# Commissioning LEED<sup>™</sup> Buildings: Different levels of sophistication require different levels of Commissioning

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#### Synopsis

A typical US Green Building Council LEED<sup>1</sup> certified building is anything but typical. For example, small office buildings are installing complex mechanical systems such as central plants with thermal energy storage and underfloor air distributions systems in an effort to increase energy efficiency. The rigors of the LEED rating system require advanced energy performance and excellent indoor environmental quality coupled with top-notch construction practices. The commissioning authority is charged with verifying that these advanced concepts are translated into reality. This paper presents three case studies that examine the ways that building type, system complexity, and owner commitment impact the scope of the commissioning process for a LEED green building.

#### About the Authors

After completing her Bachelor's degree in engineering, Treasa Sweek joined CTG Energetics, Inc. to pursue her interest in sustainability. Treasa's work with CTG Energetics has focused on commissioning, energy audits, and energy simulation. Since joining CTG, Treasa has managed commissioning projects for six LEED version 2.0 green buildings. Treasa also has experience in the evaluation of building projects for cost effectiveness and performance verification. She has provided energy analysis for many commercial, institutional, and military facilities. Treasa has conducted electrical and mechanical energy audits for over 75 buildings totaling more than six million square feet. Treasa is a professionally registered Mechanical Engineer in the State of California, and an associate member of ASHRAE.

Tom Lunneberg provides energy efficiency consulting, analysis and training to a variety of commercial and institutional clients, and is responsible for managing the day-to-day activities of CTG Energetics, Inc. Mr. Lunneberg has extensive experience in the evaluation of energy projects for cost effectiveness and performance verification and has provided analysis for numerous commercial, municipal, military, institutional, and healthcare facilities. He has conducted over five hundred energy audits throughout Southern California for a variety of

<sup>&</sup>lt;sup>1</sup> LEED<sup>TM</sup> stands for <u>L</u>eadership in <u>E</u>nergy and <u>E</u>nvironmental <u>D</u>esign and is a trademark of the United States Green Building Council.

commercial and industrial facilities. In addition, Mr. Lunneberg has provided training to a number of clients on topics of energy efficiency and energy management.

## Introduction

#### What is LEED?

The Leadership in Energy and Environmental Design (LEED) Green Building rating system is a self-assessing system designed for rating new and existing commercial, institutional, and high-rise residential buildings. It evaluates environmental performance from a "whole building" perspective over a building's life cycle, providing a definitive standard for what constitutes a green building. LEED combines seemingly disparate measurements of "greenness" within a single point-based rating system. LEED was developed by the United States Green Building Council (USGBC). The system represents the USGBC's efforts to develop a standard that improves environmental and economic performance of commercial building using leading-edge industry principles, practices, materials and standards.<sup>2</sup>

In order to achieve LEED certification, a project must meet numerous prerequisite criteria and also earn a minimum number of "points" from a list of performance criteria covering everything from site selection to indoor air quality. The number of points earned by a project determines the level of certification awarded, ranging from "Certified" to "Platinum". Commissioning the "fundamental building systems" is one of the prerequisites of a LEED green building. In addition to this prerequisite, one point can be earned by completing an enhanced commissioning process. The tasks completed as part of this enhanced process are referred to as "additional commissioning".

#### Commissioning as a buzzword

While commissioning processes and procedures have been developed and applied to a variety of buildings for almost 20 years (and have been performed for Naval ships for much longer than that), the nearly instant popularity of the LEED rating system has created new interest in commissioning. Since the release of LEED version 1.0, commissioning has been re-introduced to the building community. Because it is a requirement for LEED version 2.0 certification, many commissioning authorities throughout the country have seen an increase in project volume.

