

Framework for Sustainability Challenges within the Building Industry

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Sustainable building practices are a growing and important trend in the building industry. To help advance such practices it is important not only to study success stories, but also to identify and leverage lessons learned from past and on-going efforts. This paper presents a survey of literature focused on challenges or shortcomings as related to the implementation of sustainable building practices, and establishes a framework to characterize existing research. Five main focus areas are identified with overlapping components. The framework suggests that challenges to sustainability exist across all phases of building lifecycle. However, research bias may exist that cause challenges to sustainability in building practice to be underreported in literature.

Key Words: Challenges, Sustainability, Building Practice, Research Bias

Introduction

Constructing and operating buildings consumes more raw materials and energy than any other sector in the developed world. As such, industry has identified the need for sustainable building practices. Ongoing efforts include the rise of green building rating systems such as LEED and BREEAM, development of green building codes (i.e. the California Building Standards Code), and the introduction of frameworks for sustainable development such as The Natural Step. In 2005, 2% of non-residential construction starts were "green"; this number leaped to about 28% - 35% in 2010, and is predicted to climb to near 50% by 2015 (McGraw Hill Construction, 2010). Such rapid and wide-spread change raises the question – how successful are current sustainable building efforts?

Research has begun to evaluate the efficacy of different sustainable practices as well as identify potential challenges to sustainability within the building industry. Though several sources of challenge have been explored extensively, relatively little research addresses the full range of potential sustainability challenges to the industry. Such a gap in the literature might partially be explained through bias. Biases have been identified within the scientific research community including the survivorship or winner's bias, or the publication bias. Specifically, research is often influenced by researcher's interest (funding, data contradicting their previous findings, etc.) (Martinson, 2005), and because publishing often focuses on the "stand-outs" or data that shows positive statistical significance, researchers are more likely to publish positive results (Ioannidis, 2005). In this paper, the authors perform a preliminary literature review and develop a framework categorizing potential challenges to sustainable building practice. Potential future research is also discussed.

Review of Challenges to Sustainable Building Documented in Literature

To develop and validate a framework of existing research, the authors performed a literature review and categorized the results. Five primary sources of challenge were identified as obstacles to sustainability in the building industry. These include: false motivation, differing definitions of sustainability, shortcomings in design, shortcomings in construction and shortcomings in operation with specific examples given of each. A framework for literature related to these challenges, their interactions and potential impacts is presented and discussed below.

Framework

The following framework was developed by the authors to diagram and catalog the types of challenges to sustainable building currently explored in literature.

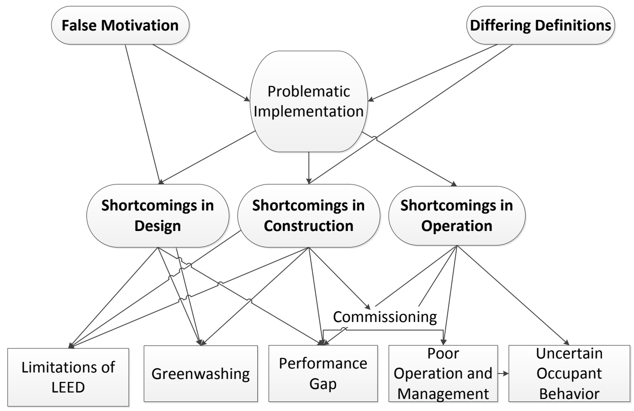

Figure 1: Framework outlining potential challenges to sustainable building as identified in the literature.

Figure 1 suggests that potential challenges are varied and occur at all phases of building projects life-cycles. In the following sections we provide supporting evidence and examples of such challenges as documented and discussed in the literature.

False Motivation

A study by UNEP found that "concern for sustainability issues is high, but the strength and depth of attitudes (level of belief) is low," and "although levels of concern are high, sustainability issues are not necessarily the highest priority for the general public which means that potential activities may be subordinated to other concerns" (United Nations Environment Programme, 2004, pg.2). Similarly, Cole (2003, p. 4) found that, "Shortsighted economic priorities and gains have always compromised environmental and social considerations in building." Much literature suggests that economic interests are one of, if not the biggest driver in decisions related to building, frequently out-weighing sustainability considerations when in competition (Cole, 2003; Ding, 2008; Reed, 2007).

