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Wood flow analysis: Quantification of resource potentials, cascades and carbon effects

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ABSTRACT

Raw materials assume different forms during their use and thereby develop a multiplicity of effects upon the political environment. This article demonstrates the method of sectoral mass flow analysis using the example of the raw material wood. Under conditions of limited resources, market analysis methods must change from single flow analysis in an open (unlimited) system to interactive flow analysis in a closed (limited) system. The method of the wood resource balance is introduced, with its basic elements of resource monitoring, bottom-up approach, data counterchecking and conversion factors. The method is applicable for manifold research topics. This is shown in three examples. The wood flow analysis represents a total resource assessment including all wood products in all process steps from forest to disposal. Based on the wood flow analysis, calculation schemes show how cascading factors can be calculated on a constant basis. Finally the CO_2 effects of total wood use are calculated on a continuous basis.

1. Introduction

Raw materials assume different forms during their use and thereby develop a multiplicity of effects upon the political environment. Political goals affected during resource utilisation are resource availability and sustainable use, resource efficiency and cascading uses, resource competition between material and energy use as well as consequences for the carbon cycle. Furthermore, resource utilisation affects general economic, social, and ecological targets. The quantification of biomass flows is important for many actual policy targets. The availability of resources is crucial for the environment and sustainability. The competition between different uses is increasing. Therefore the EU policy relies on efficiency in resource utilisation and cascading uses.

2. Methodological elements of the wood resource balance

2.1. *Balance framework*

In a world with sufficient supplies of resources, accurate and exact knowledge of interactions was not considered important to collect. Until 2000 the wood industry needed wood and obtained it from forests which had regularly had enough wood to deliver. Residues were hardly analysed in depth and household consumption was roughly estimated. This changed dramatically with the raising demand for energy wood. Simply adding some new resource flows was not sufficient to understand the new resource situation. The market analysis methods had to be changed from single flow analysis in an open system to interactive flow analysis in a closed

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system. As in accountancy, each flow is counted twice, at specific points at start and end, and all outgoing and ingoing flows must balance. The Wood Resource Balance (WRB) was initiated in 2004 [1]. Table 1 is a simple version with higher level sectors. Each of them may be separated into subsectors. New sectors may be integrated as long as it is done on both sides.

A good example of the functionality of the balance is the pellets market. The first versions of the balance did not show pellets at all. The resource 'sawdust' was directly transferred from the sector of industrial residues to households where it was used for heating as pellets. With the growing market relevance of pellets, it was questioned whether pellets were integrated at all. To integrate pellets visually into the balance, sawdust was transferred to the category of an 'energy producer' that produced an energy product, pellets, which appeared again on the left side of the balance, from where it flows to households that consume them as pellets for heating. The sector 'energy producer' may be separated into pellets, briquettes, chips and others. In the future the production of refineries will grow. So far refinery products do not appear on the left-hand side of the balance because it is assumed that they leave the balance border from the wood sector to transport or chemical industries.

Resource flows between sectors of wood use and resource sectors may be calculated in two ways. In a first attempt the consumer side shows the actual consumption and the resource side the potential availability. In this case the balance is not even because the calculation of consumption and potential are different calculation systems. Normally the technical potential [2] is used but the kind of potential chosen is a matter of data availability or target setting. In this context it is important to realise that both sides of the balance are not really interactively connected and the balance shows a surplus or deficit. The EUwood study [3] and the EFSOS II study [4] were calculated in this way because important information was missing – the resource mix of the consuming sectors.

2.2. *Resource monitoring*

The sectors on the right side of the balance consume more than a single resource. If the panel industry were to consume, for example, 10 hm^3 (There is a conflict between the European wood enterprise use of M m^3 in their published statistics and the international standards [5] to describe 1,000,000 cubic metres. In this paper in accordance with the Système International, we will use 1 $hm^3 = 10^2 * 10^3 = 1{,}000{,}000\ m^3$.), we would not know which resources they were using (pulp wood from forest, industrial residues or post-consumer wood). In most cases such information is not contained in official statistics. This problem is even more relevant in the energy sector than in the wood industry. Furthermore, the total consumption in the energy sector is only partially registered (household energy wood) or completely unknown. Almost all consumption sectors are underestimated because of cut-off limits (fewer than 10 employees) of official statistics or incomplete coverage.

For this reason and due to a growing scarcity, a resource monitoring system was established after the Renewable Energy Act in Germany (1999) [6]. If the parent population is not known (e.g., wood disposal sector or biomass power plants), the best sample cannot give an answer on market volumes and potentials. The following data collection method is more or less applied in such cases [7]:

1. Collection of all addresses in all address sources
2. Consolidation of the address/data stock
3. Development of a questionnaire with basic information (capacity/production)
4. Field work with mail questionnaire (twice)
5. First telephone contact with all unreached addresses to confirm existence
6. Second telephone interview with existing plants with basic questionnaire

After parent population is determined:

7. Detailed questionnaire (sample)
8. Projection from the partial return sample on the parent population.

Such a survey may include 4000 written questionnaires, 3000 telephone interviews and the sample inquiry which is the easier part. Using this procedure, 2194 saw mills [8], 541 biomass power plants (BPP) over 1 MW [9], and 1279 disposal companies [10] are now known by site in Germany. The detailed information on resource mix is gained with the sample inquiry [9]. The resource mix or other structural information from sample inquiry is then filled into the parent population dataset via imputation methods.

Sectors with much higher market actors (private households [11], BPP below 1 MW [12]) are surveyed via samples and the parent population is either known (households) or may be

Table 1 – Basic wood resource balance [3].

Sources	Uses
Forest biomass	Wood industry
Wood outside forests	Refineries
Industrial residues	Biomass power plants
Recycling	Households
Energy products	Energy producer
Total availability	**Total consumption**

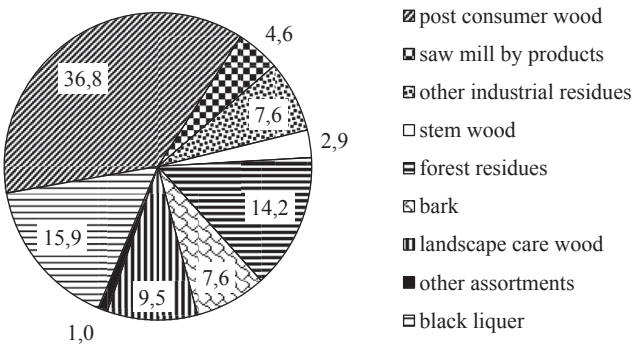

Fig. 1 – Resource mix of biomass power plants in (>1 MW, Germany 2011) [9].

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