Optimizing Resource Efficiency and Carbon Intensity in the Wood Processing Sector in Austria

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Abstract:

The pulp and paper industry as well as the wood processing industry are actually two major platforms in the use of biomass in a national economy like Austria. These two Austrian production sectors are currently under examination.

The aim of the research is to develop an object oriented functional model of the integrated production system of wood processing and paper production to analyze the actual situation and the effect of different technology improvement scenarios and structural changes on the economic and ecological performance. Parameters like comprehensive key data for evaluating the overall performance are suggested. Target figures within that goal are resource and energy efficiency, ecological characteristics, the value of the single process chains concerning technical innovation, changed framework requirements and structural changes. Problematic issues for the results like long term storage of carbon in products, export and import of products and intermediates etc. are addressed and discussed. From the results guidelines and recommendations for future development should be derived.

Keywords: Resource efficiency, energy efficiency, carbon intensity, wood processing

1. Introduction

Currently, economy is based on fossil and mineral resources, which end as waste or fossil CO_2 emitted into the atmosphere. The vision of a sustainable economy would need the shift to a solar based economy. Hereby the use of renewable resources for products and energy services is one of the main challenges. An efficient use of biomass is a major pillar of a sustainable resource management, a maximum of service should be provided on the way from the resource recovery to finally CO_2 in the atmosphere at the end of the product life.

As a raw material source wood is inimitable. It accumulates the bulk of the supply of biomass by 1500 billion tons. Via photosynthesis 10 % of that amount is being regenerated annually and out of the biggest part of it, the lignocelluloses composite materials are built. Wood will be the most used and most important material for our economies [1].

The efficient and gentle use of renewable resources is one of the major goals of the European sustainability strategy. Two characteristics in combination turn wood into a feedstock in demand. On the one hand CO_2-neutrality and on the other hand many capabilities.

This is the background for a closer consideration of two major platforms in the production and the use of goods out of renewable resources, especially wood. For that purpose the pulp and paper industry and the wood processing industry in Austria have been the object of research in the current project.

2. Methodology

2.1. Goal and Scope

Due to the fact that these two sectors of industry are part of a complex and interlinked system of different material and energy flows, a computer based process model is developed to analyze the performance of the overall system for resource efficiency and carbon intensity.

The model starts from the provision of forestal biomass like round wood, thinning material, industrial log wood and matured stand, covers the production processes saw mill, pulp and mechanical pulp production and ranges to the different product categories like newspaper, packaging paper and board, construction timber and other wood products.

The project strives for a process model, where the production of wood- based materials like paper and chipboard, can be displayed concerning resource efficiency, ecological aspects, synergy to the energy sector and value added.

The model should provide the opportunity to investigate the influence of technical innovation, changed framework conditions and structural changes on the environmental characteristic and the value added generation for single process chains and the overall system as well. Furthermore the model should show the possible contribution of the wood processing chain to provide biogenic energy carriers for the energy sector.

2.2. System boundaries

As it can be seen in Figure 1 the system boundary comprises the two sectors wood processing and paper production as well as the use phase, the waste collection, recovery and recycling. Within the system material-, substance- and energy- flows are considered.

