Forest Policy and Economics 66 (2016) 18–21

Contents lists available at ScienceDirect

Forest Policy and Economics

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

The wood market balance as a tool for calculating wood use's climate change mitigation effect — An example for Germany

Marcus Knauf

Dorotheenstraße 7, D–33615 Bielefeld, Germany

ARTICLE INFO

Article history:
Received 22 December 2015
Accepted 20 February 2016
Available online 1 March 2016

Keywords:
Wood market balance
Wood carbon balance
Climate change mitigation
Wood use
Substitution
Wood products pools

ABSTRACT

A wood balance provides information on timber markets at a highly aggregated level. The wood market balance that reflects wood use at the place of consumption can serve as a tool for creating a wood carbon balance. The article shows how a wood market balance can be applied to determine the climate change mitigation effect of wood use. Together with inventory data on forest development, a wood market balance can be used to determine the forest-based sector's contribution to climate change mitigation at various levels (national or regional). The methods and results are shown for Germany and the year 2010.

1. Introduction

Wood balances provide information on timber markets at a highly aggregated level. They show the type, the source and quantity of the wood consumed, how it was used, and how much of it was used for each specific purpose. Knauf (2015) has taken the wood balance derived by Mantau (2012), which looks at wood input into the industry and works backwards to the woody biomass sources, and the wood balance of Seintsch and Weimar (2013), which shows domestic wood use based on timber harvests and exports, and developed them further to create a wood market balance. A wood market balance presents wood use at the place of consumption and provides the basis for creating an expanded wood carbon balance. As such, a wood market balance provides information for determining the effect of wood use on climate change mitigation.

Although wood consumption reduces the forest carbon stock, it positively effects climate change mitigation by increasing the amount carbon stored in wood products (HWP carbon stock) and by substituting fossil fuels using wood energy (Knauf et al. 2015). In the future, changes in the HWP carbon stock will, similar to forest sequestration, be included in the framework of the UNFCCC (IPCC, 2006; 2003; UNFCCC, 2002) as a carbon sink (IPCC, 2014; UNFCCC, 2011; 2010). Thereby it is accepted that there is no immediate release of CO_2 from felled trees in the year of removal (Perez-Garcia et al., 2005; Skog, 2008), as had earlier been assumed (IPCC, 1997). The C-effects of material substitution are based on the observation that the production and disposal of wood products usually requires less (fossil) energy and thereby emits less CO_2 than that of non-wood products (Frühwald and Solberg, 1995; Lippke et al., 2004; Sathre and O'Connor, 2010; Taverna et al., 2007). The C-effects of fuel substitution are due to the reduction/avoidance of CO_2-emissions as a result of using wood instead of fossil fuels (Gustavsson et al., 2007; Reijnders, 2006; Sathre and Gustavsson, 2009). In addition to changes to the forest carbon stock, the forest-based sector's overall effect on climate change mitigation is attributed to changes in the HWP carbon stock and material and fuel substitution.

The wood market balances show wood use with respect to its place of consumption, i.e., the amount of wood contained in the finished product. Thus, information is provided that can be used to determine changes in the HWP carbon stock and the substitution effects. The following shows how the wood market balance presented by Knauf (2015) can be used as a tool for creating wood carbon balances and calculating the effect of wood use on climate change mitigation at regional and national levels. Basis for this calculation is the average substitution factor for material and fuel substitution calculated by Frühwald and Knauf (2014) (cf. Knauf et al., 2015).

2. From wood market balance to a wood carbon balance

The starting point for discussion is the further development of the wood balance for Germany for the year 2010 (Mantau, 2012) towards a wood market balance, as shown in Table 1, presented by Knauf (2015). On the sources side of the balance sheet, the item "unofficial felling" of Knauf's 2015 balance has been corrected in accordance with the ex-post calculations by Jochem et al. (2015) based on data from timber harvest statistics and the national forest inventory (BWI) 2012 (Thünen Institut, 2015) from 23.2 Mio. m^3 to 21.2 Mio. m^3 (reducing

E-mail address: mknauf@knauf-consulting.de.

http://dx.doi.org/10.1016/j.forpol.2016.02.004
1389-9341/

Table 1
The German wood market balance 2010 (Knauf, 2015).

German Wood Market Balance 2010

Sources	[Mm³]	[Mm³]	Uses
Official felling	54.4	22.3	Sawnwood
Net import	4.2	7.0	Pulp
Unofficial felling	23.2	15.2	Panel
Bark	4.7	1.2	Other products 1st conversion
Landscape care wood	4,5	−4.5	Residues for domestic energy use
Short rotation plantation	0	22.6	Energy use > 1 MW
		7.2	Energy use < 1 MW
Post–consumer wood	14.0	33.9	Energy use, households
		0.1	Energy use, others
Adjustment	0.0	0.0	Adjustment
Total	**105.0**	**105.0**	**Total**

Table 2
The German wood market balance 2010 — adjusted version.

German Wood Market Balance 2010

Sources	[Mm³]	[Mt]	[Mm³]	[Mt]	Uses
Official felling	54.4	27.2	22.3	10.3	Sawnwood
Net import	4.2	2.1	7.0	3.2	Pulp
Unofficial felling	21.2	10.6	15.2	7.0	Panel
Bark	4.7	2.6	1.2	0.6	Other products 1st conversion
Landscape care wood	4.5	2.3	−7.3	−3.3	Residues for domestic energy use
Lhort rotation plantation	0	0.0	22.6	11.8	Energy use > 1 MW
			7.2	3.7	Energy use < 1 MW
Lost–consumer wood	14.0	6.5	33.9	17.6	Energy use, households
			0.1	0.1	Energy use, others
Adjustment	0.0		0.8	0.3	Adjustment
Total	**103.0**	**51.2**	**103.0**	**51.2**	**Total**

this item by 2 Mio. m^3). Thus, the balance total shows a contradiction of 2 Mio. m^3 to 103 Mio. m^3 (Table 2).

