COST PREMIUM AND THE LIFE CYCLE COST OF GREEN BUIDLING IMPLEMENTATION IN OBTAINING GREEN STAR RATING IN AUSTRALIA

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Abstract:

Due to many obvious environmental issues, green building concept is now being widely recognized and practiced in the industry as an environmentally friendlier building. However, one of the main barriers to the green building market is that the identified cost premium. It has always dwarfed the growth of green building construction despite of its perceived benefits. Therefore, this research aims to identify the impact of life cycle cost (LCC) on green buildings implementation focusing on the Green Star rating in Australia. In LCC, the entire life span of the green building implementation is considered focusing on the major cost components of LCC namely design, purchase and construction cost, maintenance cost, operational cost, development cost and the demolition cost. Each credit point of Green Star rating tool is analyzed and identify whether there is any component of LCC is attributed in achieving the specific credit point. Finally, the results are presented in tabulated format, highlighting the costs to be evaluated against the cost premium for each credit point. According to the research, 63% of the credit points allocated in Green Star rating tool have a direct impact on the LCC of the building.

Keywords: Green buildings, Green Star rating, Life cycle costing.

INTRODUCTION

Green buildings have become a buzzword in the era but yet there are many misconceptions and myths attached to this concept. “Cost” is one of the main topics discussed whenever the topic is surfaced. There is a perceived idea within the society that the cost of green buildings is quite higher compared to conventional buildings and there are many other counter arguments too. One of which is the life cycle impact which is most disregarded by the society when decision making for green buildings.

However, due to these misconceptions, the cost of green building is the most critical factor that affects its development (Zhang, 2014) and the much expected cost premium certainly acts like a significant

barrier and even completely filter projects from consideration (Pearce, 2008). When considering the initial cost, there are certain research available in the literature which discuss about the cost premium. Davis and Langdon (2007) report that there is a slight increase in cost whereas the initial impact on construction costs is likely to be in the order of 3 – 5% for a 5 Star solution in Green Star, with an impact of a further 5% plus for a 6 Star non iconic design solution. While that is the case in Australia, in Israel, it is reported that the optimum alternative, involved an additional cost, ranging between 4% and 12%, whereas under the economical alternative the additional cost was only 0.12–1.33% (Gabay et al., 2014). Similarly, Hwang and Tan (2012) and Zhang et al. (2011) also reported on the higher cost premiums as the most significant obstacle in green construction management. Considering residential buildings in China the analysis results showed that the incorporation of green systems causes the construction costs to increase by 10.77% more than the traditional building, whereas the amount of working days only increases by two days (Kim et al., 2014). For a same building compared with a green building with the use of general design, construction techniques and tools, the use of green building design, construction techniques and methods will make additional costs of about 2% of the total investment on average, raising initial costs 5% - 10% higher than the ordinary building. Further, green building cost premiums were expected to change according to the type of green certification, the desired level of green rating, and the nature of the buildings, and would likely increase with higher levels of certification (Tatari and Kucukvar, 2011).Therefore, it is considered that the most significant barriers to sustainable design and construction were first cost premium of the project and long pay back periods from sustainable practices (Ahn et al., 2013).

However, in all these research available, only the initial cost is considered. However, according to Bond (2011), the main barriers were identified as the usual initial cost and lack of consumer information about benefits and savings from incorporating energy efficient and water saving devices and features were identified in Australia and New Zealand. According to Liu et al. (2014) the incremental costs of the energy efficiency technology applications account for a large proportion of total incremental costs of green buildings, but in return energy efficiency technology applications on green buildings can bring incremental economic benefits, as well as environmental benefits. In addition, with prices of oil and natural gas skyrocketing in recent years, having energy savings in green building every year increases the building value, as occupants are able to recoup their investment in the building within a shorter period of time (Hwang and Tan, 2012).

However, according to Mcauley (2008), there is a broader economic picture of the indirect economic benefits of green buildings such as higher public profile, increased productivity and improved health and morale of employees. Green buildings can result in significant economic savings by improving employee productivity, increasing benefits from improvements in health and safety, and providing savings from energy, maintenance, and operational cost (Ries et al., 2006). Further, according to Ries et al. (2006), based on a research on a green factory building, productivity increased by about 25%; statistically significant absenteeism results varied; and energy usage decreased by about 30% on a square foot basis compared to a normal conventional factory building. According to Mcgraw Hill Construction (2013), in new green buildings operating costs decreases over 8% over a period of one year and for green retrofits there is a decrease of 9%.

