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Biomass streams in Austria: Drawing a complete picture of biogenic material flows within the national economy

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ABSTRACT

In order to achieve the targets defined in the European Union's "Low Carbon Roadmap", the "Energy Roadmap 2050" and the "Bioeconomy Strategy", an enhanced use of biomass is required; not only for energy but also for material uses. In this context and to facilitate targeted resource and energy policy measures, profound knowledge of the status quo of biomass utilization is of crucial importance.

The core objective of this paper is to provide complete flow diagrams of the biomass streams within the Austrian economic system from a meso-scale perspective, taking into account all types of uses. Contrary to material flow accounts (MFA), internal streams (e.g. due to biomass processing and transformation, recycling and reuse of residues and by-products, stock changes of end-consumer products) are explicitly taken into consideration and quantified. This approach reveals gaps and inconsistencies in statistical data and facilitates conclusions about quantities not recorded in statistics. Furthermore, the structure of biomass use is visualized and the extent of biogenic material reuse and recycling is revealed.

The results show that biomass imports to Austria surpassed exports by about 15% in 2011 (based on dry mass). The distribution of biomass among the different uses depends on whether direct consumption or final uses are considered. In the latter case, which is considered more appropriate, inland biomass consumption was distributed as follows: 7% human food, 18% raw material, 38% energy and 37% animal feed. Exports are primarily composed of wood products.

Contrary to common assumption, energy recovery is still usually the ultimate step of cascadic biomass use rather than primary purpose, or based on by-products. Judging from wood quantities being processed and consumed and foreign trade data, domestic wood supply according to felling reports (and stated as "domestic extraction used" in official MFA data) is clearly underrated. Conversely, domestic feed production according to MFA data is inconsistent with official animal feed statistics and appears to be overestimated by at least 30%.

1. Introduction

The substitution of fossil-based resources is one of the core objectives of the European Union's long-term policy targets. In order to achieve the ambitious targets defined in the European Union's "Low Carbon Roadmap" (European Commission, 2011a), the "Energy Roadmap 2050" (European Commission, 2011b) and the "Bioeconomy Strategy" (European Commission, 2012), an enhanced use of biomass is required; both for material and for energy uses (see Kalt et al., 2012, for example).

Already today forestry and the wood processing industries are important elements of Austria's economy (Statistik Austria, 2014a,b). In the energy sector, biomass is the most important renewable energy source (Statistik Austria, 2014c) and is generally considered to be of high importance for the establishment of a sustainable energy system (see Streicher et al., 2010, for example). With forest resources already being utilized to a large extent (BFW, 2011) and limited agricultural land available for dedicated energy crops, the need for efficient management of biogenic resources, recycling and cascade use is becoming increasingly urgent. Profound knowledge of the status quo of biomass utilization is of crucial importance for designing targeted resource and energy policy measures.

Due to the wide range of biomass types and uses, material reuse and recycling, the structure of biomass use in a national economy is complex. Material flow accounts (MFA; see Eurostat,

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2013a) provide some insight, yet they disregard crucial aspects like transformation processes, secondary uses, recycling and stock development. Therefore they are of limited use for answering many research and policy questions.

The core objective of this paper is to provide complete flow diagrams of the biomass streams within the Austrian economic system from a meso-scale perspective. These diagrams are intended as a basis for resource and energy policy decisions, long-term planning in the context of action plans and national strategies as well as scenario development. Furthermore, the methodological approach and obtained results might be of use for researchers analyzing biomass flows in other countries or regions.

The paper does not consider the biomass streams within forests, arable land and other biomass production systems. Analyses of nutrient cycles, the humus balance or other ecological aspects are not within the scope of this work.

2. Methodology, data and difficulties

In following sections, the methodological approach, data basis, uncertainties and challenges in mapping biomass streams are described.