In addition to more work, commissioning authorities are also working on a greater variety of projects such as 20,000 square foot libraries, tilt-up office buildings and ski lodges as well as "traditional" commissioning projects like medical and manufacturing facilities. The impact of LEED is also being felt in the sophistication of mechanical, electrical, plumbing, and envelope systems for all types of buildings, affording commissioning authorities the opportunity to work on more complex building systems. Of course, the most important advantage of commissioning's sudden popularity is that more buildings are commissioned and, as a result, are working better. Not including LEED buildings, it is estimated that less than 1% of new

<sup>&</sup>lt;sup>2</sup> <u>www.usgbc.org</u>

construction projects are commissioned. Since 1999, LEED has added 370 buildings (more than 60 million square feet) to this pool.<sup>3</sup>

However, this sudden name recognition also has some disadvantages. Many building owners pursue LEED ratings without understanding the financial and temporal requirements of the building commissioning process. As a result, commissioning is often employed in a "too little/too late" fashion, in which the commissioning authority is retained too late in the design and construction process to be effective, or their scope is so limited that they cannot properly address building system deficiencies. A typical mistake that stems from lack of commissioning savvy on the part of the owner is failing to include commissioning requirements in the bid documents. In such cases, commissioning authorities often find themselves in the position of being an unpopular third wheel in the design and construction process. Then the commissioning process is often perceived as nothing more than a scheduling and budget annoyance by the project team that it has been seemingly "forced" upon. Even though many projects have good intentions when the pursue LEED ratings, their poor understanding of commissioning means that many of its benefits are never realized.

#### **Barriers to Commissioning LEED Buildings**

When commissioning a green building, a commissioning authority often wishes to be part of a process where the goal is to be able to say, "Building Y is fully functional in accordance with the owner's project requirements and the LEED green building rating system". However, such an integrated approach to commissioning has rarely been possible. Barriers to this process include owner buy-in, project team education, and the integration of commissioning with the rest of the LEED rating process.

It can be time-consuming to educate owners on the breadth and depth of the commissioning process. Commissioning is not an intuitive process to start with, and its vagaries are exacerbated by the complexities of the LEED<sup>TM</sup> rating system as well as the additional work required to produce a green building. Without support from the owner, it is usually not possible to obtain the commissioning budget and scope that are needed to commission a building holistically.

Another barrier to commissioning is a lack of knowledge and understanding on the part of the design and construction team. Many design teams are unfamiliar with commissioning as a design phase activity. Recently, one architecture firm stated, "to ensure that the [HVAC] systems operate in their most effective manner, building commissioning is highly recommended upon completion of construction". However, most design professionals and contractors profess to understand building commissioning. If a commissioning authority is brought on to a project with these misunderstandings, much time and effort must be used to educate the team members. This process can become a hindrance to the smooth integration of commissioning into a project.

<sup>&</sup>lt;sup>3</sup> 20 buildings are LEED certified. In addition, 350 buildings have completed preliminary registration. The list of buildings registered for LEED certification can be found at <u>www.usgbc.org/programs/LEEDregistration.pdf</u>

Finally, the LEED commissioning process suffers from a lack of integration with the other requirements of the rating system. The LEED reference manual lists systems that must be commissioned<sup>4</sup> and, while this list covers a great number of energy using systems, it does not include green building components required by other LEED sections such as water efficiency and indoor environmental quality. If the commissioning authority is hired to follow only the minimum requirements of the LEED commissioning process, they are often limited to the systems in this list and are not able to develop an integrated commissioning process.

When these issues are combined with the relative youth of the both the building commissioning movement and the LEED rating system, successfully commissioning a LEED building is a challenge. Despite the commissioning authority's inclination to verify all green building design features, they are forced into limiting their focus to those systems required to meet the LEED requirements. However, within the framework of the LEED commissioning requirements, different levels of commissioning can be applied depending on the owner's project requirements. Three case studies illustrate this idea. In each example, the prerequisite requirements for the LEED certification are met.

# Case Study: Low rise office building

## **Project Overview**

- **Project**: Owner-occupied non-profit headquarters building. Design-build construction contract.
- Schedule: 32 months
- LEED<sup>TM</sup> Goal: Silver
- Size: 45,000 s.f.; approximately 145 occupants
- **Occupancies**: private office, open office, conference rooms, kitchen, subterranean garage, fitness center.

