Commissioning to Meet Green Expectations

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ABSTRACT

Due to their novelty and at times scarcity, green products and strategies are likely to be misapplied, poorly installed, and wrongly (or at least not fully) utilized. Building commissioning, which has been successfully applied to energy and building operation measures, can also be applied as a quality assurance process to ensure that sustainable design features are provided, installed and used correctly in commercial buildings.

Commissioning is a systematic process—beginning in the design phase and extending through the typical warranty period—of ensuring, through documented verification, that all building systems perform interactively according to the contract documents, and that facility staff are properly trained and system documentation has been adequately provided. Ideally, this results in a facility that fully meets the design intent and the owner's operational needs (PECI 1997).

Although commissioning has historically been applied to dynamic systems (HVAC, controls, etc.), the process can also be used to address the more static features associated with sustainable building design. Commissioning, especially when applied early in the design process, can mitigate problems related to building systems and materials and ensure that the design and the final product meet owner expectations for sustainability.

Introduction

Commissioning and green building design share three things in common (York, 1998):

- They both involve a systems approach to looking at buildings and building performance.
- They both view buildings from a life-cycle perspective.
- They both involve increased attention during the design phase to ensure that the design meets owner and occupant needs.

These common features make commissioning an ideal process for ensuring that the sustainable concepts initiated in the design phase are actually successfully incorporated into the completed building.

Commissioning is a quality-assurance process designed to increase the likelihood that a newly constructed building will meet client expectations. Commissioning stretches over the entire design and construction process. It should ideally begin at the design phase, with the selection of a commissioning provider who helps ensure that the building owners and designers' intent is written into project documentation. The building designers then incorporate commissioning requirements into their specifications. Later, the commissioning provider is responsible for inspecting building systems and components during construction, and when the project is near completion, the provider and contractor conduct rigorous performance tests. At the end of the commissioning process, building operators receive training and documentation to ensure proper operation and maintenance of the building.

Sustainable design and construction concepts are relatively new to most building owners, designers, contractors and suppliers. The importance of the sustainable components and their integration into the whole building (as with most other new or nonstandard technologies) is not likely to be adequately articulated to those responsible for installing and using the components. Sustainable products and features are susceptible to substitution with less appropriate products because they are often specialty or scarce items or techniques. (One source for inappropriate substitutions is the value engineering process.) Subsequently, green products are more likely to be poorly applied, installed, and utilized by the construction and facility operations teams. Building commissioning, which has been successfully applied to energy and building operational issues, can also be applied as a quality assurance process to ensure that the sustainable features envisioned by the owner and specified in the contract documents are actually provided, installed and used correctly (Stum, 1998).

The design and construction of green buildings pose problems similar to those found in high-performance, energy-efficient buildings. This is especially true since a core component of sustainable design is energy efficiency. A good sustainable design will include systems that are "right-sized" (rather than the typically oversized mechanical systems) for the building (York, 1998). Oversizing equipment has become a standard design practice, because—due to design, installation, and/or operation errors—systems rarely function at their intended capacity. These errors occur because of the fragmentation between design, construction and operation resulting from a general lack of a systems approach in the building process. Commissioning can facilitate improved integration and communication between these phases and can also ensure that right-sized systems function as intended and specified.

LEED™ Certification

The US Green Building Council recognizes the importance of commissioning green buildings and has incorporated commissioning into the LEED™ [1] Green Building Rating System requirements. Owners of commercial buildings can submit their projects for assessment on environmental performance. Their buildings are rated in terms of sustainable site, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Buildings earn credits in each area. The system offers four levels of certification depending on the total credits earned.

Fundamental building commissioning is a prerequisite for receiving credit in the Energy and Atmosphere area. To meet the commissioning prerequisite, the applicant must:

- Engage a commissioning provider
- Document design intent and the basis of design for the building and systems
- Include commissioning requirements in the construction documents
- Develop and utilize a commissioning plan
- Verify installation, functional performance, training and documentation
- Complete a commissioning report (LEED™ 2.0)

[1] Leadership in Energy and Environmental Design

Applicants can also receive a credit point toward certification for implementing Additional Commissioning in their facilities. This level of commissioning focuses on the entire building and requires a third-party review of the design intent, the construction documents, selected contractor submittals, development of a Systems and Energy manual and a postoccupancy review. The LEED™ criteria specifically references the ASHRAE 1-1996 Guideline. This guideline focuses on mechanical systems as do most other commissioning guidelines[2]. The examples below show how commissioning can benefit not just dynamic systems but also the more static features of green buildings.

