Information Technology-Enabled Sustainable Buildings: A Real-time Monitoring Information System

Maryam Bolhari [1], Fatemeh Zare [1 +], and Alireza Bolhari[2]

[1]Islamic Azad University, Central Tehran Branch, Architecture Engineering

[2]Shahid Beheshti University, Information Technology Management

Abstract. Worldwide, environmental matters are of the main role in businesses. In order to focus on environmental issues in the building industry, assessment systems which measure sustainability of the buildings are developed internationally and buildings are assessed and certificated due to pre-defined themes. Generally, buildings are re-assessed periodically to ensure that they conform to the standards of their respective rating systems. In order to reduce the cost and enhance the efficiency of this operation, in this paper a real-time monitoring information system is developed. To do so, a gap analysis among six rating systems was conducted and four out of eleven criteria were nominated as the inputs of the information system. The results show that the information system would a) reduce the costs of the process of certificate audit, b) conserve energy in a more economical way, c) bring the building to a safer and healthier place for occupants and finally d) reduce harmful emissions. In conclusion, a deep review of the elements of the information system is presented from managerial perspective.

Keywords: Green Building, Rating System, Information Technology, Assessment Tools, Monitoring

1. Introduction

Sustainable building, and also called green building applies "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]. Worldwide, there are several assessment tools that focus on variety of sustainable development areas which are typically composed of a checklist of items organized into themes such as water, indoor environmental quality, energy, transportation, etc. These assessment tools are developed for different types of projects [2]. For this purpose, sustainable building rating systems are defined as "tools that examine the performance or expected performance of a 'whole building' and translate that examination into an overall assessment that allows for comparison against other buildings". A rating system adds value to a sustainable design or an operation of a building, when it offers a consistent and credible basis for comparison and evaluation of related technical aspects of a sustainable design [3].

The building industry devotes approximately 40% of the total energy to itself [4] and in the United States of America in year 2005, buildings were responsible for over 38% of the total sum of the U.S. energy consumption; residential buildings were consuming about 54% of that amount, while commercial buildings constituted the rest (46%) [5]. Each year, 40% to 50% of the total flow in the global economy which is about 3 billion tons is used in the manufacturing of building products [6, 7]. In the building industry, materials are responsible for different environmental impacts. Great energy contents from raw materials are consumed in this industry [8]. Common building materials are steel, stones, concrete blocks, paint, zinc, concrete, wood, burnt clay bricks, tiles (ceramic/burnt), glass, plastics (PVC), cement, and timber. All these materials are responsible for energy efficiency in buildings [9].

Typically, after obtaining a certificate from a rating system, an audit will be undertaken periodically to check the status of the sustainability of the buildings. The purpose of this paper is to propose a model of information system for "real-time green monitoring" to investigate if the buildings are constantly conforming to the standards of the rating systems. This model is presented to lower the overall cost of conducting periodical audits and to improve the efficiency of the sustainability by providing real-time data. So, after

+ Corresponding author. Tel.: +989122779783.
E-mail address: zare.f88@gmail.com.

obtaining a certificate of building sustainability, either the owner of the building or the authorities of the rating system's organization can benefit from this real-time green monitoring information system. In order to achieve this, six rating systems from different countries were selected. After a gap analysis, the real-time green monitoring information system is proposed for the common criteria extracted from the gap analysis.

2. Rating Systems

Building rating systems are composed of items which are structured into themes [10]. Numerous countries have developed domestic rating/assessment tools over the past few years to enhance the awareness of the sustainability level in each country's building industry. Three of the most widely-used and common rating systems; LEED, BREEAM, and Green Star, are in search of developing common metrics to help stakeholders around the world to evaluate and compare buildings in different cities by an 'international language' complex [11].

Table 1 demonstrates the six rating systems with their own unique criteria. These rating systems were selected from the most widely-used and leading rating systems from six different countries. After a gap analysis and finding the common and major criteria of the mentioned rating systems, eleven common criteria were identified (table 2).

TABLE 1: Rating systems with their criteria

	Rating Systems		
	LEED® [12]	**BREEAM [13]**	**Green Star [14]**
Criteria	Sustainable Sites	Management	Management
	Water Efficiency	Health and Wellbeing	Indoor Environment Quality
	Energy and Atmosphere	Energy	Energy
	Materials and Resources	Transport	Transport
	Indoor Environmental Quality	Water	Water
	Innovation in Design	Materials	Materials
	Regional Priority	Waste	Land Use and Ecology
		Land Use and Ecology	Emissions
		Pollution	Innovation
	Rating Systems		
	CASBEE [15]	**DGNB [16]**	**GBTool [15]**
Criteria	Indoor Environment	Impacts on Environment	Site Selection
	Quality of Services	Utilization of Resources	Project Planning
	Outdoor Environment on Site	Life Cycle Costs	Environmental Loadings
	Energy	User Health and Satisfaction	Energy and Resource Consumption
	Resources and Materials	Functionality	Indoor Environmental Quality
	Reuse and Reusability	Quality of the Technical Implementation	Functionality
	Off-site Environment	Quality of the Planning	Long-Term Performance
		Quality of the Construction Activities	Social and Economic Aspects

