Energy and Buildings 123 (2016) 106–118

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Integrated system approach to evaluate social, environmental and economics impacts of buildings for users of housings

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ARTICLE INFO

Article history:
Received 15 February 2016
Received in revised form 17 April 2016
Accepted 18 April 2016
Available online 27 April 2016

Keywords:
Integrated system
Social impacts
Economic impacts
Sustainability indicators
Sustainable buildings
Assessment tool

ABSTRACT

Sustainable building and/or green building strategies have been founded on two basic principles: energy efficiency and environmental responsibility. Energy efficiency attempts to serve a dual purpose, the first geopolitical – to end dependency on fossil fuel supplies from other countries – and the second to reduce energy consumption. While various methods for assessing the environmental impact of residential buildings are available and a number of certifications have been created, these certifications do not actually help home owners and users, but rather are endorsing buildings that have been constructed with no attempt at sustainability, thus making the diffusion of any sustainability criteria in construction that much more difficult. This study aims to develop a simple user-friendly tool for home owners that provides the same rigor that current sustainability certificates offer the professional builder and property developer. A sustainability appraisal is carried out based on social, environmental and economic impacts, each of which is evaluated using easily understandable parameters. The integrated system is then verified through the case study of a real residential building. The subsequent results demonstrate a better building performance when pursuing green demand in housing and also indicate the changes required for improvement. In applying this new integrated tool we are able to confirm its ease of use, along with its highly comparable results with any other evaluation tools currently available.

1. Introduction

The 1990 Building Research Establishment Environmental Assessment Method (BREEAM) was the first building environmental assessment rating system developed in the UK [1,2]. It was a benchmark model for methods developed in Canada, New Zealand, Norway, Singapore and Hong Kong [3]. Following this the HK-BEAM system [4] was developed in Hong Kong in December 1996. The Leadership in Energy and Environmental Design (LEED) created by the US Green Building Council (USGBC) for the US Department of Energy [5] was the next method to be created. The pilot version, known as Version 1, was developed in August 1998 and from there has evolved into the current Version 4 [6]. The 2002Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is the rating system and building environmental assessment method created in Japan and administered by the Institute for Building Environment and Energy Conservation (IBEC) [7]. The "Deutsche Gesellschaft für Nachhaltiges Bauen" (DGNB), developed by the German Sustainable Building Council, appeared on the market in 2007 and aimed to become an international rating system which would be the benchmark in Europe as it was based on legislation regarding technology in the European Standards [8]. In Spain the benchmark organisation for sustainable building is the Green Building Council España (GBCe), which was recognised as an Established Council in 2011. This organisation developed VERDE, whose principle characteristic is the study of the environmental impacts created by the different criteria examined. These rating systems have been especially important in the task of establishing criteria and indicators for architects to design sustainable buildings that investors can invest in and developers can build.

While all of these rating systems have evolved over the years and have been modified and become more demanding in line with technological advances, BREEAM and LEED would be the two building environmental assessment tools most commonly used worldwide. The most recent version of LEED clearly illustrates this point as it includes credits in the materials and resources section to analyse the lifecycle (environmental product declarations) of the materials

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http://dx.doi.org/10.1016/j.enbuild.2016.04.046
0378-7788/

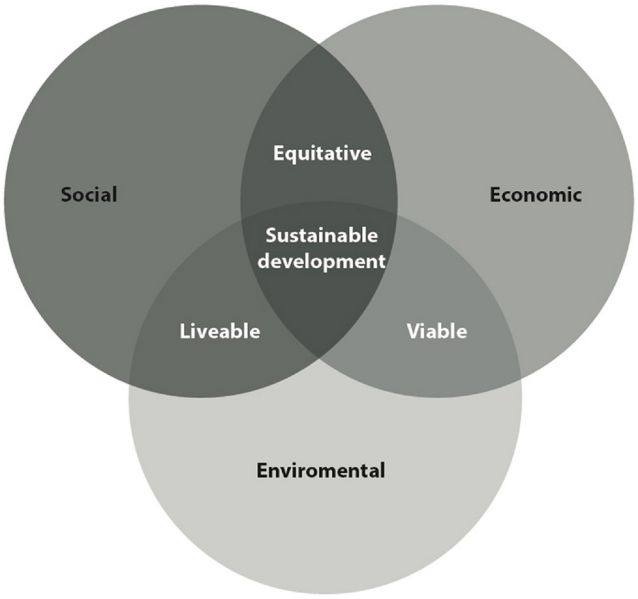

Fig. 1. Sustainable development model.

