

Sustainable Rating Systems in Buildings: An Overview and Gap Analysis

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Abstract—Nowadays environmental issues are of the main role and concern in businesses worldwide. In order to concentrate on environmental and sustainability matters in the building industry, sustainable rating systems are developed globally and buildings are assessed and certificated due to different parameters. In this paper, three widely-used rating systems from three continents; America, Europe and Australia are introduced and a comparison on their assessment categories is presented. By developing a criteria-map, 11 categories are identified and a gap analysis is performed. Results show that no single rating system covers every 11 category. Finally, recommendations are presented to lead to a comprehensive solution and the implications of the acceptance of the solution are discussed.

Index Terms—Green building, rating systems, architecture, assessment tools, gap analysis.

I. INTRODUCTION

Green building, also called sustainable building, “refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building’s life-cycle: from sitting to design, construction, operation, maintenance, renovation, and demolition” [1]. All around the world, there are numerous building assessment tools that concentrate on different sustainable development areas and are developed for various types of projects. The information and analyses during the process of buildings’ assessment lead architects and managers to a better insight into building assessment tools [2].

The purpose of this paper is to introduce three most popular, influential and technically advanced rating tools and to investigate their unique categories. This would lead to a presentation of a criteria-map of the energy assessment tools. Following, first an introduction about energy efficiency in buildings is presented and then each rating system is individually introduced and the criteria-map is proposed.

II. ENERGY EFFICIENCY IN BUILDINGS

About 40% of the energy is consumed in the building industry [3] and in United States in 2005, buildings were responsible for 38.9% of the total U.S. energy consumption and residential buildings were responsible for about 54% of

that total, whereas commercial buildings constituted the rest (46%) [4]. Every single year, 40 to 50 percent of the overall flow in the global economy – about 3 billion tons – is applied in the manufacturing of building products [5, 6]. As Fig. 1 and 2 demonstrate, over the last decade, total petroleum consumption in the residential and commercial buildings in the U.S. has declined while the electricity consumption has risen [4]. Fig. 3 presents a comparison on total energy consumption of the three countries/continents.

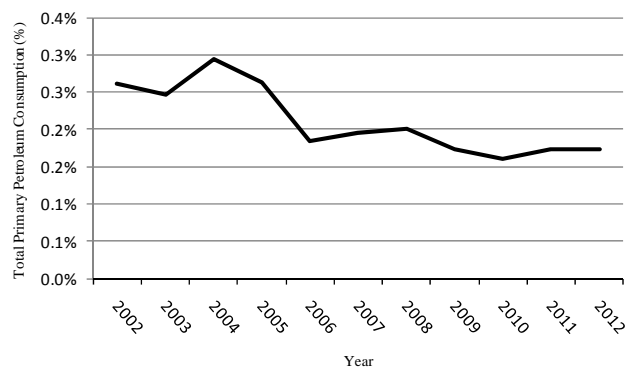


Fig. 1. Total primary petroleum consumption in the U.S. [4].



Fig. 2. Total primary electricity consumption in the U.S. [4].

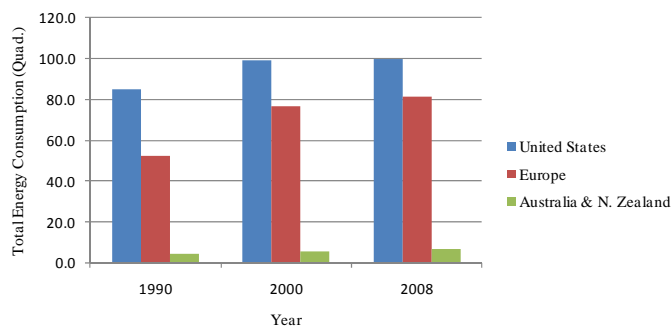


Fig. 3. Total energy consumption in three countries/continents in the building industry [4].

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In the building industry, materials -from extraction of raw materials to the construction and disposal phase- entail many environmental impacts. This industry consumes raw materials with great energy content [7]. Common building materials are burnt clay bricks, stones, concrete blocks, cement, steel, concrete, aluminium, zinc, wood, glass, tiles (ceramic/burnt), plastics (PVC), paints, and timber. All these materials are responsible for energy efficiency in buildings.

III. RATING SYSTEMS

In order to perform the gap analysis, three leading and commonly used rating systems were selected from three continents; America, Europe and Australia. Then after investigating the rating systems, gap analysis was performed.

A. Breeam

"Building Research Establishment's Environmental Assessment Method" (BREEAM) is a primary and most commonly used assessment method in the building industry. In 1990, it was first developed in the United Kingdom and is the building's environmental assessment tool with the longest history [8]. Every year BREEAM is updated but the up-to-date version is not freely available to be purchased. Even though most professionals are aware of BREEAM and numerous other rating systems have applied it as their basis, the BREEAM results are not used or recognized by United States' design professionals [9].

