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Procedia Engineering 21 (2011) 376 – 386

**Procedia  
Engineering**[www.elsevier.com/locate/procedia](http://www.elsevier.com/locate/procedia)

2011 International Conference on Green Buildings and Sustainable Cities

## Comparative review of five sustainable rating systems

Binh K. Nguyen<sup>a\*</sup>, Hasim Altan<sup>a</sup><sup>a</sup>*School of Architecture, The University of Sheffield, Western Bank, Sheffield, S10 2TN, UK*

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### Abstract

The paper presents the comparative review of five prominent sustainable rating systems namely BREEAM, LEED, CASBEE, GREEN STAR and HK-BEAM. The review process adopts a system of criteria which encompasses all features of sustainable rating tools. The main goal of the study is to consider all aspects of the systems in order to find out the best one(s). The study provides a deep insight into sustainable rating tools and can be a recommendation and reference for users when choosing between rating systems.

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Selection and/or peer-review under responsibility of APAAS

*Keywords:* Building Sustainability, Rating Systems, Sustainability Methods, Assessment Tools.

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### 1. Introduction

Worldwide there is hundreds of building evaluation tools that focus on different areas of sustainable development and are designed for different types of projects. By March 2010, there were 382 registered building software tools for evaluating energy efficiency, renewable energy, and buildings' sustainability [1]. However, only a few systems are widely acknowledged and really set a recognizable standard for sustainable development. The following five systems are chosen to be reviewed in this paper because they are currently the most popular, influential and technically advanced rating tools available [1].

- BREEAM (Building Research Establishment's Environmental Assessment Method) is the leading and most widely used environmental assessment method for buildings. It was developed in the UK in 1990 and is the building environmental assessment method with the longest track record [1].
- The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC) in 1998, provides a suite of standards for

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\* Corresponding author. Tel.: +44(0)114 222 0375; fax: +44(0)114 222 0315

E-mail addresses: [binhshef1985@gmail.com](mailto:binhshef1985@gmail.com)

environmentally sustainable construction. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in the US and 30 countries covering 99 billion m<sup>2</sup> of development area [2].

- *CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)* was developed in Japan in 2001. There are 4 basic versions of CASBEE which correspond to the individual stages of the building's lifecycle (Pre-design, New Construction, Existing buildings and Renovation) [1].
- *GREEN STAR* is a voluntary environmental rating system for buildings in Australia. It was launched in 2003 by the Green Building Council of Australia. The system considers a broad range of sustainable issues while also considering occupant health and productivity, and cost savings [1].
- *HK-BEAM* was developed 1996 in Hong Kong by the BEAM Society. It aims at promoting voluntary initiatives to measure, improve and label the environmental performance of buildings on environmental sustainability.

## 2. Review Criteria

A system of evaluating and marking was created with 9 categories of review criteria (see Table 1). Each category contributed a number of points due to their importance. The maximum final score is 100 points in total. Table 2 explains the keys used during the review process.

Table 1. Review criteria summary

Categories	Points (100 in total)
Popularity and Influence	10
Availability	10
Methodology	15
Applicability	20
Data Collecting Process	10
Accuracy and Verification	10
User-friendliness	10
Development	10
Results Presentation	5

Table 2. Keys used during the review process

Keys	Meaning
✓	Meet criterion
●	Under development
✓/-	Meet criterion with exception(s)
-	Does not meet criterion
(blank)	Information Unknown
n/a	Not applicable

### 3. Review Results

#### 3.1. Popularity and Influence

The following issues were considered under this criterion (see Table 3):

- *Well-known*: Is the system well-known among the built environment community? (2 points)
- *Importance*: Does the system play a significant part in the Built Environment? (2 points)
- *Number of Countries involved*: Countries which have buildings assessed by the system (2 points)
- *Number of Buildings/Projects involved*: (2 points)
- *Versatility*: Number of systems that use it as its basis for development or comparison (2 points)

