareness of energy by exploring the consequences of different design choices on energy use. In design review, the provider looks for design issues that may lead to inefficient system operation and wasted energy, like coincident heating and cooling. The commissioning provider also identifies places where energy efficiency measures might fail, once they are integrated with the rest of the system.

During construction, the commissioning provider ensures that delivered equipment meets the owner's energy efficiency specifications. The provider also observes installation to ensure that the equipment is installed and working correctly. For example, during functional testing, commissioning helps resolve controls system programming deficiencies that would result in inefficient operations.

Although it is difficult to quantify energy savings for new buildings without the necessary baseline data, commissioning will ensure that those energy efficiency features required by California's Title 24 Standard, or by the owner, will work as efficiently as possible.

### Note

Building commissioning is an effective way to meet energy efficiency goals. In California, state-owned buildings are required to reduce their energy consumption by at least 20% by 2015.

*State of California Green Building Action Plan, March 2005. Detailed Direction that accompanies Governor's Executive Order S-20-04. Section 1.1.2.1.*

### Quote:

From building owners/managers offering examples of how Cx saves energy.

Energy and its related cost savings used to be the most commonly mentioned benefit of commissioning. While energy savings are significant, many owners and occupants find that commissioning's other benefits are equally important.

## Commissioning's Other Benefits

**Commissioning's other benefits are far-reaching. Each of the participants in the design and construction process will benefit from commissioning, and so will the building's owner, staff and future occupants.**

These benefits include:

- Construction cost savings
- Improved indoor air quality, comfort, productivity, and reduced liability
- More effective equipment operation
- Improved coordination between design, construction, and occupancy
- Fewer system deficiencies at building turnover

## Construction Cost Savings: The Benefit of an Early Start

When commissioning starts during the design phase of a new construction project, the result is significant cost savings. Errors caught on paper, rather than on the job site, are much less expensive to fix. Because commissioning identifies and helps resolve potential problems, it reduces costly change orders and contractor call-backs. This in turn helps keep the project on schedule and on budget.

Owners who wonder how they will pay for commissioning with a limited design and construction budget should think about transferring construction phase cost savings to the design and commissioning budgets. In fact, when construction cost savings are taken into account, commissioning can pay for itself.

## Improved Indoor Air Quality, Comfort, Productivity, and Reduced Liability

The quality of a building's **indoor environment** affects the health, comfort and productivity of its occupants. Poor indoor air quality can have many causes:

- Moisture and mold in the building envelope

### **Note: Cost Savings from Commissioning**

Commissioning can produce significant cost savings in a new building project. Cost savings are usually presented as a range, since actual savings vary depending on the building type, its location, and the scope of the commissioning process. A comprehensive study found the following cost savings ranges:

|                           | (\$/sqft)       |
|---------------------------|-----------------|
| <b>Energy savings</b>     | \$0.05 → \$0.64 |
| <b>Other cost savings</b> | \$0.13 → \$2.10 |

(Annex Report, 2005 – not yet citable)

### **Example: Commissioning and Construction Cost Savings**

One study of six new construction projects found that commissioning reduced change orders by 87% and contractor call-backs by 90%, thus reducing the total construction cost by an estimated 4% to 9%.

Joy Altwies, "Information from a Commissioning Process Case History," PowerPoint presentation to *Energy 2002*, Palm Springs, CA

### **Quote**

"Over the past 20 years we have tracked the issues identified and resolved through the commissioning process. For major issues, we work with the owner and design team to develop avoided cost estimates. We find that in a typical project, the owner has recovered the full cost of the commissioning process about 80% of the way through design as a result of eliminated change orders and requests for information, improved system operation, and reduced maintenance."

--California commissioning provider |

### **Quote**

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- Inadequate outside air
- Poor diffuser layout
- Inappropriate control of ventilation air
- Poor craftsmanship in the distribution system

The consequences of poor indoor air quality range from mildly inconvenient to very serious. Temperature and lighting can both cause an uncomfortable work environment, one which hinders learning and lowers an organization's efficiency and productivity. In more severe cases, poor air quality causes headaches, fatigue or severe allergic reactions.

Commissioning reduces the risk of indoor environmental quality problems. Many comfort and air quality issues stem from a poorly maintained HVAC system, a problem that commissioning addresses directly through both functional tests and staff training.

Another common cause of poor air quality is moisture and mold in the building envelope. Commissioning helps prevent this problem because it identifies issues that contribute to poor indoor environmental conditions during design, catches installation issues during construction before they are covered up by walls or ceilings, tests control algorithms over a range of operating modes, and ensures that building staff have sufficient training and documentation to effectively manage the indoor environment.

Incorrect building pressurization can also lead to poor indoor air quality. This is especially important in facilities with labs, morgues, or any areas where pressurization is used to keep smells or toxins from migrating between spaces. When building pressure is not correctly balanced, the building loses its ability to contain hazardous materials. Commissioning ensures that pressure differentials between spaces are correct.

### More Effective Equipment Operation

Commissioning verifies that equipment is installed and operating correctly at turnover, and that building staff have the training and documentation they need to maintain this high level of performance. The

"I have project cost studies that show our company's estimate for the provision of control systems for a building that is commissioned is more accurate than for non-commissioned projects.

On commissioned projects I am thus able to provide a more competitive price and win more jobs."

--Owner of a controls contracting company |

### Diagram: Design Phase Commissioning = Construction Phase Savings |

#### Note: The IAQ Problem

Indoor environmental quality is a big problem in U.S. commercial buildings, some 20-30% of which suffer from indoor quality problems.

Poor IAQ is especially troubling in schools, where students spend close to 13,000 hours between kindergarten and 12<sup>th</sup> grade. The U.S. Environmental Protection Agency reports that half of U.S. schools – where more than 55 million students, teachers and school staff spend the majority of their time - have indoor air quality problems.

*Conditions of America's Schools*, February 1995. U.S. General Accounting Office, Health, Education, and Human Services Division, Document#: GAO/HEHS-95-61, Report#: B-259307.

#### Note: The Cost of Discomfort

Comfort problems affect every building owner – both those who occupy their facilities and those who lease them out.

#### Reduced productivity

An uncomfortable building makes everyone less productive. Occupants spend more time complaining and often take more sick days. Building staff spend more time responding to comfort complaints and have less time to attend

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result? Equipment that lasts longer, works more reliably, needs fewer repairs, and uses less energy. Equipment that operates properly also demands less “crisis maintenance” from onsite staff and expensive outside contractors, allowing staff to concentrate on their primary duties.

### **Improved Coordination Between Design, Construction, and Occupancy**

The lack of coordination between design and construction teams and building staff causes significant problems for high performance buildings. Without clear and frequent communication, there is little chance the new building will meet the owner’s expectations. Common consequences include oversized and inefficiently functioning systems, installation of the wrong equipment, and incorrect programming of the complex sequences of operation.

Commissioning improves communication between all team members. Throughout the project, commissioning tracks and resolves issues, helping focus communication on pressing problems. During design and construction, commissioning encourages participants to consider one another’s perspectives while maintaining a consistent focus on the owner’s expectations for building performance. This improves the ability of the project team to identify the best long-term solutions for problems and, as a result, ensures that systems function as intended.

As occupancy nears and the number of issues is at its peak, an owner must make many important decisions in a short time frame. The commissioning provider helps the owner with these decisions by explaining their consequences: how each choice affects the building and impacts the *Owner’s Project Requirements*.

### **Fewer System Deficiencies at Building Turnover**

During the last few months before turnover, the project team often focuses its attention on the systems and equipment most critical to obtaining permits and readying the building for occupancy. During this time, it is easy to overlook incomplete or deficient

to their regular maintenance tasks.

#### **Lost tenants**

A chronically unhealthy building can cause owners to lose tenants, and money. When tenants leave, costs pile up: rent loss due to vacancy, leasing commissions, and new tenant improvements. In addition, word of uncomfortable building conditions is likely to spread among business peers, increasing vacancy periods.

#### **Increased liability**

systems, but problems that remain after turnover do not go away.

Some deficiencies may go undetected, and can negatively affect building control, energy use, equipment reliability and occupant comfort for years. Some, however, come to the attention of building staff either through occupant complaints or in the course of routine maintenance.

Even with proper training and documentation, building staff may not have the time or knowledge to correct these lingering issues, or may only be able to address the symptoms without fixing the underlying problem. When a building has deficiencies that can only be corrected by bringing the contractor back to the site, building staff are often left to coordinate the callback and help resolve the problem.

Commissioning reduces the likelihood that problems will remain after turnover. It helps the project team identify system deficiencies as early as possible and tracks their status until they are corrected. By identifying deficiencies early and using a systematic process to track them, commissioning assists the project team in providing a building that functions properly at turnover.

**Quote**

From building staff talking about need to not have to deal with fixing problems after turnover – callbacks.

## Commissioning Costs

**The cost of commissioning is different for each project, and depends on the project's size, complexity, and the scope of the commissioning process.**

Commissioning costs are difficult to estimate. Unfortunately, there is no convention for determining which costs are a cost of commissioning. The commissioning provider's fee is the most obvious cost, but sometimes the cost to other team members who participate in the commissioning process, and the cost of correcting problems identified by commissioning, are also counted as a cost of commissioning. As a result, it is important to evaluate commissioning cost figures carefully to determine how they have been determined.

Because it is hard to define precisely, the cost of commissioning is most commonly and accurately presented as a range of potential costs rather than a specific dollar amount. No matter how it is defined, however, the cost of commissioning accounts for only a very small part of the overall construction budget, and an even smaller part of the building's lifecycle costs.

It is important to note that when the dollar value of commissioning's non-energy benefits are taken into account, the cost of commissioning is offset by more than 50%. This results from commissioning's ability to reduce a building's net life-cycle costs and its potential to reduce first costs, when commissioning begins early in the design phase of the project.