Commissioning to Meet Green Expectations

The value of commissioning is not limited to LEED™ certified projects. However, to illustrate the importance of commissioning green projects, examples in the five LEED™ areas are provided below.

Commissioning is a quality assurance process. All of the problems described below could have been caught by an architect, mechanical or electrical designer, contractor, owner or project manager. The commissioning process, however, minimizes the chances of problems occurring by documenting the design intent, completing a design and submittal review, performing functional testing, and ensuring clear system documentation and thorough training for the operations and maintenance staff. In other words, commissioning provides a systematic means of identifying and preventing potential problems.

Sustainable Sites

Commissioning buildings and aspects of their sites simultaneously makes a lot of sense where indoor and outdoor systems are interrelated. If one doesn't work, the other may be adversely affected. For example, in a 22,000 square foot green office building in Ontario, a landscape pond was being used as a cooling pond for an HVAC system.[3] At start-up the chiller didn't work as efficiently as anticipated so it rejected considerably more heat to the cooling pond than was predicted. On sunny days the pond became too warm for proper chiller operation; the higher water temperature also resulted in excessive evaporation and algae blooms. Two modifications were made to overcome the problem: 1) a spray fountain was added to increase evaporative heat loss, and 2) make-up water was added from the city mains when the outdoor air temperature exceeded 90°F, thus reducing the site's sustainability. This cooled the pond and compensated for evaporative water loss; it also helped mitigate the algae problem. In this example, problems in the chiller not only affected energy efficiency but also water efficiency, water quality, and the quality of potential wildlife habitat. Design phase commissioning to ensure proper sizing of the cooling pond to match the chiller's efficiency under real rather than ideal operating conditions and construction

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[2] The National Institute for Building Sciences (NIBS) is currently developing a Total Building Commissioning Guideline that will present the commissioning process for HVAC, electrical, envelope, fire/life-safety and other building systems.

[3] The information for this example was taken from the Green on the Grand Final Monitoring Report prepared by Enermodal Engineering, 1999, for CANMET Natural Resources Canada.

phase commissioning to ensure specified chiller efficiency could have prevented this problem.

Water Efficiency

Innovative water control systems often require commissioning in order to function optimally. For instance, soil moisture sensors control sprinkler systems so that the sprinklers don't turn on if the ground is wet enough. On the grounds of the American condominiums in Portland, Oregon, a soil moisture sensor was installed but did not function properly so the grounds were watered far more than needed – including during periods of heavy rainfall! Commissioning could have prevented this problem by ensuring the sensors worked properly at startup.

In another example, a green building architect is bidding on a project with a commissioning provider to design an apartment building that will treat grey water and black water on site. The design will include a wetland and greenhouse on the roof of the building. In a complex, experimental project such as this, commissioning can add value by ensuring the design goals are clearly documented, experts are coordinated, and testing is orchestrated effectively.

Energy and Atmosphere

Commissioning HVAC systems is even more important in green buildings than in traditional buildings because equipment is less likely to be oversized and must therefore run as intended, i.e. tolerance for large margins of error are gone. Also, HVAC equipment in green buildings may require new or unique control strategies. For example, a 200,000 square foot commercial building in San Francisco designed with considerable thermal mass couldn't use typical air handling system controls because the building temperature changed very slowly due to the thermal mass.[4] As a result, the HVAC system required a very slow response control system. In addition, at night the building is ventilated naturally so that the thermal mass grows quite cold. During the day, air is slowly delivered to the space at 65°F and the space slowly warms to 75°F. The air doesn't heat up quickly because the cold thermal mass is able to absorb some of the heat from the room. This unconventional HVAC system requires the thorough documentation and operator training that commissioning brings to projects.

A 50,000 square foot university building in California was designed to incorporate natural ventilation.[3] Central areas are air conditioned but perimeter areas use natural ventilation. A central stairway is illuminated by a skylight that opens to ventilate the building. The skylights are designed to open when the outside temperature rises above 55°F, thereby gently drawing outside air in through the periphery of the building and up to the skylights. Occupants can also open windows to control the temperature of their personal office space. Large fans were installed to facilitate air movement on very still days and days when the temperature rose above 80°F. The system controls were set properly but the

[4] The information for both of the Energy and Atmosphere examples was provided by Alisdair McGregor, Ove Arup & Partners via personal communication, 2000.

operators were never trained to operate the building systems correctly. On hot days, the top of the stairwell warmed more than anticipated so the building operators changed the setpoints. They set the fans to run whenever the stairwell temperature exceeded 72°F, which resulted in the noisy fans running more than necessary. Relying on their experience with traditional economizer systems, the operators also assumed that the vents should open only if the outside air temperature dropped below 55°F. This prevented fresh air from entering the building on warm days, exacerbating the problem and resulting in a stagnant, overheated building. Proper commissioning, including operator training and system documentation, could have avoided the operational problem.

Materials and Resources

Commissioning providers ensure that the goals of the developer or owner are understood by the designers and contractors. The commissioning provider reviews submittals for materials and products with this in mind. At one site, the developer specified a recycled-content base for a parking structure. The contractor substituted a less expensive, easier-to-obtain non-recycled product. The substitution was accepted but after the parking lot was completed the error was discovered and the owner was upset. This example illustrates the importance of having a commissioning provider involved in documenting the design intent and overseeing the submittal review process. The contractor later stated that he would not have substituted the product had he known why the product had been specified.[5]

Commissioning providers can also play an important role in ensuring that suitable, high-quality products are selected and specified. It is not uncommon to hear about new "green" products that fail. In a retail space in Wisconsin, all the drywall ordered for the project was 100% recycled content.[5] When the contractors attempted to install it, it disintegrated. They had to reorder drywall with lower recycled content from a different manufacturer. For the same building, the owner ordered non-toxic, water-based, low-VOC stain for concrete flooring. But the stain did not adhere to the concrete; it peeled instead. The contractors were forced to re-sand the concrete, which delayed the project by a week. Green building commissioning could have prevented these problems by requiring additional product information, such as manufacturers' performance tests or examples of prior successful applications. A manufacturer's inability to provide this type of data could serve as a "red flag" to alert the project team of potential problems. The commissioning provider could also request a sample of the product and test it before approving it for use on the project site.

In another example, custom triple-pane windows were designed by an architect and built by a window manufacturer for a hotel in Boston. After installation, the windows were found to leak when it rained hard. The architect claimed that corners had been cut when the windows were installed. The contractors claimed that the window was the problem. A third party was brought in and through testing determined that the window worked well but had been installed incorrectly. The architect on this project now thinks that a commissioning

[5] The information for this example was provided by Joy Altweis, Dorgan & Associates via personal communication, 2000.

provider should have been involved in overseeing testing of one window before installing all the windows and sees this as a model for commissioning static building elements[6].

Indoor Environmental Quality

Ensuring that materials meet manufacturer's claims is a challenge for green architects and builders since there are so many new products on the market and no national or international testing program in place. The owner of a large California Department of Education office building hired a green building architect to ensure that green practices are incorporated into the project.[7] This architect is requiring that indoor air quality emission test results be submitted for major materials. The architect is developing the testing requirements and will evaluate the results. For other projects where there isn't a green building architect, a commissioning provider could fulfill this role and/or work with the architect to ensure that this testing takes place.

The Commissioning Process for Green Buildings

Green building features related to mechanical or lighting efficiency can be adequately commissioned using the standard commissioning process, which focuses on functional testing. This process works well for dynamic systems; however, it may not be suitable for some of the more static features in a green building.

Some green features will be difficult to objectively test after installation, so a key component to commissioning green projects is to spend the bulk of the quality assurance/commissioning effort up front, before products and features are specified. Many green components are somewhat static in nature and once physically installed correctly (for example, ceramic tile with high recycled glass content) require no real testing to verify green performance, assuming the product claims can be trusted. Again, the emphasis on quality assurance must be focused on the specification phase, rather than after installation.

