

Sustainable Design Strategies

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Central Washington University (CWU) has developed several sustainable projects on its campus. This paper follows a paper published in 2009 when sustainable design and building was in its infancy on campus. During the initial stages of implementing sustainable construction the campus struggled with some portions of the sustainable concept. Now in a more mature phase of implementing sustainable projects the campus community has better embraced this concept. The objective of this paper is to help owners responsible for design and construction services to successfully implement sustainable design strategies and help construction educators understand the methods applied to sustainable construction. This paper describes two successful sustainable projects that have changed the perception of green building on campus and provides insight to the process that brought about this change.

Key Words: Sustainable design; green building; LEED; sustainability, 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. This paper builds on work performed by Bender and Bicchieri (2009) that demonstrates just how sustainable design can be incorporated on a campus. Case studies of two projects on the CWU campus in Ellensburg, WA, are presented to document successful strategies in sustainable design delivery. The paper is written specifically from an owner's point of view.

The two projects this case study analyzed were: 1) Hogue Technology Building, the first Leadership in Energy and Environmental Design (LEED) with a Platinum goal project on campus, completed in the spring of 2012; and 2) Barto Hall, a residence hall that was completed in the Fall of 2012 and is planned to become certified under the LEED for Homes Mid-Rise rating system.

A case study methodology was used to analyze the evidence developed from the two projects. Evidence for this paper comes from design or construction documents and personal interviews with those involved in the two projects. As Yin (1994) states, case studies offer an opportunity to explain complex causal links in real-live interventions, describe real-live contexts in which the intervention has occurred, describe interventions, and explore situations where the intervention being evaluated has no clear set of outcomes.

LEED is a rating 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, 2011). LEED for homes has also been established as a consensus-developed, third party-verified, voluntary rating system which promotes the design and construction of high-performance green homes (USGBC, 2011).

On CWU's campus sustainable design and construction and the adoption of LEED was slow to be accepted and implemented because LEED was perceived to cost too much, project team members, particularly from the owners team were not educated on LEED, and the LEED documentation was problematic. Johnson et al (2006), also found these LEED adoption issues among the owners team. They also found that if LEED was implemented there was a lack of project team buy-in. Additionally as shown in Bender and Bicchieri (2009) and presented in Sullivan (2008), project team members focused on "no cost" or "low cost" points to achieve a rating, without regard to environmental benefits.

Sustainable building practices are particularly well developed in the west coast states of Washington, Oregon and California. Marchman and Clarke (2011) identified some of the barriers which included additional costs, time, and an extreme amount of documentation. They also stated that solutions to these barriers for sustainable practices in other parts of the country were experience in LEED projects and pre-project planning. Their work suggested that a best practices guide should be developed to help foster sustainable practices. Therefore, the objective of this case study is to advance the written documentation to support these efforts.

State of Sustainable Construction in 2006-08 on Campus

During the implementation of sustainable construction on campus, sustainability was not fully embraced. In general facilities management, administrative personnel and users felt sustainable design was a noble goal but was not going to be implemented unless it did not cost anymore or it would result in energy cost savings. Additionally, if LEED certification was being pursued, the strategy was to go for the lowest cost points regardless of any environmental considerations. Two projects were designed between 2006 and 2008, one had a LEED goal of silver (minimum required for state funded buildings) and the other building was not very green (dormitory funded by bonds).

The Dean Hall science building started design in 2006, construction commenced in 2007, the building was occupied in December 2008, and LEED gold certification was obtained in 2010. One success story since 2008 was that the project was originally slated for silver certification, but obtained gold by one point due to a student project that performed a building comfort survey. A dormitory was completed in 2009 that was not LEED certified and contained very few sustainable features. The climate on campus during this timeframe is detailed in Bender and Bicchieri (2009), and can be summarized as skeptical or performed begrudgingly by facilities management and personnel.

