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Main factors influencing greenhouse gas emissions of wood-based furniture industry in Finland

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ABSTRACT

The significance of green values is growing in the furniture sector; customers are demanding more specific environmental information of the products, new regulations are tackling to reduce greenhouse gas emissions. Life-cycle assessment is an important tool for better understanding, awareness and communication of environmental issues. It can also help to develop more energy and resource efficient production processes contributing to overall improvement of environmental performance of products. The main objective of this study was to assess greenhouse gas emissions of different furniture. Eight different furniture manufacturing processes were assessed to identify main factors that contribute to greenhouse gas emissions. Life-cycle assessment software was used to assess cradle to gate impacts of manufacturing processes. Case study results shows that materials have a significant impact on greenhouse gas emissions of products (38–90 per cent). Processing and assembling can also have impact on greenhouse gas emissions (8–58 per cent); packaging and transportation have a minor role (1–8 per cent). Our results indicate that the environmental impacts of products can be reduced by influencing the materials selection and energy generation systems. Energy from renewable and biogenic energy resources can reduce greenhouse gas emissions significantly in all production stages.

1. Introduction

Nordic countries are known for high quality and design furniture. Recently also green values of materials used in the furniture have become more important. Companies in the furniture sector are increasingly interested in developing their processes to be more resource efficient and in gaining more information on the environmental impacts of their products. Drivers arising from legislation and customer awareness have become stronger and companies have set their own targets to emphasize that they pay attention to continuous improvement of their environmental performance. Many new regulations and standards have been introduced in Europe to decrease greenhouse gas emissions, and even more development will come in near future to achieve climate and energy targets of EU by 2020 (EC, 2008a, 2009). When building sector is aiming toward nearly zero energy houses, importance environmental performance of building and housing products will increase. Less energy consuming and more environmentally friendly products are needed. Also EU's green public procurement guidelines instruct public authorities to use renewable materials, reduce CO_2 emissions, avoid loss of biodiversity, protect water and reduce waste in furniture procurements (EC, 2008b, 2008c, 2008d; Parikka-Alhola, 2008). Total amount of greenhouse gas emissions (i.e. Global Warming Potential) associated with the manufacturing of a single product as a result of life-cycle assessment is a typical example of informative way to investigate the environmental impacts of products including the use of this information to create an Environmental Product Declaration (EPD), an ecolabel or other environmental information (Kivi et al., 2004; Fet et al., 2009). In furniture manufacturing, Besch (2005) tackled environmental impacts of office furniture, most of the impacts are related to the furniture production and disposal steps. Iritani et al. (2015) found that in manufacturing stage material supply and distribution of finished product are most crucial stages.

Life-cycle assessment (LCA) is a tool for better understanding, awareness and communication of environmental issues. It can help to improve environmental performance of products in their whole life-cycle (Guinée et al., 2002). Many life-cycle assessment studies

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have been carried out in the field of furniture production during the last few years. Eco-design (also design for environment) is one of the most studied field, it is a systematic way to include all environmental aspects of life-cycle to the design process, taking into account all production processes and material selections which have an impact on environmental performance (Hauschild et al., 2004; Michelsen et al., 2006). Eco-design thinking is a very timely and interesting topic that takes into account ecological values in the design process. This approach requires a totally new kind of design concept and environmental impact information on the used materials (Bovea and Vidal, 2004; Çinar, 2005; Bovea and Gallardo, 2006; González-Garsía et al., 2011, 2012; Lanoë et al., 2013; Mirabella et al., 2014). According to previous studies (Gamage et al., 2008; Iritani et al., 2015) assessment procedures are well suited for furniture production, but assessment data and large variation in materials complicate assessments.

In Finland furniture companies are using wood as their main raw material, partly because of historical reasons, but also because it has good properties for modification, as forming and bending properties. Additionally, customers consider it to be a pleasant and natural material. Consequently link between furniture and forest industries has been strong and interactive. Currently, furniture industry has raised environmental performance of furniture materials and manufacturing as one of their main improvement focus areas (Fomkin, 2010; Junnikkala, 2011; Witikkala, 2013). Previous study indicates that life-cycle thinking, management and assessment were considered to be important focus areas in the context of sustainability management within Finnish forest products industry even though they are currently not receiving enough management attention (Husgafvel et al., 2013).

This study aimed at investigate greenhouse gas emissions of the selected furniture manufacturing processes and materials, and at discuss how companies could use this new knowledge and perceive associated possibilities and challenges.