Who Commissions Green Buildings?

Implementation and management strategies for traditional building commissioning projects have been widely discussed and documented. Commissioning guidelines, such as ASHRAE Guideline 1-1996 The HVAC Commissioning Process (ASHRAE, 1996), provide guidance on the process and requirements. Traditional building commissioning has focused on HVAC and lighting controls and some limited electrical work and the commissioning provider skill set can readily be found in one person—an engineer with design, testing and operations expertise. Management and task assignments in green projects may be more complicated.

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[6] The information for this example was provided by Chris Leery, Stubbins Architects via personal communication, 2000.

[7] The information for this example was provided by Anthony Bernheim, Simon Martin-Vegue Winkelstein Moris via personal communication, 2000.

The green project will typically have the primary design team (when qualified) or an outside green consultant provide the development of the green concepts for the building. Who reviews their work? In general, if there has not been historical evidence that an area of design or construction could be significantly improved through additional review, then we recommend not to have it reviewed. However, if a review seems warranted, the typical HVAC commissioning consultant is not likely to be qualified to provide adequate design intent, design and submittal review and commissioning specification requirements for many non-HVAC green features.

In these cases, we recommend the following procedures. When the primary design team is doing the green design work in-house, we recommend that an outside consultant provide design and submittal review for selected features. The decision about which features should be commissioned should be made based on how familiar the design team is with the feature, product or application. For features that are being designed by a consultant independent of the primary design team, additional design review may not be necessary.

More than one party may be needed to provide commissioning services during design. If this is the case, we suggest that one party coordinate the commissioning effort during design. That party should have experience in coordinating and integrating experts from differing fields and understand the overall commissioning process, including the importance of clear and complete documentation of all design decisions.

Applying Commissioning to Non-Mechanical Features of Green Buildings

The primary commissioning tasks and methods for non-mechanical, non-dynamic features are to:

- Ensure that a good product or feature is selected through design and design intent review
- Ensure that the product is specified in a clear manner through specification review
- Ensure that the contractor chooses an acceptable product through submittal review
- Ensure that the contractor or subcontractors install the product correctly through site inspection
- Ensure that the appropriate O&M documentation is provided so facility staff can properly maintain the feature through O&M documentation review
- Ensure that the facility staff receive appropriate training on the use and maintenance of the feature through training verification
- Ensure that the O&M plan addresses each feature through O&M plan review
- Ensure that IEQ meets design objectives through spot testing and ongoing monitoring

Commissioning guidelines, to date, have not addressed static features to any significant degree. However, the process for commissioning static features is essentially the same as that for dynamic features; the primary difference is the level of effort required during each phase of a building's life.

Table 1 compares the timing and relative level of effort for commissioning and quality assurance activities for various green building features. The information included in the chart is based on PECI's commissioning experience and can only be compared within a

row. For example, the Materials and Resources row shows that more commissioning time is needed during design when the materials are being specified than during performance testing.

Table 1. Green Building Commissioning Level of Effort

Scores can only be compared within a row.

Green Feature	Design: Verify Design Choices & Design Intent	Design: Ensure Clear Specifications & Plans	Design: Specify Commissioning	Construction: Review Submittals	Construction: Observe Installation	Construction: Performance Test Systems	Construction: Verify O&M Plan & Documentation	Construction: Verify Staff Training	Occup.: Near-Warranty End & Post Occup. Review
Energy and Atmosphere									
Materials and Resources									
Sustainable Sites									
Water Efficiency									
Indoor Environmental Quality									

Conclusion

Commissioning static building elements as well as HVAC systems can solve many common problems green building developers, designers, builders and owners are facing. Commissioning can ensure that quality green products and features are specified and selected and that the green features specified meet the manufacturer's claims and are appropriate for the project at hand. Coordinating the many experts needed in innovative and integrated green building designs to make sure design goals are realized and roles and responsibilities are clearly delineated is another way in which commissioning providers avoid common green building problems. Finally, commissioning providers in green buildings will be asked to solve a wider range of mechanical and electrical system tuning problems. New systems will need to be commissioned (water-saving control systems and waste water control systems for example) and traditional systems may need to be tuned in new ways to meet new design criteria.

References

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