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Determining Critical Success Factors Related to Project in Low Carbon Construction: A Review

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ABSTRACT

The construction sector has started to embraced green policy in construction activities as part of support to government in promoting and developing sustainable development in the country. However not much had been done to determine the critical success factors of low carbon construction in Malaysia. This studies attempts to review the literatures in relation to critical success factors by project in low carbon construction. By studying and analysing the literature review carried out by researchers in countries around the world, it is identified that there are three categories of critical success factors for low carbon construction related to project. The critical success factors are categorized into factors related to pre-construction phase, operation phase and delivery phase of construction. Research findings in this study provide valuable references to guide the developers and project managers towards achieving success in low carbon construction in the country.

Keywords: Critical success factors, low carbon construction, project success.

1. INTRODUCTION

Malaysia started the involvement in sustainable development since the signing of Kyoto Protocol in the United Nation Framework Convention on climate change on 12 March 1999 to curb global warming (Ho and Fong, 2007). Aligned with the agreement of Kyoto Protocol after the establishment of National Energy Policy 1979, National Depletion Policy 1980, Four Fuel Diversification Policy 1981 and Fifth Fuel Policy 2000 (Chua and Oh, 2011) by the government, the development of low carbon building construction is geared towards greater stage as Malaysia launched the National Green Technology Policy 1979 and Low Carbon Cities Framework and Assessment System in September 2011(Kettha, 2011).

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An average increment of 23 percent in the emission of carbon dioxide from the year 2003 to 2008 (World Development Indicator, 2010) in Malaysia has encouraged the government to commissioned Construction Industrial Development Board (CIDB) in Malaysia which created green assessment system called Green Pass to evaluate the environment impact of building in the country as following other developed and leading nations in the world in sustainable development. On 24 July 2009, Malaysian Energy Centre certified as the first green building using Green Building Index which was introduced by Green Building Index Sdn. Bhd. as Malaysia's green rating tool in 2009 (GBI, 2009)and similar to other green rating schemes already introduced around the world such as Green Star, LEED and BREEM system (Kibert, 2007).

2. DEFINITION OF LOW CARBON UNIT

Ho and Fong (2007) defined low carbon building to building which uses about 30 kWh/m^2 to $20kHh/m^2$ of energy and fitted with high level of building insulation such as energy efficient window, low level of air infiltration and heat recovery ventilation to minimize emission of carbon dioxide. Ho and Fong (2007) also added that in tropical countries, low carbon builders are practising the usage of passive solar building design techniques, besides involved in effort of reduction of energy usage for air conditioning and water heating.

3. SUSTAINABLE DEVELOPMENT GLOBALLY

Currently, Europe is the leading continent practising low carbon emission where United Kingdom has committed to reduce carbon emission to 26% by 2020 and by less than 80% by 2050 under the Climate Change Act 2008 and to establish five years of carbon budget until the year 2050 (Innovation and Growth Team from UK Construction Industry Report, 2010). According to Morrell (2010), construction industry responsible for developing 47% of overall proportion of total United Kingdom carbon dioxide emission. Morell (2010) also added that government took initiative to create a sustainable transport system which can reduce transport emission by 14% by year 2020 including 10% of United Kingdom transport energy from sustainable renewable sources by year 2020. In United Kingdom, BREEAM green rating tool being used to evaluate green building in term of building environmental performance. As of middle of 2012, BREEAM already certified 200,000 building and over a million registered for assessment since BREEAM launched in 1990 (BRE Global Limited, 2011).

While in Australia, the government has pledged to provide 20% of the nation's energy from renewable energy source by the year 2020 and expecting to increase the percentage in future aligned with the Howard government which introduced a Mandatory Renewable Energy Target (MRET) scheme in 2001 which requires 20% of electricity supply from renewable energy sources by year 2020 (Dopita and Williamson, 2010). Besides that, the government also established the Australian Carbon Tax on 1st July 2012 to enforce companies emitting over 25000 tonnes of carbon dioxide annually to buy carbon permits as a corrective action to reduce greenhouse gas emission in Australia by 80% in 2050. (Energy Policy of IEA Countries: Australia 2012 Report). According to report titled 'A Clean Energy Future for Australia by the Clean Energy Future Group' in 2004, Australia's greenhouse pollution can be greatly reduced by the year 2040 by combination of several energy efficiency technologies such as wind turbines, solar thermal, solar photovoltaic, biomass combustion, fuel cells, geothermal, wave energy and tidal energy.

In Asian contingent, China leads the sustainable development on greater stage where established the Three Star Rating system in 2011 to evaluate and certifies green building in China. Besides Three Star Rating system, foreign green rating tool named LEED also used for green building evaluation purpose. As of July 2009, there were 30 buildings that have achieved green building certification under LEED green building rating system. Besides that, there are 210 buildings are pursuing to get certification once construction process completed (Crachilov et al. 2009). According to Los Angeles Times (2009), China has pledged to reduce carbon dioxide emission per unit of gross domestic product by 40-45% by 2020. Besides that, according to Xintian et al. (2012), Urban Development Model Evaluation System was created by the government as part of the effort towards construction of several low carbon cities in China. According to Xintian et al. (2012), there are several low carbon cities in China such as Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou and Shanghai. While Hald (2009), mentioned that buildings in Dongtan eco-city have capabilities to reduced 70% of energy consumption.

4. LOW CARBON AND SUSTAINABLE DEVELOPMENT IN MALAYSIA

Malaysia started to involve in sustainable development since the launching of several national policies such as National Energy Policy (1979), National Depletion Policy (1980), Four Fuel diversification Policy (1981) and Fifth Fuel Policy (2000) as measures to curb the emission of carbon dioxide and as an effort towards sustainable development in the country. As a subsequent effort, Malaysian launched National Green Technology Policy (NGTP) and Green Building Index Sdn. Bhd. in 2009 through the Malaysian Architect Association

and the Association of Consulting Engineers Malaysia (ACEM). The Green Building Index Sdn. Bhd. functioned to monitor the Green Building Index (GBI) system as Malaysian green rating tool to evaluate green building in Malaysia. There are six main criteria used for evaluation purpose in green certification processes which are Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning and Management, Material and Resources, Water Efficiency and Innovation.

Putrajaya, Cyberjaya and Iskandar Development Region (IDR) are chosen to be developed as green or low carbon cities in Malaysia aligned with launching of Green Technology Policy and Low Carbon Cities Framework and Assessment System on 24 July 2009 and September 2011 respectively. Iskandar Development Region (IDR) which covers an area of about 2,216.3 km^2 was developed in 2006 and the research result will be used for development of other cities in Malaysia and worldwide by researchers (Rizzo and Glasson, 2011). Iskandar Development Region (IDR) was chosen by group of Malaysian and Japanese low carbon research group and the research period is expected for 5 years beginning from the year 2011 to 2015. Ho and Matsuoka (2011), also added that the research still in preliminary study in the year 2012 where involving process in identifying the amount of carbon emission of Iskandar Malaysia and mitigation measures towards achieving low carbon region.

5. DEFINITION OF CRITICAL SUCCESS FACTOR

There are several definitions given by researchers around the globe for critical success factors where according to Rockart and Bullen (1981), critical success factors referring to factors or elements which will ensure better results in term of performance for the individual, department or organization if followed. While as explained by Leidecker and Bruno (1984) critical success factors referring to elements or factors that will ensure success to an organization in particular industry. While, Dwyer et al. (2000) recommended that any critical success factor should have about six or seven elements of factors which determines success to individual, department or organization.

6. CRITICAL SUCCESS FACTORS IN LOW CARBON CONSTRUCTION

This study discussed about the critical success factors for low carbon construction which are based on project in construction process.

6.1 Factors Related to Project

Factors related to project referring to critical success factors which generated through project related issues which may influence the success of low carbon construction. There are total of three categories of critical success factors identified by authors related to project which are factors related to pre-construction phase, operational phase of construction and delivery phase of construction.

