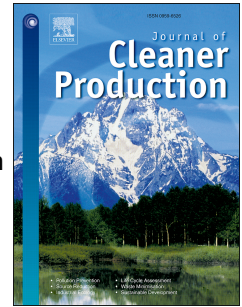


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Building-information-modeling enabled life cycle assessment, a case study on carbon footprint accounting for a residential building in China

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Abstract: Building Information Modeling (BIM) is regarded as a potential vehicle to tremendously improve the information flow throughout the life cycle of a building. The integration of BIM and Life Cycle Assessment (LCA) has potential to reduce the time for life cycle inventory, and at the same time, substantially improve the representativeness of the LCA results for the specific building design. The latter merit is not trivial. For instance, due to time limit, most building LCA studies estimate the building materials and fuels consumed in construction phase quite roughly, which excludes the choices on a wide range of construction techniques, materials, specialties and machines, no need to mention the energy consumption in operation phase, which is usually estimated in an even bolder manner. The roughness of the LCA practice undermines its credibility and hinders its application as a decision supporting tool for low carbon design. Currently, China's Architecture, Engineering and Construction (AEC) sector is undergoing a smart transformation, steered by the increased use of BIM. This paper presents a BIM-enabled LCA method and illustrates how the method can be used to facilitate the low carbon design under the circumstance of the smart AEC transition in China. A case study on carbon footprint accounting for a residential building is conducted. In this study, various software tools and data sources are combined to enhance the data flow and interoperability between BIM models and LCA models. BIM tools are used to create the BIM model, calculate the inputs (materials, construction machines, energies, water and so on) of on-site construction process and simulate the energy consumption of building operation. The eBalance, a China's local LCA software tool is applied to build the LCA model. The Chinese Life Cycle Database is used as the main data source (72.73%) to calculate the carbon footprint of the given building while the Ecoinvent database and European Life Cycle Database act as supplementary. The results show that the carbon footprint of the building is 2993 kg CO₂eq/m². The operation phase contributes to 69% of the total greenhouse gas (GHG) emission, while the building material production contributes to 24%. Concrete is the most used building material, which accounts for 82% of mass but contributes to only 44% of the material related GHG emission. Although steel and aluminum account for only 2.6% and 1.4% of mass, they contribute to 28% and 17% GHG emission, respectively. Through BIM-enable LCA modeling, the potential life cycle environmental performance of the buildings can be assessed in detail. This makes the LCA not only more accessible but also more credible for the AEC professionals to use it as a guide for the low carbon design of buildings.

Keywords: Building Information Modeling, Life Cycle Assessment, Carbon Footprint, Low Carbon Design

1. Introduction

Global warming has drawn much attention of the whole world (Gustavsson et al., 2010). As the threat of climate change becomes more acute, carbon footprinting is more and more used for quantifying anthropogenic environmental impacts and for helping tackle the threat. The carbon footprint concept makes it easy to allocate the responsibility for global warming to consumers. It is defined as the amount of CO₂-equivalent emissions caused directly and indirectly by an activity (Wiedmann and Minx, 2008), or as the total amount of greenhouse gas (GHG) emissions over the life cycle of a process or product (BSI et al., 2008). It is widely accepted that the life cycle assessment (LCA) is a useful tool for calculating the carbon footprint, especially at the product level (Wiedmann and Minx, 2008). The Architecture, Engineering and Construction (AEC) sector is criticized as a relatively less regulated field in terms of control and management of GHG emissions (Wong et al., 2013). It consumes the majority of electric power, natural gas and water (Thompson, 2011) and contributes as much as about 33% of global GHG emissions (Ürge-Vorsatz and Novikova, 2008). In the past 30 years, China, the largest developing country in the world, has witnessed fast urbanization and become the largest construction market in the world (Xiaodong et al., 2015). In this process, environmental pollution

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