Sustainable Construction in Campus Post 2008

Two buildings on campus that were recently constructed fully embrace the concepts of sustainable design and construction. The Hogue Technology Building hosts the Department of Engineering Technologies, Safety, and Construction that includes seven different technical majors. This building was constructed in two phases, an addition and renovation. A new 360 bed dormitory, Barto Hall was occupied in the fall of 2012. Both of these projects are planned to achieve the highest level of LEED certification. Both projects were delivered using the design-bid-build method. At the publishing date of this paper, certification for these two buildings has not been finalized by the Green Building Certification Institute (GBCI). However, initial review by GBCI indicates these buildings will receive at least a gold rating. Some credits or points required further clarification and are being reviewed by GBCI before a final certifications is issued.

Hogue Technology Building

This project started design in 2008 and is working under the USGBGC 2.2 reference guide. The project's goal is to achieve platinum certification. LEED credits were designed into the building or the specifications specifically call out LEED items that must be accomplished by the contractor. For example, the percentage of energy savings is a design feature and the specifications required over 75% of construction waste must be recycled.

The building was built as a living learning laboratory for the type of technical instructional pedagogy that is performed inside the building. Mechanical, electrical, structural and other systems were left exposed to facilitate student learning. For example, students learning estimating perform a material takeoff of the structural steel. If a student has doubt about a construction detail shown in the plans, he/she can generally see the detail inside the building. Additionally, this building is also being used as a model by facilities to test sustainable features that could be incorporated into future projects on campus (i.e., solar panels, wind turbines, and reflective mechanical heating panels).

Since the project was an addition and remodel the specific site was predetermined. However several credits in the sustainable site category are being sought, these are:

- Community connectivity, close to services in existing areas.
- Located in an area with public transportation.
- Covered bicycle storage and shower facility are provided.
- Provided preferred parking to low emitting vehicles.
- Did not provide any new parking.
- Habitat was protected and open space was maximized by minimizing the construction footprint and building a three story building.
- The roofing and pavement materials have a high solar reflectance index to minimize the heat island effect.
- Night time light pollution was minimized by down casting outdoor lighting and reducing light escaping from the building at night.

In the water efficiency category strategies to achieve these credits are:

- The landscaping uses native and adaptive plants.
- Drip irrigation is provided by using non potable water.
- Domestic water is reduced by using one pint flush urinals and other ultra low water use fixtures.

In the energy and atmosphere category credits are as follows:

- Estimated over 31% energy saving in the building by:
    - Embedded in the concrete slab are tubes that circulate chilled or heated water.
    - Using chilled beams.
    - Heat recovery units.
    - Solar preheat wall for outside air.
    - R-60 in the exterior walls.
    - Kalwall translucent wall systems to let light in but reduce heat loss/gain.
    - Building orientation and window placement.
    - Double door vestibules.
    - Energy efficient lighting and controls.
- Generating over 2.5% of energy requirements using renewable by:
    - Solar water heating system.
    - Photovoltaic systems providing over 28kw of electrical power.
- A commissioning agent was hired during the design and has worked throughout construction.
- No refrigerants are planned for the building.

In the materials and resources category the following credits are being sought:

- Over 95% of the existing building is being reused.
- The contractor was required to divert over 75% of the construction waste.
- Over 20% of the building materials used recycled products such as:
    - Old shipping crates were used to panel walls in the exhibit area.
    - Paperstone was used extensively throughout the building as wall paneling, window sills and counter tops.
    - Steel and rebar .
    - Carpet .
- Over 20% of the materials are either extracted, processed or manufactured regionally:
    - Rebar, wood, concrete, case work, and brick.
- 100% of wood products used in the building are certified by the Forest Stewardship Council (FSC).

In the indoor environmental quality category the following credits are being sought:

- Mechanical ventilation will be monitored for carbon dioxide.

- A higher level of mechanical and natural ventilation is being provided.
- During construction and preoccupancy the contractor was required to develop an indoor air quality management plan to include:
    - During construction materials were protected, particularly duct work and openings to installed duct work.
    - The mechanical system was flushed prior to occupancy.
- The specifications required the use of low Volatile Organic Compounds (VOCs).
- Indoor chemical pollutant control was provided by:
    - Vestibules with drop off mats.
    - Specific exhaust for the copier in a work room.
    - Fume and exhaust hoods.
- Provided building occupants with a high level of controllability for lighting and thermal comfort by:
    - Operable windows in offices.
    - Individual thermostats in offices.
- Over 90% of the building occupants have views to the outside.