2.1. Methodological approach

The applied methodological approach included the following steps:

(1) **Literature research**: The research focussed on international studies exploring biomass flows within an economy and existing publications and data for Austria. A study from Switzerland (Baier and Baum, 2008) proved to be of high value. Official MFA data for Austria are described in Eisenmenger et al. (2011) and are available for download at Eurostat (2013b).
(2) **Reviewing statistical data and selecting primary data sources**: The main data sources were identified (see Section 2.2) and online database queries were conducted. Data from industry associations were used for cross-checking, e.g. Austropapier (2014), Holzindustrie (2014), Agrana (2014), and ARGE Biokraft (2014).
(3) **Definition of a preliminary structure of the flow diagram**: Based on the previous steps, a preliminary set of nodes and streams, intended to represent all relevant flows within the economic system as well as international trade, was defined.
(4) **Devising a common and consistent level of aggregation for biomass flows**: The levels of aggregation in statistics and databases often vary widely. For further processing, data were aggregated to a common level (which is considered relatively high yet sufficiently detailed for this research question). This also included converting statistics to other statistical codes, as the product codes used in national economic (production) statistics (Statistik Austria, 2013a) are not consistent with "HS-codes" used in foreign trade statistics (Eurostat, 2013c). This was done using correspondence tables provided by Statistik Austria.
(5) **Identification of redundant data and resolving of contradicting data**: In this step some of the main difficulties in drawing a complete picture were resolved (see Section 2.3). To avoid double counting, data redundancy resulting from the use of sources with partly overlapping ranges were eliminated (e.g. the Eurostat foreign trade database and the FAO forestry database both contain data on international wood trade, but different units of measurement are used).
(6) **Definition of conversion factors and creation of a complete data base**: Based on literature and values stated in statistics, conversion factors were determined (e.g. tonnes per m^3 for wood, representative water contents of all biomass types and products). These factors were used to derive a complete representation of relevant biomass streams in tonnes (wet and dry mass basis).
(7) **Validation, identification and filling of data gaps**: Next, the ultimate structure of the diagram was decided. Compared to the preliminary structure (step 3), some nodes representing different industry sectors were merged due to insufficient data availability and/or uncertainties with respect to the origin or destination of flows. Data gaps were identified and filled based on plausibility and mass balance considerations.
(8) **Graphic representation**: Two versions of the flow diagrams were prepared; one based on the reported quantities including water ("wet mass basis diagram") and one showing quantities converted to tonnes of dry mass ("dry mass basis diagram").
(9) **Interpretation, discussion and conclusions**: The final step of the work was to interpret and discuss the results and draw conclusions.

2.2. Data

Primarily data from official statistics were used. If no official or scientifically published data were available, other publications and reports (such as annual business reports) were used. In some few cases, where no official or otherwise published data could be found, own assessments were made in consultation with national experts.

The main sources were:

National supply balance sheets (Statistik Austria, 2013b): These statistics provide data on production, foreign trade and consumption by type of use (food, feed, industrial uses) at an appropriate level of aggregation.

Forestry statistics provided by FAOSTAT (FAO, 2013): They include all relevant statistical items like production, domestic supply and foreign trade for all types of wood, paper, pulp and wood based panel and consistent units of measurement are used for all items.

Foreign trade statistics (Eurostat, 2013c): Following the "Combined Nomenclature" (CN, see European Commission, 2013), foreign trade data are available at different levels of aggregation. Four-digit codes (HS4) were generally found to be sufficiently detailed for this work. First, the complete set of HS4-data was obtained from the Eurostat database. Second, all product codes containing materials or products of biogenic origin were identified (more than 500 HS4-codes included in 47 different HS2-codes). Third, to avoid double counting all products covered by other statistics (primarily agricultural products covered in supply balances and wood included in FAO-data) were eliminated.

National economic (production) statistics (Statistik Austria, 2013b): In this statistic, the national classification system "ÖPRODCOM" is used. After the data had been converted to the HS4 classification system, the same approach as for foreign trade data was applied to avoid double counting.

National energy balance (Statistik Austria, 2014c): Data are provided for 13 types of biogenic fuels. Energy data were cross-checked with other statistics (waste statistics, forestry data and biofuel statistics).

National Waste Management Plan (UBA, 2012): The most recent waste data are provided in the "Status Report 2012" (see BMLFUW, 2013a). All available data referring to biogenic wastes were analyzed and cross-checked with other statistics.

In addition to these main sources, the following sources were used to fill data gaps and/or gain further insight: