



COMMISSIONING HIGH PERFORMANCE BUILDINGS

By **H. Jay Enck**, Member ASHRAE

Designing a sustainable, healthy, high performance building does not necessarily result in an actual high performance building. Key elements of a high performance facility can be correctly designed and constructed, but you cannot manage what is not measured.

The U.S. Green Building Council's (USGBC) research suggests that 25% of LEED certified buildings do not save as much energy as their design predicted. There are multiple reasons for this ranging from not clearly documenting the end goal (owner's project requirements) to incorrect energy modeling to uncoordinated design to poor workmanship, to improper operation and maintenance, to contractors exemption requirements in their bids. These are some potential reasons, all of which the holistic approach described

in this article can help eliminate. Most project teams seeking a third-party green building certification fail to begin with a clear understanding of how the facility will operate and the specific activities that will take place in the facility. This lack of understanding can result in a design team going in the wrong direction.

Therefore, developing a sustainable, healthy, high performance building must begin in the predesign phase. The longer a project team delays in defining high level end goals, the more costly developing a

sustainable, healthy, high performance project becomes as shown in *Figure 1*.

Identifying and documenting the project's objectives and criteria requires input from the owner, occupants, and managers responsible for cost and return on investment, operators responsible for operation and maintenance, and a commissioning authority (CxA) to implement the commissioning process. The commissioning process and the CxA provide a continuous thread from predesign through occupancy. The CxA is the only project team member who is present throughout the delivery and operation of a facility.

About the Author

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Monitoring and evaluating the design, construction, and operation of the facility is the key to achieving and maintaining the desired sustainable, healthy, high performance building over its entire useful service life.

Where to Start

In the predesign phase, owners should engage the commissioning authority prior to contracting with a design professional. If the owner has a written agreement with the design team, it may be necessary to modify the agreement to include additional deliverables required by commissioning.

The commissioning process is quality-oriented, but not quality control. For the CxA to efficiently and effectively review and identify areas of concern for the team to address, the CxA needs the owner's project requirements (OPR) and the design teams' basis of design (BOD). The OPR forms the foundation for the

design, construction, and occupancy and operation of the facility, and is the basis for commissioning.

Many assume that the architectural program (AP) provides the information required for the OPR. While the AP is important, it typically does not document the owner's high level goals. The AP, coupled with the design team's preliminary BOD, provides details that can be used by contractors or estimators to develop preliminary pricing and budgets.

Either the OPR or AP must be developed first. The logical option is the OPR. This prevents AP developments that cannot easily be changed or modified if the OPR is developed after the AP.

A well-prepared OPR gives the details necessary to evaluate the impact of sustainable development principles upon occupants. Many projects that fail to achieve green building certification are the result of not including the owner's end

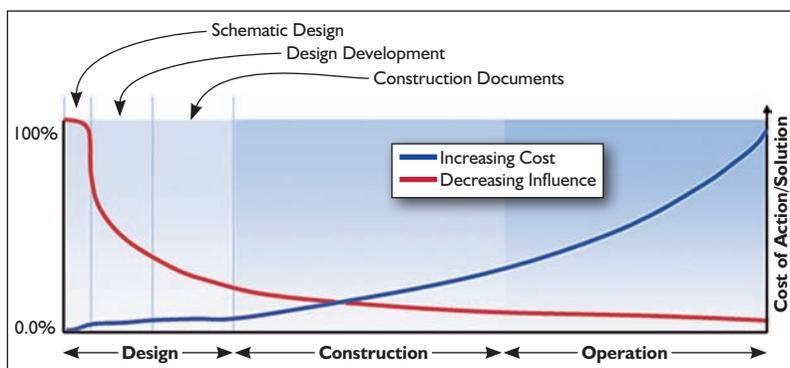


Figure 1: Costs increase the longer a project team delays in defining high level end goals.

Commissioning Case Study

Arthur M. Blank Family Office

The Arthur M. Blank Family Office (AMBFO) in Atlanta is a sustainable, healthy, high performance building delivered using the commissioning process described in this article. Arthur and Stephanie Blank included in the owner's project requirements their vision of a family office that simulated a French chateau built 50 years ago and would have a service life of several hundred years for future generations of Blanks.

The building needed to convey a feeling of home and function as an office and meeting facility in support of the Blanks' business and philanthropy interests. The feeling of home envisioned by Stephanie Blank included residential style wood windows and doors, comfortable surroundings for occupants, operable windows, kitchens and break rooms.

The Blanks' directives included:

- Allowing for 25% expansion in architectural programmed space for future needs;
- Producing a LEED certified facility to serve as an example to others;
- Eliminating visual evidence or sound of the HVAC system;
- Constructing the building of the highest quality materials, using the best design and construction practices;
- Minimizing environmental impact;
- Providing an environment that promotes productivity; and
- Spending no more money than required to meet the vision and directives.



Testing of airflow distribution pattern to assess potential of short-circuiting and adequate distribution.

Arthur Blank, cofounder of The Home Depot and owner of the Atlanta Falcons, assembled a team for the project who had never before implemented commissioning or delivered a LEED certified building. The CxA provided Holistic Commissioning™, which is a comprehensive process that focuses on assisting the project team to deliver sustainable, healthy, high performance facilities for the life of the facility. As described in this article, the OPR developed for AMBFO provided a firm foundation for integrated design, quality construction, and performance-driven operation of the building. The design reviews identified issues that were collaboratively resolved by the owner and the team.

goal sustainable requirements into the architectural definition of the design problem.

Steps for Success

Achieving a sustainable, healthy, high performance facility requires a holistic approach that exceeds requirements of green building rating system guidance. The commissioning process helps minimize concerns and risks of various building systems improperly interacting with each other. These include the building envelope and facility structure, building envelope and HVAC systems, the electrical requirements, and mechanical and plumbing systems.

When the additional necessity of increased energy efficiency and other sustainable development principles are added to the already complex process of developing and operating facilities, the Holistic Commissioning™ process becomes more important for long-term achievement of the initial end goals.

The holistic approach begins with fully implementing the commissioning process defined in ASHRAE Guideline 0-2005, *The Commissioning Process*. As described previously, commissioning's key document is the OPR, which contains development goals such as using 30% less energy and 70% less potable water. High level goals such as better indoor environmental quality, improving operational staff efficiency and reducing carbon emissions are best determined in predesign to solve the design

problems defined by the OPR and AP. To achieve the OPR's goals, including high performance building goals, requires that the OPR be included as part of the design contract requirements.

The subsequent design documents for the facility accompanied by the design team's BOD provides the owner and commissioning team the assumptions, supporting calculations, components and systems the design teams used in developing design and operational solutions. Unless the owner specifically requires it in the designer agreement, the BOD is typically not provided to the owner by the designers. However, the BOD information is critical for the owner and commissioning team to determine that the OPR criteria has been met.

To illustrate the importance of the BOD, imagine that the OPR requires a meeting space to accommodate activities ranging from banquets to educational seminars. Each activity has different HVAC requirements that limit the number of occupants who can comfortably be accommodated within the space. Without the BOD, the owner and commissioning team cannot evaluate whether the design meets the owner's needs. Typically, these limits are discovered after project completion, potentially resulting in reduced revenues for the owner.

Every high performance facility has two key elements: maintainability and measurability. Both must be included in the design and construction of a facility. Building performance diminishes when either is compromised. Facilities that don't have convenient access



Typical wall assembly showing continuous insulation to assist with energy-efficiency goal.

Examples of design issues included:

- Incorrect rainwater piping layout;
- Finishes that could have caused indoor air quality issues associated with mold and mildew;
- Architectural details that might have led to rainwater intrusion;
- Unclear sequences of operation;
- Maintenance service access problems;
- Meeting sustainable development principles contained in the LEED rating system; and
- Operational inefficiencies.



Fire damper access issue identified and resolved during construction.

The team appreciated the commissioning process because it identified potential problems early and facilitated a collaborative approach resulting in efficient resolution and reduced team risk.

The construction observations and testing identified workmanship issues as work progressed, allowing the construction team to quickly and efficiently resolve problems in a collaborative effort. These corrections saved time as well as warranty dollars. Mock-ups and in-place construction testing helped identify issues early in the installation process and set the bar for the remaining work.

Examples of issues identified and resolved included:

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for preventive maintenance or component replacement are difficult to maintain and typically perform poorly. BOD narratives should describe how the design provides for maintenance access to the building system elements of building envelope, lighting fixture lamps and major HVAC component replacement, etc.

Owners and operators cannot manage what they do not measure or recognize degradation of performance when it occurs. Measurements must be sufficiently granular to provide enough information to effectively identify optimum performance or the lack of performance without costing too much.