Factor related to pre-construction phase are:

i) Construction Cost
ii) Proper Project Schedule
iii) Type of Contractual Term
iv) Method of Procurement
v) Method of Construction Process
vi) Integration of Project Objective
vii) Focused on Energy Modelling
viii) Defined Project Mission
ix) Availability of Technical Capabilities
x) Effective Financing Method
xi) Initial Green Aspect Finalised

6.2 Construction Cost

Yang (2006) has said that construction cost for green building which is built with natural environmental protection equipment or system tend to have higher environment friendly value compare to conventional building. Meryman and Silman (2004) also have contended that cost is main problem faced by developers in green construction process. While based on the information provided by two different sources, total cost on the beginning of construction is estimated to be around from 1% to 25% (Tagaza and Wilson, 2004) and green material estimated to cost 3% to 4% more than conventional building (Zhang et al. 2010). Identification of construction cost is necessary in pre-construction phase where planner need to identify amount of sufficient budget for project before the launching of project activities.

6.3 Proper Project Schedules

Existence of proper project schedules also important for achieving success in low carbon construction. Planners need to plan project schedules before the commencement of project as early as possible as Munns and Bjeirmi (1996) have mentioned that proper project schedule before the commencement of the project is vital. Besides that, project schedule is highlighted as one of the five critical success factors identified for a project by Sayles and Chandler (1971).

6.4 Type of Contractual Term

Some researchers such as Tagaza and Wilson (2004) had also stated that success of green or low carbon construction depended greatly on the type of contract selected for the delivery of projects where misleading information in contract between developer and client may cause disaster in project. They elaborated that type of contract used in green projects must reflect the full detail the green oriented design before the design confirmed for construction in initial stage of construction phase. While another researcher, Korkmaz et al. (2010) has pointed out that proper selection of contractual term before the start of project is a success factor to deliver green projects for project delivery system.

6.5 Method of Procurement

Besides type of contractual term, selection of proper method of procurement is one of the elements of critical success factors in low carbon construction (Korkmax et al., 2010) Meanwhile, Chan and Kumarasamy (1997) also agreed that proper agreement of method of procurement before the commencement of project as the one of the factor for success of construction activities once the operation phase starts.

6.6 Method of Construction Process

Method of construction process is different between conventional and low carbon construction. According to Korkmaz (2010), in low carbon construction, proper type or method of construction process need to identified to smooth the process of construction activities during pre-construction phase.

6.7 Integration of Project Objectives

Project objective plays an important part in success of project. Integration of project objective before commencement of project in low carbon or green related project may reduce wastage in subsequent operational stage later which will eventually move the project towards success (Enanche-Pommer and Horman, 2009).

6.8 Focused On Energy Modelling

Enanche-Pommer and Horman (2009) also added that in low carbon construction, project participant need to be well focused during pre-construction phase on the energy modelling where it will save the level of energy usage and enhance the building technical standard during final delivery phase and move the project towards success.

6.9 Defined Project Mission

Pinto and Slevin (1989) clarified the important of clear defined project mission before the project starts to ensure satisfaction and awareness about the project among the project participant. Munns and Bjeirmi (1996) also pointed out the necessary of clear project objective to ensure overall success in the project.

6.10 Availability of Technical Capabilities

Besides that, Pinto and Slevin (1989) have also identified technical capabilities for the implementation of project before the project starts as one of the critical success factors for the green construction activities. Without the availability of technical capabilities, insufficiency of technical capabilities may stall the progress of the project in later stages of construction.

6.11 Effective Financing Method

Roodman and Lenssen (1995) reported that effective financing method needs to be provided to project before the commencement of project which will ensure the successful implementation of green building. They also added there are many financial institutions which are providing low interest loan or preferential lending rates for the construction of green building. Besides that, in most of developed nations, water and electricity suppliers are offering fee rebates on payment for services applied inside energy efficient buildings.

6.12 Initial Green Aspect Finalised

Hwang and Tan (2010) said that all green features as planned in planning stage or pre construction stage need to be finalised in early stage of construction to minimize the unexpected cost escalation of overall project cost and time for the launch of project.

