The Effectiveness of the Green Building Evaluation and Labelling System

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Abstract: Environmental protection is becoming an important element in the construction industry. The Taiwan Architecture and Building Research Institute developed a Green Building Evaluation and Labelling System (GBELS) to transform its built environment. Nine indicators in GBELS are used for assessment including biodiversity, greenery, soil water content, daily energy saving, carbon dioxide emission reduction, waste reduction, indoor environment, water resource, and sewage and garbage improvement. GBELS mostly focuses on social-environmental benefits and neglects the demand of clients, designers and contractors. This paper evaluates the implementation and effectiveness of GBELS. Comparisons were made between GBELS and other assessment tools. Questionnaires and structured interviews were conducted. From the survey results, the nine indicators for GBELS are found to be insufficient to provide guidelines for the construction industry. Others are needed, including management, aesthetic, economic and innovative design, and traffic and transport. A level system for each indicator and total scoring system are added for GBELS to achieve better green building quality. Recommendations are given to improve GBELS and its possible applications in other countries.

Keywords: Evaluation systems, GBELS, Green buildings, Sustainable development

Introduction

Environmental protection is an important issue around the world (Tse, 2001). Environmental impacts of buildings over their entire life cycle have been recognized as serious problems for the construction industry (Ball, 2002; Morledge & Jackson, 2001; Polster, Peuportier, Sommereux, Pedregal, Gobin & Durand, 1996).

The Architecture and Building Research Institute from the Ministry of the Interior formulated a Green Building Illustration and Assessment Handbook in 1999 to promote green buildings in Taiwan. The first issue of the handbook includes seven indicators (Chinese Architecture and Building Centre, 2007):

- i) greenery
- ii) soil water content
- iii) daily energy saving
- iv) carbon dioxide emission reduction
- v) waste reduction
- vi) water resource
- vii) sewage and garbage improvement

In the same year, a Green Building Evaluation and Labelling System (GBELS) was introduced and a Green Building Committee was established to evaluate, to encourage and to award green building designs (Chinese Architecture and

Building Centre, 2007). The government also introduced a Green Building Promotion Proposal in 2001, which required all public buildings to undertake green building designs. The government also included a Green Building Policy as an important part in Challenging 2008: National Major Development Plan in 2002. In 2003, two more indicators on biodiversity and indoor environment were included.

Descriptions of the nine existing green building indicators in GBELS are as follows:

- *Biodiversity indicator* encourages creation of high-density aquatic ecology using ecological ponds, pools and riverbanks. Formation of diversified biotope using multiple environments and multiple layered ecological greeneries can be human-disturbance free. Creation of a rich environment for species is by endemic, bird-attracting and butterfly-attracting plants, diversifying plantation of various species and preserving of topsoil, since this indicator especially refers to rural biotope and interactions among activities of species. Therefore, it is only applicable to the assessment of large site development, instead of general small building sites;
- *Greenery indicator* aims to achieve alleviated urban temperature, and to improve ecological environment. Carbon

Table 2: Comparison of environmental.

Environmental assessment tools		BREEAM	LEED	HKBEAM	GBELS
Applications	Environmental management			√	√
	Product marketing	√	√		
	Building performance targeting	√			√
	Design guidelines	√	√	√	√
	Performance based codes			√	√
Scope of study	Air pollution			√	√
	Noise pollution			√	
	Water pollution			√	√
	Waste management		√	√	√
	Ecological impacts	√		√	√
	Energy consumption				√
	Resource consumption	√	√		√

- Investigating the current practice of GBELS and its limitations
- Evaluating applications and scope of study in GBELS by comparing it with other environmental assessment tools
- Examining the implementation and effectiveness of GBELS
- Recommending methods to improve the implementation of GBELS and its possible applications in other countries

Comparing GBELS with Other Environmental Assessment Tools

Due to the complexity of management and operational structure in the construction industry (McCloskey & Maddock, 1994), and the lack of a well-defined series of indicators for evaluation in construction, there is currently no consistent environmental information available (Kuhre, 1998). GBELS is widely used in Taiwan; however, there are other construction-related environmental assessment tools in the market, such as the Building Research Establishment Environmental Assessment Method (BREEAM; BRE, 2006), the Hong Kong Building Environmental Assessment Method (HKBEAM; CET, 1999a, 1999b, 1999c) and the Leadership in Energy and Environmental Design (LEED; USGBC, 2006). BREEAM is a tool for surveyors and engineers to evaluate building life-cycle costs. Through the 'Eco-labelling' system, buildings are rated as excellent, very good, good and pass. The system mainly focuses on ecological and global effects of construction activities, such as carbon dioxide quantity emitted with less emphasis on issues like management and construction methods. HKBEAM is a classification system in which buildings are divided into four categories according to their environment-friendliness: excellent, very good, good and fair whereas LEED is a software tool used to measure environmental performance of a building site at an operational level; that is, technical information on site concerning daily environmental performance. A criticism of LEED is that it mainly concerns with technical aspect of environmental performance with much less emphasis on the management side. Table 2 summarizes the environmental assessment tools mentioned, their applications and scope of study.

From Table 2, it should be highlighted that GBELS is a comprehensive environmental assessment tool to assess environmental performance including air pollution, water

Table 3: Distribution of survey respondents.

Group	Description	Frequency	Percentage
G1	Developers	28	38%
G2	Architects	24	32%
G3	Contractors	8	12%
G4	Interior designers	4	5%
G5	Consultants	4	5%
G6	Others	6	8%
Total		74	100%

population, waste pollution, ecological impacts, energy consumption and resource consumption. The applications of GBELS are suitable for environmental management, building performance targeting, design guidelines and performance-based codes. The BREEAM, HKBEAM and LEED could not cover the above-mentioned areas as GBELS that shows the effectiveness of GBELS for international markets.

Research Methodology

To evaluate the implementation and effectiveness of GBELS, a survey was conducted. The questionnaire focused on five main areas: measurement methods, examination methods, implementation cost, existing green building indicators and new green building indicators.

The survey was sent to 200 people including developers, architects, contractors, interior designers and consultants. A total of 78 replies were received for a response rate of 39%. However, four of the questionnaires were not properly completed; therefore, only 74 questionnaires were valid. The respondents are classified into six categories, G1 to G6. Table 3 shows the details of G1 to G6 and the respondent distribution in each group.

To determine the relative ranking of factors, the scores are transformed to indices based on Equation (1) (Tam, Deng, Zeng & Ho, 2000):

$$RII = \frac{\sum w}{AN}, \quad (1)$$

where w is the weighting given to each factor by the respondent, ranging from 1 to 5 in which '1' is the least important and '5' the most important; A the highest weight, in this study $A=5$; N the total number of samples; and RII the relative importance index, $0 \leq RII \leq 1$.

Table 4: Survey results on the formulation measurement method in GBELS.

Level	Calculated the formula in GBELS before	Easy to understand the formulation of each indicator	Formulation is a good method for evaluation	Formulation is the only method for evaluation
	Response rate			
1 – strongly disagree	38%	22%	19%	32%
2 – disagree	16%	41%	22%	38%
3 – neutral	19%	32%	46%	27%
4 – agree	19%	5%	11%	3%
5 – strongly agree	8%	0%	2%	0%

Table 5: Survey results on the other measurement methods for GBELS.

Level	The formulation may restrict some good design in green buildings	There are other measurement methods providing better evaluation than the formulation	Experience in design which benefit to the environment but not qualified in the formulation
	Response rate		
1 – strongly disagree	11%	3%	30%
2 – disagree	13%	0%	19%
3 – neutral	14%	24%	37%
4 – agree	43%	35%	11%
5 – strongly agree	19%	38%	3%

After receiving the responses, individual structured interviews were arranged with ten respondents, selected from different business sectors: two developers, two architects, two contractors, two interior designers and two environmental consultants. The interviews were intended to gather further comments; elaboration and interpretation on the results obtained from the questionnaire and reduced the limitation of low response rates from G3, G4 and G5 groups.