Table 3. Popularity and Influence

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Well-known	✓ (2/2)	✓ (2/2)	✓ (2/2)	✓/- (2/2)	✓/- (2/2)
Importance	✓ (2/2)	✓ (2/2)	● (1/2)	● (1/2)	● (1/2)
Number of Countries involved	+21 (2/2)	+ 100 (2/2)	1 (1/2)	1 (1/2)	1 (1/2)
of Buildings/ Projects involved	Number Registered	+ 500,000	27,000	404	
	Certified	+ 110,000	4,400	80	237
	Development Area		+ 0.5 billion m <sup>2</sup>		+ 1 million m <sup>2</sup>
	Score	2/2	2/2	1/2	1/2
Versatility	12 (2/2)	10 (2/2)	1 (1/2)	0 (0/2)	0 (0/2)
<b>Category's score</b>	10/10	10/10	6/10	5/10	5/10

Sources: [2, 3, 4, 5]

#### 3.2. Availability

The following issues were considered under this criterion (see Table 4):

- Availability of the system itself: (5 points)
  - Easy to Access: Is it convenient to have full-possession of the system? (1 point)
  - System's Format: In what format and language is the system available? (1 point)
  - How much information is available publicly? (1 point)
  - Cost of System: (1 point)
  - Certification fee: (1 point)
- Availability of references: (5 points)
  - Availability of On-line Information: (1 point)
  - Availability of Information that is not On-line (How to obtain?): (1 point)
  - Availability of Case Studies: (1 point)
  - Availability of Users' review: (1 point)
  - System's Openness: (1 point)

#### 3.3. Methodology

The following issues were considered under this criterion (see Table 5):

- *Methodology Summary*: Identify the method used to process the inputs to produce final results/ grades/

assessments (not marked)

- *Weightings*: Identify the system applied to weigh the issue categories (not marked)
- *Rating Levels*: Is the system’s labeling classification system sufficient enough? (2 points)
- *Standardization*: Established collection procedures exist (2 points)
- *Quantitative criteria*: Does the system use prescriptive-based criteria? (1 point)
- *Qualitative criteria*: Does the system use performance-based criteria? (1 point)
- *Whole Lifecycle Assessment*: (2 points)
- *Complexity*: Assessment method’s sophistication of (Sophisticated: 2 points - Average: 1 - Basic: 0)
- *Efficiency of Assessment method* (Very high: 5 points - High: 4 - Average: 3 - Low: 2 - Very Low: 1)

Table 4. Availability

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM	
Availability of the system itself	Easy to Access	✓/(0/1)	✓(1/1)	✓/(0/1)	✓(1/1)	✓(1/1)
	System’s Format	Checklists and Excel Pre Assessment Estimators (1/1)	PDF Rating Checklists and Excel Checklists (1/1)	Assessment Software and Technical Manuals (1/1)	Excel Tools and Technical Manuals (1/1)	Checklists, Manuals, Pre Assessment Tools (1/1)
	How much information is available publicly?	Checklists and Pre Assessment Estimator (1/1)	PDF, Excel Checklists, Guides (1/1)	Assessment Tool and Manuals (Partly Japanese) (0/1)	Excel Tools and Technical Manuals (1/1)	Checklists, Manuals, Pre Assessment Tools (1/1)
	Cost of System	Free (1/1)	Free (1/1)	Free (1/1)	£200 for Manual (0/1)	Free (1/1)
	Certification Fee	£740-£1500 (1/1)	£1133-£11331 (0/1)	£1100-£1500 (1/1)	£2550-£7185 (1/1)	£6680-£12525 (0/1)
	Score	4/5	4/5	3/5	4/5	4/5
Availability of references	On-line Info. Info. that is not On-line	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)
	Info. that is not On-line	E-mail address (1/1)	Email & local Chapters (1/1)	E-mail help desk (1/1)	E-mail help desk (1/1)	E-mail address (1/1)
	Case Studies	● (0/1)	- (0/1)	✓(1/1)	✓(1/1)	✓(1/1)
	Users’ Review	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)
	Openness	✓/(0/1)	✓/(0/1)	- (0/1)	- (0/1)	- (0/1)
Score	3/5	3/5	4/5	4/5	4/5	
Category’s score	7/10	7/10	7/10	8/10	8/10	