For example, dividing electrical loads up by load type and metering each load separately; providing water meters for the main facility, landscaping, and cooling tower (if applicable); measuring natural gas consumption via a meter or energy data provided by a central plant; combined with data from the building's automation systems typically provides the variables necessary to analyze and assess overall facility performance. Measurability in smaller facilities is generally limited to electronic data collected from the utility meters and segregated electrical loads.

The size and complexity of a facility dictates the number of commissioning design reviews required. Typically, most projects have three to four reviews, with the schematic design phase being

the most important. During these reviews, changes in concepts, reconsideration of established goals and additions or reductions of requirements are easily considered and implemented within the project's budget and schedule. Modification of scope after schematic design probably will increase cost and schedule.

Cost control requires good coordination and a clearly defined scope in contract documents. Clear details and strong design coordination combined with the objectives and criteria established in the OPR and BOD are the main focus of design phase commissioning. Commissioning quality assurance design reviews compare the documentation provided by the designers (BOD, drawings, and specifications) to the OPR and identify when the high level goals are not being met. The reviews assist the team with identifying disconnects and resolving problems to bring the design into compliance or to modify the OPR as directed by the owner. Well-executed design phase commissioning minimizes risk, contractor requests for information, architect supplemental instructions, change orders, and maintenance and performance issues.

After the development of the OPR, the CxA performs the role of project advocate by providing design phase checklists, establishing information to be provided at each design milestone, conducting reviews to identify issues and then



Testing of exterior door identifying moisture intrusion issue.

- Moisture intrusion;
- Compromised service access;
- Negative pressurization of portions of the building;
- Comfort problems;
- Incorrect installation of building envelope and HVAC duct insulation;
- Rainwater drainage problems;
- Lighting fixture design; and
- Building automation control of lighting, HVAC and irrigation.

The AMBFO, completed in 2004, was the first LEED Gold certified building in Georgia and the first LEED Gold certified office building in the southeast. The building performed as intended, exceeding Standard 90.1-1999 by 35% in energy efficiency and by 26% in reducing potable water consumption while providing occupants positive physiological and psychological perceptions.



Solution as result of testing exterior door to protect wood floor.

The most important aspect of this case study is the post occupancy improvement in energy efficiency through the efforts of ongoing monitoring, commissioning, reliability-centered maintenance and modification to operations. The AMBFO increased energy efficiency by an additional 5%, resulting in energy performance that exceeds Standard 90.1 by 40%.

When the end goals of sustainability are clarified in the pre-design phase, documented, measured and verified throughout the design and construction process, project goals can be achieved with only minor initial cost impact to the budget. Quality is a team effort and even the most diligent and thorough commissioning process cannot be successful without the cooperation of the entire project team. Ongoing measurement and review by the CxA over the life of the facility provides the continuity to ensure high building performance.●

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adjudicates those issues with the team. The typical results of design phase commissioning experienced by this author are team building, long-term team relationships, clear and concise construction documents that typically reduce project risk significantly and contingency used for change orders, tighter contractor bids, a more maintainable facility, and the systems and procedures necessary to achieve and maintain facility performance.

In the construction phase, the focus shifts to the contractors' workmanship quality, correct interpretation of contract documents, maintainability, and building performance. The CxA develops construction checklists to assist contractors in implementing a quality control process, scheduling commissioning activities, and identifying early issues for the team to address. As with commissioning design reviews, construction phase commissioning helps identify issues early and uses the collaborative integrated delivery process to quickly resolve problems.

The final phase of commissioning is operation. Achieving and maintaining the benefits of a high performing building requires trained and well managed operators, and continuous measurement and analysis of building performance are essential. To provide adequate training for building operators the CxA develops training agendas based on the level of training

needed by the building operators for the systems installed. The training is implemented by the project contractors and vendors and documented and verified by the CxA.

At the beginning of occupancy, the CxA focuses on optimizing building performance and occupant satisfaction. The CxA monitors the systems, identifying opportunities for improving performance and occupant satisfaction.

The CxA resolves conflicts between various building systems and components as well as verifying the operators' understanding of how to optimally operate the building. Ongoing performance assessments throughout the life of the building identify areas for improvement to maintain performance. This information is added to the systems manual provided by the CxA and maintained by the operator.

In well-commissioned facilities, the operator's focus is preventative maintenance. In most conventionally delivered facilities, the operators are often focused on eliminating complaints. This focus may distract or prevent the operator from performing necessary maintenance. The path to a successfully operated building starts with a correctly operating facility and continues with measuring system operation variables, continually monitoring and analyzing building system performance, and reliability-centered preventive maintenance. ●

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