Results and Discussion

Formulation Measurement Methods

GBELS is using formulas to measure each green building indicator. If the architect designed buildings can achieve certain requirements of the indicator, the building can achieve a pass for the indicator. Table 4 summarizes the survey results in examining the existing formulation measurement method in GBELS. About 54% of the respondents did not have experience in calculating the formula in GBELS before and more than 63% of the respondents had difficulties to understand the formulation of each green building indicator. The interviewees argued that there was the lack of guidelines in calculating the level of each green building indicator. There were many grey areas in the formulation. From the survey results, less than 13% of the respondents agreed that the formulation was a good method for the evaluation of GBELS and less than 3% of the respondents agreed that the formulation was the only method for the evaluation. Most international environmental assessment tools are using scoring systems rather than measuring the level of each indicator.

From the results shown in Table 5, about 52% of the

respondents agreed that the formulation may restrict some good design in green buildings and more than 73% of the respondents considered that there are other measurement methods rather than the formulation that can provide better evaluation for the system. As discussed earlier, it is necessary to review and to compare GBELS evaluation methods with other environmental assessment tools that can improve the evaluation procedures.

About 14% of the respondents had experience in design that can be of benefit to the environment but were not qualified in the existing formulation measurement system. For example, the use of recycled materials generated from other construction and demolished projects cannot bring benefits to the existing formulation measurement method. The existing method can only measure the immediate effect on buildings such as the reduction of waste generation level by reusing, recycling and reducing waste produced from buildings, but cannot bring benefits for those providing long-term environmental benefits.

Examination Methods

From the survey results shown in Table 6, it should be highlighted that about 30% of the respondents agreed that the existing examination with the minimum requirements of passing four indicators being awarded a green building label did not encourage project parties to implement more environmental items in providing a better green building design. There is no difference in the existing GBELS if the building designs passing four or eight green building indicators. The implementation of environmental design for buildings requires high investment cost to pass each indicator in the system. Therefore, companies aim to achieve the minimum requirements of passing four

Table 6: Survey results on the examination.

Level	Prefer to only pass four indicators which is the minimum requirement for passing GBELS	Providing the level system in GBELS	The level system can encourage architects to achieve more indicators
	Response rate		
1 – strongly disagree	10%	8%	8%
2 – disagree	22%	10%	10%
3 – neutral	38%	22%	33%
4 – agree	22%	38%	38%
5 – strongly agree	8%	22%	11%

Table 7: Survey results on cost issues in GBELS.

Level	Design fee is fixed and limited	Increase of construction material cost	Increase of economic benefit for buildings	Encouragement methods should be provided by government
	Response rate			
1 – strongly disagree	8%	3%	5%	0%
2 – disagree	5%	11%	11%	5%
3 – neutral	24%	16%	24%	8%
4 – agree	41%	38%	46%	41%
5 – strongly agree	22%	32%	14%	46%

indicators, in which the public cannot see the difference of the buildings in passing a higher number of indicators.

From that, about 60% of the respondents agreed that level system with different ranges as excellent, very good, good and fair, should be provided for GBELS, and about 49% agreed that it could make architects achieving more indicators for green building labels. Most environmental assessment tools, including the BREEAM, HKBEAM and LEED provide at least four levels of award for each building or project, in which the project always tries to achieve the excellent performance rather than just the pass.

Implementation Costs

From the survey results shown in Table 7, about 63% of the respondents agreed that fixed and limited design fee was provided by the clients, about 70% on the increase of construction material cost and about 60% on the economic benefit after implementing GBELS. The interviewees highlighted that clients are hardly providing financial support to design green buildings, which cannot encourage them to provide green building designs. The design of green buildings can increase their construction material cost including the use of environment-friendly construction materials and recycled materials. If clients or governments did not provide financial support to design their projects, there are insufficient driving forces for architects or contractors to implement green building designs to their projects. Therefore, about 87% of the respondents highlighted that encouragement methods should be provided by the government for green building implementation.

From the survey results shown in Table 8, about 52%

of the respondents agreed that there is financial support in design fees, about 60% on the construction material cost, about 59% on the economic benefit and about 68% on the encouragement methods in implementing environmental management to foreign environmental assessment tools. Some overseas governments provided financial support for those who implemented environment-friendly methods for their projects. For example, rebate schemes supported by the Australian government provide financial support to cover partially the investment cost of installing environment-friendly equipment such as rainwater tanks and water-saving machines.

Table 9 shows the survey results on financial support from clients in GBELS. About 62% of the respondents agreed that clients should support extra design fees for green buildings. Design processes for green buildings take a longer time than the convenient ones in which green-building designing involves more research on the project background and features to suit specific environmental requirements.

