THE CONCEPTUAL MODEL OF LIFE CYCLE COSTING AUTOMATION ON GREEN BUILDING ENERGY EFFICIENT CRITERIA

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DEDICATION

Thanks a million to;

My dearest parents,
Thank you for encouragement,
For my beloved husband,
who always by my side,
Thank you for sacrifice and understanding,
For my daughter and son,
Who always bring happiness to me
and also
For my great lectures and friends
That always gives their hand
All of you inspire my effort and achievement…

I love and appreciate you forever.

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ABSTRACT

Sustainability is nowadays prominent in Malaysia building industry. According to Green Building Index Sdn Bhd (Malaysia's International Green Benchmark), more than 100 Million square feet Green Buildings were certified since 2009. However, building investors are facing the same perception as the initial cost on investment of the green concept especially on Energy Efficient (EE) approaches is very high. The uncertainties of Return on Investment (ROI) caused building industry players reluctant to incorporate the green concept in their project. Therefore, there is a need for further development of the decision making systems to support building industry in the application of their expertise, and also assist less-experienced decision makers to taking into account the continuous development of green technological expertise in energy efficient solutions. Hence, the application of Life Cycle Cost (LCC) analysis in the decision-making process represents the best method to increase sustainable building practice to meet the green building standard. This research aims to study the relationship of LCC and EE criteria of Green Building and to develop conceptual model of user requirements for LCC and EE criteria automation. Questionnaire and interview were conducted among green experts to verify the data and the conceptual model. The data from questionnaire were analyzed using Statistical Packages for Social Science (SPSS) to obtain the mean and standard deviation values to identify the significant elements of LCC and EE criteria. The results show that there are significant relationships between LCC and EE criteria which can be used in order to develop the conceptual model of LCC automation on green building EE criteria.

ABSTRAK

Pembangunan lestari telah menjadi keutamaan dalam industri pembangunan di Malaysia. Berdasarkan Green Building Index Sdn Bhd (Index Bangunan Hijau Malaysia), lebih 100 juta kaki persegi 'Bangunan Hijau' telah diiktiraf sejak tahun 2009. Walaubagaimanapun, pelabur-pelabur industri pembinaan menghadapi tanggapan yang sama mengenai kos permulaan bagi konsep hijau terutamanya pendekatan kecekapan tenaga (EE) adalah sangat tinggi. Ketidakpastian dalam pulangan pelaburan (ROI) menyebabkan pihak-pihak dalam industri pembinaan ralat untuk mengaplikasi konsep 'Bangunan Hijau' dalam projek-projek mereka. Oleh itu, terdapat keperluan untuk membangunkan lagi sistem membuat keputusan untuk menyokong industri pembinaan dalam mengaplikasi kepakaran mereka, dan juga membantu pembuat keputusan yang kurang berpengalaman untuk mengambil kira pembangunan berterusan terhadap kepakaran teknologi hijau di dalam bidang solusi kecekapan tenaga. Disebabkan itu, penggunaan analisis Kos Kitaran Hayat (LCC) dalam proses membuat keputusan merupakan langkah terbaik bagi meningkatkan amalan pembangunan lestari untuk mencapai piawaian 'Bangunan Hijau'. Matlamat kajian ini adalah untuk mengkaji hubungan Kos Kitaran Hayat (LCC) dan kriteria Kecekapan Tenaga (EE) dalam GBI dan menghasilkan konsep model automasi keperluan pengguna bagi Kos Kitaran Hayat (LCC) dan Kecekapan Tenaga (EE). Soal selidik dan temuramah dijalankan keatas pakar dalam bidang 'Bangunan Hijau' untuk mengesahkan data yang diperolehi dan model konsep yang dicadangkan. Data daripada soal selidik telah dianalisis dengan menggunakan Pakej Statistik Untuk Sains Sosial (SPSS) untuk mendapatkan min dan sisihan piawai nilai untuk mengenalpasti perkara yang berkaitan dalam Kos Kitaran Hidup (LCC) dan kriteria Kecekapan Tenaga (EE). Hasil kajian mendapati bahawa terdapat kaitan yang rapat antara Kos Kitaran Hidup (LCC) dan kriteria Kecekapan Tenaga (EE) dimana kaitan ini boleh digunakan dalam membangunkan konsep model automasi bagi Kos Kitaran Hidup (LCC) dan Kecekapan Tenaga (EE).

