Sustainable Design Strategies That Succeed

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Central Washington University (CWU) is committed to both sustainable development and operation of its campus. Sustainable design and construction offers economic, social and environmental benefits to the owner and the surrounding community. However, when used improperly, the synonymous phrase "green building" can easily be little more than public relations rhetoric. The objective of this paper is to help owners responsible for design and construction services to successfully implement sustainable design strategies that truly provide green buildings and help construction educators understand the issues behind this recent trend. This paper presents two "green" buildings: one under construction and one recently completed. This paper compares the design and construction process of these facilities. Both buildings were intended to be green from conception, however, one building has very few green features and the other building is Leadership in Energy and Environmental Design (LEED) Silver certified. Failures and successes of sustainable design are studied through these projects. Challenges are identified and lessons are provided as a model for owners to successfully implement a sustainable design strategy.

Key Words: Sustainable design; green building; LEED; construction planning, facilities management

Introduction

This general topic paper is intended to further the understanding of sustainable design and construction techniques that can be used both by practitioners and by educators implementing sustainable practices into their curriculum. Case studies of two projects on the Central Washington University (CWU) campus in Ellensburg, WA, are presented to document challenges, issues, and successes in sustainable design. The research for this paper comes from design or construction documents and personal conversations with those involved in the two projects. The projects highlighted are: 1) Dean Hall, the first Leadership in Energy and Environmental Design (LEED) Silver project at CWU, completed in December of 2008; and 2) Student Village South, a residence hall that is currently being built. Using a case study format suggested by Kardos and Smith (1979), the paper identifies the challenges which materialized on these two projects and how these challenges may be overcome on future projects.

Per Kibert (2008), the terms "high performance, green, and sustainable construction are often used interchangeably; however, the term sustainable construction most comprehensively addresses the ecological, social, and economic issues of a building." In this paper, the authors use the term "sustainable design" to include what is commonly called "green design" which comprehensively accounts for the ecological, social and economic aspects of design and construction.

There has been great progress in implementing sustainable design and construction techniques for buildings since the 1990s (Nobe and Dunbar 2004). Yet despite this progress, obstacles still exist at the implementation level in the Architecture, Engineering and Construction (AEC) community (Kibert, 2008). CWU's direction is increasingly moving toward sustainability in facilities construction and operation, so it is important to understand which factors translate into completed sustainable buildings.

LEED is a point system to achieve a certain performance standard in sustainable building. The United States Green Building Council (USGBC) created the LEED green building rating system to "encourage and accelerate global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria" (USGBC, 2008).

The authors compared the process of design and construction for both buildings to determine differences which led to one building being recognizably green and the other not. In order to gauge these criteria, a matrix was developed to measure the levels that each of these criteria may be employed. All factors which remained equal in capital project planning and construction of both buildings were not factored in the table as variables affecting green design on these two projects. Table 1 lists these factors, with notation as to how each was a determinant in decision making for Dean Hall or Student Village South.

It is clear from Table 1 that Dean Hall scored significantly higher in specific elements of sustainable design, leading to the conclusion that these factors created a successful design, despite seemingly similar initial circumstances on both buildings, such as the desire to build green, inexperienced teams, and budget constraints.

Dean Hall Project Overview

This project is a complete renovation of an existing building that housed CWU's primary science building until 1998, when it was closed due to contamination of building systems by asbestos and heavy metals. Design for this project started in 2006, construction commenced in 2007, and the building was occupied in December 2008. The project delivery used the design-bid-build method with the construction contract awarded to the general contractor with the lowest lump sum bid. This 79,500 square foot educational facility's scope of work included a complete demolition and removal of all but the concrete shell; floor and roof slabs; brick veneer; and roof assembly. New construction included an elevator; two new stair towers; new exterior shear walls along the ground floor; completely new interior finishes; and mechanical, electrical and plumbing systems. The project is anticipating LEED Silver certification, scoring 37 points on the USGBC matrix.

Dean Hall Sustainability Issues

This is the first LEED certified building on the CWU campus and it represents a new way of doing things for design and facilities management personnel. The largest change was moving away from a "doing things as we always have" mentality and from a culture of delivering the most construction for the least amount of money. This change in mentality caused a conflict between delivering a highly sustainable building and doing just enough to obtain the LEED Silver certification. This conflict is common and is noted by Johnson et al. (2006) as one of the difficulties of a developing sustainable design and construction program.

