DOI 10.1007/s12273-013-0159-y

Research Article

Architecture and Human Behavior

Life cycle assessment of a single-family residential building in Canada: A case study

Weiqian Zhang[1], **Shen Tan**[2], **Yizhong Lei**[2], **Shoubing Wang**[1] (✉)

1. Department of Environmental Science and Engineering, Fudan University, No.220 Handan Road, Shanghai 200433, China
2. Department of Civil Engineering, University of British Columbia, Vancouver, BC V6T1Z4, Canada

Abstract

The present study quantified the significant environmental impacts of a two-story residential building located in Vancouver, Canada, with a projected 60-year life span: (i) an inventory of all the construction materials was analyzed, covering the building structure and exterior and interior envelopes as well as the energy consumption; (ii) four types of functional units were defined; (iii) the five top building materials were examined, and a sensitivity analysis was conducted to investigate the impact associated with the choice of building materials. Two life cycle phases, manufacturing and operation, were more significant in all of the impact categories, and two building assemblies, the walls and the roof, bore most of the environmental loads. In terms of the sensitivity analysis, the roofing asphalt had the largest impact, dominating three of the seven selected impact categories. Despite different definitions of functional units, the function of the dwelling buildings is always the same, to provide protection and housing for their habitants. Additionally, to improve the performance of an existing building, several strategies were proposed for the building renovation and maintenance, including alternative replacement materials regarding the building components with high environmental burdens, good patterns of the occupants' consumption behaviors as well as considerations of the financial and environmental cost. Finally, limitations and challenges are discussed to explore better design decisions in future studies.

Keywords

life cycle assessment,
residential building,
sensitivity analysis,
renovation,
Canada

Article History

Received: 27 March 2013
Revised: 18 September 2013
Accepted: 30 September 2013

1 Introduction

Sustainability has become a global issue, with increasing concern and awareness about resource consumption, global warming, ozone depletion and other environmental issues. In every country, the construction and building sector has been a major contributor to socio-economic development as well as a huge user of natural resources and energy (Asif et al. 2007). Especially in industrialized countries, the building sector, including housing, accounts for 36% of the energy related to CO_2 emissions and 40% of the primary energy consumption (International Panel on Climate Change 2011). Consequently, conservation in the building sector must be prioritized to reach a sustainable society. As the most credible tool to measure the environmental impacts of products over their life cycle, life cycle assessment (LCA) methodology can be applied to the full building life cycle, making it possible to improve sustainability indicators and also minimize the environmental loads throughout a system (Fava 2004). The methodology has been used in the building sector since 1990 and is becoming more and more important for promoting sustainable buildings (Boonstra and Pettersen 2003; Ding 2008).

There have been various studies on complete LCAs within the residential building industry (Ortiz et al. 2009b). Blanchard and Peppe (1998) analyzed a 2450 ft^2 residential home in Michigan. The total life cycle energy was 15 455 GJ, and the life cycle global warming potential (GWP) was 1013 metric tons of CO_2 equivalents; in addition, different energy-efficiency strategies and substitution of selected materials have been modeled to reduce the GWP and life cycle cost. Peuportier (2001) compared three single-family houses (a

E-mail: sbwang@fudan.edu.cn