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4 Short overview of results

Fig. 1 shows Estonia's position in the global ranking of world timber markets. The most competitive industries are those producing prefabricated wood houses. Results for year 2010 indicate that Estonia has the highest RC value (3.50) in the group of prefabricated buildings among the 116 countries included. The second best result is in other manufactured wood, where Estonia ranked 8th, but the RC value was relatively low – 2.01. For Estonia the second highest RC value (3.23) was in chips and particles, but in world ranking it placed 22nd among 94 countries.

In the total sum of all observed product groups in 2010 Estonia holds 18th place (RC=1.32). In 2010, 132 countries reported export and import data of observed wood products. The most competitive country according to our calculation is Cameroon (RC=3.90), followed by Brazil (RC=2.52) and Guyana (RC=2.38). Of the Baltic and Scandinavian countries Latvia was in 5th place (RC=2.36); Lithuania, 17th (RC=1.37); Sweden, 31st (RC=0.74); Finland, 33rd (RC=0.66). 57 countries have positive RC value - their export value of observed products is higher than import value. Denmark ranked 62nd (RC=-0.28) and Norway, 102nd (RC=-2.09).

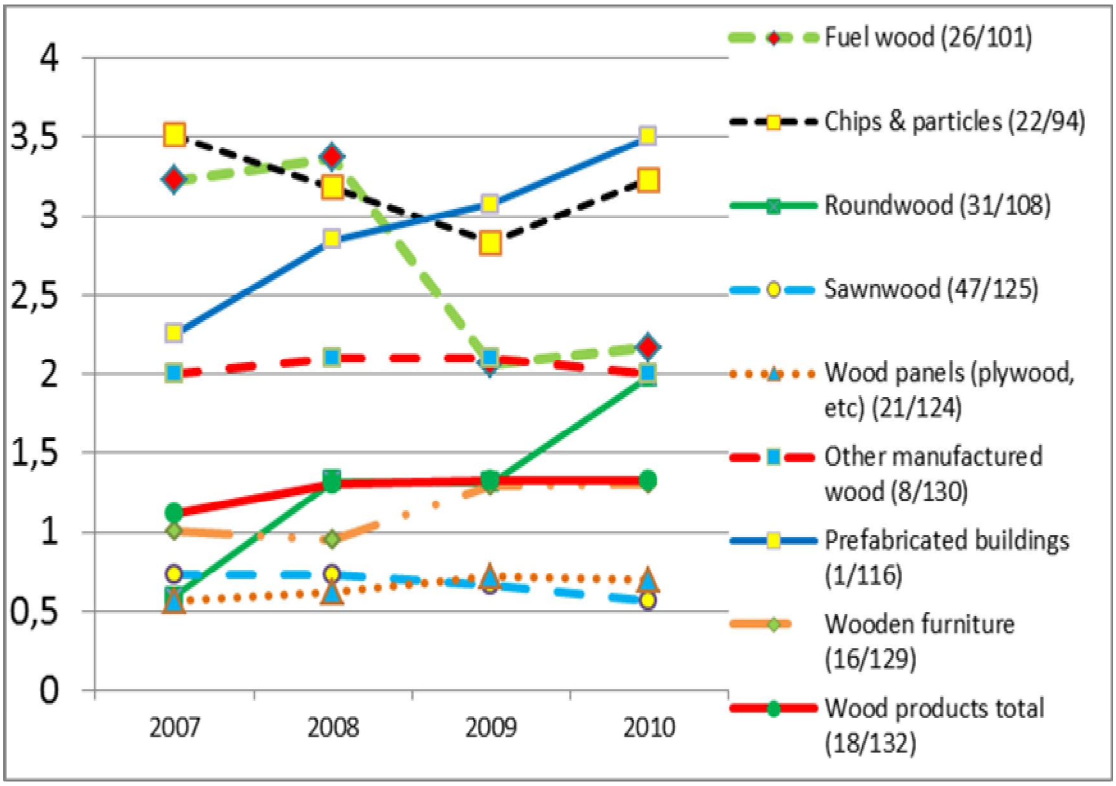

Fig. 1. Revealed competitiveness of Estonian timber products in 2010. (In parentheses Estonian rank in the world /the total number of countries in that product group in 2010, e.g. for fuel wood, Estonia ranked 26th of 101 countries.)