Green buildings normally require high initial construction material costs; however, long-term cost benefit can be achieved with high reusability of environment-friendly materials. For example, low initial cost timber formwork can only be used once but high initial cost steel formwork can be reused up to one hundred times. If construction organizations choose to use the steel formwork with a high reusability rate, companies can achieve their long-term cost saving. Therefore, about 65% of the respondents agreed that contractors, rather than clients should pay construction material cost for green buildings.

About 67% of the respondents agreed that the government should provide financial support. As discussed earlier,

Table 8: Survey results on cost issues in foreign environmental assessment tools.

Significance level	Obtaining extra design fee for green buildings	Increase of construction material cost	Increase of economic benefit for buildings	Encouragement methods provided by foreign governments
	Response rate			
1 – strongly disagree	5%	0%	3%	0%
2 – disagree	13%	16%	5%	5%
3 – neutral	30%	24%	33%	27%
4 – agree	38%	35%	43%	35%
5 – strongly agree	14%	25%	16%	33%

Table 9: Survey results on financial support from clients in GBELS. Survey results on financial support from clients in GBELS.

Significance level	Design fee	Construction material cost	Economic benefit	Project support by government
	Response rate			
1 – strongly disagree	5%	33%	11%	8%
2 – disagree	3%	32%	11%	8%
3 – neutral	30%	24%	24%	27%
4 – agree	38%	8%	27%	38%
5 – strongly agree	24%	3%	27%	29%

government providing financial support in designing and constructing green buildings by means of rebate or water-saving schemes.

Existing Green Building Indicators

From the survey result shown in Table 10, more than 70% of the respondents understood the green building indicators in GBELS. The interviewees highlighted that the industry well-understood details of GBELS and most companies also had experience in implementing it for their projects.

Table 11 shows the RII values for the existing nine green building indicators from the survey results. It should be noted that all nine indicators posses RII values of at least 0.81. From the nine indicators, daily energy saving and water resource indicators are ranked as the first importance indicators with their RII values of about 0.88. Minimizing building costs thus improving their profit is always the first goal for their projects. Most contractors are mainly concerned with the energy and water consumption as the first indications from the bills that directly affect the building cost. These can be achieved by reducing unnecessary cost on energy and water consumption through on-the-job training. Other items such as waste reduction and carbon dioxide emission reductions that do not immediately link to the project cost will not be one of their project goals.

From Table 10, it should be noted that more than 50% of the respondents disagreed that there are sufficient green building indicators in GBELS. Most of the interviewees highlighted that there are many other significant indicators to improve environmental performance for the projects, but they are not included as indicators in the existing GBELS. The existing indicators mainly concern on designing processes, in which it lacks indicators to measure the other development processes, including planning, construction and management.

Table 10: Survey results on the existing green building indicators in GBELS.

Level	Understanding of the indicators	Enough indicators
	Response rate	
1 – strongly disagree	0%	19%
2 – disagree	0%	32%
3 – neutral	27%	24%
4 – agree	35%	22%
5 – strongly agree	38%	3%

Proposed New Green Building Indicators

From the survey results shown in Table 12, about half of the respondents supported the need to add more indicators in the existing GBELS. As discussed in the previous section, the system should provide some indicators in measuring environmental performance in other development processes. This can consider the implementation of environmental management in the early project stage and thus enhances environmental performance for the whole project development processes.

After the review of GBELS and comparison with other environmental assessment tools, six green building indicators are proposed to enhance further the existing GBELS and to improve the environment. The six indicators are:

- *Management indicator* ensures effective environmental management support from top management staff to frontline workers
- *Precaution against the earthquake indicator* provides sufficient structural support to reduce the seriousness for earthquake seasons
- *Aesthetic indicator* measures design features related to environmental issues, such as green areas for leisure and use of balconies for ventilation

Table 11: RII values of the existing green building indicators.

Indicator	RII value	Ranking	Standard deviation
Biodiversity	0.81	9	0.88
Greenery	0.82	7	0.77
Soil water content	0.87	3	0.75
Daily energy saving	0.88	1	0.72
Carbon dioxide emission reduction	0.83	6	0.95
Waste reduction	0.82	7	0.98
Indoor environment	0.85	4	0.73
Water resource	0.88	1	0.68
Sewage and garbage improvement	0.84	5	0.81

Table 12: Survey results on the proposing green building indicators in GBELS.

