

TECHNICAL ARTICLE

# Analysis of Green Building Certification System for Developing G-SEED

Focusing on the Comparison of LEED and BREEAM

Yosun Yun, Dongwoo Cho and Changu Chae

G-SEED(Green Standard for Energy and Environmental Design) is operating in Korea as a certification system to evaluate the environmental friendliness of buildings.

Buildings are generating loads such as carbon dioxide emission, energy consumption, the consumption of resources, destruction of natural ecosystem, change of global climate, pollution of indoor environment, and waste generation.

For this purpose, a green building certification system has been introduced. In the green building certification system, evaluation of buildings through methods such as utilization of natural energy, adoption of energy saving system, rainwater management, etc., is induced to reduce environmental load.

These certification systems are operated by each country. The level of the certification system is different according to the characteristics such as climate environment. BREEAM in the UK and LEED in the US are operating a version for international certification as well as domestic certification.

In this study, analyze the certification system which operates the global version such as BREEAM, LEED. And to investigate the differences between domestic and international versions of each version of the certification system. Certification items classified as reflected by climate characteristics, national characteristics reflected items, general items, such as attempts to analyze the rating system. And certification items were grouped into general "Global certification items" having no specificity for locality and "Local certification items" that differ by each locality according to social, environmental, and political factors.

Using the analysis results that comparison of LEED and BREEAM, the study then aims to ascertain the possibility of whether the G-SEED can be used to certify international buildings. And explore the possibility of developing international version of the G-SEED and indicate the direction of G-SEED amendments that may arise in the future. The study results would be available as basic data at the development of G-SEED for international version.

**Keywords:** Green Building Certification System; LEED; BREEAM; G-SEED

## 1. Introduction

Green building certification systems assess buildings on items such as the use of natural energy, use of energy conservation systems, and rainwater management (KICT, 2016). By doing so, the systems aim to induce the reduction of the environmental loads of buildings. For the purposes of fulfilling the objectives of responding to climate change and reducing greenhouse gases by expanding environmentally friendly buildings, each country has developed and put into practice their own systems that certifies environmental friendliness. Several studies are underway in a number of countries to find environmentally friendly and sustainable methods of construction.

By examining the certification systems currently in operation in each country, it can be understood that their

assessment methods and systems vary in degree according to the climate and social characteristics of each country. Also, among the certification systems currently in operation by each country, some certification systems assess not only domestic but also international projects as well. Regarding such systems, this study examines BREEAM of the UK and LEED of the US, both of which are global certification systems that provide certifications worldwide. BREEAM and LEED are international certification as well as domestic certification buildings.

LEED has grown to become the world's most widely used green building rating system, with nearly 90,000 projects participating in LEED across 167 countries, including more than 39,000 certified commercial projects. Also, LEED certifies 2.20 million ft<sup>2</sup> per day, and is currently the most widely used worldwide (USGBC, 2017b).

BREEAM has nearly 250,000 registered projects in 77 countries, and including 56,000 certified projects

**Table 1:** G-SEED Rating System (New Buildings).

Categories	Average Weighting	Number of Credits	Prerequisites Credits
Land Use and Transportation	10	6	–
Energy and Environmental Pollution	30	6	1
Materials and Resources	15	6	1
Water Management	10	4	1
Maintenance	7	3	1
Ecology	10	3	–
Indoor Environment	18	6	1
Innovative Design	10	9	–

(BREEAM, 2017a). In 2012 7.5% of all certified BREEAM New Construction nondomestic assessments were of buildings located outside the UK, rising from 7% in 2011 and 4% in 2010. BRE Global data (not presented in this publication) shows that the number of certified international (non-UK) assessments has doubled year-on-year since 2009 (BREEAM, 2014).

This study aims to analyse the BREEAM and LEED certification systems currently in active operation worldwide. Both certification systems provide not only domestic certification but also international certification. In light of this aspect, this study pursues an understanding of the differences in certification items for both their domestic and international processes and also aims to classify certification items according to their properties to understand their characteristics.