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Carbon footprint of products from the Norwegian sawmilling industry

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Abstract

Carbon footprints are commonly used to assess environmental properties of building products, for comparisons of similar products and in order to minimize the environmental impact of products and projects. A carbon footprint is calculated with the use of life cycle assessment (LCA), where the emissions from cradle-to-grave are accounted for as well as emissions from upstream production like electricity. Sawmill production is a multiple output system and the choice among the methods on how to allocate the footprint have previously shown to be important. This paper finds that methodological choices for electricity mix and carbon cycle of bioenergy of a potential much larger importance. The Norwegian electricity mix is almost carbon neutral, but a change in practice to international mixes can have large impacts. Bioenergy from forests have up until now usually been regarded as carbon neutral, but an approach with carbon dept will make the emissions almost half of fossil fuels. The present article aims at providing an overview of previous LCA studies and comparing the results with recent LCA studies carried out in cooperation with Norwegian sawmill industry. This will show the possible effects for the carbon footprint of sawmill products from a changes in common practice for the choice of electricity mix and including an accounting of the carbon cycle of bioenergy.

Keywords: sawmill industry, carbon footprint, life cycle assessment (LCA)

1 Introduction

The importance of carbon footprint of sawmill products comes from the importance of forest as a large carbon sink and that buildings are using a substantial amount of carbon intensive materials and energy. Increased use of wood products could therefore be of importance in climate change mitigation. Low carbon footprint of building materials is an increasingly important parameter in sustainable building practices. Among the several measures that can be used to document environmental properties of wood products, few can be used for numerical benchmarking such as the carbon footprint. For an overview of all possible measures, se Räty et al. (2012) which have studied environmental performance measures used by professional actors in the wood value chain from sawmills to contractors.

The Norwegian Government recently published a new white paper on climate efforts. According to the report, construction materials have different greenhouse gas emissions, but these emissions should be accounted for in the sector where the emissions take place. However, a life cycle perspective is useful to compare different materials. An example of this used is to replace steel beams with gluelam beams. The report also referred to the tool www.klimagasskalkulator.no, which can be used to calculate the climate footprint of buildings including materials. Further the report acknowledges the agreement of COP17 in Durban to include Harvested Wood Products (HWP) in the national greenhouse gas inventories. (Report No. 28 to the Storting, 2011-2012).

The tool www.klimagassregnskap.no, is a free online tool provided by Statsbygg, the state building company. It is used in the BREEAM-NOR classification scheme and as a criteria in a programme Future Cities. The data for climate footprint of materials have shown not to be updated and consistent. For example gluelam beam and post which have had a large difference in climate footprint. These have not been based in best available data, which are environmental products declarations (EPD). In the next version of the tool, new data are intended to be added.

In Norway, 11 EPDs are available for solid wood products. Five are from the Norwegian sawmill's industry association and the six remaining are from individual manufacturers. The EPDs are demanded especially by Statsbygg and building projects which are to classified with BREEAM-NOR. Also there is an evaluation method for called ECOproduct where EPDs are used as data basis and which is used for comparative evaluation of materials.

Inclusion of the carbon cycle in the carbon footprint of a wood product is practised in various ways. The PAS2050:2011 use an approach for weighted average impact of delayed emissions. According to the Norwegian product category rules and practice used with the EPDs in Norway, the effects of the carbon cycle is left out of the carbon footprint of the product. This rule also account for biomass energy use and is commonly referred to as the carbon neutral approach. A third approach is to include carbon uptake and release with no temporal effects. This implies that forests sequestrate carbon during growth and that this carbon will be released during combustion or degradation of the wood. This approach has been used in EPD for Western Red Cedar in America and particleboard in Germany. Another approach incorporates the contribution that the carbon have to climate change in the time between a wood is combusted and until the forest have been regrown. Hence, the carbon emissions from wood combusted at a sawmill will create a carbon debt and with rotation period of 98 years 1 kg of biogenic CO_2-emissions will equal 0.42 kg of fossil CO_2-emissions (Cherubini 2011).

An important issue in LCA is the multifunctionality in production. This is important for the sawmilling industry where sawn wood makes up approximately half of the output of production and where other outputs like sawdust, bark and heat are sold as co-products. According to EC

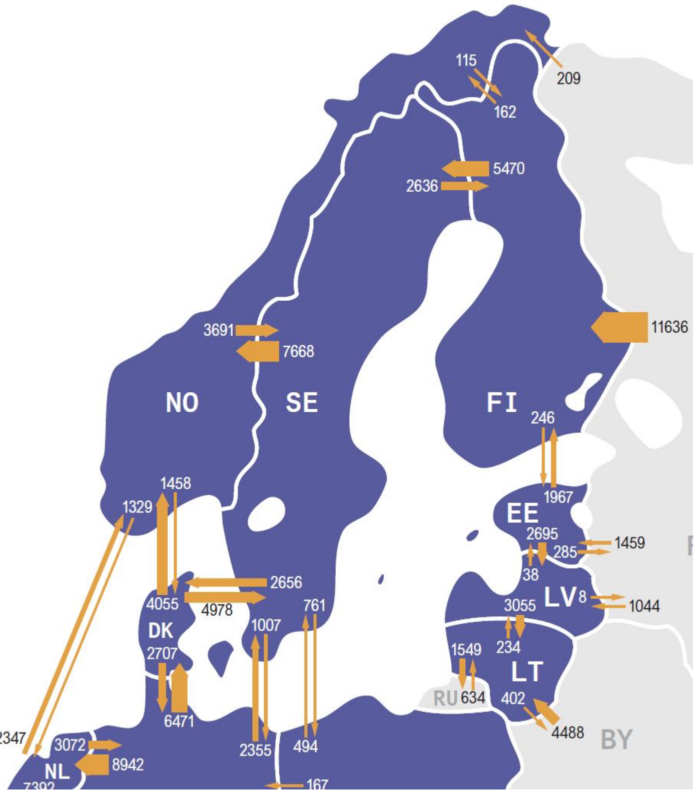


Fig. 1. The transmission of electricity between the countries in Northern Europe in 2010. (ENTSO 2011)

(2010) there are three options to deal with multifunctionality in LCA. The preferable method is subdivision, which means that the system that is studied are divided up in processes to a degree that inputs and outputs are possible to align. The second option is allocation, where the inputs and emissions are allocated between the different outputs. This can be done based on mass, energy or economic value and is valid for attributional LCA. The third option is to use system expansion/substitution, where another common production scenario for a co-product is subtracted to the main product. For example production of waterborne heat from LPG is subtracted to account for biomass based energy sold to a district heat. This approach is suitable for consequential LCA, where the goal is to assess “what if” scenarios.

At the end-of-life phase there have also been different practices on where the life phase actually is ending. Similar to multifunctionality, the question is between allocation and system expansion. Allocation is used when the benefit of a new product from waste is allocated to a new production system. This will ensure that no double counting is performed and it is therefore intended for an attributional LCA. In a consequential LCA it could be relevant to include the benefits of reuse, recycling or recovery. Another approach is proposed in Werner et al (2007) with a functionalistic approach to solve allocation problems with wood.

The Norwegian electricity production is about 95% hydropower, but also imports electricity from other countries. The Norwegian physical consumption mix (production+import) have very low carbon footprint compared to Nordic or European mix which have a lot more coal power. There has been a change in common practice of using Norwegian towards Nordic with the argument that the electricity is traded on the Nordic market. An illustration of the electricity transmissions from and to Norway is shown in Fig. *1*. Based on EU policies, a newer

