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Life cycle assessment of an apartment building: comparison of an attributional and consequential approach

Matthias Buyle*[,a], Johan Braet[b], Amaryllis Audenaert[a,b]

[a]*Faculty of Applied Engineering Sciences: Construction, University of Antwerp, Paardenmarkt 92, B-2020 Antwerp, Belgium*
[b]*Department of Environment and Technology Management, Faculty of Applied Economics, University of Antwerp, Rodestraat 4, B-2000 Antwerp, Belgium*

Abstract

Life cycle assessment (LCA) as tool to improve sustainability of the construction sector is receiving increasing attention. Different methodological approaches of LCA have already been applied in other research fields, however they have barely been applied on buildings. This study conducts a screening LCA of an apartment located in Buggenhout, Belgium, according to the two main approaches, respectively attributional (ALCA) and consequential (CLCA). Not only the as-built situation is taken into account, but also two brief optimization scenarios are included. The aim is to identify and compare possible differences in results between the two approaches when applied on the same case.
The results indicate a shift in proportions between the different life cycle stages, in particular at the end-of-life stage. However, more important are the differences between individual materials and components, which can result in different proposals for optimization. The two included optimization scenarios support this statement, the first one for the selection of insulating materials and the second one for two different actions to improve energy efficiency (increasing insulation vs. installing a heat pump).

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Keywords: Life cycle assessment, CLCA, ALCA, sustainable building, case study

* Corresponding author. Tel.: +32-474-80-52-72;
E-mail address: Matthias.buyle@uantwerpen.be

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1. Introduction

In our society buildings are omnipresent, but they inevitably entail negative consequences from an environmental point of view. During their lifespan, they consume plenty of resources and energy, occupy land and at the end they are demolished. As the interest in environmental issues is rapidly growing, also within the construction industry, more attention is being paid to energy efficiency, sustainable housing technologies and construction methods. In the construction sector, this resulted for instance in regulations to decrease energy consumption of dwellings and consequently their ecological burdens i.e., the Energy Performance of Buildings Directive 2002/91/EC (EPBD, 2003) and the revised EPBD 2010/31/EU issued by the European Union [1], [2]. But before any conclusions can be drawn about sustainability, the ecological impact of the whole life cycle has to be investigated, based on the methodology of a life cycle assessment (LCA). Despite the fact LCA takes the entire life cycle into account, still many assumptions and methodological choices have to be made throughout a study, which can lead to different outcomes. Traditionally, attributional LCA (ALCA) and consequential LCA (CLCA) are considered as the two main approaches, however, only in the last few years CLCA is becoming better known and implemented [3].

The aim of this study is to evaluate the environmental impact of a three storey apartment building according to these two main approaches, ALCA and CLCA. Not only the as-built situation but also two brief optimization scenarios will be studied, in order to see if there are differences in priority for improvements depending on the modeling approach. The building under study is a semi-terraced house, designed by Architectenbureau Luc Lodewyckx and is located in Buggenhout in central Belgium (see Fig 1). The built surface is 285 m², the heated volume 1944 m³ and the main facade is south oriented. The calculated yearly energy demand for space heating is between 35,3 and 54,0 kWh/m², depending on the size, lay-out and positioning of the apartment.

2. LCA Methodology

In current practice LCAs are executed according to the framework of the ISO 14040 series [4]. To analyze the environmental burdens of processes, products or services during their entire life cycle and to make it possible to compare different studies, four steps have to be run through: goal and scope, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) and an interpretation [5]–[8]. The first step, goal and scope, defines purpose, objectives, functional unit and system boundaries. One of the strengths of LCA is defining investigated products, processes or services based on their function instead of on their specific physical characteristics. This way, products can be compared that are inherently different, but fulfill a similar function e.g., paper towels versus reusable cotton towels for drying hands. The second step (LCI) consists of collecting, as well as describing and verifying, all data regarding inputs, processes, emissions, etc. of the whole life cycle. Third (LCIA), environmental impacts and used resources are quantified, based on the inventory analysis. At the present time there is a large set of impact categories commonly used, but ISO 14044 states that when the existing categories are not sufficient, new ones can be defined [6]. The fourth and final step is the interpretation of the results [4], [6].

Fig. 1 perspective facade