### Tables: Commissioning Costs

Widely accepted estimates of the commissioning provider's fee, relative to other project costs.

| Commissioning Scope  | Estimated Cost                       |
|--|--------------------------------------|
| Whole building commissioning from design through occupancy | 0.5 to 3% of total construction cost |
| HVAC and automated controls system only                    | 1.5 to 2.5% of mechanical contract   |
| Electrical system only                                     | 1 to 1.5% of electrical contract     |

Adapted by PECCI from Ron Wilkinson, "Establishing Commissioning Fees," *ASHRAE Journal*, pg 41-51. February 2000.

Actual commissioning costs, as reported in a study of 69 commissioning projects.

| Description   | Median Cost            |
|---|------------------------|
| Net commissioning cost - includes energy savings but excludes non-energy benefits (NEBs). | \$1.00/ft <sup>2</sup> |
| Net commissioning cost - includes energy savings and NEBs.                                | \$.35/ft <sup>2</sup>  |
| Commissioning cost as a % of construction cost – includes only energy savings.            | .6 %                   |
| Commissioning cost as a % of construction cost - includes energy savings and NEBs.        | .2 %                   |

Evan Mills, "The Cost effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory, 2004.

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### 3. The Commissioning Process

In new buildings, the commissioning process begins in pre-design and lasts throughout the construction process. Commissioning activities usually conclude during a building's occupancy and operations period. In a sense, however, commissioning never ends. Even after occupancy, periodic recommissioning is necessary to maintain the building's high level of performance.

This chapter describes the commissioning activities at each phase of the construction process: pre-design, design, construction and occupancy and operations.

#### Online Resources

[www.cacx.org](http://www.cacx.org)

##### **California Commissioning Collaborative**

Contains commissioning sample documents, including a including scope of work, commissioning plan, issues log, commissioning report, systems manual, sequence of operations, and request for proposal.

#### Publications

*Adopting the Commissioning Process for the Successful Procurement of Schools* (2003), California Department of General Services, prepared by Farnsworth Group.

*Building Commissioning Guidelines* (no date). Energy Design Resources, prepared by Portland Energy Conservation, Inc. (PECI).

*The Building Commissioning Handbook* (2004). John A. Heinz and Richard B. Casault, APPA: The Association of Higher Education Facilities Offices.

*CHPS Best Practices Manual* Vol. I "Planning," and Vol. II "Design," (2002). Collaborative for High Performance Schools (CHPS).

*Guideline 0-2005, The Commissioning Process* (2005). American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

*Model Commissioning Plan and Guide Specifications* (1998). US DOE and Oregon Office of Energy, prepared by Portland Energy Conservation, Inc. (PECI).

## Pre-Design

Pre-design activities are critical to the success of the project. They build a strong foundation for both commissioning and construction activities.

During pre-design the commissioning provider helps develop the *Owner's Project Requirements*. This important document will guide the design, construction and operations of the future building.

### Select a Commissioning Provider

During pre-design the building owner works with the architect to establish a vision for the project. Together they determine the how the building will look and function. This is the ideal time to select a commissioning provider. The commissioning provider leads the commissioning process and verifies that the building meets the owner's expectations at each stage of the design and construction process.

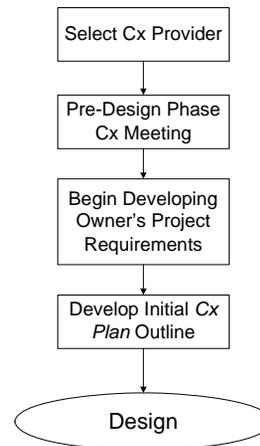
The commissioning provider has many responsibilities. He or she ensures that team members understand their role in the commissioning process. The provider fosters communication and promotes a positive, team-based approach to problem solving.

A well-qualified commissioning provider has a depth of troubleshooting and problem solving experience, and the diagnostic monitoring, testing and analysis expertise needed to uncover potential problems and select the most cost-effective solutions.

Bringing the provider into the project early has several advantages:

- Architects and design engineers will find it easier to implement the provider's suggestions when they are received during pre-design. Pivotal decisions like system selection are often made at this time, and even informal discussions between the commissioning provider and the design team can have a significant impact.
- The provider's attention to the effects of design

## Pre-Design Phase Commissioning Process



### Pre-design Phase Deliverables

- Comments on the *Owner's Project Requirements* document
- *Commissioning Plan* outline listing design phase activities

### Cross Reference

The responsibilities of the commissioning provider and other commissioning team members is discussed in *Chapter 4: The Commissioning Team*.

choices on O&M practices will result in a building that is easier to operate and maintain.

- The provider's presence as a team member from the beginning increases the likelihood that other team members will recognize and appreciate the value of commissioning.

## Hold a Pre-Design Phase Commissioning Meeting

The pre-design phase commissioning meeting helps refine the scope, budget and rigor of the commissioning effort. The commissioning provider organizes and leads the meeting, and participants may include the owner or owner's representative, design professionals, the owner's construction manager, and representatives of the operations staff or future building occupants. Although the commissioning team will evolve over the course of the project, at this meeting the owner and provider begin to identify each team member's responsibilities and communicate the owner's expectations for building operation.

## Develop the *Owner's Project Requirements*

This written document details the owner's expectations of how the facility will be used and operated. It describes the building's physical and functional characteristics and sets performance and acceptance criteria.

The commissioning provider's primary role in pre-design is to help the owner and the project team document the *Owner's Project Requirements (OPR)*. Developing the *OPR* is a team effort involving the owner, design team, and commissioning provider. There are many ways to divide the responsibilities, and it is essential for owners to clearly specify the role they expect each team member to play.

The *OPR* is an essential document because it serves as a baseline for decision making throughout the rest of the design and construction process, and will be used by the commissioning provider to evaluate the project's development.

The level of detail in the *OPR* varies according to the size and complexity of the project, the owner's

### **Definition: Owners Project Requirements**

A written document detailing the owner's expectations of how the facility will be used and operated. It may include goals, budgets, limitations, schedules, and owner directives.

### **Example: Owners Project Requirements**

### **Note: Developing the OPR**

preferences, and the experience of the design team. At a minimum, the *OPR* should state the owner's goals and objectives for the building. Ideally, each item listed in the document will have defined performance and acceptance criteria.

## **Develop the Initial *Commissioning Plan* Outline**

The *Commissioning Plan* defines the scope and budget of the commissioning process. This deliverable is created by the commissioning provider, with input from the designer, and serves as a guideline for team members to follow because it identifies the processes and procedures that will be undertaken, a schedule of activities, roles and responsibilities of team members, and forms and templates that will be used to document the commissioning activities. Once the project specifications are created, they should be referenced throughout the *Commissioning Plan*.

The *Commissioning Plan* is an evolving document that takes shape throughout the commissioning process, and the owner or owner's representative should expect to review it at certain milestones. For example, during pre-design it is advantageous to specify commissioning-related tasks for the design phase. Although specific construction phase tasks usually cannot be determined yet, developing an initial plan during pre-design helps focus the scope of commissioning efforts. During design it is possible to outline the types of tests that will be conducted, and the commissioning milestones that will be integrated into the construction schedule.

### **Definition: *Commissioning Plan***

An evolving document that defines the project's commissioning activities, schedule, documentation requirements, and the roles and responsibilities of team members. The final *Commissioning Plan* should include:

- General building information and contact info
- Project goals
- An overview of the commissioning process, including the scope of commissioning
- Building and systems description, including a list of components/systems that will be/were commissioned
- Commissioning schedule
- List of team member, their responsibilities and expected deliverables
- Description of the communication, reporting and management protocols
- Detailed description of testing procedures
- Detailed description of monitoring procedures
- Recommended training activities

*Commissioning Plan* templates and samples are available on the CCC website: [www.cacx.org](http://www.cacx.org).

## Design

In design the project evolves from concept to plan, as architects and engineers develop drawings, draft construction documents and write specifications. Commissioning ensures that as the building becomes a reality, its systems and operations continue to reflect the owner's goals. [See my notes- I disagree that this should be the commissioning agent's job](#)

During design the commissioning provider reviews design and construction documents, incorporates commissioning into bid documents, and plans for commissioning activities that will occur during construction. Throughout, the provider keeps a *Design Phase Issues Log* to track issues that require further attention.

### Perform Commissioning-Focused Design Review

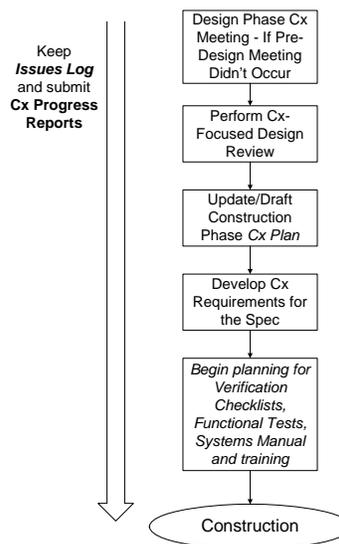
During design, the design team makes decisions about how to accomplish the owner's goals as they are described in the *Owner's Project Requirements (OPR)*. The commissioning provider carefully reviews design documents for clarity, completeness and compliance with the *OPR*. This includes the *Design Narrative*, in which designers describe in detail the concepts and features they intend to incorporate during schematics, and the *Basis of Design*, in which designers explain their reasoning and assumptions for choices made in the *Design Narrative*.

The commissioning provider will also review the acceptance criteria to ensure that during functional testing, systems will be shown to meet both the *Owner's Project Requirements* and the *Basis of Design*.