Using the analysis results that comparison of LEED and BREEAM, the study then aims to ascertain the possibility of whether the G-SEED (Green Standard for Energy and Environmental Design, Korea Green building Certification System) can be used to certify international buildings. And explore the possibility of developing international version of the G-SEED and indicate the direction of G-SEED amendments that may arise in the future.

G-SEED is the green building certification system of Korea that has certified over 8,000 buildings between its inception in 2002 and up to the year 2016 (G-SEED, 2017). The system, however, has only certified buildings within Korea during this period. G-SEED needs to introduce international certification for the future development.

## 2. General information of Green building Certification Systems

A general overview of G-SEED, currently in operation in South Korea, LEED of the US, and BREEAM of the UK is provided below (Figure 1).

### 2.1. G-SEED

G-SEED (Green Standard for Energy and Environmental Design) is a system used to assess green buildings that are in operation in Korea. A green building, as defined in Article 2 of the Green Building Act (2006) in Korea (Green Architecture Division, 2016), is a building that mini-

mizes its impact on the environment while at the same time providing a comfortable and healthy living environment. The G-SEED is a system used to assess such buildings and undertakes a comprehensive assessment of the environmental friendliness of buildings. The system was first introduced in 2002 to assess multi-residential housing units and currently is used to undertake assessments of new buildings, existing buildings, and green-remodelling buildings. By building code, the system undertakes assessments of buildings classified as general housing, single housing, multi-residence, general purpose, offices, schools, sales facilities, and accommodations (KICT, 2016).

G-SEED was amended in 2016 and undertakes assessments across 8 categories (Table 1) including land use and transportation, energy and environmental pollution, materials and resources, water management, maintenance, ecology, indoor environment, and innovative design. The energy and environmental pollution category constitutes the largest portion of the assessment (KICT, 2016).

### 2.2. LEED

LEED was developed in the year 2000 by the US Green Building Council and aims to reduce the use of resources; actively pursue the reuse of material and promote better recycling practices; minimize the adverse effects and maximize the positive effects the construction industry has on the environment and humans; and provide building occupants a merited in-door environment (USGBC, 2017a).

LEED also emphasizes integrated design and technology, environmentally friendly building technologies, and the most up-to-date strategies from policy experts. LEED assesses building design and construction (BD+C), operation and maintenance (O+M), interior design and construction (ID+C), and neighborhood development (ND) and provides certification standards for new construction, core and shell, schools, retail, data centers, warehouses and distribution centers, hospitality and healthcare.

Following its inception in the year 2000, LEED has been amended several times and LEED v4 is currently operating based on its 2014 amendments. Table 2 displays the assessment categories of new constructions in LEED v4. Energy and Atmosphere category constitutes the largest portion of the assessment.

**Table 2:** LEED Rating System (New Construction).

Categories	Average Weighting	Number of Credits	Prerequisites Credits
Integrative Process	1	1	–
Location and Transportation	16	8	–
Sustainable Sites	10	7	1
Water Efficiency	11	7	3
Energy and Atmosphere	33	11	4
Materials and Resources	13	7	2
Indoor Environmental Quality	16	11	2
Innovation Design	6	2	–
Regional Priority	4	4	–

**Table 3:** BREEAM Rating System (International).

Categories	Average Weighting	Number of Credits	Prerequisites Credits (Very Good rating)
Management	12	5	1
Health and wellbeing	15	7	3
Energy	19	6	1
Transport	8	5	–
Water	6	4	2
Materials	12.5	4	1
Waste	7.5	4	–
Land Use and ecology	10	4	–
Pollution	10	3	–
Innovation	10	–	–

### 2.3. BREEAM

BREEAM is the world's first certification system regarding building environments and first came into effect in the year 1990. The system aims to mitigate the life cycle impacts of buildings on the environment; enable buildings to be recognised according to their environmental benefits; provide a credible, environmental label for buildings; and stimulate demand and create value for sustainable buildings, buildings products and supply chains (BREEAM, 2017b).

BREEAM makes assessments of infrastructure, communities, new constructions, in use buildings, and refurbishments and undertakes assessments of new constructions regarding residential, commercial, education, residential institutions, hotels, and non-standard buildings.