For instance, some green buildings were reported to consume 26% less energy and have demonstrated 13% lower maintenance cost when compared to average commercial buildings (Fowler and Rauch, 2006). Therefore, it is necessary to look into this in a much broader view at the initial stages of the project. Although many focus on the initial cost premiums, to get a better view it is evident to focus on the life cycle of the building considering all the benefits and related life cycle costs. However, it must be noted that these benefits come with that cost premium which is spent on green buildings compared to a conventional buildings. Further, this Life cycle cost (LCC) approach is considered as a valuable approach enabling operational cost benefits to be evaluated against any initial cost increases (Cole and Sterner, 2000).

Life cycle costing

There are definitions put forward by many researchers on LCC. Basically it can be identified as a tool for assessing the total cost performance of an asset over time, including the acquisition, operating, maintenance, and disposal costs (Goussous and Al-Refaie, 2014). According to Addis and Talbot (2001 p. 1), LCC can be identified as:

> "the present value of the total cost of that asset over its operational life. This includes initial capital cost, finance costs, operational costs, maintenance costs and the eventual disposal costs of the asset at the end of its life. All future costs and benefits are reduced to present-day values by the use of discounting techniques."

This is very much acceptable in green buildings as well. In general it is the present value of all the costs associated with the green building over the life cycle. Further, LCC of green buildings can be illustrated as the sum of the incurring costs during economic life from building pre-decision, design, bidding, construction, completion and acceptance, until users stop using it and also including the sum of research development fee, manufacture fee, installation fee, operation maintenance fee and scrap back charges in the determining life cycle of the project or at a predetermined period of validity (Zhang, 2014).

In LCC, it is very much important to identify the necessary costs which are included in the LCC calculation. As far as a construction projects considered, there are many types of costs and externalities attached to it. LCC involves the systematic consideration of all `relevant' costs and revenues associated with the acquisition and ownership of an asset and it should not be mixed with other terminologies such as 'total cost' and full cost' (Cole and Sterner, 2000). The extent of which the costs are to be identified is clearly illustrated in Figure 1.

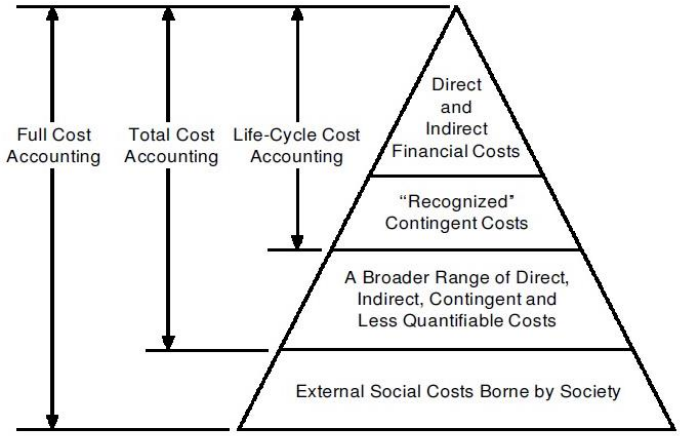

Figure 1 : Costs included in LCC
(Source : Cole and Sterner (2000))

According to Figure 1, in LCC only the direct and indirect financial costs together with recognized contingent costs are considered in monetary terms. Further, less quantifiable social costs and external social costs borne by the society is excluded from the study for LCC for green buildings.

When considering the green buildings it is necessary to identify as to which basis a green building is evaluated. Usually, green building ratings tools which are developed by many countries (Gowri, 2004, Haapio and Viitaniemi, 2008, Reed et al., 2011, Sinou and Kyvelou, 2006) act as yardstick to evaluate

the performance of green buildings (Crawley and Aho, 1999). These green building rating tools are designed for assessing and evaluating building performance through its life cycle (Sachin and Jha, 2012). Building Research Establishment Environmental Assessment Method (BREEAM) is the first ever developed green building rating tool in 1990 (Building Research Establishment Environment Assessment Method, 2015) and Leadership in Environmental and Energy Design (LEED) is widely used worldwide (United States Green Building Council, 2015). In this research the main focus is given to Green Star rating tool Australia. There are 9 credit criteria in Green Star and these credit criteria are given credit points separately and then added together to arrive at final score, based on which the certification is awarded. The certification is provided based on scale of 6 stars (Green Building Council Australia, 2015) . For the purpose of this study, Design and As built rating tool is considered.