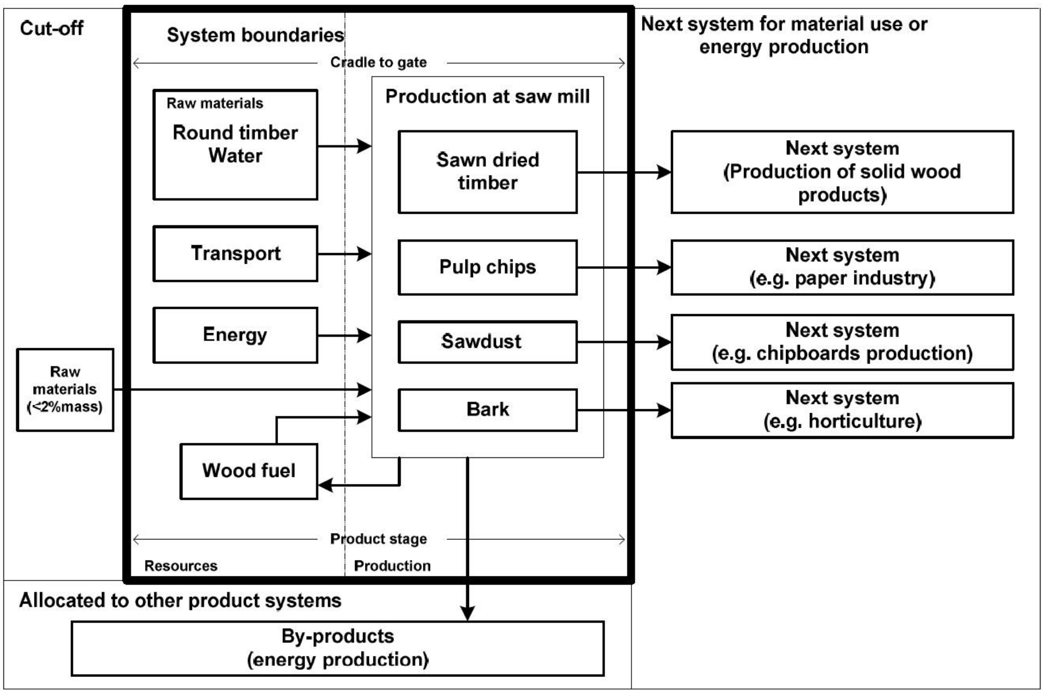


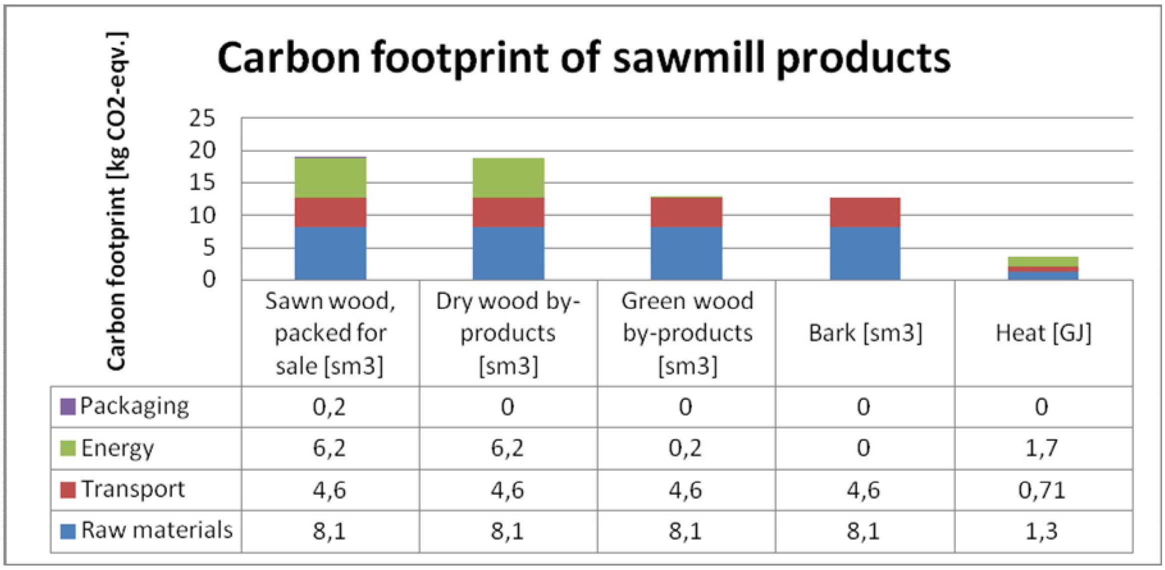
Fig. 2. Life cycle inventory system for production at sawmill (EPD-Norge 2009)

approach is to include the Guarantee of Origin (GO), where the production of renewable energy can be sold as a financial attribute on a European market. The consequence of this is that a substantial share of the Norwegian hydropower production is sold abroad and that the residual mix is closing to the European mix. The inclusion of GO in LCA is controversial as it does not follow the physical flows of a functional unit.

2 Method and material

The goal is to assess the process contributions for carbon footprints of the products from the Norwegian sawmill industry as well as the impact of different methods to calculate the impacts of electricity and bioenergy use. The sawmill products that will be assessed are: Sawn wood, bark, green by-products (sawdust, chips and hogs), dry by-products (sawdust, chips and hogs) and waterborne heat.