Table 1

	Points allocated: high = 10; medium = 5; low = 1	Dean Hall	Student Village South
Commitment to Sustainable Design		8	1
High	Strong commitment from owner organization in the form of legal documents, mission statements, or other public documents	State law silver LEED requirement But could have had a higher goal	
Medium	No public documents but sustainable design experience is part of AEC selection criteria		
Low	Informal statement from the owner		Initial "desire" to build green
Integrated Sustainable Design		10	1
High	Incorporate sustainable design professionals from start to finish of the project	2 LEED APs on the project team and monitoring progress through construction	

Medium	Consult with sustainable design professionals to improve elements of the project through construction		
Low	Solicit sporadic advice on sustainable design in the project		Held eco-charette with LEED APs and solicited green features write up from traditional design
Use of Tracking System, Such as LEED		10	1
High	Use established system from initial design	Used LEED	
Medium	Use established system to add elements in completed or near-completed design		
Low	Use established system to gauge sustainability in completed or near-completed design and to highlight "green" elements		Held eco-charette to determine green features
Recognize Cost Implications of Sustainable Design		5	1
High	Budget for potential higher first costs and/or make cost balancing sacrifices in other building values; Use Life Cycle Cost Analysis; Recognize externalities as costs.		
Medium	Make choices for best lifecycle payback in resource use; Choose sustainable features with minimal first cost impacts.	Project was over budget without LEED allocations at the start; LCCA was used in a limited fashion	
Low	Choose only features with no impact on the initial budget.		Project perceived to have budget constraints, and design removed any features which added first cost
TOTAL POINTS		33	4

As noted in Table 1, the Dean Hall project was mandated by state law to be LEED Silver or better. This requirement ensured commitment from the start. The team was led from the start of design by a LEED Accredited Professional (AP) consultant from the architectural firm. The LEED AP provided opportunities for an integrated design despite the newness of LEED. Because of the commitment to LEED Silver, the LEED AP was able to use the LEED scorecard both to keep the project on a sustainable track and to educate the rest of the team's skeptical facility personnel and tradesmen.

The LEED design effort was led by the design architect and implemented by the architect and engineering team. Meetings were held to estimate the cost of LEED points, and to work through issues. As the design progressed, strategies and accompanying LEED points were solidified. The decision on what specific LEED points to obtain was made jointly between the architects, engineers, and facilities management personnel. However, the team as a whole was largely inexperienced in applying sustainability concepts, which led to both inefficient implementation and missed sustainable opportunities. The facility management's representative became a LEED AP during construction; the contractor did not have any experienced personnel on the team; no other team members had sustainable design experience. This situation is not different from an industry-wide study (Williamson et al., 2005) that found a low level of LEED understanding among construction professionals.

Several major construction issues were present. One was recycling in a rural environment: waste diversion and recycling of many construction materials was not available as it would have been in a large city; the closest place to recycle drywall is, for example, 100 miles away; concrete products had to be totally devoid of rebar; the local paper recycler does not weigh material; diversion and LEED documentation were both made more difficult. Another construction issue was the dual duct HVAC system designed for thermal comfort; this system takes up more space than a conventional HVAC system and field coordination proved difficult. Furthermore, the LEED toolkit was not available from USGBC at the start of construction, and this caused additional inefficiencies for the general contractor.

Overall, however, the biggest threat to the sustainable design was economic. First cost was a serious concern on this project due to recent price escalation, a busy work force, and a tight construction schedule. The lowest responsive and responsible bid was over the estimate, yet the university went ahead with the project by finding other monies and by accepting few of the 20 alternates.

Cost concerns were also prevalent during design and this limited some sustainable features due to high first cost. Facilities management personnel were so highly focused on maintaining the budget, that while initially the project may have obtained gold certification, budget limitations ensured only silver certification in the end. A construction project funded by Washington State has a fixed budget and there is little or no connection to the operating budget. This system builds in conflict between how a low first cost may increase operating cost or vice versa. This problem of having a construction budget separate from the operating budget is nothing new (Johnson et al. 2006), but the reality of this situation is that it limits potential substantial energy and long term cost savings. During construction, budget issues also drove decisions and it appeared that when there was a choice between sustainable construction and the budget, budget won out, even at the expense of increased operational costs. The project management team estimated the additional cost for silver certification was approximately an additional 3%.