However, industry is beginning to recognize that the appearance or designation of sustainability has economic value (Figge & Hahn, 2012). "Greenwashing" is a term used to describe the use factors of high importance and motivation to others, in this case sustainability, to manipulate and promote ulterior objectives. This can occur in thebuilding industry when environmental spin or marketing is being used by a project or product to increase profits over sustainability objectives themselves. Spiegel (2006) takes the definition further, stating Greenwashing is "giving a positive public image to commonly or supposedly environmentally unsound practices". Greenwashing is not new as a marketing ploy. Examples pre-date Frank Lloyd Wright as demonstrated in his promotion of his project as climate responsive, affordable housing in the southwest region of the United States. Wright claimed the buildings had lower energy consumption than comparable housing in the region, but he failed to test them, and his claim later proved to be untrue (Schiler & Brahmbhatt; 2006).

Greenwashing may, indeed, be widespread:

> *"The entrenched mantra of profit maximizing poses a systemic challenge to the ideals of sustainable construction. During the past twenty years, "corporate social responsibility (CSR) has emerged as the conflicted, paradigmatic compromise between the public demand for sustainable goods and services and investors' demands for business competitiveness (i.e. maximum profits). The former has gained prominence due to environmentalists and scientists' dire warnings about our impact on the planet's health and the latter is propelled by the global dominance of neo-liberal capitalism." (Alves, 2009, pg.3)*

Frequently, in the building industry, sustainability and economic interests may be at odds and many times stakeholders elect to pursue economic over environmental advancement. Furthermore, they may be willing to falsely claim environmental motivation, even when economic concerns dominate.

Differing Definitions of Sustainability

The world's interest in and awareness of green building is increasing (Cole, 2003). Through evaluation of energy and environmental performance spanning a broad spectrum of sustainability, green building rating systems have led the way in defining green building (Gowri, 2004). To date, the Leadership in Energy and Environmental Design (LEED) rating system has made the largest impact on the United States construction industry. Due to its popularity and common acceptance among stakeholders, LEED, in many cases, has become synonymous with sustainability in the built environment. This has the potential to lead people to believe – if it's LEED, it's sustainable. As a result, LEED can serve as a false ceiling for sustainability that leads construction professionals to think less about the complex nature of the full range of environmental, social, and economic issues, and rather focus on the more narrow and prescriptive definitions outlined in a checklist (Ding, 2008).

The root cause of many challenges to sustainability is, many times, miscommunication. The limitation of thinking that LEED is synonymous with sustainability is just one example. Frequently, projects are hindered because stakeholders do not clearly understand or convey a comprehensive definition of sustainability. Many times, in fact, stakeholders might have differing and competing definitions of sustainability and therefore are working toward differing or competing objectives. Specific examples of obstacles to green building resulting from divergent goals are included in the discussion below.

Shortcomings in Design

The first challenges to sustainable building typically occur during the planning and design phases of a project. These may include problems with design intent, misunderstanding of the problem definition, or lack of effective design tools and methods. Examples currently presented in the literature regarding design shortcomings primarily focus on issues related to using LEED and greenwashing.

Limitations of LEED

Frequently, sustainability is not measured by the full range of ecological, social, and economic impacts of the project but instead by how many LEED points are achieved (Schendler & Udall, 2005). Existing literature contains many critiques of the use of LEED as a sustainability guideline. A few are presented here. The use of green building rating systems as design guidelines cannot be adequate or appropriate (Ding, 2008). Green building rating systems are not meant to select optimum project options and designs, they are meant to evaluate building design against a predesigned environmental criterion (Ding, 2008; Schendler & Udall, 2005). Project teams should be focused on solid environmental design instead of obsessively focused on points, but this is commonly not the case (Schendler & Udall, 2005).

LEED and other rating systems tend to over-simplify problems and their solutions due to their prescriptive nature. Environmental issues are broad, complex, and tough to capture (Ding, 2008). The number of factors surrounding environmental performance is enormous and knowing which area to address should be project specific. Weighting factors can help but, as previously discussed, they are subjective and, many times, universal. Rating systems do not currently reflect the complexities of our environment, nor are we capable of molding a fixed measuring system to a vastly multi-dimensional environment (Cole, 2003). The ability to collect data about all environmental factors is not yet possible. Thus, instead of trying to compute, understand and rank each factor or LEED credit, it may be better to apply systems thinking and try to minimize all.

Due to the complex nature of sustainability and its definition, one strategy adopted by industry to promote sustainability is to use energy consumption as a metric or benchmark for sustainability. Significant research exists around building energy performance as an indicator of the relative success or shortcomings of sustainable building. LEED has been criticized for not putting sufficient weight on energy, and allowing buildings to be certified without sufficient consideration toward reducing energy consumption. Such criticism reveals a potentially fundamental shortcoming. Ding (2008, p. 457) wrote with regard to LEED, "there is at present neither a consensus-based approach nor a satisfactory method to guide the assignment of weightings." LEED has since used the U.S. EPA's

TRACI Impact Categories to “weight the system,” and will soon switch to a set of impact categories the USGBC has internally developed. While these weighting systems continue to change, they remain subjective and constant across all projects while the projects themselves are not homogenous. Weighting systems can reduce the promotion of regionally appropriate design strategies and their cultural underpinnings (Cole, 2003).