The owner's project requirements included creating a sustainable building focused on providing a productive, pleasant environment for its inhabitants and achieving a LEED rating. The owner hired the commissioning authority and the LEED coordinator (separate companies) shortly after construction began at the end of the design development phase.

## **Green Building Systems**

Many of the building design features were integrated as part of the green building design certification process. These features include a central chilled water plant with ice-based thermal energy storage, underfloor air distribution system, occupancy sensors and daylight sensors throughout the building, water–efficient plumbing fixtures, operable windows, operable rooftop

<sup>&</sup>lt;sup>4</sup> The LEED<sup>TM</sup> reference manual states that the following systems must be commissioned: HVAC systems and their controls, ductwork and pipe insulation, renewable and alternative energy technologies, lighting controls and daylighting systems, waste heat recovery, advanced technologies such as thermal energy storage.

monitors, sustainably harvested wood for interior finishes, low-emitting materials, and photovoltaic electricity generation.

#### **Commissioned Systems**

Many of the energy-using systems incorporated as part of the green building design were commissioned. The systems commissioned in this building include:

- HVAC central plant & main air handling units. This system includes an evaporatively cooled chiller, ice-based thermal energy storage tanks, and a hot water boiler.
- underfloor air distribution system
- occupancy sensor and daylight sensor controls
- photovoltaic system
- building direct digital control system. This system controls the building HVAC, lighting, and window systems. It also includes points to monitor energy consumption of major building end uses.

#### **Results & Conclusions**

The commissioning process verified the installation and functionality of the commissioned systems listed above. Throughout the design review process and the installation verification process, the commissioning authority highlighted several design and installation issues. These issues were discussed by the project team and resolved. If the design issues raised by the commissioning authority had not been corrected, the thermal energy storage system would not meet peak cooling loads. As a result, the electricity savings that the owner is depending on would not have been realized.

During system installation, the mechanical contractor used commissioning checklists to document the installation process. Before functional testing, the checklists and associated manufacturer's start-up forms were completed and signed off. This process pointed out that, in some cases, features and controls included in submittals could not be installed as intended. In these cases, the commissioning authority tracked the differences and made sure that the documents turned over to the owner were correct.

This commissioning process resulted in functional systems and a well-organized manual for the owner. Due to the mismatch between the complexity of the systems installed and the relative sophistication of the building maintenance staff, the turnover package was especially important. The commissioning authority tracked the training program for the commissioned systems and worked with the contractors to format the operational and maintenance manuals. This commissioning process met both the prerequisite requirements and the "additional" requirements of the LEED Rating System.

Although no specific commissioning requirements were included in the construction bid documents, the design/build contractor and their sub-contractors went out of their way to accommodate the commissioning process.

#### **Barriers and Lessons Learned**

The greatest challenge in this project was educating the design and construction team regarding the scope of commissioning. The commissioning authority's position in the project hierarchy helped overcome this challenge. Because the commissioning authority was hired directly by the owner and the importance of a LEED rating was made clear, the project team took the extra effort needed to understand the commissioning process. Once the level of effort was understood, commissioning was integrated into the project schedule and, when necessary, commissioning issues took priority.

# Case Study: Manufacturing Facility

#### **Project Overview**

- **Project**: Owner-occupied manufacturing facility. Traditional plans and specifications construction contract.
- **Construction Schedule**: 8 months (Project designed more than a year before it was constructed)
- LEED<sup>TM</sup> Goal: Silver
- Size: 6,700 s.f. office; 43,700 s.f. manufacturing space
- Occupancies: office, open air manufacturing facility.

This project was conceived more than a year before it was constructed. When a contractor was hired to build the design, the owner added LEED certification as a project requirement. The owner hired the commissioning authority at the beginning of the construction process. In lieu of a LEED accredited professional, the company's project manager coordinated the LEED application.