The design review process has several steps and takes place throughout the design phase of the project:

1. During schematics, the provider does a general review to ensure that a basic level of quality is

### Design Phase Commissioning Process



### Design Phase Deliverables

- Regular commissioning progress reports
- Comments on the *Basis of Design (BOD)*, *Design Phase Issues Log* and *Design Narrative* documents
- Draft construction phase *Commissioning Plan*
- Commissioning specifications for inclusion in the bid documents

**Comment:** Reviewers: There is a lot of debate on how far the CxP should go in reviewing designs. For example, should the CxP only look for barriers to functional testing or operations, or should the CxP do a more inclusive review, for example, looking at sizing issues and alternate design choices that improve efficiency?

How should the Guide address this? Choose one perspective – or offer them all up as options?

### Note

If commissioning begins in design, the commissioning provider should also complete the *pre-design* task of helping develop the *Owner's Project Requirements (OPR)*.

### Definition: Design Review

A process of review in which the commissioning provider examines design documents to help ensure that a design is likely to meet the *Owner's Project Requirements*. Design review both enhances design and fosters communication between designers,

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present. The provider checks for items such as legibility, labeling, and continuation of items from sheet to sheet. Next, the provider examines the implications of system choices to ensure that the design will meet the specifications in the *OPR*.

2. About mid-way through the design process the provider performs a coordination review to examine how systems will interact and whether there are any potential conflicts.
3. Near the end of design the provider conducts a final check. When the specifications are drafted, the provider does a detailed check for errors.

The most important decisions for the commissioning provider to examine are the sizing and selection of building systems and equipment. Issues requiring further attention are noted in the *Design Phase Issues Log*, along with their eventual resolution. The commissioning provider will update the *Issues Log* regularly and submit it to the owner and the design team for discussion at design meetings.

It is not the role of the commissioning provider to approve recommendations resulting from the *Issues Log*. It is the owner's responsibility to evaluate the provider's recommendations, discuss them with the design team, and decide whether or not to require that the issue be resolved.

### **Update/Draft Construction Phase Commissioning Plan**

The construction phase *Commissioning Plan* defines the responsibility of each team member during construction, sets a schedule for the commissioning process, and describes procedures and tests. The *Commissioning Plan* is an evolving document, and the provider will update it regularly as the project moves forward. During the design phase, the following elements should be added to the *Commissioning Plan*:

- Systems and assemblies to be verified and tested
- Commissioning schedule during construction and during warranty
- Roles and responsibilities of team members

owners, and builders.

Design review may address any of these issues:

- Barriers to functional testing
- System performance problems
- Energy-efficiency improvements
- Indoor environmental/air quality (IAQ) issues
- Operation and maintenance issues

#### **Definition: Acceptance Criteria**

The conditions that must be met in order for an aspect of the project to meet defined requirements, thus permitting subsequent activities to proceed.

Acceptance criteria should be included in the *Owner's Project Requirements*.

#### **Example: Design Review Issues**

#### **Definition: Basis of Design**

A document that records the concepts, calculations, decisions, and product selections used to meet the *Owner's Project Requirements* and to satisfy applicable regulatory requirements, standards, and guidelines.

#### **Definition: Issues Log**

A formal and ongoing record of problems or concerns, and their resolution, that have been raised by the commissioning provider or any member of the commissioning team during the course of the commissioning process. There are usually three different issues logs created in the course of the commissioning process: *design review*, *construction observation*, and *functional testing*.

#### **Definition: Design Narrative**

A written description of the concepts and features the designer intends, during schematics, to incorporate into the design to meet the *Owner's Project Requirements*. A design narrative accompanies each design submittal.

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- Documentation and reporting requirements, including procedures and formats
- Communication protocols
- Commissioning procedures
- References throughout to project specifications

## Develop Commissioning Requirements for the Specifications

Commissioning requirements define the contractors' commissioning-related responsibilities, including equipment installation and start-up, documentation, and functional testing. It is very important to include commissioning requirements in the specifications. If commissioning is not included, the owner should expect to receive a change order for the additional commissioning tasks.

The designer is responsible for developing detailed commissioning requirements, although in practice the commissioning provider will likely draft the language and review the requirements before they are released. The commissioning requirements should describe:

- How potential contractors are expected to interface with the commissioning provider's construction oversight and testing procedures
- Appropriate staff training requirements, especially if installing contractors or manufacturer's representatives will be required to participate
- Special equipment or instrumentation that must be installed to obtain measurements during performance testing
- The party(s) responsible for compiling the equipment, O&M manuals and the deadline for their delivery to the commissioning provider

Many aspects of the commissioning process, particularly comprehensive system testing, may be new to contractors. When this is the case, owners must ensure that contractors are correctly informed about what commissioning requires of them, before contractors submit their bids. Owners can do this by inviting the commissioning provider to discuss the process and its requirements at a pre-bid meeting and by providing sample test protocols and other documentation to contractors in advance of the submission deadline.

At a minimum, the *Design Narrative* includes:

- Objectives and purpose of each system
- How the objectives will be met
- Indoor/outdoor design conditions
- Occupancy, usage, and schedule assumptions
- Internal loads assumptions
- Zoning descriptions
- Ventilation requirements
- Envelope requirements
- Equipment sizing calculations and criteria
- All sequences of operation
- Energy efficiency control strategies
- Design intent for all efficiency measures
- Reference to pertinent local or state compliance documents

### Note

It is very important to *include commissioning requirements in the specifications*. If commissioning is *not* included, the owner should expect to receive a change order for the additional commissioning tasks.

### Note: Commissioning Requirements in the Specifications

MasterFormat™ is the specifications-writing standard for commercial building design and construction. In the 2004 Edition, it states that a summary of the commissioning scope should be placed in Division 01, 019100, "General Requirements."

In each of the other Divisions there are Titles for commissioning, where requirements relevant to that Division should be placed. This is a very important step to ensure that all parties understand the commissioning requirements that apply to them.

The MasterFormat 2004 Edition is available at the CSI website: [www.csinet.org/masterformat](http://www.csinet.org/masterformat).

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## **Begin Planning for *Verification Checklists, Functional Tests, Systems Manual, and Training Requirements***

Development of the *Verification Checklists, Functional Tests, Systems Manual* and staff training all occur towards the end of the construction process. Since they require careful planning, the commissioning provider will usually start preparing for them even before construction begins.

### **Note**

Since the comprehensive system testing that occurs during the commissioning process is new to many contractors, it may be helpful to provide them with sample test protocols, to give them a sense of the expected rigor. A clear description of roles and responsibilities during testing is also very important.

### **Example: *Design Review Issues Log***

## Construction

During construction the commissioning provider monitors numerous aspects of the project to ensure that building systems and equipment are installed and tested according to the owner's requirements.

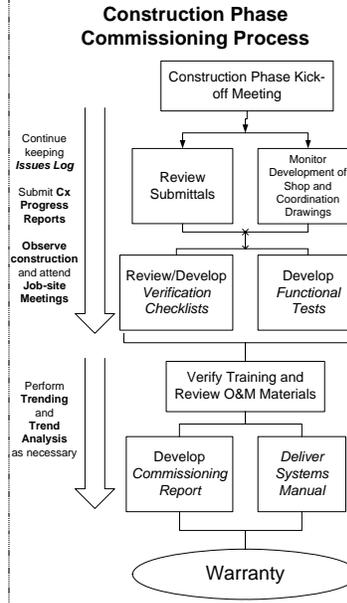
As in design, the provider keeps an *Issues Log* to track issues that require further attention. Toward the end of construction, the provider will conduct functional tests, deliver a *Systems Manual* and supervise/conduct staff training.

## Construction Phase Meetings

The commissioning provider coordinates the kick-off meeting with the owner, construction manager, design team, and representatives from each of the subcontractors (general contractor, mechanical, electrical, controls, and the testing and balancing specialist). Ideally, this meeting takes place before construction begins.

The kick-off meeting introduces the team members to the schedule of commissioning activities, responsibilities, and procedures for documenting and resolving issues and communicating expectations. The kick-off meeting also provides an opportunity for the team members to offer their ideas and suggestions to the commissioning provider for inclusion in the final *Commissioning Plan*.

Throughout the construction process, the commissioning provider attends planning and jobsite meetings to stay informed of construction progress. As needed, the commissioning provider attends regular construction meetings and holds a line item on the agenda. Later in construction, the commissioning provider will conduct separate meetings devoted to commissioning issues. The owner's representative(s) should attend commissioning team meetings in order to stay up-to-date on changes that may affect the project's ability to achieve requirements in the *OPR*, commissioning issues and the scheduling of training for building staff.



## Construction Phase Deliverables

- Updated *Commissioning Plan*, with schedule
- Construction observation *Issues Log*, with updates
- Construction checklists and functional test forms, blank and completed
- Reports of submittal reviews
- Report of training completion
- Report of *Systems Manual* review
- Minutes from commissioning meetings
- Periodic commissioning progress reports
- Draft *Commissioning Report*

## Note: What if Cx starts during construction?

Starting commissioning during construction is not ideal. Commissioning recommendations are more difficult and expensive to

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## Review Submittals, Monitor Development of Shop and Coordination Drawings

The commissioning provider reviews construction documentation to verify that it complies with the *Owners Project Requirements (OPR)* and to collect information that will be used to write functional tests and develop the *Systems Manual*. The owner's support can be critical in helping the commissioning provider obtain documentation in a timely manner. The commissioning provider pays close attention to any proposed substitutions or deviations from earlier documents, checking to see if they will have any adverse affects. Some guides recommend a sampling strategy in which 5-10% of the submittals are selected for a closer quality-control inspection.

