SUSTAINABLE PROJECT MANAGEMENT FOR GREEN CONSTRUCTION: CHALLENGES, IMPACT AND SOLUTIONS

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ABSTRACT

With augmenting cognizance of environmental issues and growing concern over climate change, sustainable construction is gradually put forth globally. However, construction of green buildings in Singapore still encounters impediments as there is a lack of proper project management framework for such projects. Based on the survey and interview results from 31 industry experts, this study aims to identify common challenges encountered during management of green construction projects and their impact on project performances, ultimately proposing some solutions to overcome the barriers. Findings from this study are: (1) main dissimilarities between conventional and green construction projects exist, especially in the level of details and communication required; (2) there is no paucity in sustainable knowledge in the Singapore construction industry; however, challenges against implementation of the knowledge exist, influencing project performances, and the lack of investment on management of green building construction is the most paramount barrier; and finally (3) to overcome the barriers, a project management framework for green building construction should be developed, possibly promoting adoption of sustainable management approaches for future green building projects.

Keywords: *Green Building, Sustainable Development, Project Management, Singapore.*

1. INTRODUCTION

In Singapore, buildings contribute 16% of the nation's total energy consumption and the energy cost can constitute about 20% to 40% of the total operating cost (IMCSD Committee, 2009). According to Perez-Lombard *et al*., (2008), both commercial and residential buildings are responsible for 20% to 40% of the world's energy consumption. With the recent mounting global concern of the negative impacts of human activities on the environment, almost all industries are steering towards sustainable development and implementing green measures (Gunawansa and Kua, 2011; Kua, 2011). The building construction industries from various countries have taken these 'green measures' in their strides, putting strong accent on green building construction (Hwang and Tan, 2010). In line with this trend, Singapore has also shifted its focus in making sustainable development a key national priority (Singapore Green Building Council, 2009; Lutchmeeduth *et al.,* 2010).

According to the Building and Construction Authority of Singapore, since the launch of the Green Mark Scheme in 2005, the number of green mark certified buildings in Singapore has increased to more than 750 from the mere 17 buildings in 2005 (BCA, 2011). To promote environmental sustainability in buildings, the BCA had also formulated the 1st and 2nd Green Building Masterplan together with other efforts to thrust forward in developing more green buildings in Singapore. By year 2030, through BCA's 2nd Green Building Master Plan, the Inter-Ministerial Committee on Sustainable Development (IMCSD) targets to have at least 80% of the buildings in Singapore to achieve the BCA Green Mark Certified rating (BCA, 2009b).

Under this circumstances, the specific objectives of this study are: (1) To compare design, construction, and commission stages between conventional and green building construction projects based on a

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comprehensive literature review; (2) To investigate common challenges that project managers encounter while managing green building construction projects; and lastly (3) To propose some plausible solutions for improving the current green construction project management. The findings from this study will contribute to more intensive and effective implementation of green building construction in Singapore.

2. GREEN BUILDING CONSTRUCTION

2.1. DEFINITION

The construction of green building is part of sustainable construction. According to Kibert (2008), sustainable construction addresses the ecological, social and economic issues of a building in the context of its community. Sustainable construction is applied throughout the entire life cycle of construction, from preconstruction to disposal of the building. Such construction aimed to reduce the impact of the construction practice on the environment through its planning and managing of a construction project complying with the contract document (Glavinich, 2008).

2.2. GREEN BUILDING DESIGN

Green building design can be more complicated than what is typically required for conventional buildings, considering that evaluation of alternative materials and systems is commonly necessary by the design team (Glavinich, 2008). In conventional building projects, schematic designs that consist of simplified and general concept of how buildings will be like, is being used at the beginning of the project process (iiSBE, 2009). However, in green building projects, a holistic and integrated design process is being used right at the start of the project as green buildings have many unique design features not typically found in conventional building and requires deep integration (Kibert, 2008). The cardinal green building design features are divided into three broad categories – namely indoor lighting, building materials and layout (Yudelson, 2008). In a green building, the lighting design integrates low-energy lighting fixtures with natural lighting through strategic window installation and usage of energy-efficient fluorescent lighting (Yudelson, 2008). Environmental friendly building materials, such as recyclable bamboo flooring, as well as toxic free materials, such as formaldehyde-free cabinets and non-toxic paint, are used in green buildings to ensure that they are sustainable (Yudelson, 2008). Building layout plays a significant role in ameliorating energy efficiency of the building. Green buildings also take advantage of natural ventilation through the building's orientation (Yudelson, 2008).

2.3. CONSTRUCTION OF GREEN PROJECTS

Other than conventional construction procedures, green building projects have to implement sustainable construction practices, which are usually listed in green building rating systems such as LEED. One example of such practices is a waste management plan (CIRIA, 2001) to minimise waste generation on the construction site (Kibert, 2008). A green building construction also have to adopt sustainable practices such as using recycled aggregates for concrete work and using timber which are from renewable sources (CIRIA, 2001). In addition, the main contractor and project manager have to ensure that pollution from the construction is kept to the minimum by controlling soil erosion, waterway sedimentation and airborne dust generation (USGBC, 2009). Furthermore, the natural habitat should be conserved through prudent sitting of building to minimise the disturbance to existing natural environment (USGBC, 2009). These considerations are often neglected in traditional construction.

2.4. GREEN BUILDING COMMISSIONING AND CLOSING OUT

The commission and closing out of a green building project is usually more complicated than that of conventional project (Glavinich, 2008). This is especially so when the developer wish to attain third party green certification (Glavinich, 2008) such as LEED, BREEAM and Green Mark. There is also a responsibility to impart the knowledge of green buildings system to new facilities management teams and

end users to maintain sustainability (CIRIA, 2001). In addition, ease of maintenance has to be ensured (CIRIA, 2001).

3. CHALLENGES IN GREEN CONSTRUCTION PROJECTS

3.1. HIGHER COSTS FOR GREEN CONSTRUCTION PRACTICES AND MATERIALS

As compared to conventional projects, green projects tend to cost more to construct. According to an estimate by Tagaza and Wilson, (2004) capital costs for green projects range from 1 to 25% higher. The higher costs are due to design complexity and the modelling costs needed to integrate green practices into projects (Zhang *et al.*, 2011). Higher costs are also associated with green materials and using green construction technologies (Hwang and Tan, 2010). Zhang *et al.* (2011) calculated that using green materials costs from 3 to 4% more than conventional construction materials. Some green materials cost significantly more than their conventional counterparts, compressed wheat board costs about ten times more than ordinary plywood (Hwang and Tan, 2010). The higher costs of green construction directly affect the project manager, because they are responsible for managing and delivering their projects within an allocated budget (Pettersen, 1999; Ling, 2003).

3.2. TECHNICAL DIFFICULTY DURING THE CONSTRUCTION PROCESS

A project manager implements a project plan by authorising the execution of activities to produce project deliverables (Pettersen, 1999; Ling, 2003). Often, green technologies require complicated techniques and construction processes (Zhang *et al.*, 2011). If complexities are not addressed well then it may affect the project manager's performance. Tagaza and Wilson (2004) suggested that one of the main challenges in green building is the technical difficulties experienced during the construction process. Similarly, design can be more complicated than that of a conventional building due to the evaluation of alternative materials and systems (Hwang and Tan, 2010).

3.3. RISK DUE TO DIFFERENT CONTRACT FORMS OF PROJECT DELIVERY

Tagaza and Wilson (2004) reported that the success of developing and implementing a green design depended greatly on the type of contract selected for the delivery of the project. The type of contract used in green projects must incorporate the details of a fully integrated green design. This creates a problem if the design is locked before being developed fully. Multiple changes of significant scale are likely if green features are incorporated at a later stage, resulting in a greater overall project cost (Hwang and Tan, 2010).

3.4. LENGTHY APPROVAL PROCESS FOR NEW GREEN TECHNOLOGIES AND RECYCLED MATERIALS

The market environment suggests that the planning process can be protracted as the process of approving the use of new green technologies and recycled materials can be lengthy (Tagaza and Wilson, 2004). Similarly, surveys conducted by Zhang *et al.* (2011) and Eisenberg *et al.*, (2002) show that additional time is expected in order to gain approval. A lengthy approval process presents a challenge to project managers as they must develop the schedule and approve progress payments to vendors and suppliers (Pettersen, 1999; Ling, 2003).

3.5. UNFAMILIARITY WITH GREEN TECHNOLOGIES

Many studies have verified that green technologies pose certain challenges for developers, clients and contractors. Two reasons suggested by Eisenberg *et al.* (2002) are insufficient knowledge or technical expertise and unfamiliarity with the products, materials, system, or design. The main challenge is that green technologies are usually more complicated and are different from conventional technologies (Tagaza and Wilson, 2004). This was confirmed by Zhang *et al.* (2011). A project manager has to deliver

the project with the required performance specified by the client (Pettersen, 1999; Ling, 2003), and unfamiliarity with the performance of green technologies may affect the performance outcome.

