Resources, Conservation and Recycling 78 (2013) 81–91

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Potentials for cascading of recovered wood from building deconstruction—A case study for south-east Germany

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ARTICLE INFO

Article history:
Received 8 February 2013
Received in revised form 8 July 2013
Accepted 8 July 2013

Keywords:
Building stock
Cascading
Demolition waste
Secondary resources
Urban deposit
Waste wood

ABSTRACT

Increasing scarceness of primary raw materials leads to a heightened focus on secondary resources. Deposits from urban infrastructure, mainly the building stock, are a potential major source of secondary resources. However, reliable information concerning available volumes and qualities is lacking. We analyzed incorporated amounts of wood in the building stock of south-east Germany, and calculated resulting streams of recovered wood in order to quantify potentially available volumes for an environmentally beneficial cascading utilization of these secondary resources. By applying a new method using data from sample buildings in regard to the quantity and quality of incorporated wood and statistical data concerning the building stock, the stock of wood based materials in buildings and the recovered wood resulting from demolishing for the year 2011 were calculated.

We found that considerable amounts of recovered wood in suitable condition for a resource-efficient use in cascades can be expected to originate from the building stock: 26% of the recovered wood is suitable for re-use and 27% could be channeled into other high-value secondary applications.

These first initialized concepts of a cascading utilization of recovered wood should be further refined and extended to utilize the existing potential to its optimum.

1. Introduction

1.1. Problem statement

The *Europe 2020* publication of the European Commission states increasing resource efficiency as a major strategy for generating economic growth, to fight against climate change and limit the adverse environmental impacts of resource use (European Commission, 2010). The corresponding flagship initiative enumerates the re-use of valuable materials which would otherwise be wasted as a favorable measure in order to reduce the pressure on primary materials, such as raw wood from forests (European Commission, 2011).

On a national level, the German Government aspires to a doubling of resource productivity by the year 2020, compared to 1994 as a baseline (BMU, 2002, 2012).

In addition to focusing on resource efficiency, the finite nature and instability of fossil resources supply has led to a heightened awareness concerning the importance of renewable resources for an additional and more sustainable supply for both energy-related and material use.

This paper focuses on wood as a versatile renewable resource with a high potential relating to the mitigation of climate change: First, wood products act as a carbon pool during their lifetime. Second, these products can substitute for others produced from scarce and potentially more energy-intensive resources. Third, they can substitute for fossil fuels, when used for combustion with energy recovery after their service life (Werner et al., 2005; Richter, 2009).

In addition, however, also wood as a regrowing and thus renewable resource is not available infinitely with respect to volumes and regional availability. In recent years, an increasing competition for wood, intensified by rising prices for fossil fuels, can be detected (Schwarzbauer and Stern, 2010). To ensure a stable supply for multiple purposes and to meet the growing demands, the efficiency of the use of wood as a resource has to be enhanced and additional sources for wood have to be identified.

1.2. Cascading of wood – state of the art

A suitable means suggested both by science (Fraanje, 1997; Gärtner et al., 2012; Goverse et al., 2001; Haberl and Geissler, 2000; Lafleur and Fraanje, 1997; Sathre and Gustavsson, 2006; Sirkin and ten Houten, 1994; Werner et al., 2007) and legislative bodies (BMU, 2008, 2012) to achieve a more efficient resource use is the concept of cascading, meant as the sequential use of a certain resource for different purposes.

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http://dx.doi.org/10.1016/j.resconrec.2013.07.004

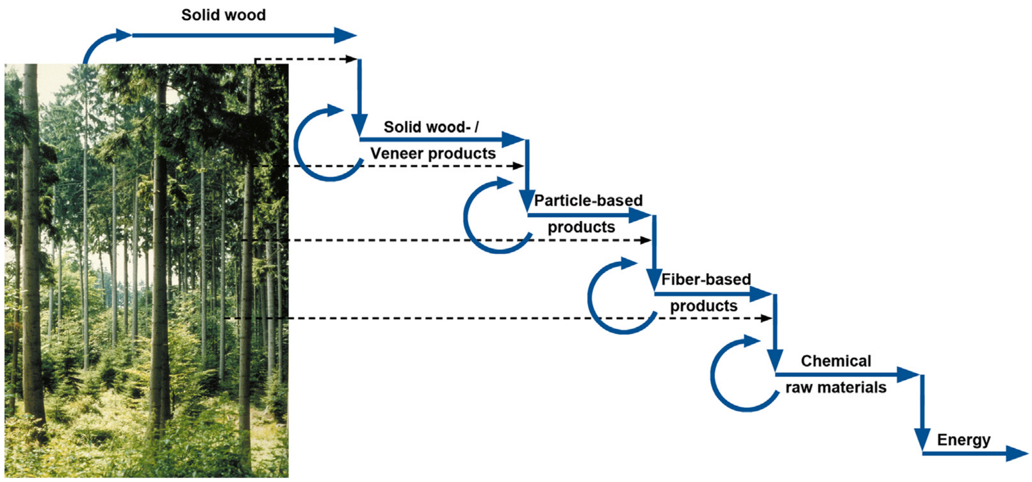

Fig. 1. Cascading use of wood to improve resource efficiency (based on EPEA, 2009).