The BREEAM International version, amended in 2016, makes assessments across 10 different categories (Table 3), which include management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution, and innovation. As is the case with LEED and G-SEED, assessments regarding energy constitute the highest portion of the assessment. BREEAM provides a minimum standard for prerequisite credits only for its very good ratings.

### 3. International Version of LEED and BREEAM

In this section, the international versions of the BREEAM and LEED were examined. LEED does not have a separate version of certification for its domestic and international version, whereas BREEAM provides a domestic version for use within the UK and a separate international version.

This study examined the certification items regarding new construction in LEED v4.0 BD+C (Building Design and Construction) and certification items regarding all buildings in BREEAM International New Construction 2016. Certification items were grouped into general "Global certification items" having no specificity for locality and "Local certification items" that differ by each locality according to social, environmental, and political factors. Local certification items were identified by whether a certification standard used the local standards as provided in the manual.

When grouping the certification items, not only the certification items that applied to local certification items in its entirety to assessment methods but also partial applications of local standards were counted as items following local certification standards.

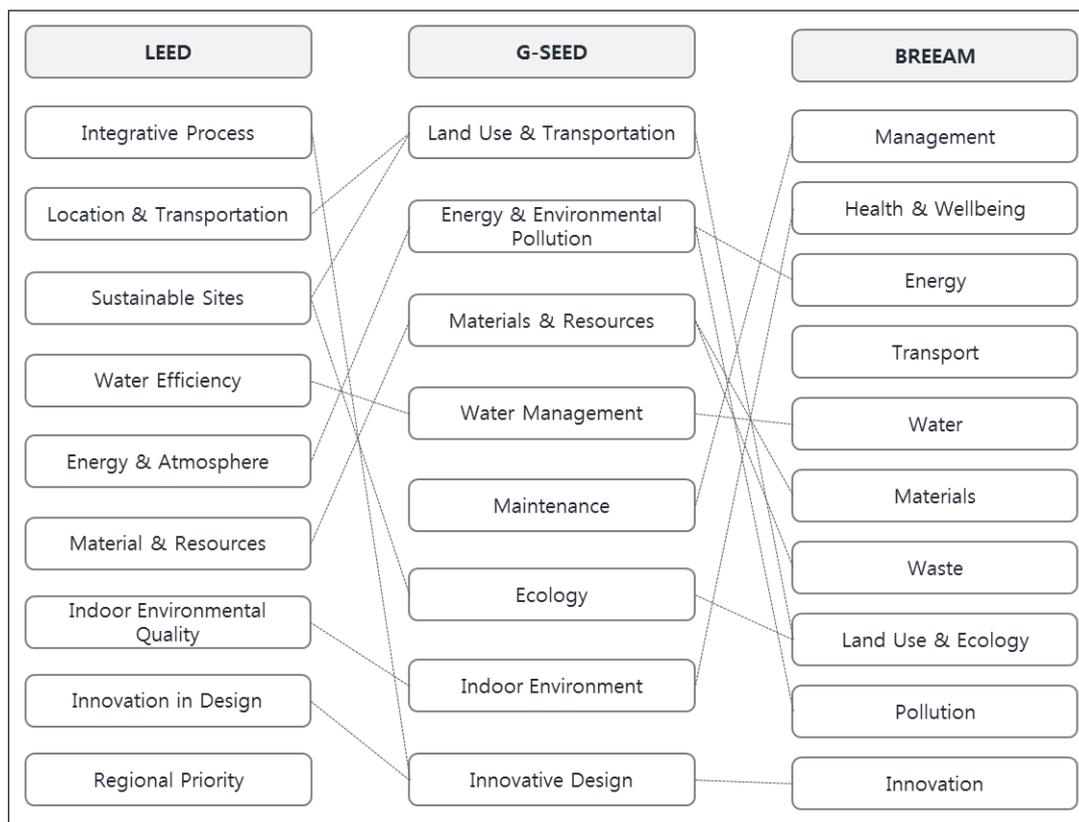


Figure 1: G-SEED, LEED and BREEAM Categories.

### 3.1. LEED for International

LEED<sup>1</sup> does not have a separate standard for domestic and international version and makes assessments of both domestic projects and international projects using a single standard. However, for international projects that necessitate the inclusion of related standards or regional properties, local regulations having similar levels are followed.