Factors related to operational phase of construction are:

i) Better Process Checklist
ii) Support of Top Management
iii) Effective Project Management
iv) Proper Monitoring of Project Stage Implementation Process
v) Simplify Work Processes for Highly Technical Matter
vi) Effectiveness of Approval Processes

6.13 Better Process Checklist

Besides that, Parfitt and Sanvido (1993) have strongly encouraged usage of better process checklist to check the progress of the project. They also added that it is essential to prepared with proper process checklist to check the correct techniques or method used during construction process or operational stage which may ensure the success of project.

6.14 Support of Top Management

Pinto and Slevin (1989) has stressed the important of assistance and support of the top management in ensuring success in operational phase of construction activities. Without the support of top management, achievement in project activities during operational stage is doubtful (Iyer and Jha, 2005) as workers tend to lose the basic support and coordination to move forward achieving success in low carbon construction.

6.15 Effective Project Management

Existence of effective project management in the project may help to deliver success in advance projects (Isik et al., 2009). Without effective project management from project manager and developer, the construction process may not progress in positive mode during the operational construction phase.

6.16 Proper Monitoring of Project Stage Implementation Process

Pinto and Slevin (1989) also stressed that throughout the research study, proper monitoring of project stage implementation process may speed up the project activities in operational stages without restraint.

6.17 Simplify Work Processes for Highly Technical Matter

Meryman and Silman (2004), also has identified that act of simplification of work processes during operational phase of construction for highly technical matter in low carbon construction as one of critical success factors for success in low carbon construction. They explained that technical barrier may removed by changing into the conventional method in simplifying the work process in low carbon construction.

6.18 Effectiveness of Approval Processes

Approval processes need to be carried out in urgent in low carbon or green related projects as tend to consume more time than conventional projects during operational stage in construction. Ling (2003), mentioned that approval of payment to vendor and supplier need to be carried out on time. Tagaza and Wilson (2004), added that due to lengthy of time needed for approval to use new green technologies in operational stage, developers need to make the earlier arrangement as soon as possible during operational stage of construction. Delay in approval may cause delay to progress of construction. Zhang et. al., (2011) and Eisenberg et al. (2002) also added that more time needed for approval process in low carbon or green related projects.

Factors related to delivery phase of construction are:

i) Acceptable Level of Quality
ii) Flexible government policies

6.19 Acceptable Level of Quality

There is level of acceptable quality from overall result of project by the client. Achieving the level of quality required by client is essential for the success of low carbon construction. Iyer and Jha, (2005) considered quality as one of the part of traditional 'iron triangle' criteria to achieve success in overall construction process. Odusami (2002) has also prioritised quality as one of the important skills for construction professional. Project manager and developer need to ensure the level of quality for a project achieved in delivery phase of construction as promised to client for success of construction process.

6.20 Flexible Government Policies

While Hwang and Ng (2012) have mentioned that government policies related to green construction processes during the delivery of final product may also influence the success of green construction. They elaborated that government policy which consists of strict policies and regulation of environment may cause

trouble for the developers to comply the project under the green certification process. Failure of obeying the regulation may cause the project to delay after crossing the timeline of project.

Table 1: List of Critical Success Factors in Low Carbon Construction

List of Critical Success Factors	Yang (2006)	Merryman and Silman (2004)	Tagaza and Wilson(2004)	Zhang et al. (2011)	Iyer and Jha (2005)	Odusami (2002)	Munns and Bjeirmi (1996)	Parfitt aand Sanvido (1993)	Pinto and Slevin (1989)	Korkmaz et al. (2010)	Chan and Kumarasamy (1997)	Enanche-Pommer and Horman (2009)	Isik er al. (2009)	Ling (2003)	Hwang and Tan (2010)	Sayles and Chandlert (1971)	Eisenberg et al. (2002)	Roodman and Lessen (1995)
Factors Related to Pre-Construction Phase																		
Construction Cost	X	X	X	X														
Proper Project Schedule							X									X		
Type of Contractual Term			X							X								
Method of Procurement										X	X							
Method of Construction Process										X								
Integration of Project Objective												X						
Focused on Energy Modelling												X						
Defined Project Mission							X		X									
Availability of Technical Capabilities									X									
Effective Financing Method																		X
Initial Green Aspect Finalised															X			
Factors Related to Operational Construction Phase																		
Effectiveness of Approval Process			X	X										X			X	
Simplify Work Processes for Highly Technical Matter		X																
Proper Monitoring Stage									X									
Effective Project Management													X					
Better Project Checklist								X										
Support of Top Management					X				X									
Factors Related to Delivery Construction Phase																		
Flexible Government Policies															X			
Acceptable Level of Quality					X	X												