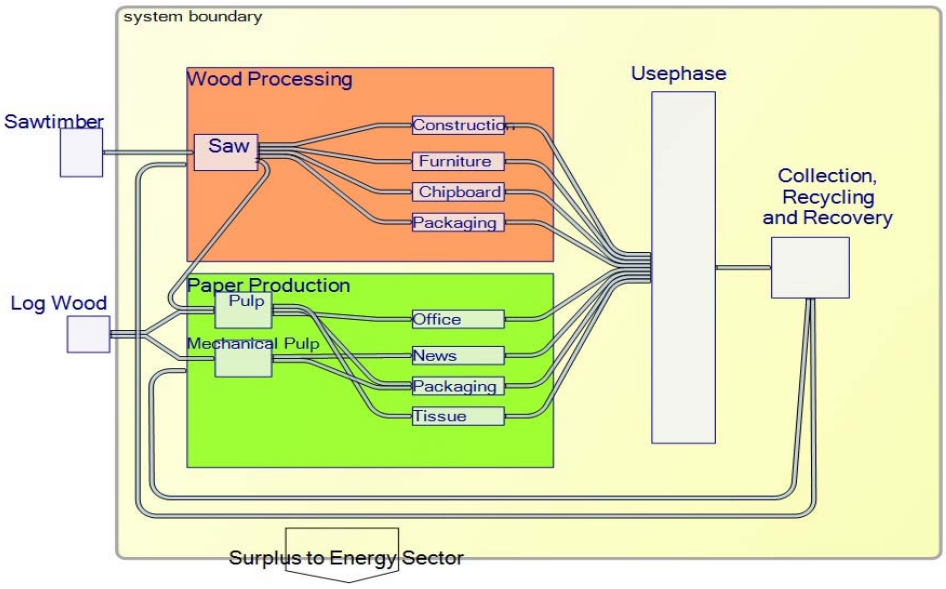

Figure 1: System boundary, main material flows, main processes

2.3. Modelling approach

In the course of the project a static model is developed, which represents the complex system of the two branches. As modelling tool GaBi4 [2], an object oriented programming tool is used. GaBi has been developed mainly for integral accounting and life cycle assessment (LCA). It allows the creation of production system models. This software uses different object categories in a hierarchic structure. The most common categories are flows, processes and plans. The processes are defined by their in- and output flows and are placed on the plans. They can be connected with flows to form process chains. The objects or modules can be taken out of databases or defined by the user.

The intended static model must allow changing the functional characteristics of the single processes and flows as well as the structure of the production system in general.

2.4. Description of the Model

Figure 2 shows the principle of the horizontal assembly of the model for the paper sector. On the left hand side there are the incoming flows like log wood (green arrows). They get into a process of bearing wood and debarking with the respective process characteristics. The bark- flow ends up in a combustion process (red rectangle) that provides thermal energy and electricity. The debarked wood chips flow to further treatment in processes for mechanical, sulphate- or sulphite pulp. The produced (half-) products are the inputs for the paper- and board- machines where the final products are produced.

A similar model exists also for the wood processing sector and both can be merged in the used software to an integrated total model.

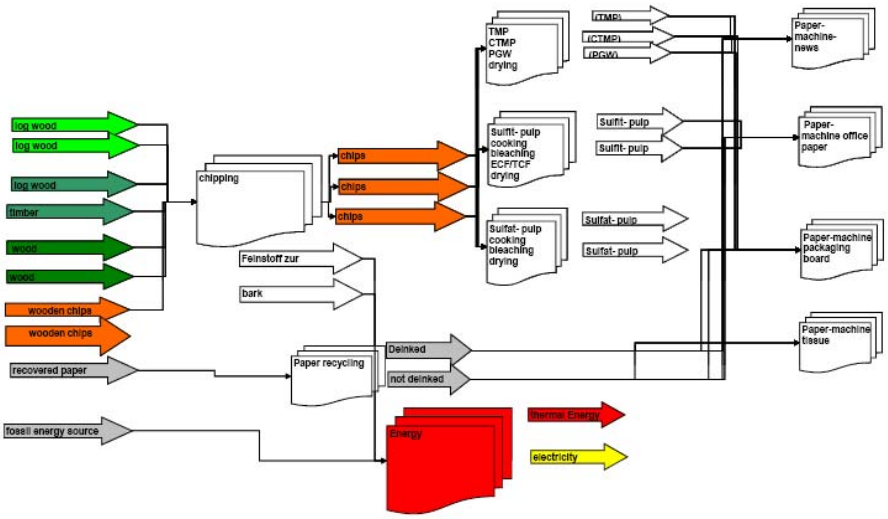

Figure 2: flows and aggregated processes in the paper production system

Each of the processes is described by a proportion of in- and output- flows that determine the characteristic of the process. To allow changes of that characteristic, the amounts of the single flows and the relation between them can be changed by parameters.