2. Material and methods

2.1. Goal and scope

The goal of this study was to assess greenhouse gas (GHG) emissions of case furniture according ISO 14040 and 14044 standards. Manufacturing of eight pieces of furniture were assessed covering three different furniture manufacturers. In this study, life-cycle phases from “cradle to gate” were assessed to determine steps from the raw material acquisition to finalized furniture at the factory. System boundary of the studied system is presented in Fig. 1. Functional unit of studied system is one piece of furniture.

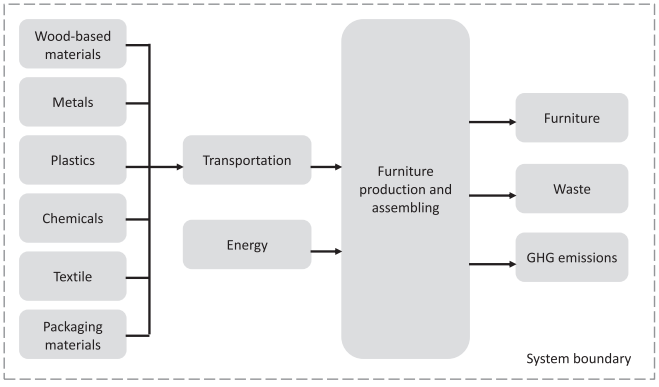

Fig. 1. System boundary of studied system.

2.2. Inventory

The studied furniture were from three furniture manufacturing companies (Isku, Martela and Puustelli), these companies provide a wide range of different kinds of furniture products for offices and households. The inventory data were conducted in the production places, where associated raw materials, transportation distances and production processes were inventoried by Fomkin (2010), Junnikkala (2011) and Witikkala (2013). For this study, eight pieces of furniture were selected and their production processes were assessed on site. In some cases, comparison of potential options to improve their environmental performance was also studied. Detailed inventory data of the studied furniture are shown in Table 1. The main raw materials of office chair (1) are metal, wood, plastic and wool-polyamide fabric. The main raw materials for the student chair (2) are wood-based composite and metal. Public space chairs consists of wood-based composite, upholstery and steel base. Two different surface coatings for metal base were selected for public space chair: powder coating (3A) and chroming (3B). Public space chair (4A & 4B) consists of form wood-based composite and base. The main raw materials of student desks (5A & 5B) are wood-based materials and metal base. The main raw material for office desk (6) is chipboard for the top and metal base. Office cabinet (7) consists of particleboard and HDF-board. Some veneer is used in the framing and in the sliding door. Components of kitchen cabinet (8A & 8B) consist of birch timber, glue and coating. In all cases raw materials manufacturing rate differ from each other, plastic parts are mainly ready formed parts for furniture, and otherwise wood parts can be veneer or timber which is upgraded in a production site.

Transportation methods and distances were identified for each raw material according to procurement of furniture manufacturers. All manufacturing facilities are located in southern part of Finland. Raw materials were mainly coming from Finland by a lorry and when material or product was coming abroad (Central and South Europe or North America) also freighter was used. The electricity consumption of each furniture production process was measured and the amount of raw materials and possible waste generation were also measured for the assessment in situ.

Material datasets were taken from the databases for all the raw materials and some suitable product specific LCA reports were also available. Different databases were used to cover all the processes needed in the assessment, mainly using GaBi 4 Professional database (PE International, 2013) and other databases to cover some missing datasets such as Ecoinvent 2 (Swiss Centre for Life Cycle Inventories, 2013), VTT/KCL-eco (VTT, 2013), and CPM LCA database (CPM, 2013). Used inventory data for the assessments is listed in Table 2.

2.3. Life cycle impact assessment

The assessments were carried out using GaBi 4 Product Sustainability Performance -software. Main focus was on greenhouse gas emissions, thus studied impact assessment was Global Warming Potential (GWP 100 years), which gives results on kg CO_2-equivalents. GWP was selected to show how furniture sector can respond to EU climate targets, and which production steps are most important to tackle. GWP was calculated using CML 2001–2010 impact assessment method (Guinée et al., 2002). Both fossil and biogenic greenhouse gas emissions were counted to GWP value.

In this study wood inherent property, carbon content, wasn't calculates as part of GWP. According nominative standard EN 16449 wood material carbon content can be calculated and added to the GWP value in the environmental product declaration. In our case we wanted to show released emissions as such. Of course biogenic