No changes were made to the database used by Mantau (2012) in the development of the wood balance towards a wood market balance by Knauf (2015). This allows for a comparison of the wood balance accounting tools and wood market balance. In the discussion, Knauf (2015) noted that the amount of residual wood in the production process (from semi-finished products to finished product at the place of consumption) assumed with approximately 18% was underestimated, which led to an overestimation of the amount of material actually used. With regard to establishing the effect of wood use on climate change, an overestimation of material use results in an overestimation of the CO_2 reduction effect. Therefore, an adjustment is necessary. On the basis of the LCA data from Rüter and Diederichs (2012) and the empirical surveys conducted by Mantau et al. (2013) it is assumed that 30% residual wood occurs during the processing of sawnwood into finished wood products (e.g. glulam) and 15% in the processing of wood-based panels. The lower amount produced in processing wood-based material is due to a large proportion of the processed products being used in the furniture industry with optimized cutting technology (and thus less waste). As long as there is no more accurate empirical data available on the amount of residual wood produced by wood processing, the values determined here are considered a realistic assessment and accepted as basis for calculation.

The volume figures are converted into mass (oven dry, ODT) by means of conversion factors. The conversion factors calculated by Mantau (2012) are used to determine the volumes shown on the uses side of the balance sheet; a density factor of 0.46 ODT/m^3 [1] was used for material use and a density factor of 0.52 ODT/m^3 [2] for energy use.

The next step uses the adjusted wood market balance for 2010 (Table 2) to create a wood carbon balance (Table 3) in which wood mass is calculated into tC using the conversion factor of 0.5 (Smith, 2004). The use of this factor is deemed accurate within the framework of these calculations. A differentiation between softwood (factor of 0.51) and hardwood (0.48), as shown possible based on Lamlom and Savidge (2003) and carried out in the IPCC assessment (2006), appears unnecessary in relation to the accuracy of these calculations.

3. Calculating the C-effect of wood use

3.1. Calculating the HWP carbon stock

As in the wood market balance, which shows material use with respect to place of consumption, the wood carbon balance shows material use on the uses side of the balance sheet with respect to input to the HWP carbon stock (total of the balance sheet positions sawnwood, panel, other products and residues for energy use). The output is derived from post-consumer wood entered on the sources side of the balance sheet and the unused waste wood such as rotten wood or wood used without a positive C-effect (e.g. open fires without heat utilization). The amount of output without a positive energetic C-effect is specified in the literature as 20% (Knauf and Frühwald, 2013) or 30% (Rüter, 2011). To remain on the conservative side (no overestimation of the wood product carbon stock), this calculation assumes an amount of 30%.

Given the largely constant consumption of paper products in Germany (VDP, 2014), the carbon stock for products from pulp and pulp is considered constant.

Germany is to a lesser extent a net importer of raw timber (4.2 Mio. m^3 of a total of 79.2 Mio. m^3 consumed timber in 2010, around 5.3%). According to IPCC (2014) regulations, imported wood is taken into account in the land of origin. It is assumed that the net imported portion of the consumed timber is attributable to the HWP carbon stock in the land of origin. The calculated change in the HWP carbon stock (2.6 Mio. tC) is adjusted to reflect the difference of 5.3% (0.1 Mio. tC).

Table 4 balances HWP carbon stock inputs and outputs (HWP carbon stock balance sheet with inputs on the left and outputs on the right). The difference between inputs and outputs corresponds to the change of the HWP carbon stock which in business accounting would represent a balance sheet profit (2.5 Mio. tC for 2010).

3.2. Calculating material and fuel substitution

Material and fuel substitution can be assessed using substitution factors (cf. Sathre and O'Connor, 2010). Here (fossil) CO_2 emissions attributed to wood products (usually during production and disposal) are compared with emissions attributed to non-wood products based on life cycle assessments (LCA) or environmental product declarations (EPD) and then related to the mass of carbon in the wood product (finished product) or the mass of carbon in the wood, which is used for energy. Products or construction elements with the same functional units are compared (e.g. the wall of a house with similar physical properties or the same amount of generated energy). The substitution factors are usually given in tC/tC.

The substitution effect is calculated based on the substitution factor calculated by Knauf et al. (2015) for material substitution of SF_{Ma} 1.5 = tC/tC and for the fuel substitution of SF_{Fuel} 0.67 = tC/tC. The substitution factor used for material substitution of $SF_{Ma} = 1.5$ tC/tC is based on idealized material-flow model starting with the German timber harvest data and lies between the value of 2.1 tC/tC proposed by Sathre and O'Connor (2010) and the value proposed by Taverna et al. (2007) for the Switzerland of about 0.8 tC/tC. The applied substitution factor of $SF_{Fuel} = 0.67$ tC/tC corresponds to the value used by Rüter (2011) and

[1] Calculation base: share of softwood species at 90% (cf. Jochem et al., 2015) with an average density (OD) of 0.44 g cm^{-3} and hardwood species with an average density (OD) of 0.64 g cm^{-3}, see Kollmann, 1982).

[2] Calculated difference between the other balance sheet items. Compared to material use, the calculated value reflects a greater use of higher density hardwoods, such as beech or oak.