LEED: Leadership in Energy and Environmental Design, Presented in U.S.A. in 1998.
BREEAM: Building Research Establishment Environmental Assessment Method, Developed in U.K. in 1990.
Green Star: a rating system for buildings, Developed in 2003 by the Green Building Council of Australia
CASBEE: Comprehensive Assessment System for Building Environmental Efficiency, Developed in Japan in 2001.
GBTool: Developed by the International Framework Committee for the Green Building Challenge, an international project that has involved more than 25 countries since 1998.
DGNB: Deutsche Gesellschaft für Nachhaltiges Bauen, Germany in 2007.

3. The Monitoring Information System and Discussion

In order to continuously ensure that the buildings still remain sustainable within the standards of the rating systems, a real-time information technology enabled monitoring system is proposed. This information system encompasses different technologies and can be applied in commercial, institutional and residential buildings providing real-time sustainability data for either building owners or the authorities of the rating system's organizations. This information system includes those criteria which are variable over periods of time. These criteria include water, energy, resource usage and indoor environment measures. Consequently,

criteria such as innovation, land and management which do not vary over the time are not included in the monitoring system. These criteria are measured once at the time the certificate is issued.

TABLE 2: Eleven identified common criteria of the rating systems

Common Criteria	Waste/Pollution	Well-being	Water	Innovation
Rating Systems	BREEAM (Waste/Pollution), Green Star (Emission), DGNB (Utilization of Resources and Waste Arising)	BREEAM (Health and Wellbeing), DGNB (User Health and Satisfaction)	BREEAM (Water), LEED (Water Efficiency), Green Star (Water), DGNB (Utilization of Resources)	LEED (Innovation in Design), Green Star (Innovation)
Common Criteria	Land	Indoor Environment	Quality	Management
Rating Systems	BREEAM (Land Use and Ecology), LEED (Sustainable Sites, Regional Priority), Green Star (Land Use and Ecology), DGNB (Impact on Environment), GBTool (Site Selection, Environmental Loadings)	All Rating Systems	LEED (Indoor Environmental Quality), Green Star (Indoor Environmental Quality), CASBEE (Quality of Services), DGNB (Quality of the Technical Implementation, Quality of the Planning, Quality of the Construction Activities), GBTool (Indoor Environmental Quality)	BREEAM (Management), Green Star (Management), DGNB (Quality of the Planning) ,GBTool (Project Planning, Long-term Performance)
Common Criteria	Energy	Transportation	Resources	
Rating Systems	All Rating Systems	BREEAM (Transport), Green Star (Transport)	All Rating Systems	

Figure 1 demonstrates the proposed monitoring system. This information system contains three major modules: a) input data which gathers information throughout the buildings. This can be done by the use of sensors attached to the inputs [17]; b) the monitoring system which analyzes the input data and c) management dashboard which represents the online status of the sustainability of the buildings.

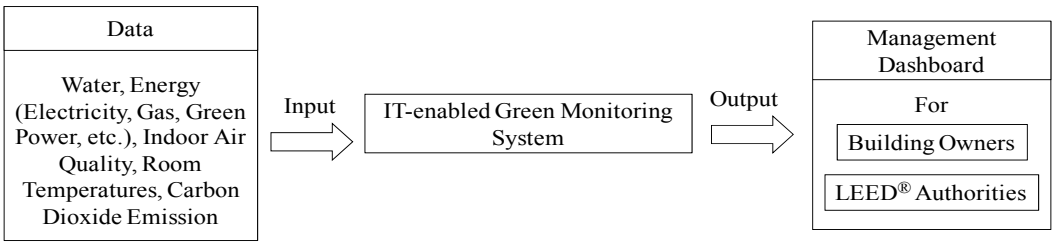

Fig. 1. The proposed green monitoring information system

This system checks for:

- Water efficiency: if the pattern of the water usage is in acceptable tolerance
- Energy efficiency: if the utilization pattern of the energy including electricity, gas, green powers etc. are within the standards
- Does the indoor air quality meet standards?

- Is the room temperature is within the limits (thermal comfort)?
- Does the total carbon dioxide emission is due to the permissible limits?

By deploying this information system, the owners of the buildings and the rating system organizations will be able to ensure that the operating costs of the building would reduce, energy such as gas and electricity would be conserved economically, the building would be safer and healthier for the occupants and finally harmful emissions are reduced and controlled in amount.

4. References

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