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A framework to assess the role of stakeholders in sustainable building retrofit decisions

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ABSTRACT

Stakeholders are concerned with increasing the sustainability of their existing buildings from social, environmental, economic, and technical perspectives. Several studies indicate that conflicting stakeholder requirements are a main barrier in implementing sustainable retrofits with the decision often made based purely on short-term economic grounds. However, most studies did not take into account the important role that different stakeholders can play in determining the type and extent of any retrofit measures, or develop methodologies that integrate social, environmental, economic, and technical concerns. In this research, a House of Quality (HOQ) model is developed that synthesizes differences among the stakeholders and integrates their competing objectives to establish hierarchy of retrofits that meet the stakeholder requirements in using the existing building. The developed model is tested on a decision to sustainably retrofit an existing US Navy case study building. The HOQ analysis revealed that the stakeholder type for this case study did not affect the ranking of their requirements, and in general, all 5 of the main groups of stakeholders involved in this study, agreed without persuasion that the primary reasons for implementing sustainable retrofits in each of the four main systems are to save energy, reduce costs, and adhere to policy.

1. Introduction

Buildings are responsible for half of the total greenhouse gas (GHG) emissions in the United States (US), with adverse impacts on the global environment, human health, and the economy (U.S. EIA, 2012). It is estimated that 80 percent of the energy consumed throughout a building's lifecycle occurs when it is occupied and in use, where the service life range is 30–70 years. This fact requires the architecture, engineering and construction (AEC) industry to produce buildings that will be resource-efficient during their lifecycle, and more importantly renovate the existing building stock according to modern sustainability criteria (UNEP, 2007). The US Energy Information Administration estimates that by the year 2035, approximately 75 percent of the aging built environment will be new or will require a major renovation (U.S. EIA, 2009).

This important role that existing buildings play in achieving energy reductions is emphasized by several policies and executive orders (EO). For example, the US Energy Policy Act (EPA) of 2005 and subsequent EO-13423: Federal Leadership in High Performance and Sustainable Buildings require all federal agencies to reduce energy intensity by 30 percent for new buildings and 15 percent for the existing Federal capital asset building inventory by 2015 when compared to the 2003 baseline (Energy Policy Act, 2005). As a result, agencies such as the General Service Administration and the Department of Defense were allotted approximately $30 billion to invest in energy efficient upgrades to their existing facilities (ARRA, 2009).

For existing buildings, energy use reduction can be achieved either through continuous maintenance of the facility or a major sustainable retrofit. Maintenance is only a short-term solution to the larger problem of an aging building in terms of reducing energy consumption and carbon footprint (Poel, van Cruchten, & Balaras, 2007; Tainter, 1995). On the other hand, a sustainable retrofit extends the life span of a building while improving performance and preventing the early onset of obsolescence (Menassa, 2011). For example, maintenance of a building's heating, ventilation and air conditioning (HVAC) system can include replacing air filters, but the system may still need other repairs over its lifetime as opposed to a sustainable retrofit where the older HVAC unit is replaced with a more energy efficient model (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009).

From a sustainability perspective where balancing economic, environmental and social aspects are important, a decision on

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whether a building should undergo sustainable retrofit needs to be agreed on by the building stakeholders. Sustainable retrofit projects involve complex processes that are typically unfamiliar to some stakeholders, and a concise decision-making framework is necessary to align their requirements and determine an economically and environmentally acceptable engineering solution (Klotz & Horman, 2010; Lapinski, Horman, & Riley, 2007). The stakeholders in this context are defined as the people who directly or indirectly have a vested interest in the building, its operation, and the outcome of a future retrofit project. Building stakeholders can include the owner, tenants, investors, building operator, and the designers to name a few. These stakeholders have varying and in most cases conflicting perspectives on how, when, and why a building should be sustainably retrofitted (Bernstein & Russo, 2009; Yudelson, 2010). For example, the owner might be motivated to sustainably retrofit to reduce life cycle costs, and increase return on the investment. On the other hand, the tenant is interested in clear incentives such as lower rent or increased employee productivity. Other important issues arise when the owner feels that they are paying for the improvements in the building, but the tenants are reaping most of the benefits, such as reduced energy costs (Beheiry, Chong, Asce, & Haas, 2006; Bosch, Pearce, & Asce, 2003; Fuerst & McAllister, 2011; Poel et al., 2007).