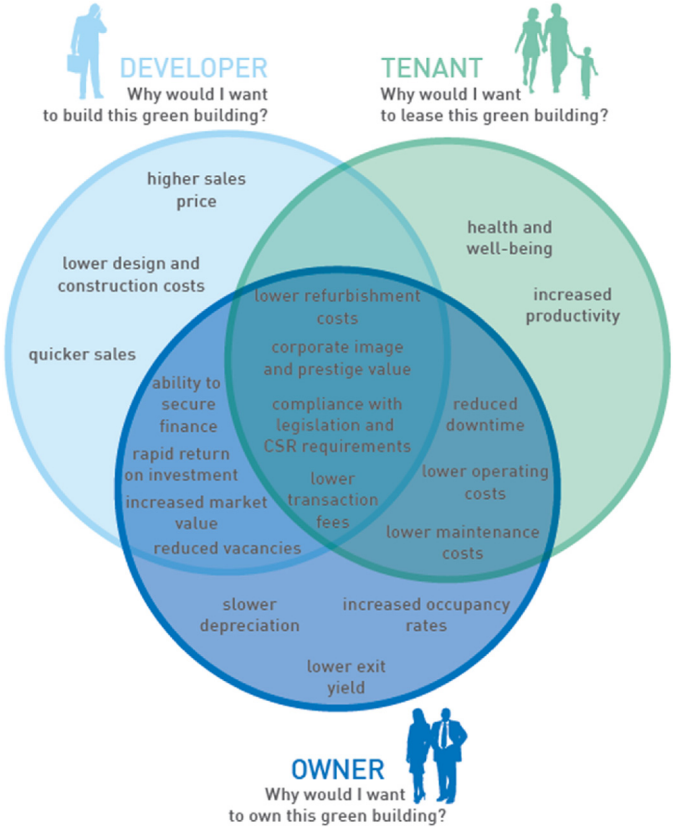

Fig. 2. Building stakeholders overview connections.

used to construct the building, and it now also includes credits in the Indoor Environmental Quality category for acoustic quality [9].

To provide the reader with more information and a general overview of these methods, a number of articles on energy performance rating systems will now be reviewed. A benchmark study on BREEAM, LEED, CASBEE, BEAM plus and the Chinese ESGB methods was carried out by Lee [10] and covers the history of these rating systems, how the assessment categories and criteria etc., are structured, to which type of buildings they can be applied, the method of the rating systems and other useful data.

Todd et al. [11] makes an important point about the method developed in this study: initially, these building environmental assessment tools focused on making environmental improvements in order to construct green buildings to which systems to assess social and economic aspects, in other words sustainable buildings, would be applied later. Most of these assessment tools, therefore, focus on physical and environmental aspects and give social and economic factors little importance. Son and Changwan [12], proposed a model designed to predict the costs of green building projects based on the level of detail in a project's planning phase.

Haapio and Viitaniemi [13], in their study, made a further relevant point in that the term "building performance" in itself is complex because the priorities of the various parties involved in the construction process are different: investors prioritise economic aspects and owners and renters prioritise health and comfort.

According to Alvarez [14], 50% of the world's population now lives in cities, and in Europe this figure equates to 70%–80% of the total population. Construction and maintenance in these cities account for 40% of all materials used, 33% of the energy consumed and 50% of the waste emissions produced. Consequently, and because building sustainability rating systems place such tremendous importance on the energy criteria, the weighting given to this aspect ranges from 18% in BREEAM to 33% in LEED.

In a case study Schawartz and Raslan [15] compare different energy simulation tools and how they affect BREEAM and LEED. The results obtained vary according to the energy simulation tool. The principle factors responsible for this variation are how the methods deal with the surface area of a building and how the temperatures each system uses to make calculations are characterised, which together affect the energy demand of a building. The conclusion was that BREEAM was awarded 6 out of the 27 available credits and that LEED failed to reach the minimum requirements and therefore obtained no points at all. However, if we consider the different relative importance that the two methods place on energy there was, in fact, no real difference. What does need to be stressed, though, are the differences between energy simulation tools and the effect these can have on the various sustainability rating systems.

Ferreira et al. [16] make an important contribution with their work comparing the two most popular sustainable building assessment systems in Portugal, LiderA and SBTool, with BREEAM and LEED. SBTool, interestingly, bases its criteria on the three pillars of sustainability: environmental impacts, weighted at 40%, social impacts, weighted at 30%, and economic impacts, also weighted at 30%.

Seinre et al. [17] contribute a study on different impact categories such as Indoor Climate Quality, Energy Water Use, Material Impact and Project Site, and place them into two groups according to whether their impact is environmental or economic, representing graphically the weight of the different impact categories in BREEAM, LEED and the method suggested by the writers of the article in the case of Estonia. Appollini et al. [18] proposed a review focused on the definition and measures of sustainable supply management, including environmental and social aspects.

Many of these methods, including BREEAM and LEED, contain a qualitative Life Cycle Assessment (LCA). Castellano et al. [19] provide a table showing the different rating systems and which phases of the life cycle of a building are taken into account in each. However, if an analysis with quantitative results is required, the rating system has to be different and has to be based on the analysis of the life cycle of a building. As Castellano et al. [19] point out, this method is based on international legislation, i.e. ISO 14044:2006 and ISO 14040:2006, and, with regards to the construction sector in Europe, is complemented by legislation EN 15978 and EN 15804. It must be added that, at present, when carrying out an LCA on a