Table 5. Methodology

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Methodology Summary	Score-based system. Building's performance is rated based on overall score.	Score-based system. Building's performance is rated based on overall score.	Building is rated based on the 'BEE Factor'	Score-based system. Building's performance is rated based on overall score.	Score-based system. Building's performance is rated based on overall score.
Weightings	Applied to each category	All credits equally weighted.	Highly complex system applied at every level	Applied to each category	Applied to each issue category
Rating levels	5 levels (1/2)	4 levels (1/2)	5 levels (1/2)	6 levels (2/2)	4 levels (1/2)
Standardization	✓(2/2)	✓(2/2)	✓(2/2)	✓(2/2)	✓(2/2)
Quantitative criteria	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)	✓(1/1)
Qualitative criteria	✓(1/1)	✓(1/1)	✓(1/1)	- (0/1)	✓(1/1)
Lifecycle Assess.	✓(2/2)	● (1/2)	✓/- (1/2)	✓/- (1/2)	✓(2/2)
Complexity	Average (1/2)	Basic (0/2)	Sophisticate (2/2)	Basic (0/2)	Average (1/2)
Efficiency	Average (3/5)	High (4/5)	Very high (5/5)	Average (3/5)	Average (3/5)
Category's score	11/15	10/15	13/15	9/15	11/15

Sources: [2, 4, 6, 7, 8]

### 3.4. Applicability

The following issues were considered under this criterion (see Table 6):

- *Stages of building lifecycle influenced*: Maximum 10 points (6 stages: 10 points - 5 stages: 8 – 4 stages: 3 – 6 stages: 4 – 1 or 2 stages: 2). The following stages of building lifecycle are considered:  
Pre-Design/ Planning/ Site Selection  
Design/ Procurement  
Construction/ Post Construction Review  
Existing Building Management/ Operations/ Maintenance  
Tenant Fit-Out/ Refurbishment  
Demolition
- *Technical contents*: Maximum 10 points are awarded for each sustainable aspect. The score for this issue is the average of all aspects' scores.

Table 6. Applicability

Criteria		BREE	L	CASB	GREEN	HK-
		AM	EED	EE	STAR	BEAM
Stages of building lifecycle influenced	Pre-Design/ Planning/ Site Selection	-	-	✓	-	-
	Design/ Procurement/	✓	✓	✓	✓	✓
	Construction/Post Construction Review	✓	✓	-	✓	-
	Existing Building	✓	✓	✓	●	✓
	Management/Operations					
	Tenant Fit-Out/ Refurbishment	✓	✓	✓	✓	-
	Demolition	-	-	-	-	-
	Score	6/10	6/10	6/10	4/10	2/10
			10			
Technical Contents	Social & Economical Aspects	7	7	5	5	6
	Energy & Resources Consumption	8	7	6	6	8
	Environmental Loadings	8	8	7	6	6
	Living Quality	7	6	6	8	8
	Management & Other Aspects	8	7	5	7	6
	Score	7/10	7/10	5.5/10	6/10	7/10
			10			
Category's score		13/20	13/20	11.5/20	10/20	9/20

Sources: [1, 2, 7, 9, 10]

### 3.5. Data Collecting

The following issues were considered under this criterion (see Table 7):

- *Data Gatherer*: Identify the party which in charge of data inputting process (2 points)
- *Data Collecting Method*: Identify the method used to input data (2 points)
- *Documentation*: What type of documents needed for the assessment? At what stage of the project? Is it easy to gather those documents? (2 points)
- *Measurability*: Does the tool use measurable method to collect data? (2 points)
- *Convenience*: Is it easy and quick to gather data without excessive technical knowledge? (2 points)

### 3.6. Accuracy and Verification

The following issues were considered under this criterion (see Table 8):

- *Accuracy of Data Processing Stage*: (High: 2 points – Medium: 1 – Low: 0)
- *Accuracy of Data Outputting Stage*: (High: 2 points – Medium: 1 – Low: 0)
- *Verification*: Define the system for verifying assessment results, maximum 4 points:
  - Assessor Qualification: What qualification a person must have to be an assessor? (1 point)
  - Level of Detail of Check: To what level of detail do assessors review the applications?(1 point)
  - Third Party: Does the verification process involve third party assessment? (1 point)
  - Are the verified results widely acknowledged in different countries? (1 point)