As described by Sirkin and ten Houten (1994), resource cascading is a method to enhance the efficiency of resource utilization by a sequential re-utilization of the same unit of a resource for multiple high-grade material applications followed by a final use for energy generation. Thereby, primary raw materials are saved and positive effects due to the substitution of finite materials by renewable resources can be increased (Gustavsson and Sathre, 2011).

To maximize the effects of a cascading utilization, secondary resources should be used in the application with the highest possible quality for which they are intrinsically suitable (Fraanje, 1997; Haberl and Geissler, 2000). For example, high quality recovered wood from the building sector in large dimensions and without contamination, such as solid beams, should first be used to produce timber of smaller dimensions, such as lamellas, which after a service time as flooring can be chipped and used in a second cascade step as particle- or fiberboards, and finally as an energy carrier, rather than being immediately used for energy production after the first product life as a beam (Fig. 1).

Previous studies have shown various benefits from cascading. Fraanje (1997) examined the effects on primary resource use by the cascading of pine wood in the Netherlands. He found that large savings of primary resources were possible and the time a resource is used could be extended considerably by cascading. Dornburg and Faaij (2005) compared cascading chains with wood from short rotation poplar, considering land use, CO_2 emission reduction and economic performance. They concluded that cascading has the potential to improve both CO_2 emission reductions per hectare and CO_2 mitigation costs of biomass usage. Sathre and Gustavsson (2006) analyzed the energy and carbon balances of cascade chains for recovered lumber with several post-recovery options such as particleboard production, re-use and burning for energy recovery. They compared the balances of cascaded products to the use of virgin wood and to the use of non-wood products. Cascading was found to have positive effects on the balances, especially due to a reduced demand for non-wood products when wood is cascaded and owing to energy savings by direct cascade effects. Gärtner et al. (2012, 2013) conducted Life Cycle Assessments (LCA) of different wood cascade chains. They concluded that generally the impact on the environment decreases with more cascade steps of using wood as a material resource before a final use for energy production.

However, most studies also discussed restrictions of the benefits of cascading. Sathre and Gustavsson (2006) concluded that benefits from cascading are minor, if virgin biomass were available yet remains unused due to cascading of recovered wood. However, this is not the case in the study area of Bavaria, despite a continuing increase of overall forest stocks. A considerable part of the increase of stocks is contained in small privately owned forests and a mobilization of these resources could not be achieved, despite great efforts over the last years. Furthermore, recovered wood today mainly substitutes virgin wood of lower quality as raw material for wood panel manufacturing (mainly particleboard). These assortments are also the main input for the growing wood use in domestic heating, which has led to rising raw wood prices and competition for these assortments between material use and use for energy production in recent years (Friedrich et al., 2012). An increase in the use of recovered wood by cascading would therefore alleviate this competition and prevent rising prices for manufactured wood products, which ultimately would lead to a partial displacement by non-wood products. This also is in accordance with the conclusion of Sathre and Gustavsson (2006) that a cascading use of recovered wood avoids the use of more energy intensive non-wood products, if forest resources are limited.

Gärtner et al. (2013) detect possible constraints in the delay of the energy recovery step for several decades which would be caused by an extensive cascading of recovered wood. This may lead to the replacement of possible cleaner energy sources in the future, when the cascaded wood finally reaches its end-of-life. Nonetheless, those possible negative environmental effects are counterbalanced by the prolonged carbon storage in the wood due to cascading, thereby contributing to the mitigation of climate change. It is evident that a cascading utilization of wood is not to be favored uncritically. Yet, when taking into account legislative requirements and the situation in the study area regarding wood demand and availability, it seems a concept worth encouraging.

Currently, in Germany, cascading of wood as a strategy to extend the material lifetime has not yet been implemented sufficiently. Close to 80% of the total amount of recovered wood is incinerated, mainly in large-scale power plants with effective flue gas cleaning. Regarding the use of recovered wood as a secondary raw material, particleboard is the only noticeable industrial application (Friedrich et al., 2012; Mantau et al., 2012). Re-use is common in small amounts with old furniture. Other technically feasible applications, e.g. as input for other wood-based composites such as MDF (Medium Density Fiberboard) and OSB (Oriented Strand Board), or raw material for the pulp and paper production are not practiced, mainly due to only minor cost benefits, necessary technological process adaptations, and concerns of customers toward materials generated from “waste”.