## Perform Ongoing Construction Observation

Throughout construction, the commissioning provider attends job site meetings, observes the construction process, and keeps a *Construction Phase Issues Log*. If the provider finds any conditions that might affect the ability of the building's systems or operations to meet the owner's performance expectations, they are recorded in the log. The provider also uses the *Issues Log* to track the resolution of these findings, and will frequently refer to it during regular construction meetings. The *Issues Log* becomes part of the permanent construction record.

## Verification Checklists and Functional Tests

*Verification checklists* are used by contractors during start-up as equipment comes online. They are sometimes called "prefunctional tests," and list activities that must be completed prior to and during start-up to ensure equipment is properly installed and ready for functional testing. Verification checklists. Once complete, they provide vital information about the equipment, its condition upon delivery, and issues that arose during start-up. The checklists help the commissioning provider verify correct installation and, after turnover, help building staff in their maintenance tasks.

Responsibility for developing verification checklists

implement as the project progresses. However, when commissioning begins during construction, the sooner the provider can be brought in, the better. Even with a late start, commissioning can significantly benefit overall building operations.

When commissioning starts during construction, the provider can still conduct construction observation and keep an *Issues Log*. However, if commissioning requirements were not included in the spec, the provider's recommendations may involve change orders and addendums, resulting in added expense to the owner.

If the project is applying for LEED certification, it is important to review the requirements to ensure that the necessary commissioning activities are completed.

### **Note: Communication is Key**

During construction, the commissioning provider will produce several types of documentation for the owner's representative(s) and other members of the construction team. In order to get the full benefit -of these reports, it is very important to establish a clear process for sharing information, before construction starts.

### **Note: Managing the Construction Schedule**

The General Contractor develops the project schedule and the commissioning provider should provide dates for milestones and testing. The provider also reviews the schedule looking for potential conflicts and to ensure there is sufficient time for testing at the end of the project.

### **Example: Construction Observation Issues Log**

### **Note: Issues Log v. Punch List**

The commissioning provider's *Issues Log* is not a substitute for the punch list usually developed during

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varies. Contractors are usually responsible for creating them, but only if this requirement is documented in the specifications. The commissioning provider reviews the checklists and may assist in developing or enhancing them. Contractors complete the checklists when they execute equipment start-up, often with commissioning provider oversight. In some cases, it may be possible for the commissioning provider to use spot checks or sampling to verify that verification checklists have been completed accurately.

*Functional tests* verify that the systems as a whole, as well as individual pieces of equipment and their components, meet the performance requirements specified in the *OPR*. Test procedures are often prepared, witnessed, and documented by the commissioning provider and conducted by the contractors, although other arrangements are possible. The control system contractor is an important participant in this process, as the control system interacts with several other commissioned systems. Data loggers or the building automation system should be used when systems need to be monitored over time and during normal building operations.

During functional testing, the commissioning provider uses an *Issues Log* to track any performance issues that may arise, and their resolutions.

### **Verify Training of Owner's Staff and Review O&M Manuals**

Operations and maintenance (O&M) training and instructions are vital to the long-term operational health of the facility. Thorough training gives staff the information they need to operate the facility. The O&M manuals become a valuable reference after training ends, and ensure that operational knowledge stays with the facility, even when the staff does not.

The commissioning provider ensures that the O&M manuals are completed on time, and verifies that the information is clear, complete and available for use during the training sessions. The commissioning provider works with the owner's representative(s) and building staff to ensure that training agendas meet the specifications in the contract documents and the *OPR*.

construction. The two serve very different goals. Punch lists verify that equipment has been delivered and installed as required by the spec. The *Issues Log* documents findings that affect the way equipment operates and systems interact. Issues logs and punch lists are also developed differently. The punch list is created during a walk-through, which usually occurs very near construction completion. The *Issues Log* is kept throughout the construction process.

#### **Definition: Verification Checklist**

A document that identifies the steps that must be taken to verify the readiness of a piece of equipment for functional testing.

#### **Definition: Functional Test**

Tests that evaluate the dynamic function and operation of equipment and systems using manual or automated monitoring methods and either passive observation or active testing of operation. Functional testing is the assessment of the system's ability to perform within the parameters described in the *Basis of Design*.

Functional tests are not usually performed on systems tested and approved by regulatory authorities. However, the provider's scope may be drafted to include participation in these tests, if the owner desires.

#### **Example: Functional Testing Issues Log**

#### **Note: The Controls Contractor and Functional Testing**

Although correct equipment installation will be confirmed using verification checklists, performance and system interactions must be tested using the controls system. The controls system contractor is therefore

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Often the provider will interview team members, including the building staff, to determine training needs.

If contract documents specified that contractors, designers and/or manufacturers' representatives are to conduct trainings, the commissioning provider may recommend agenda items and/or oversee these sessions.

### **Develop *Commissioning Report* and Review/Deliver *Systems Manual*, including *Recommissioning Plan***

After all construction phase commissioning tasks are complete, the commissioning provider delivers the *Commissioning Report* and the *Systems Manual* to the owner.

The *Commissioning Report* summarizes the commissioning effort and evaluates whether each piece of commissioned equipment meets the **specifications in the OPR.**

The *Systems Manual* is a comprehensive package of documentation that assists the owner in better understanding, operating and maintaining building's systems. Much of the information in the *Systems Manual* will be provided by the design engineer, contractor, or equipment providers. The commissioning provider can assemble the document, or can provide an outline and review submissions in various stages of completion, depending on the commissioning scope.

The *Systems Manual* should not be confused with the O&M manuals, which are only one part of the more comprehensive package. The *Systems Manual* includes information collected during the commissioning process, and provides a perspective on the building that is system-based, rather than equipment-based.

The *Systems Manual* may include a *Recommissioning Plan*, although the plan may also be developed later, after occupancy.

a crucial participant in functional testing, and it is important to document this in the specifications.

#### **Note: What happens if equipment fails to perform?**

If functional testing shows equipment that does not perform as specified during functional testing, the commissioning provider will document the issue in the *Issues Log* and bring it to the attention of the project team. The provider will communicate the potential consequences to the owner, who must decide whether to require corrective measures. If it is in the commissioning scope, the provider may work with the project team to achieve acceptable performance.

**Comment:** Reviewers: What terminology to use? "Commissioning Final Report" or "Final Report" are other commonly used terms.

#### **Note: Building Staff and Testing**

Building staff should participate in pre-functional and functional testing as early and often as possible. Their involvement provides valuable hands-on training in running and troubleshooting the systems and equipment they will soon manage. In addition, building staff can often identify no-cost changes to design details that result in significant improvements to ongoing operations, for example, point naming conventions, alarm messages or graphic layouts of the emergency management system.

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#### **Definition: Commissioning Report**

The *Commissioning Report* is written by the commissioning provider and provides an overview of the commissioning process. It usually includes:

- A written narrative offering the provider's opinion of each of the commissioned system's compliance with both contract documents and the *OPR*, as well as any unresolved commissioning issues.
- Copies of project documentation: the commissioning plan, functional tests, individual

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commissioning reports and reviews, issues logs, and all major communications, like emails, memos, and letters.

**Definition: Systems Manual**

The *Systems Manual* is a comprehensive documentation package that assists the owner and building staff in understanding, operating and maintaining building systems. It is not a standard market offering and should be included in the specifications.

The *Systems Manual* includes:

- Final versions of project documentation, including the *OPR* and other design narrative documents
- Space and use descriptions
- Single line drawings and schematics for major systems
- As-built sequences of operation for all equipment
- Control drawings
- Time-of-day schedules and schedule frequency
- Instructions for operation of each piece of equipment for emergencies
- Description and rationale for the building's energy- and water-saving features and strategies, operating instructions for those features, and caveats about their function and maintenance relative to energy use
- Guidelines for establishing and tracking benchmarks for whole building energy use and equipment efficiencies of cooling, heating and service hot water equipment
- Seasonal start-up, shutdown, manual and restart operation procedures, and recommendations regarding seasonal operational issues that affect energy use
- Recommendations for recalibration frequency of sensors and actuators by type and use
- A list of user-adjustable set points and reset schedules with a brief discussion of the purpose of each

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and the range of reasonable adjustments with energy implications, and a schedule to review them for relevance and efficiency

- Plans for ongoing commissioning or the recommended frequency for recommissioning, by equipment type, with reference to tests conducted during initial commissioning
- Guidelines for energy accounting
- A list of diagnostic tools
- Commissioning *Final Report*

**Note: Sampling Pros and Cons**

Sampling can be an effective way to minimize the costs of commissioning. Rather than reviewing, inspecting, or testing every item, only a random sample is selected. In order for sampling to be effective, however, commissioning must begin during pre-design and the most critical or failure-prone components and systems must be weighted most heavily when selecting the sample. The provider's scope of services and the specification should define this in detail.

**Note: Additional Training Options**

There are many possible formats for staff training. A manufacturer's rep can conduct onsite sessions, staff can be sent to an offsite location such as the factory, or training can be held virtually using internet or video technology. Content can be equally diverse. Training sessions can include focused walk-throughs of the facility during construction and classroom work. It is usually helpful to record training sessions so future staff members can benefit from the training.

## Occupancy and Operations

Upon turnover, the building is in the hands of the owner and operators. Although the project is considered complete, some commissioning tasks continue during the typical one-year warranty period.

The active involvement of the commissioning provider during the initial occupancy period is essential to the success of the commissioning process.

### Help Resolve Outstanding Commissioning Issues

It is common for some commissioning issues to remain unresolved, even after turnover. When this is the case, the commissioning provider can assist the owner in coordinating contractor callbacks, since he or she has been involved in the project for some time and can identify how best to resolve an issue.

### Perform Seasonal/Deferred Testing

Seasonal testing is conducted to verify proper system operation during, at minimum, winter and summer. Some testing of heating and cooling systems can be performed under simulated conditions during the off-season, but natural conditions usually provide more reliable results. Testing that was delayed due to site and equipment conditions or inclement weather will also be completed during occupancy.