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EE	-	Energy Efficiency
LCC	-	Life Cycle Costing
LCCA	-	Life Cycle Costing Analysis
GBI	-	Green Building Index
DOE	-	Department of Energy
CO_2	-	Carbon Dioxides
RNC	-	Residential New Construction
ABCSE	-	Australian Business Council for Sustainable Energy
PTM	-	Pusat Tenaga Malaysia
ZEB	-	Zero Energy Building
PAM	-	Pertubuhan Akitek Malaysia
ACEM	-	Association of Consulting Engineers Malaysia
MS	-	Malaysian Standard
OTTV	-	Overal Thermal Transfer Value
DSS	-	Decision Support System
BIM	-	Building Information Modeling
LEED	-	U.S Green Building Council
BEC	-	Building Energy Consumption
DO	-	Development Order

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Construction industry in Malaysia contributes about 3-5% of the Gross Domestic Product (GDP) and provides employment to about 700,000 people, or about 10% of the total labour force (Kamaruzzaman, 2003). Hence, the construction industry plays a significant role in the development of Malaysia. Despite the tremendous benefits of construction, its activities becomes major impact to environmental damage through depletion of the natural resource base, degradation of fragile eco-zones, chemical pollution and the use of harmful building materials to human health. It has been estimated that buildings producing over 300 million tonnes of 'greenhouse' gases each year (Miller, 1992). The summary report following the 1992 Rio Earth Summit declares that the construction sector is a major user of natural resources. Products of buildings and infrastructures construction in civil engineering are major contributors to economic development and quality of live. However, as the environmental impacts due to construction activities become more apparent, a rapid movement towards sustainable development particularly Green Construction is gaining momentum.

Green building known as green construction refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle from planning to design, construction, operation, maintenance, renovation, and demolition. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment (U.S. Environmental Protection Agency, 2009).

Green building ratings began developed in the 1990s with BREEAM (UK, 1990) and later LEED (USA, 1996) being the better known ones. Green rating tools were conceived to be able to assist architects, designers, builders, government bodies, building owners, developers and end users to understand the impact of each design choice and solution. Green rating tools by its nature and role is very dependent upon location and environment and thus climate. Malaysia's Green Building Index or GBI is the one of rating tool for the tropical zones other than Singapore Government's GREENMARK. Most of the main criteria on green rating are strong emphasis on Energy Efficient around 23% to 35% score compare to other green criteria. For instance, maximum score to achieve GBI points for Non-Residential tool is 35%. It means that to achieve green building standard, the main requirement is to score on Energy Efficient criteria. To create Energy Efficient (EE) building, building designer have to establish EE performance analysis to reduce energy consumption in the buildings, thus reducing CO^2 emission to the atmosphere.

Despite the green building is gaining momentum, its barriers on implementation still need to be encountered. High cost for green appliances and lack of motivation from customer's demand were identified as the two major barriers in China (Zhang, 2011).

This study finding could tell us that main consideration for investor and customer is about cost benefit and awareness on investing green building. In conjunction with that, the evaluation process of cost benefit on green building need to be carried out by integrates green building Life Cycle Costing (LCC) and green rating standard for better decision making. Life cycle costs are the total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span (DOE, 1995). The minimum total LCC represent the best cost elements is achieved. Hence, the selection of investing by using life cycle cost analysis will be more reliable and helps the stakeholders to put on consideration towards a cost effective building design with good performance.

1.2 Problem statement

Since Malaysian government is actively promoting policies on green technologies and reduction of carbon emission, many industrial players including building investors take into account and implementing the green concept on their project. However, buildings investor facing a same major consideration on decision making that the initial cost to build green building is more expensive which approximate 40% higher compared to conventional method. They also claimed that the investment on green technology is so expensive at initial stage. They believed that sustainable development is economically non-viable because higher capital upfront and they only adopt sustainable features that would lead to immediate payback (Kai Chen Goh, 2013). These uncertainties of return on investment caused construction industry players reluctant to incorporate EE concept in their project. Therefore, the need for additional information on figure up accurate valuation to assist investor perception of green building cost benefit is necessary and crucial.