When considering the above literature, there is a significant lack of focus on the LCC consideration in the green building implementation. Most of the research studies focus on the initial cost premium and there are clear evident provided that poor consideration on cost saving over the life cycle of green buildings act as a barrier to the implementation of green buildings. However, the significance of these life cycle costs are not much considered in the literature. Therefore, this research aims to focus on the green rating tools specifically the Green Star Australia and identify whether it is necessary to focus on the LCC at the initial stages of decision making for green buildings and for green certification in the long run.

RESEARCH METHODOLOGIES

In this research, initially the credit points of Green Star rating tool - Design and As built is evaluated. There are altogether 29 credit subcategories in the Green Star rating tool which are classified under main 8 categories. These eight main categories are management, indoor environmental quality, energy, transport, water, material, land use and ecology and emissions. Further, there is a separate category named as innovations, to reward the innovative practices, and it is not considered in this research due to the vague nature in allocation of credit points. Each sub category in analyzed thoroughly for the research whether to identify there is any LCC cost components associated with the particular credit point. Based on the literature, the LCC can be simply expressed from Equation (1).

$$Life\ Cycle\ cost = Capital\ cost + Life\ time\ operating\ costs + Life\ time\ maintenance\ cost + Disposal\ cost - Residual\ value$$

Equation 1: Life cycle cost

As given in Equation 1 all these cost components are included in the LCC. Capital cost is the initial investment made for the project. Capital cost is considered in the calculation of the cost of the project and compared to the conventional buildings. It is argued that in green buildings the capital cost is comparably high. This is discussed in detailed through the literature. As per the objective of the research the credit points are analyzed as to evaluate whether there are any other related perceived operating or maintenance costs deemed to be included in the project if the certain credit point is achieved. As an example, if a building is using water saving sanitary equipment to achieve the potable water credit, it is necessary to calculate those savings in the initial stages rather than only considering the initial capital cost. Therefore, when analyzing the credit points, such credits with LCC cost associated other than the capital cost is identified in the study. These are then provided in a Table (Table 1) as indicating whether there is an impact on the LCC or not.

Further, according to Equation 1, only the maintenance cost, operating cost, disposal cost and the residual value is directly considered in the calculation. However, in this research LCC calculation is considered in a broad perspective. Therefore, according to literature, as illustrated in Figure 1, for LCC calculations it is necessary to define the boundaries as to which extent the costs are considered. As given in Figure 1, recognized costs are identified as LCC and as a result the cost savings through

water savings, energy savings and the like are considered to be taken for the LCC calculation which can be recognized financially. However, the less quantifiable costs and benefits such as health benefits and social costs are not considered as attributable to the LCC calculation. Similarly, externalities borne by the society is also not considered for LCC identification.

Based on the above defined boundaries, each credit point is analyzed and decided whether there is an impact on LCC. If a particular credit has a LCC impact, it is deemed to be identified as a credit which require a LCC calculation carried out at the initial stage of the building to make batter decision. Further, credit points are also allocated to each credit and analyzed so that it is possible to identify the amount of credits which requires LCC calculation data. In allocating credits, if there is a rage of credits available for a project the maximum is stated in reported Table 1. Apart from that, there are certain credits which are not allocated with credit points as these are considered to be minimum requirements to be met. In such cases these credits are identified in the table without any credit point allocation.

ANALYSIS ON CREDIT POINTS WHICH REQUIRES LCC

A detailed illustration on the Green Star rating credit points are reported in Table 1. It provides all the credit points classified according to the necessary main categories and identified under main credits. For each credit point it is identified whether there is an impact on the LCC or not. According to the Table 1, there are 100 credit points allocated and out if which 63% requires LCC. Further, there are certain credits which are not given credit points as those are considered as minimum requirements. However those credit points have a direct impact on LCC. These are ‘minimum lighting comfort’, ‘glare reduction’ and ‘light pollution’. The importance of these is not reflected within the 63% of credit points which require LCC calculations.