#### **Green Building Systems**

Many of the building design features were integrated as part of the green building design certification process. These features include direct/indirect lighting fixtures in the office, blownin wall and roof insulation, a radiant barrier at the roof of the office, a 85-kW photovoltaic system, a storm water collection/retention system, a daylighting control system in the manufacturing area, exhaust air heat recovery, waterless urinals, tankless domestic hot water heaters, occupancy sensors in office areas, window shading, sustainably harvested wood framing, and low-emitting furnishings.

#### **Commissioned Systems**

Nearly all of the energy-using design features were commissioned. The systems commissioned in this building include:

- heating system for the office building,
- lighting control systems,
- photovoltaic system,

- storm water collection/retention system,
- domestic hot water system, and
- plumbing fixtures.

None of the manufacturing process equipment was commissioned.

#### **Results & Conclusions**

The commissioning process verified the installation and functionality of the commissioned systems listed above. Due to the owner's keen interest in sustainable design and energy efficiency, some systems were modified or re-designed during construction. The commissioning authority tracked the building system design and installation. When the intent of certain design concepts was unclear, the commissioning authority worked with the designers and contractors to clarify and document the installation. Commissioning issues that were identified were discussed by the project team and resolved promptly.

This commissioning process resulted in functional systems and a well-organized manual for the owner. Due to the mismatch between the uniqueness of the systems installed and the sophistication of the building maintenance staff, the turnover package was especially important. The commissioning authority tracked the training program for the commissioned systems and worked with the contractors to format the operational and maintenance manuals. This commissioning process met the prerequisite requirements of the LEED rating system as well as the requirements for the "additional" point.

#### **Barriers and Lessons Learned**

The greatest challenge in this project was tracking and documenting the installed systems. This project was located in a small town and built by a group of professionals who work together regularly. Although the building installation was exemplary, design documentation was minimal in many cases; some systems had nothing more than a hand-drawn sketch to explain the installation. In these cases, the commissioning authority developed narratives that describe the equipment, installation, and system operation. These narratives offer the most detailed written explanation that the owner received.

# Case Study: Mid-rise office building

#### **Project Overview**

- **Project**: Owner-occupied corporate headquarters building for international divisions. Design-build construction contract.
- Schedule: 15 months
- LEED<sup>TM</sup> Goal: Silver
- Size: 245,000 s.f.; approximately 850 occupants
- **Occupancies**: offices, conference center, product development wing, product display area, fitness center, kitchen.

The Owner's project requirement for this building was to obtain a LEED rating. The architect brought the commissioning authority and LEED coordination company on board during the design documents phase.

#### **Green Building Systems**

Many building design features were integrated as part of the green building design certification process. These features include a green roof covered with lightweight vegetation, 100% reclaimed water system used for site irrigation, a 200 kW fuel cell to generate electricity and heat water for the kitchen, a variable speed centrifugal chiller, and an underfloor air distribution system.

#### **Commissioned Systems**

Many of the energy-using systems incorporated as part of the green building design were commissioned. The systems commissioned in this building include:

- HVAC central plant & main air handling units,
- HVAC direct digital control system,
- lighting control system, and
- fuel cell heat recovery system.

Due to project schedule and commissioning scope, almost none of the sustainable design features incorporated as a part of the LEED process were commissioned. The systems that were commissioned included the minimum list required by LEED.

#### **Results & Conclusions**

The commissioning process verified the installation and functionality of the commissioned systems listed above. During and after construction, the commissioning authority highlighted several design and installation issues. When raised during commissioning meetings, the project team discussed these issues. Some items were resolved while others were not. The construction and commissioning teams worked on some of the building equipment for several months after occupancy. The commissioning authority also tracked the mechanical systems and lighting-control training program and worked with the mechanical contractor to format the operational and maintenance manuals.

Three of the most visible LEED design features were not commissioned: the irrigation system, the green roof, and the underfloor air distribution system. While there have been no significant problems discovered with the green roof or irrigation system, the underfloor air distribution system suffered a few installation and operational glitches. If the construction schedule had allowed this system to be commissioned, it is likely that these issues would have been discovered.