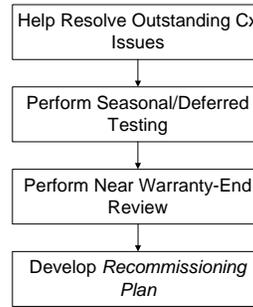
### Perform Near Warranty-End Review

Shortly before the expiration of the contractor's one-year warranty, the commissioning provider may return to the building to review system operation and interview building staff. The provider can assist staff in addressing any performance problems or warranty issues. The commissioning provider may also add information about the facility to the *Commissioning Report* at this time.

### Develop Recommissioning Plan

Commissioning produces high performance buildings – those that meet the owner's expectations, operate

### Occupancy and Operating Phase Commissioning Process



### Occupancy and Operations Phase Deliverables

- Summary report from seasonal testing
- Warranty review of each system
- “As operated” sequence of operations (developed either by the commissioning provider or the controls contractor)
- Final *Commissioning Report* (including findings from Occupancy and Operations Phase)
- Final *Issues Log*

### Definition: Recommissioning Plan

A document containing all the information required to recommission the facility. The plan may include specific tasks, their descriptions, and

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efficiently and provide a safe and comfortable indoor environment for occupants. But after occupancy, the work is not over. Maintaining the building's optimal performance requires periodic recommissioning. A *Recommissioning Plan* will help owners and building staff plan and prepare for recommissioning. The commissioning provider can help draft the plan, if it is in his or her scope.

schedules. Other information which may be helpful includes operational requirements for key systems, functional tests, and documentation templates.

## 4. The Commissioning Team

Assembling the commissioning team is usually the first, and one of the most challenging, parts of kicking off a commissioning project. This chapter discusses:

- Who should be on commissioning team, and how responsibilities are usually assigned
- The role of the commissioning provider, and different parties that can serve as the provider
- The commissioning provider selection process
- How to evaluate commissioning provider qualifications
- Commissioning provider certification programs

### Online Resources

[www.bcxa.org](http://www.bcxa.org)

#### **Building Commissioning Association**

Membership Directory Search allows user to search for BCA member commissioning providers in a specific state or region.

[www.cacx.org](http://www.cacx.org)

#### **California Commissioning Collaborative**

Contains a collection of resources to help owners select a commissioning provider, including recommended qualifications, comparison of provider certification programs and a list of providers doing business in California.

[www.energydesignresources.com](http://www.energydesignresources.com)

#### **Cx Assistant**

A free, web-based tool that helps owners and designers choose the appropriate range of commissioning services for their project.

### Publications

## **Commissioning Team Members and Their Responsibilities**

**The commissioning team works together to identify and resolve problems early in the design and construction process, and follows them through to their eventual resolution, ensuring that the final delivered building meets the owner's needs.**

**Clearly defining and documenting the responsibilities of each team member is vital to the success of the commissioning project.**

It is important to note that neither the commissioning team nor the commissioning provider manage the design and construction process. Team members are not authorized to direct work, nor accept a building or system. Rather, their purpose is to facilitate communication, resolve issues, and document performance.

Together, the commissioning provider and the owner assign roles and responsibilities to members of the commissioning team. Budgets and special project characteristics will affect the team's structure, and the commissioning provider can help the owner assemble a team that best matches the size and complexity of the project.

Roles and responsibilities are usually outlined at a commissioning scoping meeting, which should occur early in the project and which all team members are required to attend. At this meeting, the owner and commissioning provider describe each team member's responsibilities, as well as the commissioning scope, process, and schedule.

Each team member's responsibilities are outlined below. Of course, actual responsibilities will vary.

### **Commissioning Provider**

In design, the provider helps document the owner's

#### **Note**

The commissioning team does not manage the design and construction of the project. Its purpose is to promote communication among team members, identify and resolve problems early in the process, and document the performance of the building.

#### **Note**

Members of a design and construction team must communicate clearly and openly in order to accomplish their goals. The commissioning process facilitates good communication by setting clear performance goals and requiring regular meetings among all team members.

#### **Note: Who's on the Commissioning Team?**

Commissioning team members usually include:

- Commissioning provider
- Building owner or owner's representative
- Building Manager and O&M Staff
- Design professionals
- Contractors or manufacturers' representatives
- Testing specialists
- LEED coordinator

#### **Note: The Commissioning Provider's Responsibilities**

- Organize and lead the commissioning team
- Ensure that the owner's expectations are adequately documented in the *Owner's Project Requirements, Basis of*

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expectations for building operations in the *Owner's Project Requirements* and submits comments on the design professionals' submissions, including the *Basis of Design* and the *Design Narrative*. During construction, the commissioning provider visits the job site frequently, documents any deficiencies in an *Issues Log*, attends team meetings, oversees the start-up and functional testing of systems and their components, and verifies that all necessary documentation and training are completed. During occupancy and operations, the provider makes periodic visits to the site, conducts testing that could not be conducted during construction, and, if it is in the scope, will continue to help the owner and building staff resolve any remaining operational issues.

### **Building Owner or Owner's Representative**

The owner makes crucial contributions to the success of any commissioning process. The owner's primary responsibilities are to support the commissioning team and to clearly communicate expectations about how the building should operate. However, it is equally important for the owner to be a strong advocate for commissioning. This means not only supporting the commissioning provider's responsibility to identify issues, but the rest of the team's responsibility to resolve them. The owner's support enables the commissioning process to proceed more smoothly, correct more building problems and thus produce greater benefits.

In addition to affirming the roles and responsibilities of the commissioning team, the owner guides the process by clearly articulating the expectations for how the building will operate. These expectations should be well-documented because they serve as the foundation not only for commissioning but for almost every decision to be made during design and construction.

### **Building Manager and Staff**

The building's future staff can both contribute to and benefit from the commissioning process. In order to realize these benefits, however, building staff must be selected and brought to the table as early in the process as possible.

*Design*, and *Design Narrative*

- Review design submittals
- Prepare and update the *Commissioning Plan*
- Assist in documenting the commissioning requirements to be included in the spec
- Organize and lead commissioning meetings
- Develop and maintain *Issues Logs*
- Observe construction
- Observe and document functional testing
- Verify that the *Systems Manual* is complete
- Review staff training plans and materials, attend sessions, and verify that training is acceptable
- Prepare and submit the final *Commissioning Report*
- Conduct periodic site visits during first year of occupancy, conduct any deferred testing, and serve as a resource to building staff

#### **Note: The Owner's Responsibilities**

- Clearly communicate his or her expectations for the project
- Hire the commissioning provider
- Assign staff to represent the owner's interests during the commissioning process
- Work with the commissioning provider to determine the scope and goals of the commissioning process
- Review and comment on reports submitted by the commissioning provider
- Approve startup and functional test completion
- Begin including future building staff in the process as soon as possible
- Consider the recommendations of the commissioning provider when directing the construction team or accepting building or systems.

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In pre-design, the manager or operator should contribute to the development of the *Owner's Project Requirements*. In the final phases of design, the insights of a manager or operator can lead to no-cost changes that significantly improve the staff's ability to operate and maintain the building. For example, modifications to point naming conventions, alarm messages and graphic layouts of the energy management system. Building staff may also comment on system choices, layout, and other factors that affect maintainability.

By participating in the commissioning process, building staff will gain an understanding of the building's systems and their interactions well in advance of turnover and occupancy. Observing functional tests will also improve the staff's understanding of equipment and control strategies.

### **Design Professionals**

Design professionals may include the architect, mechanical design engineer, electrical design engineer, or other specialty sub-consultants. The design professionals develop plans and specifications for the building that meet the owner's needs and expectations. Their role in commissioning is to work with the commissioning provider to document the owner's expectations for building operations in the *Owner's Project Requirements (OPR)* document and work with the team to resolve issues that arise during design and construction.

Design professionals' specific commissioning-related responsibilities may vary, depending on their interests and the owner's needs. During design they respond to issues raised by the commissioning provider and ensure that commissioning is detailed in the specifications. During construction they assist in resolving any construction or operational issues. In complex projects, the design professionals may review commissioning and functional test plans, and may witness some functional tests.

#### **Note: The Building Staff's Responsibilities**

- Review designs for maintainability
- Participate in periodic site walk-throughs
- Participate in commissioning process meetings
- Observe functional testing
- Participate in training sessions

#### **Note: The Design Professionals' Responsibilities**

- Work with commissioning provider to develop the *Owner's Project Requirements (OPR)*
- Develop the *Basis of Design* and *Design Narrative*, based on the *OPR*
- Respond to the commissioning provider's comments on all the above documents
- Participate in commissioning meetings

#### **Note: Responsibilities of the Contractors or Manufacturers' Representatives**

\*\*\*Commissioning responsibilities must be documented in the spec, or contractors and manufacturers' reps will not be responsible for completing them.

- Attend pre-bid and pre-construction meetings
- Integrate commissioning milestones into the construction schedule

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## **Contractors and Manufacturers’ Representatives**

Contractors and manufacturers’ representatives construct the facility and provide, install, start-up and often test the building’s systems and their components. Their commissioning responsibilities are limited, however, to what appears in the specifications.

If it is specified, it will be the responsibility of contractors and manufacturers’ representatives to ensure that the completed building systems operate as intended. Their specific tasks usually include working with the commissioning provider to ensure that commissioning milestones are integrated into the construction schedule, conducting performance tests (developed by the commissioning provider) on the systems they install, helping resolve any deficiencies, and documenting system startup. They are also responsible for providing system documentation and training building staff.

## **Testing Specialists**

If the complexity of the project requires special testing, the specialists performing these tests should also be involved in commissioning. Test results and recommendations from these specialists should be submitted to the commissioning provider for review. They may also be required to review documentation relating to the systems they test and to train operators on the proper use of this equipment.