As mentioned earlier, there are eight main categories in Green Star rating tool. The 63% of these credit points which require LCC calculations can be attributed to the relevant categories as well. If the requirement of LCC for each category is considered 3% of the credit points are from Management category and energy category contributes to 22%. Indoor environment quality contributes to 8% and both material and water categories contribute 12% each. Emission category has 5% of credits and land use and ecology derives 1%. The transport category does not contribute to this. Therefore the maximum of the contribution with cost savings and life cycle impacts are from the energy category which is then followed by material and water categories.

There are certain credit points in illustrated in this Table 1 which are achieved through the design. However, these credit points derived any social and health benefits which are not reflected in the LCC calculations and therefore not considered here. These credit points include, ‘exhaust or elimination of pollutants, ‘internal noise levels’, ‘reverberation’, ‘acoustic separation’, ‘daylight’, ‘views’ and ‘sustainable transport’. These add up to a 19% of the total credit points available.

Table 1 : Analysis on the credit points

Credit Nr	Main Credit	Sub Credits	LCC Y/N	Credits	Comments
		Management			
1	Green Star accredited professional	Green Star accredited professional	No	1	Only at the initial stage one off payment
2	Commissioning and tuning	Environmental performance targets	No	Req	To obtain the credit there will not be a LCC. However, by commissioning and tuning there will be cost savings in the building within the life cycle
		Services and maintainability review	No	1	
		Building commissioning	No	1	
		Building system tuning	No	1	
		Independent commissioning agent	No	1	
3	Adaptation and resilience	Implementation of a climate adaptation plan	No	2	Part of the initial process only
4	Building Information	Building operations and maintenance information	No	1	Only an initial cost
		Building user information	No	1	
5	Commitment to performance	Environmental building performance	No	1	Only an initial cost
		End of life waste performance	No	1	
6	Metering and monitoring	Metering	No	Req	Setting up the metering system will be one off initial cost
		Monitoring	Yes	1	Monitoring the energy and water usage and taking necessary actions will be done throughout the life cycle. It includes costs throughout the life cycle.
7	Construction environmental management plan	Environmental management plan	No	Req	Only an initial cost
		Formalized environmental management system	Yes	1	Additional costs incur within the construction phase of the building and the demolition
8	Operational waste	Performance pathway: specialist plan	Yes	1	Operational waste must be handled throughout the building life cycle. There will be many costs occurring within the life

Credit Nr	Main Credit	Sub Credits	LCC Y/N	Credits	Comments
		Prescriptive pathway: facilities			span of the building. Further there will be numerous social benefits which may not be reflected in the LCC calculation as well
Indoor Environmental Quality					
9	Indoor air quality	Ventilation system attributes	Yes	1	Maintenance and cleaning incurs over the life cycle. Many social benefits are derived which may not be captured by LCC
		Provision of outdoor air	No	2	This is done in the design. Derives many social and health benefits
		Exhaust or elimination of pollutants	No	1	This is done in the design. Derives many social and health benefits
10	Acoustic comfort	Internal noise levels	No	1	This is done in the design. Derives many social and health benefits
		Reverberation	No	1	This is done in the design. Derives many social and health benefits
		Acoustic separation	No	1	This is done in the design. Derives many social and health benefits
11	Lighting comfort	Minimum lighting comfort	Yes	Req	Requires maintenance over the life span. Derive many health and social benefits and also has many LCC associated. Further there is energy savings also
		General illuminance and glare reduction	Yes	1	
		Surface illuminance	Yes	1	
		Lighting control	Yes	1	
12	Visual comfort	Glare reduction	Yes	Req	Requires maintenance over the life cycle.
		Daylight	No	2	This is done in the design. Derives many social and health benefits
		Views	No	1	This is done in the design. Derives many social and health benefits
13	Indoor pollutants	Paints, adhesives, sealants and carpets	Yes	1	Requires maintenance over the life cycle and there will be a disposal cost as well.