Table 7. Data Collecting

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Data Gatherer	Management team or assessor (2/2)	Management team or Accredited Professional (2/2)	Design/management team (1/2)	Design team (1/2)	Management team or Assessor (2/2)
Data Collection Method	Checklists or Online-spreadsheet (2/2)	Checklist or Excel spreadsheet (2/2)	Excel-spreadsheet (2/2)	Excel-spreadsheet (2/2)	Checklist or Online Tool spreadsheet (2/2)
Type of Documentation	Online and/or hardcopy (drawings, surveys, reports, contracts, etc.)	Online and/or hardcopy (drawings, specifications, reports, etc.)	Online spreadsheet, no hardcopy	Online and/or hardcopy (drawings, surveys, reports, contracts, etc.)	Hardcopy (drawings, surveys, reports, contracts, agreements, etc.)
At what stage of project	Design Review and Construction Review	Design, Construction and Operation	Preliminary and execution design, completion	Design Review and As Built Review	Design Review and Construction Review
Ease of Score	- (1/2)	- (1/2)	- (1/2)	✓ (2/2)	✓/- (2/2)
Measurability	✓/- (1/2)	✓/- (1/2)	✓/- (1/2)	✓ (2/2)	✓/- (1/2)
Convenience	✓/- (1/2)	✓/- (1/2)	✓/- (1/2)	✓ (2/2)	✓/- (1/2)
Category's score	7/10	7/10	6/10	9/10	8/10

Table 8. Accuracy and Verification

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM	
Accuracy of Data Inputting	High (2/2)	High (2/2)	High (2/2)	Low (0/2)	Medium (1/2)	
Accuracy of Data Processing	Medium (1/2)	Medium (1/2)	High (2/2)	Medium (1/2)	Medium (1/2)	
Accuracy of Data Outputting	Medium (1/2)	Low (0/2)	High (2/2)	Medium (1/2)	Low (0/2)	
Assessor Qualification	Trained and licensed by BRE	Trained and must pass an assessor examination. Must be a first-class architect.	Trained and must pass an assessor examination	Trained and certified by GBCA	Trained and certified by HK-BEAM Society	
Verification	Level of Detail of Check	Detailed assessment of	Administrative and credit audits	Document review	Detailed assessment	Detailed assessment

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
	documents		(depends on the selection of tolls)	of documents	of documents
Third Party	✓	✓	✓/- (If required)	✓	✓
Acknowledged Score	✓ (4/4)	✓ (4/4)	● (3/4)	- (3/4)	● (3/4)
Category's score	8/10	7/10	9/10	5/10	5/10

Sources: [1, 2, 4, 8]

### 3.7. User-friendliness

The following issues were considered under this criterion (see Table 9):

- *Ease of use*: Complexity of the system. Is it easy to get used to the system? (2 points)
- *Product support*: Maximum 8 points:
  - Availability and responsiveness of direct request for assistance (2 points)
  - Availability of FAQs and Record of Enquiries (2 points)
  - Availability of training courses/sessions (2 points)
  - Adequacy of built-in or attached instructions/helps. Are they sufficient enough? (2 points)

Table 9. User-friendliness

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Ease of use	✓	✓	-	✓/-	✓
Direct request for assistance	✓/-	✓/-	✓/-	✓/-	✓
Product support* Record of Enquiries and FAQs	✓/-	✓	✓/-	✓/-	-
Availability of training	✓	✓	✓	✓	✓/-
Built-in instructions/helps	✓	✓	✓/-	✓	✓
Category's score	8/10	10/10	6/10	8/10	8/10

### 3.8. Development

The following issues were considered under this criterion (see Table 10):

- *System's maturity*: Identify when the system was initiated and first available for public use. (2 points)
- *System's stability*: Availability of Testing & Development process and systems for revisions. (2 points)
- *Update*: How is the tool constantly improved? (2 points)
- *Development approach*: Identify if system was developed using a consensus-based approach, life cycle analysis, expert opinion approach, or other. (2 points)
- *Future development*: Potential improvement of the system and the expansion of its influence (2 points)