The budget issues combined with the newness of university sustainability policies engendered a lack of team buy-in from facility managers, tradesmen, and building occupants. Generally, people tended to like sustainable items that could save money but were skeptical of any extra expense that could not produce monetary results. For example, items that lower energy use or consume less water were favored over items that may produce a similar LEED point but that do not result in an operational saving, such as providing covered bicycle racks.

Student Village South Project Overview

Student Village South (SVS) is a pair of new residence halls being built on campus to replace beds lost in a recent removal of two other residence halls. Scheduling of the project was very tight to accommodate on-going campus residency goals for housing.

The project is located on a state university campus, but it is a self-funded housing system, repaying bond loans with future rental income. The campus housing system competes with local development and has to aim for comparable rent prices, despite additional measures necessary for building on state property. Because it is not publicly funded, it is therefore not required to be LEED Silver certified. Using the USGBC scoring matrix, the building would score approximately 20 points. The project delivery method was design-bid-build and a construction contract awarded to the general contractor with the lowest lump sum bid.

SVS South Sustainability Issues

There was no formal commitment to sustainable design on the SVS project, although initially there was interest from the owner. The building committee and facilities planning personnel had discussed making the new residence halls green; there was even discussion of incorporating a living-learning component to gain awareness and to generate excitement about the benefits of living in a green building. An eco-charette was held during design to determine which sustainability features could be incorporated. However, the ideas were not fully embraced, sustainable criteria were not embedded in bid documents, and SVS did not attempt LEED certification, despite emphasis on sustainability in university planning.

Integrated design with a sustainable design professional throughout the process could have helped to educate the entire team on challenges and rewards of green building. On the whole, the SVS building team lacked education on green building fundamentals, long term environmental costs of traditional development, and Life-Cycle Cost Analysis (LCCA) on major systems. One example was the move to using native and adapted plants in the landscaping. This is an important step in this semi-arid climate. To add even this relatively simple sustainable design element required education – to the committee on the value of using these plants, and to the landscape architect on methods for achieving this goal. Also, despite university goals for improved stormwater quality and quantity, parking was added with standard asphalt cover, rather than more innovative designs involving impervious surfaces with storm water volume reductions. Wood was used over more permanent materials which would have aligned with university goals of durability.

There are some sustainable features in the building design. These include measures to improve energy efficiency, such as a Heating Ventilating and Air Conditioning (HVAC) system with heat recovery units, high efficiency water heaters, Energy Star appliances, and efficient lighting. Water efficient plumbing features and landscaping will be installed to reduce water needs. Covered bike stalls and a stop from the local transit system will reduce dependency on automobiles. Low VOC-emitting materials will be used in carpeting, paints, and coatings. Carpet, metal decking, and exterior siding are all high in recycled material content. Daylight and views will be provided in every major space. Finally, exterior lighting meets dark-sky requirements. If a LEED scorecard had been used to gauge progress, it would have become clear how many more features would need to be incorporated to be considered "green."

The primary reason for minimal sustainable design was budgetary. Dean Hall opened bids one month prior to most of the design work on this project. Since bids came in higher than the allocated budget, the SVS team anticipated high costs. The perception was that LEED is expensive and not worth the added cost; the building team said it could be green without LEED. Major decisions were based on first-cost over life cycle costs. Additionally, communication amongst the many involved parties was weak and contradictory, causing a sustainable design problem. For example, some energy saving features were discussed as excellent candidates for LCCA with probable short-term payoff, but the information did not filter back to the decision-making building committee. The information presented at their meeting was only that an energy model would be cost-prohibitive, with additional added first cost for any major energy efficiency upgrades. Without a LCCA, and a fear of cost escalation due to the bid climate, the building committee selected standard building methods and mechanical equipment over more energy efficient building envelope materials and other systems. University housing does not pay utilities based on metered data, so there is not the direct incentive to reduce energy demand for individual buildings. Any added costs from energy modeling, extra insulation, additional sensors, and the like were dismissed as outside the expected ability to finance the project. Occupant comfort was limited to traditional means, allowing, for example, operable windows, but not sensors to slow air flow when windows are open. For a university that is planning to remain in place indefinitely, long term operational costs should be considered to justify the use of the most energy efficient systems.