Credit Nr	Main Credit	Sub Credits	LCC Y/N	Credits	Comments
		Engineered wood products	Yes	1	Requires maintenance over the life cycle and there will be a disposal cost as well.
14	Thermal pollutants	Thermal comfort	Yes	1	There are lot of LCC associated provided that the space is mechanically ventilated
		Advanced thermal comfort	Yes	1	
		Energy			
15	GHG emissions	GHG Emissions reduction – Prescriptive pathway	Yes	20	There are lot of LCC associated and energy saving as well
		GHG emissions reduction – NatHERS			
		GHG emissions reduction – BASIX			
		GHG emissions reduction – NABERS energy commitment agreement			
		GHG Emissions Reduction – Modelled performance			
16	Peak electricity demand reduction	Prescriptive pathway: On-site energy generation	Yes	2	There are lot of LCC associated and energy saving as well
		Modelled performance pathway: Reference building			
		Transport			
17	Sustainable transport	Performance pathway	No	10	This is decided during the initial stages of the project and has no recurring cost to the life cycle
		Prescriptive pathway			
		Water			
18	Potable water	Performance pathway	Yes	12	There are lot of LCC associated and water saving as well
		Prescriptive pathway			
		Material			
19	Life cycle impacts	Performance pathway – Life cycle assessment	No	7	LCA calculation is carried out at the initial stage
		Prescriptive Pathway – Life cycle impacts	Yes	5	There are lot of LCC associated with concrete, steel and building reuse

Credit Nr	Main Credit	Sub Credits	LCC Y/N	Credits	Comments
20	Responsible building material	Structural and reinforcing steel	Yes	1	LCC should be carried out. There will be maintenance costs, demolition costs associated
		Timber products	Yes	1	
		Permanent formwork, pipes, flooring, blinds and cables	Yes	1	
21	Sustainable products	Product transparency and sustainability	Yes	3	LCC should be carried out. There will be maintenance costs, demolition costs associated
22	Construction and demolition waste	Reduction of construction and demolition waste	Yes	1	LCC will be considered at the end of the life span of the building
Land use & Ecology					
23	Ecological value	Endangered, threatened or vulnerable species	No	Req	The site is selected accordingly at the initial stages
		Ecological value	No	3	
24	Sustainable sites	Conditional requirement	No	Req	The site is selected accordingly at the initial stages
		Reuse of land	No	1	
		Contamination and hazardous materials	No	1	
25	Heat island effect	Heat island effect	Yes	1	LCC is considered in landscaping for heat island and other measures
Emissions					
26	Stormwater	Reduced peak discharge Reduced pollution targets	Yes	2	LCC is considered provided that there is treatment is done
27	Light Pollution	Light pollution to neighboring bodies	Yes	Req	LCC is considered and there will be maintenance costs
		Light pollution to night sky	Yes	1	
28	Microbial control	Legionella impacts from cooling systems	Yes	1	LCC is considered and there will be maintenance costs for the system
29	Refrigerant impacts	Refrigerant impacts	Yes	1	LCC is considered and there will be maintenance costs for the system

CONCLUSIONS

This paper discussed on the extent to which the LCC calculations are required to to make better decisions at the initial stages of green buidlings in terms of obtaining the Green Star certification. All the credit points of Green Star rating tools is evaluated and the credit points which require LCC calcualation or the credit points with an impact on the life cycle is identified in detail and clearly reported in Table 1.

According to the analysis, a minimum of 63% of credit points require LCC calculations at the initial stages of decsion making. However, this does not include the credit points which are not given with credit points and considered as minimum requirements by the Green Star rating tool. This illustrates the significance of carrying out LCC calculation at the initial stages of the decision making proces for the green buidlings which aims to obtain green buidling certification. However, it can be argued that there is a lack of LCC done focusing on the green rating tools and the specific credit points of green buidling rating tools. Therefore, this research clearly signifies the requirement and importance of developing LCC calculation model which can be used to identify the LCC impact in obtaining green building certification at the initial decision making stages.

Apart from that, according to the analysis, there are certain social and health benefits which are not considered in LCC calculations. These constituted to 19% of the credit point allocation as given in the Table1. Therefore, it is necessary to further capture all these remote cost and benefits to get a well informed decisions at the early stages of the project.

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