3.6. GREATER COMMUNICATION AND INTEREST REQUIRED AMONGST PROJECT TEAM MEMBERS

To be successful, the project manager must manage a large number of suppliers, subcontractors and team members. Communication is especially critical for the green project in order to convey the sustainable practices expected from the team members. Interest amongst team members is important, Tagaza and Wilson (2004) found that the initial enthusiasm for separating waste materials amongst sub-contractors dissipated as the projects progressed and the recycling skips were found to contain a mix of materials.

3.7. MORE TIME REQUIRED TO IMPLEMENT GREEN CONSTRUCTION PRACTICES ON SITE

Random checks and on-site visits by project managers are usually required to ensure that sustainable practices are implemented on-site (Tagaza and Wilson, 2004). This is essential because workers may tend to forego time-consuming sustainable practices when there are time pressures to complete a project.

4. RESEARCH METHODOLOGY

To achieve the objectives of this study, a comprehensive literature review on green and sustainable building construction was first carried out. The aim of the literature review was to find out what are the essential differences between conventional and green construction projects in design, construction, and commissioning phases and what are the challenges encountered in green building construction project management. In addition, the objective behind the review was to explore some innovative management skills applied in these projects that can be implemented in Singapore's context. The examination and analysis of past work related to green construction also provided a better understanding of green and sustainable building construction and the project management processes involved.

Then, a survey questionnaire was developed to capture a specific set of challenges encountered in the Singapore construction industry. The survey also captured a comprehensive and accurate outlook of management culture adopted by local green construction industry. The survey questionnaire consisted of a section that could capture the profile of respondents. The next section carried questions regarding the profile of green building construction projects undertaken by the respondents. The third section asked the respondents to rate challenges encountered during management of green construction, and the last section required the respondents to pick out solutions to overcome those challenges. The questionnaires were sent via email to 101 Green Mark Professionals (GMPs) and Green Mark Managers (GMMs) registered under the BCA's Green Certified GMP and GMM scheme.

5. SURVEY RESULTS AND DISCUSSIONS

Out of the questionnaires disseminated, 31 completed sets were received. The survey results were analysed, performing descriptive as well as statistical analyses such as one sample t-test, ANOVA and Post-Hoc test. The respondents were from 19 consultancy (61%) and 12 project management companies (39%). All of the respondents had more than 2 years of experience on green building construction projects and majority of them (19 out of 31 respondents; 61%) had 3 to 4 years of experience. Also, there were 5 respondents (16%) who had more than 4 years of experience in the area. The following sections elaborate the analysis results.

5.1. CRITICAL CHALLENGES

The survey results revealed that all the respondents encountered some challenges during the management of green building construction. Table 1 presents the summary of Top 5 Challenges identified based on the respondents' input.

Table 1: Top 5 Challenges Faced in Green Building Construction Management

Respondent (%)	Challenges
100	Increase of Project Cost
83.9	Lack of Communication and Interest among Project Team Members
77.4	High Implementation Cost of Green Practices
67.7	Lack of Credible Research on Benefits of Green Buildings
51.6	Lack of Interest from Clients

The respondents reported that green construction projects would result in the increment of total project costs as relatively new technologies and systems are required to fulfil expected performances of buildings constructed. Also, consultants who are specialised in green technology need to be hired to assess and validate systems to be used for green buildings. This increases not only project cost, but also complexity of communication among project team members. The knowledge and critical information provided by green consultants should be clearly delivered and communicated to project team members who may not be familiar with specific knowledge areas required to construct green buildings. This may cause miscommunication or disconnection of information flow.

Furthermore, with consideration of tight schedule of construction projects, project team members may not take sufficient time to understand green requirements, negatively affecting their interests in green features. Similarly, green practices may be costly to be implemented. When new technology and systems are introduced, project team members need to be trained and until they exhibit a certain level of performance on the newly adopted concept and practices, the investment in implementing green practices may not be paid back. As a result, it is not surprising that a lack of expressed interest from clients becomes one of the critical challenges in managing green construction projects. This challenge may be solved by promoting various benefits and incentives from going green, but as indicated by the survey, the respondents felt a lack of research on true benefits of green buildings, which discourage project owners to consider and implement green measures to their projects.

