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Environmental and financial life cycle assessment of 'open-renovation-systems': methodology and case study

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Abstract

The emphasis in this research is on affordable and innovative semi-prefabricated 'open-renovation-systems' for extending residential buildings. Based on an existing LCA (life cycle assessment) and LCC (life cycle costing) methodology, two methodological issues in evaluating renovation interventions are assessed: (1) the allocation of the environmental impact of the existing structures and materials to the life cycle before and after renovation and (2) the energy calculation method. An existing semi-prefabricated 'open-renovation-system' for a rooftop extension is assessed both on element and building level from an environmental and financial life cycle perspective.

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Keywords: Life Cycle Assessment (LCA); Life Cycle Costing (LCC); sustainable renovation; rooftop extension; semi-prefabricated elements; allocation; building lifespan; energy calculations

1. Introduction

Renovation in Europe is mainly focusing on reducing the operational energy of buildings and hence has often a narrow scope regarding sustainability. A screening of current practices in Flanders (Belgium) confirms that renovations are often limited to small interventions to improve the energy performance and shows that these interventions often miss a long term vision. In Flanders, we are mainly dealing with a privative housing ownership and most of the renovation interventions are ad hoc solutions for ad hoc renovation questions. As these interventions

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are so specific, they are often expensive and time consuming. Examples in other contexts show that a different approach is possible.

In the Netherlands, for example, prefabricated industrial building systems are more and more used. As prefabricated building systems are assembled off-site, the work on-site is limited to the mounting of the prefabricated elements, attaching these elements on the existing structure and some finishing works. These aspects reduce the renovation time of a building to a few days, which leads to less disturbance for the neighborhood and the inhabitants of the renovated houses. The 'Bestaande Wijk van Morgen' project in Kerkrade West [1] and the passive renovation project 'De Kroeven' in Roosendaal [2] are two examples of large scale renovations projects in the Netherlands that used prefabricated elements for the building envelop renovation. These projects confirm that prefabricated industrial building systems can result in faster and affordable renovations. Beside these projects, some innovative European demonstration projects have been set-up in the last decades. TES EnergyFacade [3], IEA ECBCS annex 50 [4] and E2ReBuild [5] are some examples of such projects. These projects show that a high quality renovation can be reached by the use of prefabricated elements while inhabitants can remain in their houses during the renovation works. The TES Energy façade project shows furthermore the many possibilities of prefabricated elements for renovation with volume expansion [6].

Beside the problem of the ad hoc renovation market in Flanders, there is a need for a more flexible building stock. A growing Flemish population accompanied by a decreasing household size results in a need for additional houses [7]. The needs of a household moreover change over time, e.g. due to family expansion or contraction or evolving comfort requirements. A flexible and adaptable housing stock could hence contribute in the overall aim to move towards a more sustainable built environment. Interventions as splitting, combining and extending existing buildings are possible solutions to deal with these changing needs and to avoid spatially underused buildings and will be more and more required in the future. In order to execute these interventions in a sustainable manner there is a need for affordable and adaptable building systems with a low environmental impact.

This paper focuses on the assessment of the life cycle financial and environmental impact of rooftop extensions. The goal of the paper is twofold: (1) some methodological issues in evaluating renovation interventions are discussed and analyzed and (2) an existing semi-prefabricated 'open-renovation-system' for a rooftop extension is assessed both on element and building level from an environmental and financial life cycle perspective.

Nomenclature

LCA	Life Cycle Assessment
LCC	Life Cycle Costing
EDD	Equivalent Degree Day

2. Methodology

The assessment of the life cycle environmental impact of the rooftop extension is based on the Belgian MMG LCA method developed by OVAM [8]. This method follows an integrated life cycle approach, as recommended by the European standards EN 15804 [9] and EN 15978 [10] for the evaluation of construction materials and buildings. The MMG method considers the entire life cycle of the building, mainly classified as the initial stage, use stage and end-of-life (EOL) stage. The set of impact categories in this method not only includes the ones of the CEN standards, but comprises also seven additional impact categories (referred to as CEN+ indicators). The results are expressed in environmental costs, i.e. external costs caused by environmental impacts. At the research division Architectural Engineering of the KU Leuven, the MMG method was translated in an excel based tool. The life cycle financial cost calculations, based on an LCC approach, was moreover integrated in this tool, allowing for a combined assessment of environmental impacts and financial costs. In this paper the emphasis is on two methodological issues in evaluating renovation interventions, and more specific rooftop extensions: (1) the allocation of the environmental impact of the existing structures and materials to the life cycle before and after renovation and scenario analysis concerning the first life span of the building and its components and (2) energy calculations.

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