In the innovation and design category several credits are being sought:

- Renewable energy and sustainable technologies education are being highlighted by providing a self guided tour of the building and a living laboratory for active student learning.
- Open space crated by the landscaping will be a smoke and tobacco free zone.
- Housekeeping operations will use only green cleaning products.
- Further water reduction was obtained by using ultra low water consumption fixtures.
- LEED accredited professionals on the design team are engineers, architects, facilities management representative, and the end user.

Barto Hall Dormitory

This project is slated to be the first LEED Homes-Mid-Rise on campus. The project has a planned certification level of platinum. The residence life administrators realized and as shown in the Princeton Review (2009) students want to live in a sustainably built and operated residence hall. The project was designed in 2009 and awarded to the low bidder in late 2010. The project was bid with many of the more expensive LEED features as alternatives. Since this project's bid date coincided with a recession, great prices were obtained and all alternatives were selected. This LEED category required that a third party LEED consultant be retained.

In the innovation and design category credits are being sought:

- An eco design charrette with the design team, residence hall administrative people and campus facilities management personnel was held.
- Reusing all of the concrete rubble from the demolished dormitories as base course material.
- Achieving exemplary water savings by using ultra low bathroom fixtures.

Credits for location and linkages being sought:

- The site was selected on an interior location of campus.
- Extensive community resources such as shopping, a gym, barber, etc are located close to this location.
- The site uses existing infrastructure; i.e., roads and utilities.
- Access to open space is in very close proximity.

Credits being sought for the sustainable site category are:

- Reduced irrigation requirements by using drip irrigation.
- Reduce heat island effects by using high solar reflectance index materials for the site and roof.
- Surface water is being controlled and cleaned by using permeable paving and establishing sediment basins.

- Non toxic pest control will become part of the maintenance operations.
- The dorms are four stories high to achieve very high density for a mid-rise.
- Alternative transportation is encouraged by covered bicycle storage, located near public transportation, and preferred parking for low-emitting vehicles.

The water efficiency category strategies to achieve an over 20% reduction in water use are:

- Using high efficient drip irrigation from a non potable source.
- Using very high efficiency fittings and fixtures in the bathrooms.

In the energy and atmosphere category 20 of the 30 points possible being sought are:

- Using heat recovery units.
- Extremely efficient building envelope using above code R values in walls and roofs.
- 56kW of photovoltaic panels will be installed on the roof.
- Very high efficient water fixtures will reduce demand for hot water.
- Extensive metering and monitoring of electrical and mechanical systems.
- High efficient lighting with daylight harvesting automatic switching.

In the materials and resources category several credits are being attempted:

- An extremely material efficient framing design and construction plan through:
    - Limiting waste.
    - Detailed construction documents.
    - Detailed lumber cut lists and ordering.
    - Off site fabrication of wall assemblies.
- A majority of the materials are specified to be environmentally preferred products or recycled materials include:
    - Carpet, linoleum, plastic laminate, and ceramic tile.
    - Metal decking, metal roof panels, metal siding, and reinforcement bar.
- The contractor is required to meet certain construction waste reduction plans.
- Regionally produced materials are:
    - Brick, fiber cement siding, concrete, metal roof panels, and wood.

Indoor environmental quality is very important for a living space. The following credits are being sought:

- Ventilation is being enhanced by bringing into the building additional outdoor air into each dorm room.
- A third party commissioning agent has been hired to ensure al equipment is operating properly.
- The building's air systems use high grade filters rated at better or above.
- Before students occupy the building it will be flushed by increased ventilation.
- There is not a garage associated with the project.

Awareness and education of the buildings features are being expressed through:

- Environmental kiosk with an interactive dashboard for the building occupants and visitors.
- Facilities management personnel will be trained to maintain the building in an environmental manner.