The vertical assembly of the model is shown in Figure 3. As it can be seen here the single processes can be aggregated to groups of processes (for example technologies) or to form production sites as it is the case in the existing model for the paper sector.

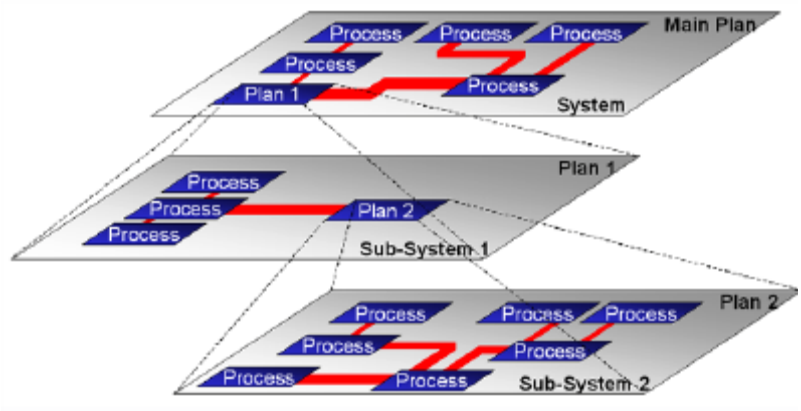

Figure 3: nested plans in GaBi4 [2]

3. Current model- current results

A model describing the Austrian pulp and paper industry exists already in the following way. It allows on the one hand balancing the material and energy flow [8] and on the other an assessment of the whole life cycle of the products including different end of life options. As it can be seen in Figure 4 the inner rectangle describes the system boundary for the material and energy flow analysis (MFA; EFA) and the bigger rectangle those of the LCA.

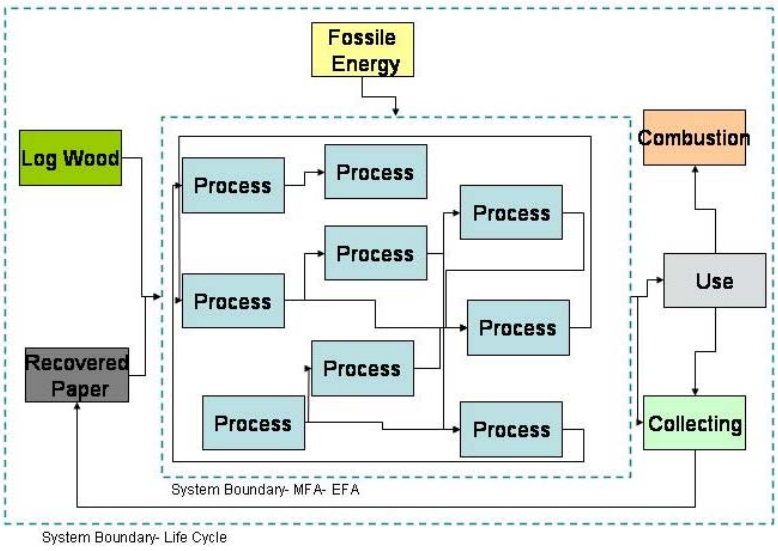

Figure 4 System boundaries- existing model for the paper industry in Austria

After the collection of available information for the production sites in Austria from literature [i.e. 3, 4, 5], relevant processes were chosen in databases like ECOINVENT [6] or PE-ProfDB [2]. They have been compared with the data in the BREF-document for pulp and paper industry [7] and have been adapted consequently. For the single production sites, process plans have been created in GaBi4 and approximately adapted to reality. After the creation of process plans for the single sites the plans were merged by nesting into product- groups by means of relevant flows like wood, pulps or energy carrier. In further assembling of the model the life cycle of the products has been implemented at highest aggregation level. This enabled the holistic view on the production sector from “cradle to grave”.

The model's sensitivities were tested and validated. The determined results are fictitious in that sense that they reflect primarily the effects of the model on impacts and changes but not the exact actual situation in reality.