Table 10. Development

Criteria		BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
System's Maturity	Launch Date	1990	1998	2001	2002	1996
	Available for Public	1990-21	1998-13	2002-9	2003-8	1996-
	Score	2/2	2/2	1/2	1/2	2/2
Systems Stability	Testing & Development	✓	✓	✓	✓	✓
	System for Revisions	✓	✓	✓/-	✓	✓
	Score	2/2	2/2	1/2	2/2	2/2
Update	Update period	Annually	2 years	Annually	Annually	As required
	Latest revision	2008	2009	2008	2009	2010
	Score	2/2	2/2	2/2	2/2	1/2
Development Approach	Consensus-based	-	✓	✓	-	●
	Life Cycle Analysis	✓	●	✓/-	✓-	✓
	Expert Opinion	✓	✓	✓	✓	✓
	Score	1/2	1/2	2/2	1/2	1/2
Future development		1/2	1/2	1/2	2/2	2/2
Category's score		8/10	8/10	7/10	8/10	8/10

Sources: [2, 4, 6, 11, 12]

### 3.9. Result Presentation

The following issues were considered under this criterion (see Table 11):

- *Presentation Method*: End products of assessment process, ratings, result product. (1 point)
- *Clarity*: Well-defined, easily communicated, and clearly understood among multiple parties. (2 points)
- *Comparability*: Amenable to normalization for comparisons over varying building types, locations, years, or different sustainable design characteristics. (1 point)
- *Result Usability*: Usability of result documentations. (1 point)

Table 11. Result Presentation

Criteria		BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Presentation Method	End products	Percent (%) of credits achieved	Percent (%) of credits achieved	Spider diagram, histograms, BEE graph	Percentage score (/100)	Percent (%) of credits achieved
	Ratings	Pass/ Good/ Very Good/ Excellent/ Outstanding	Certified / Silver / Gold / Platinum	C/ B-/ B+/ A/ S	One Star/ Two Star/ Three Star/ Four Star/ Five Star/ Six Star	Platinum/ Gold/ Silver/ Bronze

Criteria	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Result	Certificate	Award	Certificate	Certificate	Certificate
Product		letter, and certificate	and published online	and published online	and published online
Score	1/1	1/1	1/1	1/1	1/1
Clarity	Well-defined	✓	✓	✓/-	✓
	Communication	✓	✓	✓/-	✓
	Understandable	✓	✓	-	●
	Score	2/2	2/2	1/2	1/2
Comparability	- (0/1)	- (0/1)	✓(1/1)	●(0/1)	✓(1/1)
Result Usability	- (0/1)	- (0/1)	✓(1/1)	✓(1/1)	- (0/1)
Category's score	3/5	3/5	4/5	3/5	4/5

Sources: [2, 4, 5, 11, 12]

#### 4. Conclusion

This paper presents a complete and detail comparative review of five well-known sustainable rating systems. Various aspects of these systems were scrutinized and analyzed in order to find out the finest one. The result of the study, i.e. final scores of five rating systems, is shown in Table 12. BREEAM and LEED - with their strong bases, large investments and proven advantages – both scored the highest with 75 points. CASBEE, GREEN STAR and HK-BEAM make up the lower group. All of these 3 systems are the upcoming ones that are trying to have more influence across the field. CASBEE scored a little higher than GREEN STAR and HK-BEAM mainly thanks to its highly intricated Excel Estimator [1].

However, it is not just the final score that matters, but the whole review process itself. The information, analyses, valuations and comparisons during the process would help architects, developers, managers, etc. to have better insight into sustainable rating tools. They provide a systematic and valuable reference source for various research which are related to sustainable development.

Table 11. Result Presentation

	BREEAM	LEED	CASBEE	GREEN STAR	HK-BEAM
Popularity and Influence	10	10	6	5	5
Availability	7	7	7	8	8
Methodology	11	10	13	9	11
Applicability	13	13	11.5	10	9
Data Collecting Process	7	7	6	9	8
Accuracy and Verification	8	7	9	5	5
User-friendliness	8	10	6	8	8
Development	8	8	7	8	8
Results Presentation	3	3	4	3	4
Final Score (/100)	75	75	69.5	65	66

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