Renewable and Sustainable Energy Reviews 56 (2016) 906–915

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Key Performance Indicators (KPIs) approach in buildings renovation for the sustainability of the built environment: A review

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ARTICLE INFO

Article history:
Received 22 December 2014
Received in revised form
27 November 2015
Accepted 30 November 2015

Keywords:
KPI
Sustainability
Assessment
Built environment
Building
Renovation
Review

ABSTRACT

The reduction of the energy consumption and the improvement of the indoor climate issues when renovating can achieve added benefits including reduced outlay on government subsidies, and improved health due to less air pollution and a better indoor quality conditions and improved worker productivity. This is the essence of assessing the level of sustainability of building renovation projects. The functionality of the Key Performance Indicators (KPIs) approach has made it one of the most popular and valuable tools among recorded literature regarding the measurement of the level of sustainability of construction projects. The aim of this paper is to review the previous studies that employed the KPIs approach in buildings renovation for the measurement of the sustainability of the built environment. This work provides a brief foreword regarding the state of the art in building renovation projects, as well as the suitability of the application of the KPIs approach for the assessment of the level of sustainability in such projects and analyzes the results of the literature review. The future trends in building assessment methodologies for sustainability purposes are also presented, while some significant conclusions are also given based on the identification of the existing gaps of the specific field.

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http://dx.doi.org/10.1016/j.rser.2015.11.096
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1. Introduction

1.1. State of the art in building renovation

The transition of the European community towards sustainability is a combination of economic, environmental, and social challenges that entails the adoption of strategic approaches across all sectors. The built sector accounts for the 40% of Europe's energy consumption and more than the 40% of the European existing building stock is, in fact, older than 50 years [7]. Energy savings through the renovation of the existing building stock is one of the most attractive and low cost options to reduce the emissions of CO_2 and improve Europe's energy security. By reducing energy consumption and focusing on indoor climate issues when renovating, co-benefits can be achieved including reduced outlay on government subsidies, and improved health due to less air pollution and a better indoor climate, both of which also lead to fewer hospitalisations and improved worker productivity. Consequently, the need for taking drastic action for the sustainability of building renovation projects is evident throughout the European policy and legislation.

Europe 2020 is the EU growth strategy of the current decade. Concretely, the union has set five ambitious objectives to be reached by 2020 in specific fields, energy being one of them. More specifically, energy efficiency is one of the five pillars of action of the 2020 energy strategy as well as a key factor in achieving the long-term energy and climate goals. Europe is blessed with a vast amount of potential when it comes to saving energy. Energy conservation is largely dominated by existing buildings. Thus the reuse of the existing housing stock in European countries is increasingly becoming a primary concern of European housing policy and practice because the annual production of new dwellings amounts to only about 1% of the housing stock [18].

A key driver for implementing energy efficiency measures are the building energy codes, through which energy-related requirements are incorporated during the design or retrofit phase of a building. While several Member States had some form of minimum requirements for thermal performance of building envelopes in the 1970s, the Energy Performance of Buildings Directive (EPBD) was the first major attempt requiring all Member States to introduce a general framework for setting building energy code requirements based on a “whole building” approach. Major changes are currently taking place through the application of the cost-optimality concept in energy performance requirements as introduced by the recast EPBD which should also gradually converge to nearly zero energy standards, a requirement for new buildings from 2020 onwards. Prior to the implementation of the recast of the EPBD, the largest percentage of the existing building stocks across Europe presented annual energy demands for space heating and domestic hot water in the range between 150 KW h/m² year and 300 KW h/m² year [4]. However, the success of the EPBD has been recorded in literature using actual case studies– the average energy consumption of dwellings has been reduced by at least75 KW h/m² year [10] and the total annual primary energy demand for all end-uses in energy efficient buildings does not usually exceed 120 kW h/m², corresponding to about 24.5 kg CO_2/ m² [3]. By 2012, the primary energy consumption of dwelling has dropped to less than 80 KW h/m² year, whereas class A dwelling currently consume not more than 60 kW h/m² year [10].

The Renovate Europe is a major EU-campaign initiated by EuroACE (The European Alliance of Companies for Energy Efficency in Buildings). Renovate Europe currently organizes events through-out Europe and publishes reports on boosting renovation measures in Europe. The campaign aspires to reduce the energy demand of the EU building stock by 80% by 2050 compared to 2005 levels. This is expected to be accomplished by encouraging all renovations to be deep or staged deep renovations in order to triple the EU's average renovation rate from the current 1% to 3% per year before 2020.

Additionally, the Strategic Energy Technology Plan (SET-Plan) represents the principal decision- making support tool for the energy technology policy for Europe. The SET- Plan provisions the refurbishment of at least 50% of existing public buildings strategies and for the complete refurbishment of 50% of all existing buildings.

Evidently, the sustainable renovation and energy upgrading of the European existing building stock is considered to be part of the solution of the European community's vision. Building renovation projects are not simply about the realization of low energy buildings by reducing the buildings' energy consumption and incorporating low carbon technologies. Sustainable construction and building renovation are about reducing the long-term costs and focusing on the long-term affordability. They are about the simultaneous maximisation of the energy and cost efficiencies and the improvement of the well-being, and health of the residents of the renovated building. A sustainable building renovation project is anticipated to increase the comfort levels and the quality of life, while minimizing the negative environmental impacts and increasing the economic sustainability of the construction.

1.2. Essence of Key Performance Indicators in building renovation

A number of approaches have been previously employed for the definition of the level of sustainability of renovation projects of the built environment. Key Performance Indicators (KPIs) reflect a project's goals and provide means for the measurement and management of the progress towards those goals for further learning and improvement. Consequently, the functionality of the KPIs approach has made it one of the most popular and valuable tools among recorded literature regarding the measurement of the level of sustainability of construction projects. In particular, the suitability of this approach to a building renovation project emerges from the fact that the sustainability of a building renovation project is affected and depended on a long list of aspects.

The key objective of this review paper is the demonstration and appraisal of the previous work that has been conducted for the assessment and definition of the level of sustainable constructions, through the adoption of KPIs methodologies. This will also lead to the definition of the current gaps that exist in this field, and indicate the aspects that need addressing in the future. This work begun with a brief foreword regarding the state of the art in building renovation projects, as well as the suitability of the application of the KPIs approach for the assessment of the level of sustainability in such projects. This paper will review the available literature that employed the KPIs approach in buildings renovation for the measurement of the sustainability of the built environment. Section 3 will analyze the results of this literature review, and also examine the functionality of the proposed KPIs in the sustainability assessment of building renovation projects. In the next section, the future trends in building assessment methodologies for sustainability purposes are presented, while some significant conclusions based on the analysis of this work will be drawn in Section 5.

2. Previous studies employing KPIs in building renovation

A number of studies have previously employed the KPI concept to define the sustainability of constructions and building renovations. Eight generic categories on the performance of the buildings have been identified, which employed a range of KPIs for their

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