Purpose and Methodology

The purpose of this research was not only to report on two successful case studies, but also to explore the changes in sustainability culture accompanying the recent construction on campus. A sustainable culture is a current adaptation to the phrase "local sustainable development" (Roberts, 1996). What a local sustainable development or sustainable culture attempts to provide is based on five basic concepts as defined by Roberts (1996):

- Improve quality of life on a broad definition of welfare and happiness, including non-monetary factors with the natural environment and social needs of the community.
- Seek economic, social and environmental issues as interlinked and recognize the need to tackle them in an integrated way.
- Take account of the impact of development on the natural environment and its capacity to support human activities in all decisions.
- Balance the importance of individual rights with that of collective responsibilities.
- Seek cooperation between "experts", the influential and members of the public to ensure that development meets people's needs.

A qualitative research methodology was used to explore and expose the culture of sustainability as it developed and as it currently exists on CWU's campus by using observations and questions in the field to identify a cultural materialistic theory of sustainability (Creswell, 1998). Interviews were conducted with seven key participants who hold over 100 years of experience in facilities management building capital projects on campus. To establish a level of validity, and to expose common themes associated with the culture of sustainability on campus, two different researchers interviewed the participants who were selected based on their experience and knowledge about sustainability on campus. Data was collected through taking notes while the interviewees were being interviewed. Questions that guided the interviewers included:

1. What do you feel changed with facilities management to appear more supportive of sustainable practices on campus?
2. What were the external and internal influences that could have created a sustainable culture on campus?
3. Do you feel projects constructed on campus created a sustainable culture?
4. Explain how education, experience, or familiarity with sustainable practices has helped on campus?

Results

Information collected from the interview process suggested that several themes may be evident in the reasons for a sustainability culture developing on campus. Three of the most distinctive themes found were: 1) a significant history of energy conservation, and therefore acceptance, of sustainability practices related to facilities management, 2) a widespread perception that sustainability is a desirable criterion when procuring facilities for the university, and 3) the recent economic conditions that have had an unexpected impact on the affordability of sustainable construction practices.

History

One of our initial hypotheses was that the university had only recently become a "believer" in the value of sustainable practices and LEED certification for its buildings. When this hypothesis was proposed, we were bluntly told that CWU had a long and continuous history of pursuing sustainable practices in the form of energy conservation. These type of responses clearly demonstrate the point of view that sustainability means energy conservation. For example, a comparison of total annual kilowatt-hours of electricity and therms of natural gas used to power the university from 1998 and 2012 show a moderate to significant drop in the quantity used. This reduction is in spite of a sizeable increase in the total square footage of buildings on campus over the same time frame. All of this energy reduction can be traced to a continual series of energy improvements made to the campus infrastructure over many years. However, additional sustainable practices were limited.

Perceptions

Throughout the interview process, a variety of perceptions influencing sustainability decisions on campus became evident. Sources of influence were both internal and external to the campus community. Internal influences were those individuals or entities that embraced the idea of sustainability within the university environment (i.e., students, faculty, administrators, and facilities management). The internal influences were those people and entities that were the drivers of the university moving to use sustainable practices. External influences were the entities or individuals

that provided opportunities for the university to move to accept concepts of sustainability on campus. Examples of influence sources are summarized in Table 1. The purpose of this table is to summarize the efforts that went into influencing many of the sustainable design strategies for the two buildings.

Internal influences were based largely on the perception that the university could get better results with fewer resources, whereas external influences tended to be based on the perception that sustainability was the right thing to do. Consultants and a cultural shift have helped the university realize the sustainable design means more than just saving on energy costs. Regardless of the source, however, the bottom line is the overall perception that sustainability in facility operation and building construction "made the most common sense."

Due to the traditional delivery method of projects on campus, contractors did not influence the adoption of LEED, they merely executed contractual provisions. The influence of contractors on the adoption of LEED is an area of future work the authors plan to pursue. With the adoption and greater use of Integrated Project Delivery (IPD) method, the authors feel contractors will play a larger role in influencing sustainable construction.