A study report to California's Sustainable Building Task Force on October 2003, demonstrated conclusively that sustainable building is a cost-effective investment and its findings should encourage communities to ''build in green''. The report encourage for better understanding why there are lacks of practical information and how about to synchronize the green standards that need to be achieved with optimum cost benefit. In conjunction to this scenario, a process framework for building design are needed to support multi stakeholder decision making that facilitates the inclusion of green issues in early design phase of building development.

In spite of the progress in development of methods and tools to support sustainable building design such as Green Building Index in Malaysia, there is still a gap on understandable decision-making support system facing by the investor. LCC analysis seems to a comprehensive assessment method to ameliorate this problem. Hence, the implementation of life cycle tool in the decision-making process becomes priority to increase sustainable building practice that meet the green building standard.

Since expenses on energy consumption are very much higher due to poor consideration on energy performance, control measure at early stage is very important to put attention on energy efficient as the main element for green building approach. This research concerned wills therefore identifying the relationship between the LCC of energy efficient buildings and GBI score on Energy Efficient (EE) criteria. This effort is to guides decision makers in selecting their green concept. The questions arise to suit the problem statement as stated below;

i. What will be the decision making consideration in having energy efficient building?

ii. What will be the factors that influence the investment of energy efficient building?

iii. What is the relationship within design and cost in building life cycle?

iv. Does life cycle costing analysis will help to ease developer to make decision on the willingness to spend for energy efficient building?

1.3 Aim and Objectives of the Study

This research aims to develop the conceptual model of Life Cycle Costing automation on Green Building Energy Efficient criteria. To attain this aim, the following objectives are pursued:

i. To identify the principles and variables of Life Cycle Cost (LCC).

ii. To investigate cost incurred for Energy Efficient (EE) in Green Building Index (GBI).

iii. To develop and verify the conceptual model of LCC automation on green building EE criteria.

1.4 Scope of the Study

To achieve the aim, the research used the Malaysia's Green Building Index, GBI. Within all criteria of GBI, Energy Efficiency items (EE) of Residential New Construction (RNC) for high-rise building will be highlighted. This study is not covering other criteria on GBI beside Energy Efficiency (EE).

1.5 Significance of the Study

This research will contribute the following significant aspects:

i. A conceptual model of user requirement LCC and EE criteria automation can be developed.

ii. In line with the development of knowledge, this research will assist other researcher to conduct a further research on developing a tool or best practice on decision making system for selecting green concept.

iii. Since LCC is an effective tool to increase sustainable building practice, this research will help to increase awareness among industrial practitioners for a better understanding about LCC concept on green building cost benefit.

1.6 Brief Research Methodology

There were several methodologies used in various stages of this research. In preliminary study stage, literatures from journals and articles were reviewed to formulate research scope, aim, and objectives of the research. On the other hand, literatures were also reviewed to explore concept of energy efficient, life cycle cost and decision support system for energy efficient building. After that, data was collected from several different parties through several different methodologies such as expert interview, questionnaire survey, and record review. In this research, expert interviews were conducted with green building consultants. In addition questionnaire survey forms

were distributed to respondents that involve in green building especially on Residential New Construction for high-rise building such as architect, GBI consultants, mechanical & electrical engineers, project manager and contractors. Meanwhile, record review was conducted with consultants who involve in development of green project to verify the data obtained and to verify the conceptual model that have been proposed. Then, all the data obtained were analysed according to the objectives that have been outlined in this research. Based on data analysis, discussion was made according to the objectives. Finally, conclusion was prepared to conclude the findings and appropriate recommendations were proposed for future studies.

1.7 Expected Findings

The first expected finding is to list the principles and variables of the LCC. By indentifying the significant elements in principles and variables of LCC, it will help the researcher to identify the importance elements of LCC that to considered in the conceptual model in automate the LCC and green building EE criteria. Second expected finding is to investigate cost incurred effects from EE designed based on GBI. By developed matrix checklist with two elements, cost incurred in LCC and EE criteria in GBI, a table of matrix analysis were produced with the means score which represent percentage of cost incurred. Lastly, by the data obtained it is expected to develop a conceptual model of LCC automation on green building EE criteria.

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