Significance level	Need to add more indicators in the existing GBELS	Modify each indicator as a score rather than pass or fail	Provide the total score and levels for projects
	Response rate		
1 – strongly disagree	0%	0%	5%
2 – disagree	8%	5%	3%
3 – neutral	43%	16%	30%
4 – agree	33%	46%	32%
5 – strongly agree	16%	33%	30%
Total	100%	100%	100%

Table 13: RII values of the proposed green building indicators.

Indicator	RII value	Ranking	Standard deviation
Management	0.81	1	0.99
Precaution against earthquake	0.52	6	1.17
Aesthetic	0.68	4	1.09
Economic	0.72	3	1.12
Innovative design	0.76	2	1.00
Traffic and transport	0.68	4	1.26

- *Economic indicator* promotes effective energy and material consumptions, which encourages energy saving and supports reusing, recycling and reducing construction and demolished materials
- *Innovative design indicator* encourages using innovative design to improve environmental performance for buildings, such as using natural lighting for indoor activities and reduce west-facing windows
- *Traffic and transport indicator* encourages using environmental vehicles that reduce pollution emission during construction process

From the results shown in Table 13, it should be highlighted that the management indicator is ranked as the first with its RII value of about 0.81. Assessment of management is the most critical factor to improve environmental performance. The degree of management participation is important for successful implementation of green buildings. Such participation includes top (project managers and contract managers), medium (site managers, site engineers, site quality and environmental managers) and frontline (supervisors) levels of employees.

These can improve overall performance of companies and outcomes of construction projects. Getting top management involvement in environmental management would lead to the success of such programs. Support from the top management should be received from the very early stage of each process. Top management can make commitments by approving environmental budgets and endorsing proposals.

The innovative design indicator is ranked as the second importance indicator from the survey with its RII value of about 0.76. The use of rainwater tanks can save using natural water for buildings. Some residents only decide to use the collected rainwater for toilet flushing, not for drinking which involves special installation, maintenance and water quality control.

From the survey results, precaution against the earthquake indicator is ranked as the last importance indicator with its RII value of about 0.52. Although earthquakes commonly occur in Taiwan, most buildings are designed so that this element does not play a major role. Therefore, precaution against the earthquake indicator should not be included as one of the indicators in GBELS.

From the results shown in Table 12, about 79% of the respondents suggested to modify each indicator as a score rather than just a pass or a fail and about 62% to provide the total score and levels for each project. Only providing a pass or a fail in the existing GBELS cannot encourage the industry to use innovative designs and to provide 100% commitment to some indicators. Companies will only implement as the minimum requirements that are sufficient to score a point. Therefore, modifying the existing GBELS to a scoring system can help comparing buildings in the implementation of green design. An award scheme should also be implemented to deliver achievement of the highest score building.

Recommendations

There are many environmental evaluation systems available around the world, such as BREEAM, LEED and HKBEAM. Taiwan is currently using the local system GBELS to evaluate green buildings. Based on this study, GBELS has already been shown to achieve encouraging results for green buildings. In addition, experience gained from other assessment tools can be used to improve GBELS. The followings are suggested to fine-tune GBELS:

- To evaluate the existing formulation measurement methods for each indicator in which some indicators need to be modified for easier understanding and measurement
- To include indicators in *management, aesthetic, economic, innovative design and traffic and transport* in the evaluation for GBELS
- To provide a level system for GBELS which encourages designers to aim for better green building quality and to give 100% contributions rather than just the minimal requirements of passing each green building indicator
- To provide the total score for GBELS which helps understanding and compares project green building levels and satisfaction levels of green building labels
- To provide some incentive methods and encouragement methods by clients and governments to designers and contractors who implement green building designs

This study found that GBELS is comprehensive and has been successfully implemented in Taiwan. It is suggested that GBELS could be applied in other countries with similar temperature and weather patterns such as China including Hong Kong, Macau, Japan, India, Indonesia, Korea and parts of Australia. The implementation of GBELS in developing countries can gain examples and experience from Taiwan and thus effectively improve their project performances.

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