The additional costs to the project for these green features were estimated to not materially affect the project budget because bids came in far lower than anticipated. The cost to employ more sustainable features, and document them through the LEED process, was within the bid day margin of error. Additionally, alternates could have been written for the higher first-cost items that would have made for a truly sustainable building. Several people involved in decision making said that they wish the project had gone with LEED certification once bid day costs were known.

Conclusion

Using Table 1 as a guide, the authors conclude that the capital planning and construction variables which differed in the two projects were the cause of one building being sustainable and the other not, even though both started with owner desire for a green building. Thus, commitment, integrated design, use of a tracking system such as LEED, and recognition of budget implications are the key factors to ensure a sustainable building.

Additional efforts in these areas could further ensure a sustainable building. For better commitment, firm owner policies and guidelines should be developed. In the case of Dean Hall, a tract of land equal to the building footprint was proposed to be set aside as open space, but this was not done because there was not any established policy for a process to do this. Specific, written policies for sustainable design and construction can help ease the pressure when other values are in conflict, such as cost. Specific sustainable design standards and policies are needed, particularly for owners who develop multiple buildings over time. This will save valuable cross-checking on goals within the specification development period. Cutting edge materials and methods should be researched for thorough understanding of their capabilities in the given application and location. Wherever possible, acceptable material specifications from past buildings can be incorporated into the design and construction of future buildings.

To implement an integrated design strategy, departments will need to collaborate; facilities management, administration, educational departments should all be working together toward common goals. This collaboration will require strong leadership on the part of sustainability champions in order to remain effective. Owner teams will need to find consensus on sustainable features and methods. Persons in the leadership roles need to be committed to sustainable design for maximum effectiveness. These leaders will need to be proactive in holding meetings and in allocating time to incorporate sustainable features into buildings.

The use of a tracking system such as LEED ensures that the myriad changes to a building during design and construction do not lose sight of the sustainability goal. Dean Hall had far more budget pressures than did Student Village South, but cost cutting measures were immediately evaluated for their impact of the overall sustainability of the building by the LEED points they would impact. Similarly, despite a skeptical team, the LEED system served to implement, educate, and document sustainable building. Even if the decision is made to not seek LEED certification, the scorecard can be used to continually monitor decisions in design and construction. Changes in points are indicators that a building is moving toward or away from sustainable design.

Costs need to be evaluated holistically. First costs are important, but more appropriate in sustainable design is LCCA of materials and systems. Additionally, new value systems need to be created to include not only economic costs and savings, but also intangible, non-economic costs and benefits such as resource availability, clean air, habitat conservation, and education.

In comparing the two buildings' LEED score and first costs, the full value of a sustainable design is apparent. Dean Hall scored 37 points on the LEED scorecard at a total cost increase of 3%, while SVS scored only 20 points at a traditional construction baseline cost. Therefore, the cost to obtain LEED certification is certainly within the margin of error on bid day. Basic LEED certification should be attempted at a minimum, and various levels of LEED may be achieved by offering bid alternatives.

Furthermore, cultural and behavioral change is necessary within the AEC and owner organizations. This can be accomplished largely through education and simple incentives programs. Curriculum may include metering; energy engineering; analysis of the advantages and disadvantages of features; policy development; and general awareness of sustainable design. It is necessary to educate the occupants in order to maximize beneficial aspects of the building's operation for the people that use it, the environment, and the organization's budget. Sustainable design does not need to be time consuming. In the early stages of design, spending additional time on education may delay the design process, yet there is evidence that providing this time for information gathering and education will result in a more sustainable building. To help change the current culture, other sustainability initiatives must be tied together. At CWU, goals for carbon neutrality, storm water management, increased recycling totals, environmental and occupational education are being cross-coordinated with the goals of sustainable design.

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