The life cycle inventory of sawmilling in Norway is based on the procedures in the product category rules (PCR) for solid wood products previously used to make EPDs for Norwegian wood products. The system boundaries for this approach are illustrated in Fig. ***2***. The base case is assessed with the process contributions for the carbon footprint and is using the same data and procedure used to make EPD for Norwegian sawn wood (Wærp et al, 2009). Additional three scenarios have been assessed using other procedures for calculating emissions from electricity and bioenergy consumption. The alternative with Nordic electricity mix have been calculated based on an average Nordic consumption for 2008, 2009 and 2010 from ENTSO (2010 & 2011) and NORDEL (2008). The second alternative has been to calculate the electricity based on residual electricity mix when GO are accounted for. The third has been to use the carbon dept approach from Cherubini (2011) with assumption of a 98 years rotation period. For life cycle impact assessment, the IPCC2007 100yr has been used.



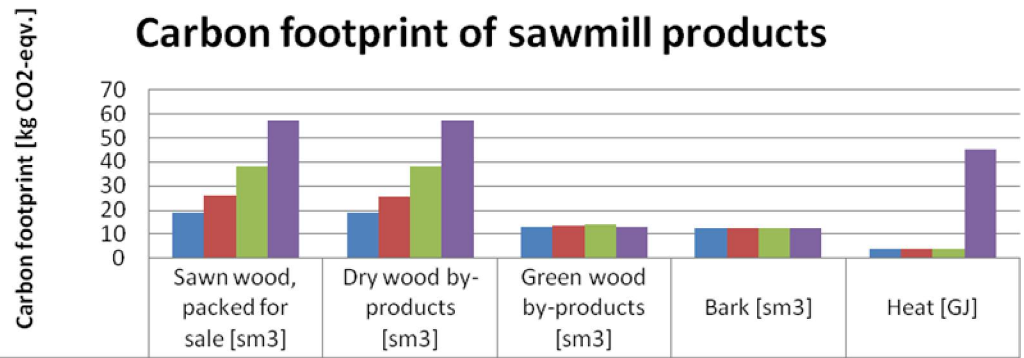
	Sawn wood, packed for sale [sm3]	Dry wood by-products [sm3]	Green wood by-products [sm3]	Bark [sm3]	Heat [GJ]
Packaging	0,2	0	0	0	0
Energy	6,2	6,2	0,2	0	1,7
Transport	4,6	4,6	4,6	4,6	0,71
Raw materials	8,1	8,1	8,1	8,1	1,3

Fig. 3. Process contribution for carbon footprint of sawmill products after EPD from 2009

3 Results and discussion

The results of process contributions to the carbon footprint of sawmilling products are shown in Fig. ***3***. It is clear that upstream processes of forestry and transport to sawmill have the largest contributions to the carbon footprint. The sawn wood and dry by-products have larger footprint based on the energy use in the kiln drying. The heat production has additional emissions caused by direct methane emissions from the combustion process.

Three alternative scenarios related to impacts for energy is assessed and the results are illustrated in Fig. 4. The first scenario with a Nordic el-mix shows a moderate increase of about 30 % for the carbon footprint of sawn wood and dry by-products. Green by-products, bark and heat shows only marginal differences. The second approach with residual el-mix have the same relative impact, but the increase for sawn wood and dry by-products are about 100%. The largest effects are in the third scenario which applies the carbon debt accounting approach for biogenic carbon dioxide emissions. It shows a more than an order of magnitude of increase in carbon footprint. This again have a large impact of the kiln dried products. Sawn wood and dry by-products have an increase of almost 300% compared to the base case.



	Sawn wood, packed for sale [sm3]	Dry wood by-products [sm3]	Green wood by-products [sm3]	Bark [sm3]	Heat [GJ]
EPD 2009	19,1	18,9	12,9	12,7	3,71
Nordic el-mix	25,9	25,7	13,3	12,7	3,83
Residual el-mix	38,3	38,1	14,1	12,7	4,06
Carbon debt	57,3	57,2	12,9	12,7	45,2

Fig. 4. Sensitivity analyses of different methological choices for calculating electricity and bioenergy use for products from the Norwegian sawmilling industry.

4 Conclusion

The results show that:

- The calculations of carbon footprint of sawmilling products after the procedure used for EPDs show that upstream transport and forestry operations have the largest contribution.

- New procedures for calculating emissions from Norwegian electricity consumption can change this and increase the footprint of kiln dried products by 30% for a change to Nordic electricity mix and a 200 % increase with the residual electricity mix approach.

- A change from the carbon neutral assumption for forest bioenergy to a carbon dept approach can increase the carbon footprint of sawn wood by 300%. Hence, it is the methodological choice with the highest effect on carbon footprint of kiln dried sawmill products.

Further work should look more into the appropriateness of these methods approaches to attributional LCA and EPDs.

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