Table 1
Table of Internal and External Influences on Sustainable Decisions

Internal	External
Administrative desire to reduce carbon impact	State legislative funding levels
Poor performance of existing buildings	State funded grants supporting sustainability
Faculty support of sustainability	Marketing efforts to potential students & donors
Student expectations related to environment	Partnerships with state & local organizations
Building committee recommendations	State mandates requiring LEED certification
University policy	Professional organizations
	Cultural shift in consultants, architects, and engineers

Economics

The most compelling theme identified in the interviews dealt with a variety of economic issues. Nothing makes sustainability more sustainable itself than when it aligns with the economic motivations as well. In Central Washington University's case, cost data indicates that the 14 year history of continuously investing in a variety of energy conversation projects resulted in energy costs over that time period rising only 2.9% annually. If the effects of inflation are included, this reflects a net reduction in energy costs over the last 14 years. In the face of steadily falling state funding levels for higher education, this reduction in a large budget item creates a strong motivation to make sustainability the norm rather than the exception.

A second economic motivation has resulted from the reduced cost of construction brought on by recent economic conditions. Design estimates for construction projects often lag changing construction costs. When construction costs are on the downswing, bids are often lower than expected. As a result, the university's facilities management group has had the opportunity to include a number of sustainability features in its projects that might otherwise not be there. Design features necessary for LEED certification were specified as additive alternates; e.g., solar panels. Then because of the budget levels and low bids these alternatives were accepted and implemented. This resulted in a second economic motivation to incorporate sustainability features in a construction contract as bid alternatives.

Conclusion

Sustainability planning and construction on capital projects at CWU's campus has matured to a state that it is accepted by facilities management, administrative personnel and users of the facilities. Projects highlighted in this case study research demonstrate solid sustainable features, practices, and a commitment to sustainability.

Prior to 2009, this campus begrudgingly accepted the concept of sustainable design and construction or felt they were practicing sustainable design by focusing solely on energy conservation. Furthermore, the existing policies were mainly tied to a very non-descriptive goal by the state legislature that sustainability would be incorporated into the capital projects. It was also left to the institution to define these policies. What also came out of the research was that sustainability concepts usually would follow the ebb and flow of the types of technology available to achieve a certain level of sustainability on various projects. Since then, projects on campus are planned to accomplish the highest LEED rating possible. Achieving the highest LEED rating was also incorporated into the bidding process where bidders were given the opportunity to incorporate sustainability practices into the bid as alternates to the base bid. This would allow the owner to pick and choose different sustainable practices based on the funding provided by the state since the amount was quite limited. This shift in thinking is reflected in the two projects highlighted in the paper. Other university facility managers and educators may want to use these projects as examples of sustainable design and construction.

It is worth noting that on CWU's campus decisions made to become sustainable were very complex decisions. Decisions were based on previous projects, performance of existing buildings, a history of energy conservation, a perception that "going green" would result in a positive image, funding, ability to achieve high sustainable standards, external influences such as consultants and the difficulty of the projects.

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References

Cresswell, J.W. (1998). *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. California: Sage.

Bender, W.J. and Bicchieri, K. (2009). *Sustainable Design Strategies That Succeed.* Associated Schools of Construction Proceedings of the 46th annual conference.

Johnson, B.T., Folkestad, J.E., Dunbar, B.H., (2006). *Identifying Barriers to Certification for LEED Registered Project.* Associated Schools of Construction Proceedings of the 42nd annual conference.

Marchman, M and Clarke, S. (2011). *Overcoming the Barriers to Sustainable Construction and Design Through a Cross-Reference of West Coast Practices*, 47th ASC Annual International Conference Proceedings

Princeton Review. *2009 College Hopes and Worries Survey*. January-March, 2009.

Roberts, I. (1996). Local Sustainability (Leicester, Environment). International Institute for Environment and Development. URL http://pubs.iied.org/pdfs/9046IIED.pdf

Sullivan, J.M., (2008). *Developing a Decision Model for the Assessment of Sustainable Alternatives*. Associated Schools of Construction Proceedings of the 44th annual conference.

USGBC, (2011, October). LEED definition. URL http://www.usgbc.org

Yin, R. (1994). Case study research: Design and methods (2nd ed.). Thousand Oaks, CA: Sage Publishing