The following related issues are also discussed in literature and, typically, connect shortcomings in design with shortcomings in operation when documenting challenges to sustainable building.

The Performance Gap

Further criticism of LEED frequently cited in literature is that LEED buildings do not performing as intended. This “performance gap” is well documented; however, in some cases the performance gap may be caused by factors unique to LEED, such as “Designing for Points”. Multiple studies have suggested that LEED buildings frequently do not perform as intended, and may even use “more energy than their conventional counterparts” (Newsham, 2009). Measured energy performance of LEED buildings has little correlation with certification level or the number of energy credits achieved in design estimates (Newsham, 2009). A potential way to fix this disparity, one done by other rating systems, is to base credits on actual energy performance instead of anticipated or estimated energy performance.

The PROBE Studies (Post-occupancy Review of Buildings and their Engineering) suggest that the actual energy consumption of buildings is usually on the order of magnitude of twice as much as predicted by an energy model (Menezes et al., 2012; Bordass, Leaman & Ruyssevelt, 2001). Post-occupancy evaluation (POE) are typically used as a vehicle for systematic study of occupied buildings to learn lessons that will improve current conditions and improve future building design (Meir et al, 2009). The PROBE studies published 23 post occupant survey’s examining the performance of building (Bordass, Leaman & Ruyssevelt, 2001). The goal of this project was to help increase awareness among the building industry and its clients regarding success and failure factors related to building performance (Bordass, Leaman & Ruyssevelt, 2001).

PROBE Studies suggest that energy models are usually inaccurate due to faulty assumptions during the design stage. Often, design is not complete when an energy model is produced – so assumptions are necessary. Assumptions frequently lead to oversimplification of the building fabric; building usage patterns and occupant behaviors, plug loads, etc. Designers also often assume ideal operation of mechanical systems. Although models have the potential to be robust, simplistic models are frequently used. In general, the process of transferring a real building to a computer model is complex. If simplified, uncertainties are introduced and the model will most likely be inaccurate. These inaccuracies have been identified in literature as a major challenge to green building design and analysis. Goals for energy use are often defined before design starts, and inaccurate model results are used to meet such goals (Bordass, Leaman & Ruyssevelt, 2001; Bordass, Cohen & Field, 2004; Menezes et al., 2012; Carbon Trust 2011).

It is common during design development for the building fabric, controls, and other elements to be changed at the request of the owner or by value engineering performed by the project team. While design changes can improve building performance they often have the opposite effect since they frequently occur to fix funding deficiencies or cost overruns (Bordass, Cohen & Field, 2004; Menezes et al., 2012).

Shortcomings in Construction

Building performance is affected by the quality of construction. Multiple case studies exist in literature highlighting poor construction as a detriment to sustainability (Bordass, Leaman & Ruyssevelt, 2001). Inputs into the energy model usually assume optimum construction and ideal assembly with insulation in every crevasse, no extra thermal bridging, and an absence of gaps and cracks in the envelope. This idealization is simply not a reality of construction (Bordass, Cohen& Field, 2004; Menezes et al., 2012). In addition, dishonest builders may exasperate the problem by substituting cheaper products for the green products specified during construction. Mitigating sustainability challenges and abuses during construction is difficult unless an economic incentive is put forward to motivate designers and contractors to build buildings that are constructed and perform as intended.

Building commissioning is one strategy adopted by industry to address such challenges. Building commissioning is a process that ensures building systems are designed, installed, functionally tested, and capable of being operated and maintained according to the owner's wants and needs (Elzarka, 2009). Inadequate or non-existent building commissioning can directly increase energy use in buildings (Bordass, Leaman & Ruyssevelt, 2001; Carbon Trust, 2011). LEED requires a minimum level of commissioning. However, current commissioning practices are often insufficient in scope for today's multifaceted systems. Adequate, comprehensive commissioning is essential and should be specified; if possible, the designer and builder of each system should be involved in the process with the commissioning agent. The commissioning agent is vital as he or she ensures proper integration of various systems. Seasonal commissioning is also important to ensure optimal performance of the systems year round (Carbon Trust, 2011). Continuous commissioning is defined as the comprehensive and ongoing process to address operating problems, improve comfort, optimize energy use, and identify retrofits for existing buildings. Continuous commissioning can have a positive return on investment in terms of both energy and capital (Liu et al., 2005). Meir et al. (2009), proposes that POEs should be included in the commissioning process as an important and inevitable step towards making buildings more sustainable. Challenges in commissioning persist, however, as the best practices in commissioning have high upfront costs, are time consuming, non-standard, and remain unknown by many within the industry.