## **LEED Coordinator**

The LEED Coordinator works closely with the project team to track and document what, when and by whom environmental measures are implemented, everything must be done in order for the project to achieve the desired certification level. The LEED coordinator’s role requires managing a multitude of complex details that are unique to LEED projects and the LEED rating system. These responsibilities overlap with those of the commissioning provider, but are also very different. The responsibilities of these two roles are almost always too great for a single individual.

- Supply the commissioning provider with all requested drawings and respond to requests for information and change orders
- Work with the commissioning team to remedy all deficiencies
- Provide documentation for the *Systems Manual*
- Develop and conduct training for building staff
- Approve and carry out functional testing

## Selecting a Commissioning Provider

**One of the first and most important decisions a building owner will make is selecting the commissioning provider.**

The commissioning provider's role can be filled by several different parties. In deciding who will provide commissioning services, building owners and managers have at least three distinct options from which to choose: an independent third-party provider, the design professional, the contractor, or the owner's staff.

The commissioning provider leads the commissioning team and facilitates the entire commissioning process. The commissioning provider can employ or partner with a technology specialists, so he or she need not be a technical expert. The provider should, however have solid, hands-on experience with HVAC systems and controls.

Since each project is unique, it is important to select a commissioning provider whose expertise and experience most closely match the project's specific objectives and scope.

There are several steps to selecting a provider, and they are each discussed in detail below:

- Decide which party will provide commissioning services and determine the scope of the project
- Conduct a selection process
- Evaluate provider qualifications

### Commissioning Provider Arrangements

#### Independent Third-Party Provider

An independent third-party commissioning provider is an individual or firm hired directly by the owner. A third-party provider is solely responsible to the building owner, and can thus play an objective role in ensuring that the project team delivers a building that meets the owner's expectations. The third party can be a designer or contractor, but should not be on the team

#### **Definition: Independent Third-Party Commissioning Provider**

A commissioning provider hired directly by the building owner and not responsible to, or affiliated with, any other member of the design and construction team.

**Comment:** Reviewers: Please be sure to comment on this section, based on your experiences.

delivering the project and should not have financial ties to any member of the project team.

Although this arrangement offers owners the surest guarantee of commissioning provider objectivity, the independent third-party arrangement also requires owners to manage an additional contract, and may add to the cost of commissioning. For large or complex projects, especially buildings with highly integrated, sophisticated systems, the higher first cost is usually offset by the cost savings that result.

#### Design Engineer or Architect

Some design engineers or architects are qualified to act as the commissioning provider. This is more often the case in smaller projects with less complicated systems.

The design professional's familiarity with the project may reduce the cost of commissioning and speed up the project schedule. However, this arrangement can be problematic, and is generally not recommended. When one is immersed in a project, it is easy to overlook issues that may appear obvious to someone with a fresh perspective. It is also very difficult for anyone to review their own work in an unbiased way.

In cases where a design professional also serves as commissioning provider, the potential for conflict of interest must be addressed. The design firm should present their plan for mitigating any potential problems, and commissioning requirements must be included in the design professional's contract.

When undertaking this arrangement, owners should keep three points in mind. First, commissioning is usually not included in the design professional's fees. Second, not all design professionals have the ability to oversee all aspects of the commissioning process, for example writing specifications or troubleshooting systems. Third, the owner may have to exercise a higher degree of diligence in overseeing the commissioning activities.

#### Contractor

Contractors often have the knowledge and capability

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to test the equipment they install, especially in smaller projects with clearly detailed commissioning requirements. In fact in the past, mechanical contractors routinely conducted performance tests and systematic check-out procedures on installed equipment. As construction budgets became tighter, however, most contractors stopped performing these services.

Hiring the contractor to serve as commissioning provider can be particularly helpful when commissioning begins during construction. But here again, there is the potential for conflict of interest, and this arrangement is not generally recommended. Will a contractor objectively test and assess their own work, especially when reporting deficiencies increases their costs?

When the contractor serves as the commissioning provider, the potential for conflict of interest must be addressed. For example, a test engineer may be hired to commission the equipment with test results reported directly to the owner. Again, the owner or the design team will have to exercise more diligence in overseeing the commissioning activities.

Owners should also keep in mind that although contractors may be capable of testing the systems they install, they may not be skilled at testing other equipment or diagnosing system integration problems. And, commissioning requirements are probably not included in the contractor's fee.

#### Owner's Staff

In some cases, the owner's staff has the time and knowledge to act as the commissioning provider. This may occur when members of the owner's staff have previous experience in commissioning, or have both an expert level knowledge of building systems and the opportunity to receive training in the commissioning process.

When the owner's staff serves as the commissioning provider, the benefits can be great. They include vastly improved communication and reduced costs. However, owners should carefully consider whether

**Note: Training Programs for the Owner's Staff**

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their staff has the capacity and qualifications to play this role.



## ***The Selection Process***

**As in evaluating provider qualifications, the selection process should be appropriate to the size, complexity and special needs of the project.**

There are two primary methods for selecting a commissioning provider: competitive bid and selection by qualification.

### **Competitive Bid**

A competitive bid selection process is one in which the owner issues a Request for Proposals (RFP). This process can be time-consuming and expensive. It requires the owner to carefully evaluate each submission.

### **Selection by Qualification**

Selection by qualification can be used on any project, and is especially useful when the project is simple or small. In this case, the provider is selected based on qualifications and rate schedule, supplied as a response to a Request for Qualifications (RFQ). Although this process is often simpler than the competitive bid process using an RFP, it does require the owner to carefully evaluate the providers' qualifications and interview past clients and references.

***Example: RFQ and RFP sample documents***

## Evaluating Commissioning Provider Qualifications

**The size, complexity and special needs of the project determine the qualifications one looks for in a commissioning provider.**

The more complex the project, the more experience is required of the commissioning provider. On projects with special or mission-critical needs, for example hospitals or labs, it is particularly important to select a commissioning provider with directly relevant experience.

### Recommended Provider Qualifications

Individual projects may require a commissioning provider with more, less or different experiences than those described below. This list is by no means all-inclusive.

#### Technical knowledge

In all commissioning projects, the commissioning provider should have experience and up-to-date technical knowledge in the related fields of design, construction and building operations. The provider should also have extensive and recent hands-on field experience in all aspects of the commissioning process. The commissioning provider can employ or partner with technology specialists who have expertise in systems with which the provider is not experienced. However, the HVAC and controls systems are so central to commissioning that the commissioning provider should have a good technical knowledge of the fundamentals, design, and operation of the HVAC system and the implementation of controls systems.

#### Relevant experience

The commissioning provider must have experience troubleshooting commissioned systems. In more complex projects, the provider should have at least five years' experience.

The provider should have served in a similar capacity on at least two other projects with similar needs. In a more complex project, the commissioning provider

#### **Note: Cx Assistant and the CCC**

Together, these two online tools are an excellent resource in evaluating provider qualifications.

#### **Cx Assistant**

[www.energydesignresources.com](http://www.energydesignresources.com)

Cx Assistant is a free, web-based tool that helps owners and designers choose the appropriate range of commissioning services for their project.

Cx Assistant outlines three types of commissioning projects, and provides sample documents for each:

- Abbreviated commissioning, for the most simple projects
- Standard commissioning, applicable to most projects
- Comprehensive commissioning, for the most complex projects

Cx Assistant was developed by Energy Design Resources ([www.energydesignresources.com](http://www.energydesignresources.com)), the educational component of Savings By Design, a statewide new-construction energy efficiency program in California.

#### **California Commissioning Collaborative (CCC)**

[www.cacx.org](http://www.cacx.org)

The recommends provider qualifications for each of the three types of commissioning projects defined by Cx Assistant.

The CCC is a non-profit organization made up of government, utility, and building services organizations.

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should have experience on at least four similar projects.

#### Non-technical skills

The provider should have excellent written, verbal, organizational, and conflict resolution skills.

#### References and sample work products

The commissioning provider should provide references and work products from other, similar commissioning projects.

#### Objectivity

In all commissioning projects, the commissioning provider should be able to provide an objective and unbiased point of view. If a project is complex, involves highly specialized systems, or has mission-critical goals, the provider should be an independent third-party.

### **Commissioning Certification Programs**

There are at least five organizations that certify commissioning providers. Each has its own set of requirements and gives a different title to the providers it certifies. The California Commissioning Collaborative a comprehensive and up-to-date comparison of provider certification programs.

It is important to remember that certification is not a substitute for relevant experience. Owners should carefully evaluate the provider's qualifications, regardless of whether a provider is certified.

#### **Note:**

When evaluating commissioning provider qualifications, owners should follow the following steps:

1. Evaluate the provider's technical knowledge and experience with similar building systems and problems
2. Evaluate the provider's non-technical skills
3. Establish whether commissioning is one of the individual or firm's core services
4. Request and contact references
5. Request and review sample work products

#### **Note: California Commissioning Collaborative Website**

[www.cacx.org](http://www.cacx.org)

## 5. Strategies for Promoting Efficient Operations over the Long Term

Now that the new building has been delivered with all its systems working well, what can an owner, building manager, or operator do to keep it operating efficiently? There are a few key factors that can make the difference between commissioning benefits that are short-lived, and those that endure over the long term. This chapter details several practices that promote efficient operations:

- Design a building that facilitates good O&M practices
- Compile and update comprehensive O&M manuals for all building equipment and systems
- Provide training for building staff before construction is complete, and continuously after occupancy
- Implement a preventive maintenance program for all building equipment and systems
- Track building performance
- Recommission the building

### Online Resources

### Publications

*Strategies for Improving Persistence of Commissioning Benefits* (2003). US DOE/PIER.