Related to Project from Previous Literature

7. DISCUSSIONS AND RECOMMENDATIONS

Low carbon and sustainable development construction started to gain popularity since the 1980's leading nation such as USA, United Kingdom, Australia and developing countries such as Malaysia, Singapore, India and China. Identification of critical success factors for low carbon construction through this research study will encourage more developers to start building low carbon units rather than conventional units which may compromise its design in term of environmental aspects.

Figure 1 illustrates the theoretical relationships between the list of critical success factors related to project and the success of low carbon construction. After the literature reviews have been completed, the critical success factors have been examined, identified, selected and synthesized. The factors related to project are being represented by these variables: (1) Factors Related to Pre-Construction Phase, (2) Factors Related to Operation Construction Phase and (3) Factors Related to Delivery Construction Phase.

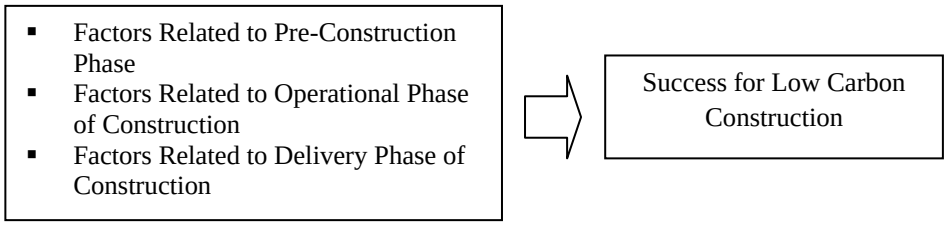

Figure 1: Theoretical relationships between the list of critical success factors related to project and the success of low carbon construction.

8. CONCLUSIONS

Construction activities involving low carbon constructed units are started to increase in around the world. World leading nations such as United States and United Kingdom pledged to increase low carbon construction and reduce conventional constructions to significant figure by period of 10 years. While in Malaysia, government initiative in embracing sustainable development is visible through the formulation of several environmental policies and establishment of low carbon cities across the country. Besides that, effort taken by private developers to build and certified large number of green buildings in Malaysia reflected the passion and responsibility of the developers in environmental preservation. Furthermore, in future this study suggests that identification of the critical success factors related to project which are categorized into three main groups which are factors related to pre-construction phase, factors related to operational construction phase and factors related to delivery construction phase.

Factors related to pre-construction phase cost are proper project schedule, type of contractual term, method of procurement, method of construction process, integration of project objective, focused on energy modelling, , defined project mission, availability of technical capabilities, effective financing method and initial green aspect finalised competency. While factors related to operational construction phase are better process checklist, support of top management, effective project management, proper monitoring of project stage implementation process, simplify work processes for highly technical matter and effectiveness of approval process. Lastly, factors related to delivery phase of construction are flexible government policies and acceptable level of quality.

9. RESEARCH LIMITATIONS AND FUTURE STUDY

The current study has some limitations while creating path for future research. This study has evaluated the current literature contributed by researchers related to the critical success factors in perceptive of project on low carbon construction around the globe. As the overall topic is large, future researchers in Malaysia should took the opportunity to explore further on the other group of undisclosed critical success factors such as related to project manager, project team, client, equipment and external factors in low carbon construction. Besides that, finding from this study should be used for reference by developer to drive low carbon construction in the country towards success as there is no proper critical success factors framework available as a guideline for developers and project managers in Malaysia. Future researcher should also try to help the government to boost the success rate of low carbon construction in Malaysia by providing data obtained through research for evaluation process and further development of existing low carbon cities across the country such as Project Iskandar and Cyberjaya where may help the government in its long term plan of achieving sustainable development in Malaysia.

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