#### **Barriers and Lessons Learned**

The project construction schedule was the greatest barrier to a successful commissioning process. The building owner had a hard deadline for occupancy and the building was "fast-tracked" from the beginning of the project. In addition, commissioning was not integrated into the project when the construction schedule was set. The schedule was so aggressive that the project team was not able to integrate commissioning into the construction process. As a result, issues raised by the commissioning authority during construction were not always addressed. In some cases, prefunctional checklists were not completed during installation and start-up. Functional testing was not conducted until after occupancy which, in some cases, was well into the warranty period.

Another barrier was the commissioning authority's position in the project hierarchy. The architecture firm that hired the commissioning authority was a sub-contractor to the design-build contractor. Because of this organization, it was difficult for the commissioning authority to represent the owner's needs to the design-build contractor. In some instances, this hierarchy caused commissioning tasks to be delayed or disregarded.

A third barrier was that commissioning was not established as an initial project goal. As a result, a basis of design document was not maintained. If the commissioning team had been established at the beginning of this project, it is likely that commissioning could have been completed much sooner and with fewer deficiencies.

One reason for these hurdles is that this building was the first LEED version 2.0 green building in California. As a result, everyone on the project – including the commissioning authority – was learning the LEED process and requirements. Despite many hurdles, the building was occupied on time and the owner is happy with the result.

## Conclusion

To successfully commission a LEED green building, owners must understand and support the commissioning process, commissioning must be a goal early in the project, and the commissioning team must have the authority to get design and construction issues addressed and resolved promptly.

Commissioning authorities must plan to educate building owners on the financial and temporal requirements of the building commissioning process. In addition to explaining commissioning, the owner's education process should include an introduction to the additional design and construction work required to produce a green building and information regarding the LEED certification process. Until LEED and commissioning are more common, owners should not expect LEED rating without some increase in first cost.

As soon as LEED becomes a project requirement, the commissioning authority should be hired. At minimum, a commissioning authority should be consulted before bid documents are issued to make sure that commissioning requirements are properly included in the construction documents. To obtain both the prerequisite requirements and the "additional commissioning" requirements, the commissioning authority should be hired during the conceptual design phase and should be retained through the end of the contractor's warranty.

Either the building owner or the owner's representative should hire the commissioning authority. The commissioning team must be able to get issues addressed and resolved by the project team. To do this, the commissioning authority must be able to raise issues with the owner if the project team is not responsive. When commissioning authorities are sub-contractors to the design and/or construction team, commissioning tasks can become secondary to other project deadlines.

	x+ Building Info
Cx+ INTRODUCTION	Please input the information about the New Office Building building systems below:
Cx+ TOOL Cx+ RESOURCES	Central HVAC System Type: Packaged DXHVAC
Cx+ Commissioning Tool RESET BUILDING INFORMATION	Type of Air Distribution: Overhead Constant Volume Delivery
SET NEW COMMISSIONING LEVEL	Building Controls Information: No Building Automation System or Demand Control Ventilation
SCOPE GENERATOR SAMPLE SPECIFICATIONS GENERATOR PROJECTED COMMISSIONING COSTS	Enter the following additional building information:
COMPLICITIES CONTRACTOR	Building location: Los Angeles Metropolitan Area 💌
	Who is the client for Developer
	Submit Building Information

One way to overcome education hurdles is to refer owners and design professionals to one of the several Internet resources that explain the commissioning process. One such resource, developed by Pacific Gas & Electric Company, provides project specific commissioning information to design teams and owners. The tool enables the user to evaluate probable commissioning cost, to identify the

appropriate commissioning scope, and to access sample commissioning specifications related to their construction project.

Both the LEED rating system and the commissioning process are relative newcomers to the building construction industry. Though many contractors and design professionals profess to be familiar with commissioning, few projects implement a true commissioning process. However, the rapid popularity of the LEED rating system is an indictor that LEED certification may become commonplace in the near future. As commissioning is employed in each LEED green building, owners and project teams will better understand the process. This understanding will help to overcome the current hurdles to commissioning a LEED green building.