In addition, sustainable retrofit decisions are commonly based on maximizing energy savings to recover initial upfront costs within an acceptable period of time. However, this focus on maximizing economic benefits often results in overlooking more than 50 percent of possible energy savings methods like engaging building stakeholders in the process (Azar & Menassa, 2012; Schneider & Rode, 2010). For example, if building stakeholders know about the building's energy performance and are involved in the decision process to reduce energy consumption, they will have bigger incentive to reduce energy use through behavioral changes that do not require any additional expenditure. Moreover, in most cases the chosen retrofits do not contribute to achieving stakeholder requirements of improved comfort, health and productivity (Heerwagen, 2000). Thus, aligning stakeholders' requirements for enhanced work environments, profit maximization, and energy savings, among others is a fundamental challenge that needs to be addressed if the targeted reduction in energy use is to be achieved from the retrofit. A more complete approach to a truly sustainable retrofit should include stakeholder requirements to achieve social, economic and environmental equity (Savitz & Weber, 2006). Thus, it is imperative to understand how the requirements of the different building stakeholders might affect the sustainable retrofit decision, and to what extent are those requirements influenced by social, environmental, economic, and technical considerations.

2. Literature review

A number of studies in the US indicate that there is a significant market demand for sustainable buildings; however, sustainable building retrofit projects are still not as widely pursued for several reasons including: lack of information about the building and its systems after the design phase (Bosch et al., 2003), reluctant stakeholder commitment because energy costs are not high enough to create strong incentive for retrofits (Beheiry et al., 2006), and perceptions that sustainably certified buildings do not guarantee energy savings (Menassa, Mangasarian, Asmar, & Kirar, 2012; Scofield, 2009).

Bosch et al. (2003) presented an analysis of nine sustainable design and construction guidance documents used by public schools that were created to educate decision makers in regards to sustainable design and construction practices. Their analysis concluded that efforts were focused on designers and owners and that much less information was targeted to other important building stakeholders such as facilities managers and tenants.

Recent research has focused on translating the long-term benefits of sustainable retrofits into economic metrics for decision-making. Juan, Gao, and Wang (2010) developed a decision support system to assess existing office building sustainability conditions and recommend an optimal set of retrofit measures that considers the trade-offs between cost, resource consumption, energy performance, and CO_2 emissions. Chidiac, Catania, Morofsky, and Foo (2011) developed a methodology to rank the energy savings potential for a large set of Canadian office building stock and select the optimum energy saving measures to adopt for each building. Entrop, Brouwers, and Reinders (2010) investigated energy performance indicators in Dutch residential dwellings and developed a methodology that incorporated additional revenues within the financial analysis of energy saving techniques. The research incorporated a long-term financial gain as a benefit for pursuing sustainable retrofits into the decision-making process and revealed that much shorter payback periods in return on investment (ROI) methodologies could be achieved. Menassa (2011) presented a quantitative American options approach to determining the value of single or multi-phase investment in sustainable retrofits for existing buildings by taking into account different uncertainties associated with the life cycle costs and perceived benefits of the investment. The results of a case study example indicated that when uncertainty is high, dividing the decision into several phases helps increase the value of the investment and provides stakeholders with flexibility to abandon the retrofit project if necessary.

Furthermore, technical, economic, and environmental implications of existing building sustainable retrofits have been explored in several studies (Chidiac et al., 2011; Entrop et al., 2010; Gaterell & McEvoy, 2005; Gluch & Baumann, 2004; Juan et al., 2010; Nemry et al., 2010; Papadopoulos, Theodosiou, & Karatzas, 2002; Poel et al., 2007). However, most of these initiatives have focused only on technical aspects of retrofits.

Very few studies in literature studied what motivates public and private building owners to pursue green and sustainable building design initiatives. Yudelson (2010) outlined multiple reasons why building owners and operators are interested in energy efficient and sustainably retrofitted buildings. The primary motivating factors include growing tenant demand to lower operating costs associated with electricity, fuel, and water consumption; higher employee productivity; investors seeking more socially conscious investments, and reputation. Fuerst and McAllister (2011) also investigated the rational to pursue sustainable building design. Their study determined that investors are able to achieve higher net operating income due to increased demand from tenants, lower costs of ownership due to energy and other utilities savings; as well as, an element of protection from future regulatory changes.

However, few studies have explored the interaction between the owners/investors and other stakeholders and their different requirements from a sustainable retrofit in existing buildings. Rey (2004) proposed a multi criteria assessment methodology for existing building retrofit strategies which simultaneously takes environmental, social, and economic criteria into account to support the decision-making process. The author concluded that beyond the economics of building performance, other elements related to a building's specific use by varying stakeholders have great importance in the choice of the most suitable retrofit strategy, and that greater collaboration is required between stakeholders.

Further review of literature revealed several barriers that inhibit building stakeholders from making reasonable and effective decisions to sustainably retrofit their existing buildings. Implementing these retrofits involves a significant amount of planning and communication with numerous stakeholders to obtain a commitment to shared goals and achieve a beneficial solution for all involved