Shortcomings in Operation

A building's level of sustainability is closely related to its operation. Research exists that highlights reasons why buildings do not meet their design intent as a result of challenges during operation. In many cases, occupants may have significant impact on energy use - operable windows, appliances, information and communication technologies, lights, available plugs for personal use, even heating and cooling can all impact performance. Furthermore, as building equipment becomes more efficient, the occupant may begin to play a larger role in overall performance. Education can improve occupant impact. However, if education is not an option, an alternative is to limit the control granted to the occupant (Carbon Trust, 2011).

Three levels of occupant education have been identified as contributing to sustainability goals. First, all occupants must share a basic understanding of sustainability. Second, all occupants must be able to recognize what sustainable features of their building's design (Carbon Trust, 2011). Third, occupants must understand the building's design intent and how and why of the system's interworking (Bordass, Cohen& Field, 2004; Carbon Trust, 2011). Deuble and Dear (2010) showed that, in general, occupants of green buildings are more forgiving of less than ideal indoor environments than occupants of conventional buildings. Several on-going research programs are studying how to successfully promote occupant behavior that results in greater building energy efficiency.

For a building to perform as intended, it must be operated correctly. Facility management has a great amount of influence over energy systems performance. Ensuring proper management and personnel who understand and know how to maintain proper controls is essential. Energy policies and energy audits are advisable and retro commissioning has been shown to have a positive return on investment (Liu et al., 2005). In new construction, implementation of advanced and complex systems can result in significant energy savings if management is proficient in operating the system. Problems occur when operators find a system too complex to use, or operate it in default mode. Systems have been known to default-to "on" and continuously run, or they may never be tuned as the seasons change or as occupancy changes resulting in wasted energy. It is common to find that energy systems such as variable speed drives, heat recovery, free cooling, and plant sequencing systems are working poorly if at all. The situation becomes more difficult in a rented facility and even worse in multi-tenanted buildings; the landlord, tenants, and building managers often impede investment and exacerbate the wasteful operation of systems (Bordass, Cohen& Field, 2004).

Critique of the Framework

The framework presented is intended to illustrate and organize current themes in existing literature regarding challenges to sustainable building practice, as well as the interactions that occur between them. Undoubtedly, additional challenges and relationships exist. Literature may be biased towards underreporting failures or shortcomings. The winner's bias general focuses on the thing or data that "survived" (succeeded) and tries to attribute a value to them (Young, Ioannidis & Al-Ubaydli, 2008). The problem is that survivors do not always accurately represent a population and attributed values can be arbitrary and debated. In order for results to survive to the publishing phase, failures are often ignored or underrepresented. (Young, Ioannidis & Al-Ubaydli, 2008). Statistically, only a small number of reports showing insignificant or non-significant results are published while, presumably, a large number sit in a "file drawer" inaccessible (Scargle, 1999). Such research biases may exist in literature related to sustainability challenges within the building industry since preliminary investigation of the literature reveals relatively few mentions of failures – although anecdotally they appear more common in industry. In general, companies are significantly more incentivized to market success than admit failures.

Future Research

Review of existing literature suggests that challenges to sustainability within the building industry are fundamental to sustainable building practice (motivation for and definition of) and occur across the building lifecycle (throughout design, construction and operation). It is critical, therefore, that research continues to identify and explore these and additional more comprehensive challenges to advance sustainability within the industry. The framework presented is likely incomplete, and gaps in the research need further investigation. Future research should be expanded in an attempt to avoid the publication bias and promote greater sharing of "lessons learned".

However, with rapidly increasing degradation to the world's ecological systems expanding the report and attention to challenges may not be enough. Leading thinkers in the sustainability movement suggest that a paradigm shift is necessary. The popularized definition of sustainable development coined by the Brundtland commission is, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, pg. 27). However, instead of settling for "less bad," it may be essential in the sustainability movement to strive for "more good."

Such a goal is embodied in theories such as "regenerative development" or "regenerative design". Bill Reed, one of the leading thinkers of regenerative design, has developed a theory of different levels of design, distinguishing between design that regenerates systems on earth, and design that degenerate systems on earth. Reed believes that most sustainable development falls below the mid-line separating degenerative and regenerative systems. Reed sees sustainability as the break-even point, nothing is getting better, and nothing is getting worse. This theory supports the Brundtland commission's sustainability definition. In order to curb society's ecological systems downward spiral (Reed, 2007), therefore, regenerative systems are necessary to help reverse the trend and are important candidates for further research.

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