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Cost–benefit analysis method for building solutions

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HIGHLIGHTS

- A new cost–benefit method was developed to compare building solutions.
- The method considers energy performance, life cycle costs and investment willingness.
- The graphical analysis helps stakeholders to easily compare building solutions.
- The method was applied to a case study showing consistency and feasibility.

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ABSTRACT

The building sector is responsible for consuming approximately 40% of the final energy in Europe. However, more than 50% of this consumption can be reduced through energy-efficient measures. Our society is facing not only a severe and unprecedented environmental crisis but also an economic crisis of similar magnitude. In light of this, EU has developed legislation promoting the use of the Cost-Optimal (CO) method in order to improve building energy efficiency, in which selection criteria is based on life cycle costs. Nevertheless, studies show that the implementation of energy-efficient solutions is far from ideal. Therefore, it is very important to analyse the reasons for this gap between theory and implementation as well as improve selection methods. This study aims to develop a methodology based on a cost-effectiveness analysis, which can be seen as an improvement to the CO method as it considers the investment willingness of stakeholders in the selection process of energy-efficient solutions. The method uses a simple graphical display in which the stakeholders' investment willingness is identified as the slope of a reference line, allowing easy selection between building solutions. This method will lead to the selection of more desired – from stakeholders' point of view – and more energy-efficient solutions than those selected through the CO method.

Contents

Abbreviations: EPBD, EU-Energy Performance of Buildings Directive; EU, European Union; CO, Cost-Optimal; CBA, Cost benefit analysis; DHW, Domestic Hot Water; LCC, Life Cycle Costs.

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1. Introduction

One of the main contributors to the world's severe environmental crisis is energy production and usage. In the EU-27, 80% of total GHG emissions are energy related [1]. In 2007 the Intergovernmental Panel on Climate Change (IPCC) [2] stated that the biggest portion of growth in carbon emissions was related to the buildings' operation. The building sector is responsible for consuming approximately 32% of the final energy and almost 40% of primary energy in Europe [3]. In many countries energy is also an important issue due to their high dependency on fossil fuel imports. Moreover, in 2013 more than half (53.2%) of the EU-28's gross inland energy consumption came from imported sources [4]. One obvious way to solve Europe's energy problems is to reduce energy consumption [5]. This can be achieved through building energy-efficient measures [6,7].

In order to deal with these issues and to accomplish the European climate and energy targets for 2020 [8], 2030 [9] and 2050 [10], substantial changes must be applied within the building sector. The Directive 2002/91/EC on Energy Performance of Buildings (EPBD) and its recast, the Directive 2010/31/EU, are currently the most important policies [3,11]. They aim to improve buildings' energy performance. In order to fulfil the requirements of these directives, several energy-efficient measures are to be applied both in new buildings and in retrofitting operations. In order to evaluate the energy and economic performance of building elements, the EPBD recast [3] has been imposed on EU Member States to implement a comparative methodology for calculating Cost-Optimal (CO) levels of minimum energy performance requirements for buildings and building elements [3]. The framework for the CO methodology has been published in the delegated regulation 244/2012 [12].

The CO method defines a reference scenario, representing the local building market, and compares several alternative building solutions based on their primary energy demand and Life Cycle Costs (LCC). The solutions are graphically represented, based on these parameters. This methodology assumes that the solutions (presented as dots) will draw a typical U-shaped curve, as shown in Fig. 1. The less expensive solution is therefore easily identified at the bottom. The selection process of the CO method indicates the CO building solution as the one leading to the lowest estimated LCC [12].

The selection criteria for EU's CO method focuses on the lowest LCC solution, and therefore prioritised over energy performance. This is because the development of the CO method was in alignment with policy makers needs and not with building investors or users' interests. This method was developed to be applied in the macro economy and aims to support the definition of reference values for CO solutions in EU Countries. In cases where stakeholders are less concerned with economic performance or more aware of environmental problems, this methodology can unnecessarily lead to higher energy consumption. In these cases it is necessary to develop and apply methods specifically developed to be used by small investors in a micro economy context.

Congedo et al. [14] and Baglivo et al. [15] applied the CO method to identify cost-optimal levels in new residential buildings located in a warm climate. The results showed that there is a gap between the CO solution and the energy-optimal solution, suggesting that this aspect should be thoroughly analysed. Becchio et al. [16] and Pikas et al. [17] reached the same conclusions. Due to

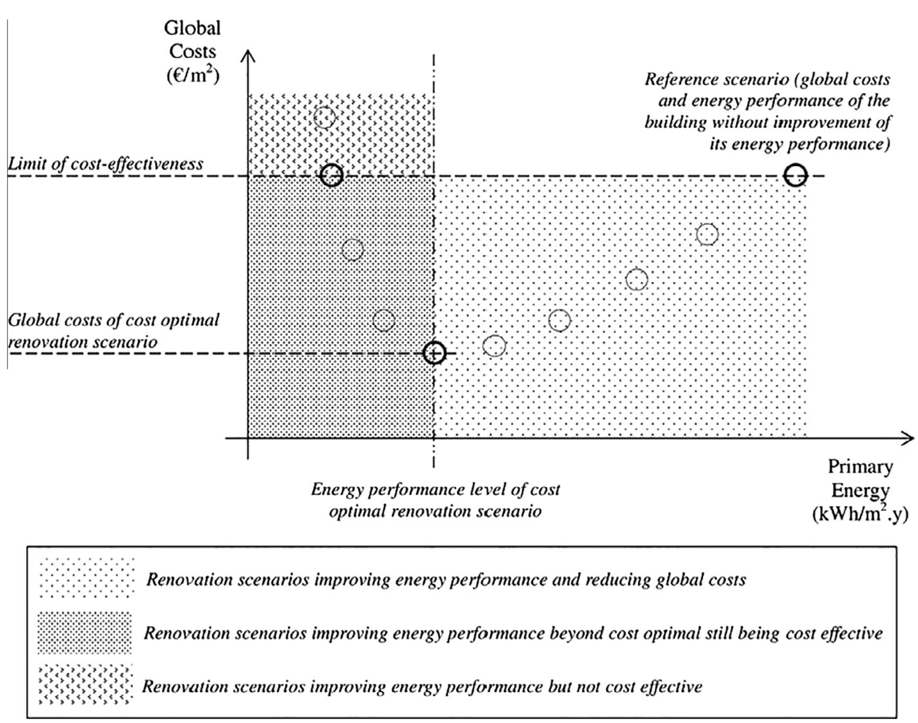

Fig. 1. Graphical representation of the Cost-Optimal method [13].