BREEAM can be applied to these building types: hospitals, schools, courts, retail outlets, industrial units, prisons and offices. The nine categories of BREEAM are: "Management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, and pollution" [10].

B. LEED®

The Leadership in Energy and Environmental Design (LEED®) was established by the United States Green Building Council in 1998 and is currently the leading rating system for sustainable constructions in the United States market. Since its development, LEED® has applied in about 30 countries around the world. This rating system is the most commonly used rating system by Federal and state agencies in U.S., which makes it effortless to communicate a sustainable design's success with other designers [9]. The LEED® 2009 "Green Building Rating System for New Construction and Major Renovations" is to certify the construction of institutional, commercial and tall residential buildings of all sizes in both private and public sector. Its purpose is to encourage and enhance durable, affordable, healthful, and environmentally-friendly efforts in the design and construction of buildings. LEED® 2009 is addressed in seven categories: "Sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority" [11].

C. Green Star

Green Star -an Australian rating system for buildings- was developed in 2003 by the Green Building Council of Australia. This rating system examines an extensive range of sustainable concerns among occupant health, productivity,

and cost saving issues [8].

The nine categories of which Green Star assesses are: "Management, Indoor environment quality, Energy, Transport, Water, Materials, Land use and ecology, Emissions, and Innovation" [12]. The Green Star score is translated into "Green Stars" as Best Practice, Australian Excellence, and World Leadership [13].

IV. GAP ANALYSIS AND CRITERIA-MAP

As stated earlier, the contribution of this paper is to develop a criteria-map to compare the categories of the rating systems and to identify the probable gap. Table I demonstrates BREEAM, LEED® and Green Star assessment models and their categories. Based on the categories of the mentioned three rating systems, new 11 categories are identified and the categories of the BREEAM, LEED® and Green Star are classified into these 11 new categories. These categories are: management, energy, water, transportation, resources, land, innovation, indoor, waste, pollution, and well-being. Subsequent to the mapping of the BREEAM, LEED® and Green Star, a criteria-map of the three rating systems is developed. Figure 4 illustrates the criteria-map.

TABLE I: RATING SYSTEMS AND THEIR CRITERIA.

				Rating Systems		
				BREEAM	LEED®	Green Star
Categories	Management			Management	Sustainable Sites	Management
	Health and Wellbeing			Indoor Environment Quality	Water Efficiency	Indoor Environment Quality
	Energy			Energy	Energy and Atmosphere	Energy
	Transport			Transport	Materials and Resources	Transport
	Water			Water	Indoor Environmental Quality	Water
	Materials			Materials	Innovation in Design	Materials
	Waste			Land Use and Ecology	Regional Priority	Land Use and Ecology
	Land Use and Ecology			Emissions		Emissions
	Pollution			Innovation		Innovation

The criteria-map implies that:

- LEED® does not offer directly a measurement in management and well-being, as BREEAM in innovation and indoor and Green Star in waste and well-being.
- LEED® does not offer an independent category for transportation; 4 out of 15 sub-criteria of the sustainable sites are dedicated to the status of transportation.
- Two categories of LEED® - water efficiency and materials and resources - are responsible for waste; in each one sub-criterion.
- Three out of 15 sub-criteria of the sustainable sites in LEED® offer measurements for pollution.
- No single rating system covers all 11 categories.

V. DISCUSSION

After an introduction about three rating systems, a comparison on their categories is made and a criteria-map is presented. As stated earlier, there is no single rating system to cover every 11 category. As a result, it is recommended to undertake further investigations among other popular and widely-used rating systems to find out comprehensive

solutions. Besides, the important note is that in action, some of the rating systems measure environmental impacts and do not measure sustainability. So, the comprehensive solution ought to be designed in a way to measure sustainability in focus. Furthermore, as Potbhare et al. [14] state, prior to the presentation of the comprehensive solution, the characteristics that might affect its acceptance must be identified and measured.

Category	Management			Energy		
Rating System	B*	L**	G***	B	L	G
Criterion	Management	NA	Management	Energy	Energy and Atmosphere	Energy
Category	Transportation			Resources		
Rating System	B	L	G	B	L	G
Criterion	Transport	Sustainable Sites	Transport	Materials	Materials and Resources	Materials
Category	Innovation			Indoor		
Rating System	B	L	G	B	L	G
Criterion	NA****	Innovations in Design	Innovation	NA	Indoor Environmental Quality	Indoor Environment Quality
Category	Pollution			Well-being		
Rating System	B	L	G	B	L	G
Criterion	Pollution	Sustainable Sites	Emission	Health and Well-being	NA	NA
Category	Water			Waste		
Rating System	B	L	G	B	L	G
Criterion	Water	Water Efficiency	Water	Waste	Water Efficiency – Materials and Resources	NA
Category	Land					
Rating System	B	L	G			
Criterion	Land Use and Ecology	Regional Priority	Land Use and Ecology			

* BREEAM, ** LEED®, *** Green Star, **** NA: Not Available

Fig. 4. The Three rating systems' criteria-map.

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