O&M Best Practices series (1999). US EPA/US DOE.

## **Good O&M Begins During Design**

### **Like commissioning, successful O&M begins in the design phase of a project.**

Commissioning brings O&M considerations to the table during pre-design and design. At this time, the commissioning provider will identify any potential barriers to good O&M in the facility design and suggest alternative approaches.

Commissioning also provides a forum for soliciting input from building staff during the early stages of design. Building staff have an excellent perspective on how design choices affect their ability to maintain the building, and can often identify items that result in significant improvements to ongoing operations. For example, ensuring consistency with point naming conventions and selecting equipment that matches the staff's skills.

### **Example: Design recommendations that facilitate good O&M**

- Provide ground-floor access to the chiller room through a connected loading dock
- Provide one or more roll-up doors of sufficient size to permit removal and replacement of chillers or other major equipment without the need to disassemble equipment
- Provide sufficient clearance on all sides of the chiller and other major equipment to perform all maintenance
- Install hoist or crane equipment over banks of chillers or other major equipment
- Install sufficient valves to permit the isolation of an individual chiller without having to shut down the entire air conditioning system
- Install walkways around elevated equipment
- Provide roof access with adequate openings via stairs, not ladders
- Provide direct ceiling access to each terminal box

## **O&M Manuals and Sequences of Operation**

**The O&M manuals and Sequences of Operation contain essential information about building equipment and are two of the most important parts of the *Systems Manual*. They will be used by building staff for years to come.**

### **O&M Manuals**

The final, as-built O&M manuals must be well-organized, detailed, and delivered in time for staff training.

In order for building staff to use O&M manuals effectively, the information they contain must be well-organized. An index or table of contents will improve usability and, if it created early in the project, can also serve as a checklist to ensure all contents have been received. It may also be helpful to organize the manuals by system, rather than specification number.

The information in the O&M manuals must be detailed enough to help building staff operate, maintain and troubleshoot equipment. Too often, contractors wait until the last minute to submit their sections of the O&M manuals. This may be at the end of construction, or even later, after occupancy. If the commissioning provider plans to use the O&M manuals to develop functional tests or as a reference during staff training, the due date should be included in the specifications and set as soon as possible after submittals are approved.

The process of keeping the O&M manuals up-to-date begins almost as soon as they are completed. After functional testing and staff training, the commissioning provider may add information gathered during the commissioning process, like equipment submittals, design documents, control strategies, sequences of operations, and copies of the commissioning tests. After occupancy, building staff

### **Note: Who is responsible for creating the O&M manuals?**

O&M manuals are the product of a team effort, and individual responsibilities will vary on each project. In the most common arrangement, contractors produce sections on the equipment they install and the commissioning provider reviews their submissions and compiles the final manual. Alternatively, the commissioning provider can provide a very detailed outline of the manual's contents in the spec. In any case, the commissioning provider will want to review the manual carefully, to ensure it meets the owner's needs.

It is important to note that contractors are not required to produce O&M manual materials unless it is written in the specifications. For manuals to be optimally useful, the specifications should include the level of detail required in the materials and their due date.

### **Note: Recommended O&M manual contents**

- Name, address, and telephone number of installing contractor
- Product data
- Test data
- Performance curves (for pumps, fans, chillers, etc.)
- Installation instructions
- Operation requirements
- Preventive maintenance requirements
- Parts lists
- Troubleshooting procedures specific to the equipment design and application
- Equipment submittals
- Design documents
- Control strategies
- Sequences of operations
- Copies of commissioning tests
- Warranty information

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are responsible for updating the manuals as new material becomes available. This may include checklists, and updates to reflect changes to equipment or operations.

### **Sequences of Operation**

Sequences of operation help building staff understand how the control system should operate. Without detailed sequences, staff will have difficulty verifying correct operation and troubleshooting problems. Although the sequences provided in the contract drawings and specifications provide a good overview, they may not address critical system interaction details, for example, the relation of building pressure control and economizer operation.

At a minimum, a detailed sequence of operations should be created for each HVAC and lighting system.

*Example: Sequences of Operation*

## **Building Staff Training**

**Training is perhaps the most essential factor in good O&M. Unless operators and managers have the right knowledge and skills, it will be impossible for the building to perform optimally over the long term.**

Training for building staff should occur throughout the project, starting during construction and prior to substantial completion. Starting training during construction gives staff the best opportunity to learn about building systems and equipment. The staff's observation of functional testing may be their first training experience in the new building.

The commissioning provider works with the owner to develop a training plan that will prepare building staff to maintain building performance after turnover. Training may include classroom work and hands-on site demonstrations. Training should also include site orientation. This is best done during construction, while the building's walls are still open and access points are visible – a key reason why it is so important to start thinking about training during design.

Training will likely occur over several days. If staff is brought into the project at the end of construction, it is helpful if their first training session provides an overview of the project, including a discussion of the project's goals in the *Owners Project Requirements* and *Basis of Design*. This gives building managers and operators a thorough understanding of why the facility was constructed and how it is intended to operate, as well as its limitations.

In buildings where O&M activities are led by a facility manager who does not have a technical background, the commissioning provider will work with contractors to ensure that the manager understands the capabilities, intended function, and required maintenance of the building systems. Emphasis should be placed on preparing the facility manager to respond to occupant complaints without circumventing design intent. It will also be important to provide the facility manager with a list of resources for maintenance

### **Note: What if training will not begin until after construction is complete?**

If training will not begin until after construction is complete, it is important to hold a site tour for facility staff before finished walls go up, so they can see how systems connect first-hand, rather than just on paper. As an alternative, contractors can be asked to video or photograph systems immediately after installation.

### **Note: Training requirements in the spec**

Training requirements must be clearly detailed in the specifications. Important points to include are:

- Contractors' requirements regarding developing training materials and conducting training sessions
- Training topics
- Who should attend
- When and how the training will be conducted (onsite, factory, classroom, before or after construction)
- How the training will be documented (written documentation, video)

### **Note: Suggested training topics**

- Descriptions of systems/equipment and their warranties
- Operation instructions and procedures: equipment start-up and shut-down, seasonal changeover, and manual/automatic control
- Emergency instructions and procedures
- Operation and adjustment of dampers, valves and controls
- Adjustment instructions: information for maintaining operational parameters
- Requirements and schedules for maintenance on all operation and maintenance-sensitive equipment
- Common troubleshooting

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assistance.

## Ongoing Training

A work environment that provides high-quality operator training, time to study and optimize building operation is most likely to maintain a high level of building performance, year after year. Building operators should be encouraged to increase their knowledge and enhance their job skills by taking readily available training courses offered by utility energy centers, training organizations, and equipment manufacturers.

- problems, their causes, and corrective actions
- Indoor air quality, health, visual comfort, acoustic comfort, and safety issues
- Recommendations for special tools and spare parts inventory
- Hands-on operation of equipment and systems
- Review of operation and maintenance manuals, and their location onsite
- Building walk-through
- Review of related design intent documents
- Energy management control system operation and programming
- Control sequences and strategies
- Thermostat programming
- Relevant commissioning reports and documents
- When and how to recommission building systems
- Sound energy management practices
- Exotic or special equipment like scrubbers, fume hoods, or water features/fountains

From CHPS Best Practices Manual, 2002, p. 437 and ASHRAE Guideline 0 – 2005, p. 12.

### **Note: Ongoing Training Opportunities**

#### Building Operator Certification

The BOC's competency-based trainings are designed specifically to help building operators improve their ability to operate and maintain comfortable, efficient facilities.

BOC courses are offered at two skill levels and cover several topics, including electrical, HVAC and lighting systems, indoor air quality, environmental health and safety, and energy conservation. Classes are usually a combination of lecture, discussion and small group activities. BOC classes are held continuously, at locations across California.

Course schedules and descriptions

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are available at the BOC website:  
[www.theboc.org](http://www.theboc.org)

[include BOC logo]

Pacific Gas & Electric  
Pacific Energy Center (PEC)  
San Francisco  
[www.pge.com](http://www.pge.com)

Sacramento Municipal Utility  
District  
SMUD Customer Service Center  
Sacramento  
[www.smud.org](http://www.smud.org)

Southern California Edison  
Customer Technology Application  
Center (CTAC)  
Irwindale  
[www.sce.com](http://www.sce.com)

## **Preventive Maintenance**

### **Preventive maintenance saves energy, increases equipment life, and helps prevent unexpected equipment failure.**

Good preventive maintenance practices require building staff to continuously monitor building equipment and document all maintenance activities. In some buildings, a computerized maintenance management system is used to generate work orders, and can be used to help develop a *Preventive Maintenance Plan*. In others, the commissioning provider can help staff develop the plan.

### **Developing a Preventive Maintenance Plan**

A *Preventive Maintenance Plan* consists of a checklist of maintenance tasks and a schedule for performing them. Most of the required information will have been gathered during the commissioning process, or can be obtained from the O&M manuals.

Preventive maintenance checklists should be kept separately for each piece of equipment and updated after maintenance tasks are performed. It may be helpful to structure checklists as logs, with room for at least two people to sign off: the technician who performs the maintenance task and the supervisor who verifies the task was performed.

The preventive maintenance schedule is usually determined by the manufacturer's recommended service intervals, often measured in hours of equipment run time.

Many major controls contractors offer preventative maintenance modules for their software that automatically track activities and alert staff when maintenance is needed. These systems can provide valuable information to building staff, especially if they are operational prior to occupancy and the staff is well-trained in using them.