5.2. IMPACTS OF THE CHALLENGES

The respondents were also requested to rate the extent to which the challenges described above influence three main project objectives, namely schedule, budget, and quality, with a scale of 1 to 5 (1 – No Impact; 2 – Insignificant Impact; 3 – Moderate Impact; 4 – Extensive Impact; and 5 – Extremely Extensive Impact). Table 2 summarises the analysis results. The analysis reported mean scores of 3.320, 4.100, and 3.160 for schedule, budget, and quality, respectively. According to the one-sample t-test performed, the mean scores of schedule and budget were statistically different from 3 at the significance level of 0.05, which was a hypothesised mean, indicating that the challenges would significantly influence schedule and budget objectives of green building construction projects.

In addition, the result from ANOVA and POST HOC test established that the challenges had the strongest impact on project budget, compared to their impact on project schedule and quality (ANOVA p-value = 0.000; POST HOC p-values = 0.010 for Budget vs. Schedule and 0.000 for Budget vs. Quality. This can be interpreted that the challenges discussed in the previous section indeed have more impacts on project cost.

Table 2: The Impact of the Challenges on Project Performance

Objectives	N	Mean	Standard Deviation	One Sample T-Test (p - value)	ANOVA test (p - value)	POST HOC (p - value)	
Schedule	31	3.320	0.871	0.048		Schedule vs. Budget	0.010
Budget	31	4.100	0.539	0.000	0.000	Schedule vs. Quality	0.609
Quality	31	3.160	0.820	0.282		Budget vs. Quality	0.000

5.3. SOLUTIONS FOR THE CHALLENGES

The respondents were also asked to choose solutions that could help to overcome the top 5 challenges listed in Table 1. The percentage of respondents who chose particular solutions for each of the challenges is provided Table 3.

Table 3: Solutions for the Challenges

Respondent (%)	Solutions	Challenges
67.7	Government to provide incentives to offset high premiums of green building projects	
64.5	Educating owners on the future benefits of green buildings	
48.4	Public and market demand for green buildings	Increase of Project Cost
25.8	Interest free lending schemes provided by government to overcome market and financial barriers.	High Implementation Cost of Green Practices
22.6	Insistence from client	
9.7	Green Mark Certification to be made mandatory for all new and existing buildings by authority	
74.2	Conduct tool-box meeting for regularly	Lack of Communication and Interest among Project Team Members
45.2	Engaging personnel with green building background	
96.8	Subsidy from government for R&D in green building systems and management	Lack of Credible Research on Benefits of Green Buildings
87.1	Bonuses provided for staff if the building is green mark certified or qualified for green mark awards	Lack of Interest from Clients

Both challenges involving "Increase of Project Cost" and "High Implementation Cost of Green Practices" are cost related and considered to be the biggest challenges that a project management team has to overcome. Considering that most projects performed in the Singapore construction industry are awarded based on the lowest tender price, project cost related issues are very sensitive to all stakeholders in the industry. Hence, a green building project will be pale in comparison to conventional building projects in terms of cost. While there is BCA's green mark incentive scheme which is capped at an exhaustive amount of $20 million (BCA, 2009a), according to one of the survey respondents, the fund has been running out very fast and with tighter budget, future projects may only aim to attain minimum green requirements so as to comply with local regulations. To overcome the problem of high cost involved in green building construction, all respondents felt that the government should provide a larger scale of incentives. Also, about 65% of the respondents argued that educating clients on future benefits of going green could be one of the workable solutions to the cost related challenges. With clients internalising the potential benefits reaped from green buildings, high cost premium may have less deterrence from the perspectives of clients. Furthermore, this will become a remedy for the identified challenge, "Lack of Interest from Clients".

Since green building construction is a fairly new concept in the Singapore construction industry, it is also important to communicate the green goals and objectives to all stakeholders and project team members in order to achieve successful project execution. For the lack of communication between project members as a challenge in green building project management, 74.2% of the respondents agreed that regular tool box meetings would work for ensuring that important information about the project is communicated. More specifically, engaging green consultants was recommended by 45.2% of the respondents to overcome communication problems among project team members.

The poor demand for green buildings could also be due to the lack of credible research on their benefits. 96.8% of the respondents felt that subsidy from government for research and development of green building systems and management could essentially provide concrete evidence of how beneficial they are to humans, society as well as the economy.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

This study aimed: (1) To compare design, construction, and commission stages between conventional and green building construction projects based on a comprehensive literature review; (2) To investigate common challenges that project managers encounter while managing green building construction projects; and lastly (3) To propose some plausible solutions for improving the current green construction project management. The literature review carried out for this study revealed that the main dissimilarities between conventional and green construction projects are the level of details and communication required. Succinct schematic design is usually adequate at the planning stage of conventional projects while green projects require superlative communication which can only be achieved through delivery systems like design-build, where building design and construction is carried out as a single entity. Furthermore, detailed integrated design process is employed at the start of the project as unlike conventional building design, green design features are unique and requires deep integration with every building aspect.

Results from the survey revealed the top 5 challenges in managing green building construction projects and there are: (1) Increase of Project Cost; (2) Lack of Communication and Interest among Project Team Members; (3) High Implementation Cost of Green Practices; (4) Lack of Credible Research on Benefits of Green Buildings; and (5) Lack of Interest from Clients. These challenges were found to be interrelated, ultimately resulting in high cost premium of green buildings. The lack of R&D on benefits of green buildings and green technologies is a main driver behind the lack of demand for green buildings to go beyond legislative requirement. In addition, green building constructions requires collaborative effort and communication between project team members. However, many local projects adopt conventional design-bid-build form for management, causing the lack of communication. All of these factors make it more difficult to manage green construction projects when compared to conventional projects, discouraging owners to take up green building projects.

6.2. RECOMMENDATIONS FOR THE INDUSTRY

As compared to conventional building project management framework, the framework for managing green building projects should be more detailed and allow greater communication between all personnel involved. Considering that such framework is still unavailable in Singapore and is perceived to be helpful in green building project management as reflected in the survey questionnaire, having a project management framework catered to green building construction can acilitate its adoption for future projects. Here, integrating the research findings with conventional project management framework and Sustainable Construction Framework (Hill and Bowen, 1997), a suggested Green Building Construction Project Management Framework (GBCPMF) for local construction industry is proposed.

During the inception of a green construction project, integrated environment management (IEM) (Hill and Bowen, 1997) should be implemented to reduce adverse impacts and at the same time, enhance the benefits of green projects on the surrounding environment. Environmental assessment is to be done to single out likely construction impacts on the environment; seeking alternatives to alleviate the impacts and establish rectification schemes and monitoring programmes if the impacts cannot be mitigated or removed (Hill and Bowen, 1997). Assessment of life cycle environmental costs of resources and products used should be carried out at the planning stage so that project teams can decide and choose suitable products to be used in green buildings. Throughout the whole construction project, the project team should abide to ISO4000 Environment Management System (EMS) and carry out EMS fitted for the project accordingly.

The next step of the planning stage is to set the desired level of environmental performance according to Singapore's environmental policies, which the clients or building owners wish to obtain. Therefore, the project team should look into BCA Green Mark Assessment Criteria and Building Control Act (Chapter 29) Building Control (Environmental Sustainability) Regulation 2008 to determine how the building should be built in order to comply with legislative requirement or to obtain certain level of awards.

The last step of the planning stage of a green construction project is to develop an organisational structure, which determines the relationship between important personnel involved in the projects. Some examples of these personnel are contractors, engineering consultants, environmental management team, client and affected parties. In addition, modes of communication between each team member should be established to facilitate great communication within the project team. The responsibilities and authorities of all personnel should also be clearly listed and defined to prevent any finger-pointing and confusion during the construction process.

During the construction of green buildings, environment management program based on Green Mark requirements on sustainable construction should be adopted. These sustainable construction practices includes efficient use of concrete for building elements, conservation of existing building structures and use of sustainable materials and products (BCA, 2009a). Standard work procedures of various activities should be communicated to all personnel involved in the project to have better control. Penalties and incentives schemes can be implemented during construction stage and operation of green buildings to ensure compliance with local environmental standards. The project should be monitored and documented to enhance management of the whole construction process. Audits of environmental performance should be carried out at fixed intervals internally by environmental managers or externally by consultants in accordance to Building Control Regulation and Green Mark Assessment to ensure compliance.

Last but not least, professionals' knowledge and experience on green building construction should be enhanced and upgraded through regular upgrading courses to keep them updated with the evolving information on technologies, products and materials relevant to green building construction.

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