Available online at www.sciencedirect.com

ScienceDirect

Construction and Building Materials 23 (2009) 28–39

Construction and Building MATERIALS

www.elsevier.com/locate/conbuildmat

Review

Sustainability in the construction industry: A review of recent developments based on LCA

Oscar Ortiz [a,b,*], Francesc Castells [a], Guido Sonnemann [c]

[a] *University of Rovira i Virgili, Environmental and Analysis Management Group (AGA), Department of Chemical Engineering, Av. Països Catalans 26, 43007 Tarragona, Spain*

[b] *University of Pamplona, Faculty of Engineering and Architecture, Km 1 Vía Bucaramanga, Pamplona N de S, Colombia*

[c] *University of Rovira i Virgili, Visiting Senior Research Fellow, AGA Group (AGA), Spain*

Received 19 September 2007; received in revised form 9 November 2007; accepted 25 November 2007
Available online 21 February 2008

Abstract

This review brings together research on life cycle assessment (LCA) applied within the building sector. More than ever, the construction industry is concerned with improving the social, economic and environmental indicators of sustainability. By applying LCA it is possible to optimise these aspects, from the extraction of raw materials to the final disposal of waste building materials. Firstly, this review details LCA concepts and focuses on the LCA methodology and tools employed in the built environment. Secondly, this paper outlines and discusses the differences between the LCA of building materials and components combinations versus the LCA of the full building life cycle. Finally, this work can be used by stakeholders as an important reference on LCA including up to date literature on approaches and methodologies to preserve the environment and therefore achieve sustainable development in both developed and developing countries.

The present review has tried to compile and reflect the key milestones accomplished in LCA over the last 7 years, from 2000 to 2007 within the building sector. In summary, it can be stated that the application of LCA is fundamental to sustainability and improvement in building and construction. For industrial activities, SMEs must understand the application of LCA, not only to meet consumer demands for environmentally friendly products, but also to increase the productivity and competitiveness of the green construction markets. For this reason, this review looks at LCA because of its broad international acceptance as a means to improve environmental processes and services, and also for creating goals to prevent adverse environmental impacts, consequently enhancing quality of life and allowing people to live in a healthy environment.

Keywords: Building materials; Building life cycle; Construction industry; LCA; Sustainability; Sustainable development

Contents

* Corresponding author. Address: University of Pamplona, Faculty of Engineering and Architecture, Km 1 Vía Bucaramanga, Pamplona N de S, Colombia. Fax: +57 34 977559621.

E-mail addresses: oscar.ortiz@urv.cat (O. Ortiz), francesc.castells@urv.cat (F. Castells), Guido.Sonnemann@unep.fr (G. Sonnemann).

0950-0618/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.conbuildmat.2007.11.012

1. Introduction

The term sustainable development can be described as enhancing quality of life and thus allowing people to live in a healthy environment and improve social, economic and environmental conditions for present and future generations. Since the world commission on environment and development (WCED), entitled Our Common Future (1987), sustainable development has gained much attention in all nations and a report was published which called for a strategy that united development and the environment and which also made a declaration describing sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs [1]. Sachs [2] believed that the great challenge of the 21st century would be sustainable development. Vollenbroek [3] stated that sustainable development is a balance between the available technologies, strategies of innovation and the policies of governments.

The improving social, economic and environmental indicators of sustainable development are drawing attention to the construction industry, which is a globally emerging sector, and a highly active industry in both developed and developing countries [4–6]. Socially and economically, the European Commission (2006) stated that 11.8 million operatives are directly employed in the sector and it is Europe's largest industrial employer, accounting for 7% of total employment and 28% of industrial employment in the EU-15. About 910 billion euros was invested in construction in 2003, representing 10% of the gross domestic product (GDP) and 51.2% of the Gross Fixed Capital Formation of the EU-15 [7]. By contrast environmentally, this sector is responsible for high-energy consumption, solid waste generation, global greenhouse gas emissions, external and internal pollution, environmental damage and resource depletion [8–10].

In order to overcome the increasing concern of today's resource depletion and to address environmental considerations in both developed and developing countries, life cycle assessment (LCA) can be applied to decision making in order to improve sustainability in the construction industry.

The aim of this review is to systematically examine previous LCA research on the building sector in order to analyse the current situation and to outline the key challenges concerning LCA and the construction industry. Firstly, this paper provides details of LCA and its methodology, which is based on International standard series ISO 14040. Secondly, the review systematically explores and evaluates the different ways of using LCA for building materials and component combinations (BMCC) and LCA of the whole process of the construction (WPC), for example, in urban constructions of dwellings, commercial buildings and other civil engineering projects over the last 7 years, from 2000 to 2007. Following this, we present the discussion of the perceived advantages and limitations of LCA, and finally, we look at the outlook and challenges for ongoing research in LCA and draw some conclusions.

2. Conceptual basis of life cycle assessment (LCA)

Life cycle assessment (LCA) is a methodology for evaluating the environmental load of processes and products (goods and services) during their life cycle from cradle to grave [11–16]. LCA has been used in the building sector since 1990 and is an important tool for assessing buildings [17,18].

Klöpffer [19] stated that LCA has become a widely used methodology because of its integrated way of treating topics like framework, impact assessment and data quality. The description of the LCA methodology is based on the International standards of series ISO 14040 and consists of four distinct analytical steps: defining the goal and scope, creating the inventory, assessing the impact and finally interpreting the results [20]. This paper will now briefly explore LCA methodology.

Firstly, defining goal and scope involves defining purpose, audiences and system boundaries. Secondly, the life cycle inventory (LCI) involves collecting data for each unit process regarding all relevant inputs and outputs of energy and mass flow, as well as data on emissions to air, water and land. This phase includes calculating both the material and the energy input and output of a building system. Thirdly, the life cycle impact assessment (LCIA) phase evaluates potential environmental impacts and estimates the resources used in the modeled system. This phase consists of three mandatory elements: selection of impact categories, assignment of LCI results (classifications) and