It may be helpful to review the *Preventive Maintenance Plan* at a yearly "lessons learned" meeting with building staff, consultants, and the owner. This meeting allows all parties to review

#### **Note**

Preventive maintenance can save building owners time and money by:

- Maintaining efficient facility operations
- Extending equipment life
- Increasing energy savings
- Preventing losses of equipment, time, productivity, and resulting revenue

#### **Note: Preventive maintenance and energy savings**

Energy savings from preventive maintenance really add up. Simply replacing worn fan belts on a regular basis can save 2-4% of total fan energy. Cleaning air filters and cooling coils regularly can save 1-3% of the building's total cooling energy.

#### **Note: The Preventive Maintenance Plan**

The *Preventive Maintenance Plan* should include an up-to-date equipment list. For each piece of equipment, the following information should be included. Much of this will be gathered during the commissioning process.

#### Required information

- Unique equipment identification number
- Name plate information
- Manufacturer's name
- Vendor's name and telephone number
- Equipment location
- Date installed

#### Desirable information

- Expected equipment life
- Expected annual energy use
- Maintenance schedule
- Maintenance task descriptions
- Forms for collecting and documenting required information

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whether the building's operating intent has changed, review maintenance activities, and share information about plans and requirements during the coming year. It may be beneficial to bring in a third-party facilitator to run the meeting, so attendees can focus on the discussion.

### **Outsourcing Preventive Maintenance**

When building staff is not available or trained to perform preventive maintenance tasks, it may be advisable to purchase a maintenance service contract from the equipment vendor, installing contractor, or a maintenance service contractor. Service contractors hired during the construction phase should receive the same training as would have been provided to in-house staff. In cases where maintenance is outsourced, the O&M manuals will be particularly important.

**Note: Maintenance service contracts**

A service contract should cover all the manufacturer's recommended preventive maintenance procedures, as described in the O&M manual. More information on service contracts can be found in *Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings*, one of seven volumes in the O&M Best Practices series. All seven are available in the CCC library: [www.cacx.org](http://www.cacx.org).

## **Performance Tracking**

Tracking building performance helps building staff detect problems early, before they lead to tenant complaints, high energy costs, or unexpected equipment failure. In fact, in today's buildings problems may be impossible to detect without performance tracking. There are three important strategies for performance tracking: benchmarking, utility tracking, and trend analysis.

## **Benchmarking**

Benchmarking is a way for building owners and operators to track their building's energy use over time and compare it to other buildings. Owners of multiple buildings can use benchmarking to compare buildings and prioritize improvements.

Several online resources are available to help with building benchmarking. Two of the most comprehensive and widely applicable are ENERGY STAR Portfolio Manager and the Cal-Arch Building Energy Reference Tool.

### ENERGY STAR Portfolio Manager

This web-based tool uses the energy bill data and building characteristics supplied by building staff to rank the building compared to other, similar buildings. When it compares building, Portfolio Manager takes into account factors that are outside the control of the building staff, like climate, occupancy level, hours of operation and space use. Buildings scoring 75% or higher can apply for the ENERGY STAR label.

Portfolio Manger is the most widely used building benchmarking tool. It was developed by the U.S. Environmental Protection Agency (EPA) and since 1999, approximately 12% of the total building market has been benchmarked using this tool.

### Cal-Arch Building Energy Reference Tool

This web-based tool shows how a building's energy use per square foot compares to other California buildings. Unlike Portfolio Manager, Cal-Arch doesn't take anything into account except the size of the building and the amount of energy it uses. As a result,

### **Note: Benchmarking Tools**

ENERGY STAR Portfolio Manager  
[www.energystar.gov/benchmark](http://www.energystar.gov/benchmark)

Cal-Arch Building Energy Reference Tool  
<http://poet.lbl.gov/cal-arch/>

Lawrence Berkeley National  
Laboratory Cleanroom  
Benchmarking  
<http://ateam.lbl.gov/cleanroom/benchmarking/>

Oak Ridge National Laboratory  
Benchmarking Spreadsheets for  
Office Buildings  
<http://eber.ed.ornl.gov/commercialproducts/cbenchmark.htm>

Cal-Arch can be faster and easier to use, but may not be as helpful in detecting and explaining differences in performance. Energy-intensive buildings like labs or data centers may receive low rankings because they use a lot of energy, even though they use it very efficiently.

## Utility Tracking

Utility tracking and troubleshooting are key elements in ensuring long-term building performance. Where benchmarking compares utility consumption against other buildings, utility tracking measures the building's energy use over time and helps staff understand the building's energy consumption patterns. By tracking performance over time, building operators can spot emerging problems before they cause occupant discomfort or premature equipment failure. There are a host of energy accounting software tools available. Utility tracking can also be automated using an Energy Information System (EIS).

## Trend Analysis

The data handling capabilities of DDC systems allow building staff to "listen" to the building by supplying data on building operations over time.

In order to be useful, a DDC system must have enough memory to trend and archive data. It is also important to understand how the system stores data. Is it automatically downloaded to a hard drive, or does this process need to be scheduled?

Without analysis capabilities, however, the data will be useless. When building staff are not familiar with the trending capabilities of the DDC system, or unskilled in how to set up trends and interpret data, it may be helpful to bring the control vendor onsite for training.

### **Note: Utility Tracking Strategies and Tools**

- Compare average daily consumption curves for different years, looking for significant variations not attributable to changing loads or weather
- Compare peaks and valleys of curves to identify energy efficiency opportunities
- Select the type of EIS that matches the building's needs – there are several, including:
- Utility-EIS: automates process of gathering utility data
- Demand Response: a feature that helps a building reduce energy use when total system loads are high
- Enterprise Energy Management: tracks utility data for several buildings, and compares them
- Web-based Energy Management and Control: allows for the monitoring of utility data over the internet

## **Recommissioning Plan**

**Recommissioning occurs when a building that has already been commissioned undergoes another commissioning process to help keep it operating optimally.**

Ideally, a plan for recommissioning is established as part of a new building's original commissioning process.

The need for recommissioning depends on several things: changes in the facility's use, quality and schedule of preventive maintenance activities, and the frequency of operational problems. In California, recommissioning is required of all state buildings over 50,000 square feet on a recurring five-year cycle, or whenever major energy consuming systems or controls are replaced.

Recommissioning is similar to new building commissioning, although the phases and goals are slightly different. Recommissioning begins with a review of the operational requirements of the building, to determine if there have been any changes. When changes have occurred, systems are reviewed to determine if corresponding changes in equipment or operations are necessary. Next, systems are inspected, just as they would be in new building commissioning, and any issues are recorded in an *Issues Log*. Functional performance tests and trend logs may be used to determine if the systems are still operating as intended. Minor system improvements may be implemented during recommissioning, while others may require more significant design, scheduling and budgeting. The *Systems Manual* will also be reviewed to determine if updates or trainings are required. Finally, the *Owner's Project Requirements* document is updated to reflect any changes in building systems and functions.

When a facility has known problems, a commissioning provider may be the best choice to lead the recommissioning effort. Even when the facility has enough resources to staff the recommissioning effort

### **Note: Time to recommission?**

Positive answers to two or more of the following questions indicates that it may be time to recommission:

- Is there an unjustified increase in energy use? Is energy use more than 10% higher than previous years?
- Have comfort complaints increased compared to previous months or years?
- Has nighttime energy use increased?
- Is building staff aware of problems but without the time or in-house expertise to fix them?
- Has control programming been modified or overridden to provide a quick fix to a problem?
- Are there frequent equipment or component failures?
- Have there been significant tenant improvement projects (build-outs)?
- For State of California buildings over 50,000 square feet: Has it been five years or more since the previous recommissioning process? Have any major energy consuming systems or controls been replaced recently?

internally, a third-party commissioning provider brings a fresh perspective that is especially helpful in solving nagging problems. Staff should work as closely with the commissioning provider as time permits, since the troubleshooting techniques and systems knowledge they will gain will be useful during normal building operations.

In cases where the building staff has the time and resources to lead the recommissioning effort, it is possible to recommission without hiring a third-party provider.

## 6. Getting Started

So how does an owner or building manager get started with commissioning? There are a few key steps that will help get a new commissioning project off to a strong start:

### **Become informed about commissioning**

Explore the resources listed in this Guide, explore online resources, and begin talking to others about their experiences, including designers and contractors.

### **Determine what local, utility and government resources are available**

Contact utility representatives and government agencies to learn about the incentives they offer for commissioning and other energy efficiency products and services.

### **Start early! Identify an upcoming project that could benefit from commissioning – preferably one not yet in design**

Begin thinking about the special needs of the project and the commissioning scope that will be required to meet them. Consider holding a “lessons learned” workshop on a recently completed project to identify issues that commissioning should address. If a full commissioning process cannot be implemented, think about how to employ selected commissioning strategies.

### **Obtain buy-in from members of the organization**

Consider giving a presentation on commissioning or inviting a commissioning provider to come explain its benefits to staff. Identify any individuals who may need convincing and be sure they are present.

### **Hire a commissioning provider, specify the project scope and objectives**

Identify commissioning providers working in the area and begin investigating their qualifications. Ask whether the provider’s experience is relevant to the project’s needs. Once a provider is selected, the owner and provider must work together to clearly scope the commissioning process and define its objectives. The owner should require the provider to create a detailed commissioning plan, hold a kick-off meeting, conduct site inspections, deliver progress reports and *Issues Logs*, and produce a *Commissioning Report*.

### **Designate an in-house commissioning manager**

Select a member of the owner’s project team to represent the owner during the commissioning process.

### **Include commissioning requirements in the specifications**

It is absolutely essential to include commissioning requirements in the specifications. Without them, contractors will not be required to participate in the commissioning process and may issue change orders if asked to complete commissioning tasks.

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## **Become an Advocate for Commissioning in Your Organization**

If you are in a position of authority, others in your organization will take the lead from you. If you are fully committed to the commissioning process, communicate your expectations, and become an active and interested participant in the process, you will achieve maximum benefits, and others will recognize its value as well.