In the LEED, 52 certification items of new constructions were analyzed (USGBC, 2013). Global certification items that may be used regardless of locality numbered 36 in total and accounted for 69% of the items. Local certification items capable of use in assessments in reference to local standards numbered 16 in total and accounted for 31% of the items (Table 4).

Regarding its certification items that follow local standards, LEED posits a rule of thumb where such certification items either may adhere to local standards that are similar or follow the stricter of the two standards. However, in the case of its energy category, certification must comply with USGBC certified standards and must be calculated in reference to climactic zones.

Also for its regional priority section, which is open to the application of regional properties, additional points can be acquired in categories that have been certified in previous steps. A maximum of 4 points can be acquired and the certification items that apply differ according to each region.

With the exception of certification items regarding indoor water use reduction, energy performance, and building life-cycle Impact, all other certification items in the water, energy and atmosphere, materials and resources categories can be assessed using LEED standards. Also,

most local standards are recognizable in the certification items regarding sustainable sites and indoor air quality.

### 3.2. BREEAM for International

In the case of BREEAM, domestic standards (BREEAM for UK) and international standards (BREEAM for International<sup>2</sup>) are operated separately. The international version can be used in countries not having an NSO. For cases in which an appropriate local system applicable to a type of building exists in a country, that system is prioritized for use over the BREEAM International version. In the case of new constructions, a separate standard is being operated in the Netherlands, Spain, Norway, and Sweden (Table 5).

BREEAM also operates a bespoke process (BREEAM, 2015). For cases in which a building does not fit the scope of the BREEAM, BREEAM community projects outside of the UK, and all BREEAM Infrastructure New Construction pilot projects, a bespoke assessment can be made. If an applicant applies for a bespoke process to BRE Global, a meeting takes place between BRE Global, a bespoke assessor, the applicant, and the design team to assess the use and functions of a building. Following this meeting, BRE Global determines the criteria following further discussions with the assessor and design team.

In the BREEAM, a total of 42 certification items are analyzed regarding residential buildings, non-residential buildings, and removed items (BREEAM, 2016). Global certification items that can be used in general without regard to a locality numbered 23 in total and accounted for 55% of the items (Table 6). Local certification items capable of

**Table 4:** Analysis of LEED Credits.

Categories		Credits	Global	Local
–	Credit	Integrative Process	○	
Location and Transportation	Credit	LEED for Neighborhood Development Location	○	
	Credit	Sensitive Land Protection		○
	Credit	High Priority Site		○
	Credit	Surrounding Density and Diverse Uses	○	
	Credit	Access to Quality Transit	○	
	Credit	Bicycle Facilities	○	
	Credit	Reduced Parking Footprint	○	
	Credit	Green Vehicles		○
Sustainable Sites	Prereq	Construction Activity Pollution Prevention		○
	Credit	Site Assessment		○
	Credit	Site Development – Protect or Restore Habitat		○
	Credit	Open Space	○	
	Credit	Rainwater Management	○	
	Credit	Heat Island Reduction	○	
	Credit	Light Pollution Reduction	○	
Water Efficiency	Prereq	Outdoor Water Use Reduction	○	
	Prereq	Indoor Water Use Reduction		○
	Prereq	Building-Level Water Metering	○	
	Credit	Outdoor Water Use Reduction	○	
	Credit	Indoor Water Use Reduction		○
	Credit	Cooling Tower Water Use	○	
	Credit	Water Metering	○	
Energy and Atmosphere	Prereq	Fundamental Commissioning and Verification	○	
	Prereq	Minimum Energy Performance		○
	Prereq	Building-Level Energy Metering	○	
	Prereq	Fundamental Refrigerant Management	○	
	Credit	Enhanced Commissioning	○	
	Credit	Optimize Energy Performance		○
	Credit	Advanced Energy Metering	○	
	Credit	Demand Response	○	
	Credit	Renewable Energy Production	○	
	Credit	Enhanced Refrigerant Management	○	
	Credit	Green Power and Carbon Offsets	○	
Materials and Resources	Prereq	Storage and Collection of Recyclables	○	
	Prereq	Construction and Demolition Waste Management Planning	○	
	Credit	Building Life-Cycle Impact Reduction		○
	Credit	Building Product Disclosure and Optimization – Environmental Product Declarations	○	
	Credit	Building Product Disclosure and Optimization – Sourcing of Raw Materials	○	
	Credit	Building Product Disclosure and Optimization – Material Ingredients	○	
	Credit	Construction and Demolition Waste Management	○	

(contd.)

Categories		Credits	Global	Local
Indoor Environmental Quality	Prereq	Minimum Indoor Air Quality Performance		○
	Prereq	Environmental Tobacco Smoke Control	○	
	Credit	Enhanced Indoor Air Quality Strategies		○
	Credit	Low-Emitting Materials		○
	Credit	Construction Indoor Air Quality Management Plan	○	
	Credit	Indoor Air Quality Assessment	○	
	Credit	Thermal Comfort		○
	Credit	Interior Lighting	○	
	Credit	Daylight	○	
	Credit	Quality Views	○	
	Credit	Acoustic Performance		○

**Table 5:** BREEAM Standards by Country.

Country	New Construction
United Kingdom	BREEAM UK New Construction
Netherlands	BREEAM NL New Construction
Spain	BREEAM ES New Construction
Norway	BREEAM NOR New Construction
Sweden	BREEAM SE New Construction
Germany	BREEAM International New Construction
Austria	BREEAM International New Construction
Other Countries	BREEAM International New Construction

assessment in reference to local standards numbered 19 in total and accounted for 55% of the items.

Also, of the local certification items, those certification items that required referencing of a country-specific reference sheet numbered 7 in total and included commissioning and handover, visual comfort, indoor air quality, water quality, water consumption, construction waste management, and surface water run-off.

When applying local standards to a BREEAM assessment, the assessor must send the local standard to BRE Global for approval. The sent material must include content regarding the approval of the project and must be included in the new country worksheet.

Local standards are classified by BRE using the following criteria. Cases where no specific local standard is specified, cases where an approved local standard is specified, and cases where an unapproved local standard is proposed.

All items in the Transport category are certification items that can be assessed without local standards and with the exception of water consumption in the Water category, all other items can be assessed using BREEAM standards. Also in the case of the Management and Health and Wellbeing categories, most certification items recognize local standards.

### 3.3. Comparison Of International Version of LEED and BREEAM

The results of analyzing the certification items of LEED and BREEAM indicate that LEED operates with more “Global certification items” that are unaffected by local standards and that BREEAM operates with more “Local certification items” that recognize local standards.

This difference can be explained further in terms of the operating method of each system. BREEAM operates a separate international version, while on the other hand, LEED applies the same certification standards to all domestic and international projects. It was understood that there were more items that could be assessed in a general manner in the case of the US considering that the US, being a country having a larger total area than the UK, was subject to a number of different climates.

In the case of BREEAM, when making use of local standards, the assessor must receive approval from BRE Global. However, in the case of LEED, such approval is necessary only for the Energy Performance certification items.

Similar certification items that use local standards found in BREEAM and LEED were organized in **Table 7** below. The items could be classified according to their affiliation with Site/Location, Water, Energy, and Indoor Environment/Health. Site selection involved several certification items that made use of local standards and water

**Table 6:** Analysis of BREEAM Credits.

Categories	Credits	Global	Local
Management	Project brief and design		○
	Life cycle cost and service life planning	○	
	Responsible construction practices		○
	Commissioning and handover		○
	Aftercare	○	
Health and wellbeing	Visual comfort		○
	Indoor air quality		○
	Thermal comfort		○
	Acoustic performance		○
	Accessibility	○	
	Hazards	○	
	Water quality		○
Energy	Reduction of energy use and carbon emissions		○
	Energy monitoring	○	
	External lighting	○	
	Low carbon design		○
	Energy efficient transport systems	○	
Transport	Energy efficient equipment		○
	Public transport accessibility	○	
	Proximity to amenities	○	
	Alternative modes of transport	○	
	Maximum car parking capacity	○	
Water	Travel plan	○	
	Water consumption		○
	Water monitoring	○	
	Water leak detection	○	
Materials	Water efficient equipment	○	
	Life cycle impacts	○	
	Responsible sourcing of materials		○
	Designing for durability and resilience	○	
Waste	Material efficiency	○	
	Construction waste management		○
	Recycled aggregates		○
	Operational waste	○	
Land Use and ecology	Adaptation to climate change	○	
	Site selection		○
	Ecological value of site and protection of ecological features	○	
	Enhancing site ecology	○	
Pollution	Long term impact on biodiversity		○
	Impact of refrigerants		○
	NOx emissions	○	
	Surface water run-off		○

**Table 7:** Local credits of LEED and BREEAM.

Categories	LEED	BREEAM
Site/Location	Sensitive Land Protection	
	High priority Site	Site selection
	Site Assessment	
	Construction Activity Pollution Prevention	Responsible construction practices
	Site Development -Protect or Restore Habitat	Long term impact on biodiversity
Water	Indoor Water Use Reduction	Water consumption
Energy	Minimum Energy Performance	Reduction of energy use and carbon emissions
	Minimum Indoor Air Quality Performance	
Indoor Environment	Enhanced Indoor Air Quality Strategies	Indoor air quality
	Thermal comfort	Thermal comfort
	Acoustic performance	Acoustic performance

**Table 8:** Comparison of G-SEED, LEED and BREEAM.

	G-SEED	LEED	BREEAM
Local Certification Items	25(58%)	16(31%)	19(45%)
Global Certification Items	18(42%)	36(69%)	23(55%)
sum	43(100%)	52(100%)	42(100%)

consumption and energy performance related certification items made use of local standards according to differences in rainfall volumes, energy consumption and climate. Also regarding the indoor environment of occupants, differences in living environments resulted in the use of local standards for items regarding indoor air quality, thermal conditions, and acoustics environments.

When considering the points above altogether, certification items that assess the local environment, climate, or living environment were frequently found to make use of local standards.

#### 4. Conclusion

This study examined green building certification systems that assess the environmental friendliness of buildings and examined the global certification systems known as BREEAM of the UK and LEED of the US, both of which are used to certify international projects. By examining the certification systems currently in operation in each country, it can be understood that their assessment methods and systems vary in degree according to the climate and social characteristics of each country.

This study examined the certification items regarding new construction in LEED v4.0 BD+C (Building Design and Construction) and certification items regarding all buildings in BREEAM International New Construction 2016. Certification items were grouped into general "Global certification items" having no specificity for locality and "Local

certification items" that differ by each locality according to social, environmental, and political factors. Local certification items were identified by whether a certification standard used the local standards as provided in the manual.

The results of analyzing the certification items of LEED and BREEAM indicated that LEED operates with more Global certification items that are unaffected by local standards and that BREEAM operates with more Local certification items that recognize local standards (Table 8).

An analysis of the certification items of LEED and BREEAM indicated the existence of similarities between global certification items and local certification items, while on the other hand, different items also existed. Overall, local standards were found to have been frequently applied to certification items that assess the local environment, climate, and living environment. In the case of BREEAM, several certification items required approval by BRE Global when it came to the use of local certification standards. On the other hand, in the case of LEED, only energy performance certification items required approval from USGBC.

Using the analysis results that comparison of LEED and BREEAM, the study then aims to ascertain the possibility of whether the G-SEED can be used to certify international buildings. In order to develop G-SEED, need to references the international version of LEED and BREEAM operation system. Also, it should be analysed for the certification items of G-SEED.

## Notes

- <sup>1</sup> US Green Building Council (USGBC), 2013. Reference guide for Building Design and Construction v4, US Green Building Council.
- <sup>2</sup> **BREEAM**, 2016. BREEAM International New Construction 2016 Technical Manual SD233 1.0, Available from: [https://tools.breeam.com/filelibrary/Technical%20Manuals/BREEAM\\_International\\_NC\\_2016\\_Technical\\_Manual\\_2.0.pdf](https://tools.breeam.com/filelibrary/Technical%20Manuals/BREEAM_International_NC_2016_Technical_Manual_2.0.pdf), (Accessed Feb. 6th 2017).

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## Competing Interests

The authors have no competing interests to declare.

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