By accomplishing a pure visual analysis of the Sankey- Diagrams of the model some effects have been identified by changing parameters or the structural configuration. These diagnostics lead to the expected results. For example the variation of wood- or recycling paper- inputs in some processes could be visualized on the process plans.

A more important kind of analysis is reflected in balances. In comparison of the situation in the model with the data of the year 2005 [5], it could be observed that the model and the official figures do fit, especially the figures of used material and produced goods (Table 1).

Table 1: comparison of the figures: Model- Reference [5]

Observed flow	**Model**	**Reference (figures 2005)**
Log Wood Input	*7.407.900 m^3*	*7.684.000 m^3*
Recovered Paper Input	*2.141.515 t*	*2.260.000 t*
Energy Input (fossil, natural gas)	*59.000 TJ*	*30.000 TJ*
Electricity	*4600 TJ (to grid)*	*~5000 TJ (from grid)*
Produced Goods	*4.981 Mio t*	*4.950 Mio t*
Emissions to air		
CO_2 (fossil)	*~5,000 Mio t*	*2,150 Mio t*
CO_2 (biogenic)	*~2,400 Mio t*	*3,577 Mio t*
NO_x	*10291 t*	*4785 t*
SO_2	*11468 t*	*1154 t*

Looking at the figures of the emissions to the atmosphere it must be stated that the values are too high (Table 1). This is mainly caused by the assumptions in the model for the energy and combustion system, which were necessary due to lack of data. At the moment the magnitude of the single effects are under investigation. In the first approach the energy demand of the production sites is mostly covered by their own incinerators and combustion plants and the use of pre-defined processes in databases, which are of older age. Another reason for the deviating figures are missing data on biomass input in the energy plants on site as the exceeding energy demand has been covered by natural gas.

After that reality check, the analysis of scenarios has been performed to evaluate the sensitivity of the model to changes.

Inside the system boundary "MFA- EFA" an expected change of the resource inputs could be observed by means of two scenarios, "recovered paper" and "fresh fibre", where either only recovered paper was used to provide the paper- demand or only fresh fibre. Changes in the emission to air have been assessed, but it still has to be located where exactly (in which module) in the model they are produced (for the same reason as pronounced in the paragraph before).

On the highest aggregation level, the system boundaries were extended to the life cycle, so end of life options and the sequestration of CO_2 were balanced.

There is a need for further research, especially for collecting inventory data and for the amplification of the paper and the wood processing sector to get satisfactory results.

4. Conclusions and further research

The existing model characterizes the pulp and paper industry partly in an adequate way, but still has to be adapted to reflect reality more precise. Currently the available inventory data is being collected for the wood processing and the paper producing sector by the project partners.

In further steps the existing model of the pulp and paper sector will be adapted to the new aspects and focused in detail. The previous used modules will be split in single processes in the production chain to get detailed receivers for technical innovations. For example the LCA- Data module “sulphate pulp” will be split into the modules “cooking”, “washing”, “bleaching” and “drying”. These processes are now the receivers for new in- and output coefficients.

Furthermore the model has to be extended by more detailed flow characteristics between the different processes and by new flows that are not within the current study. The existing and the new flows must be extended by some other values, like the carbon content and humidity ratio to transport the information through the developed model.

The wood processing sector has to be modelled, containing the production range- construction, chipboard, packaging and furniture. This includes the collecting of the inventory data for the single observed processes and flows in the production chains, as well as the implementing the data into the model. Thereafter the single processes have to be connected by their flows into production chains and aggregated to product ranges.

To enable the connection of the two sectors “paper industry” and “wood processing” the linking flows must have the same state. According to the computer aided modelling the production of wood based materials can be displayed concerning resource efficiency, emissions, synergy with the energy sector and value added achievement.

It is expected that the model provides assistance to assess the influence of changes to the environmental characteristic and the value of the single process chains concerning technical innovation, changed framework requirement and structural changes. The model should also show the contribution of the wood processing chain to the fulfilment of energy- demand.

Framework

The work is conducted in course of the project “HOptiMo”, funded by the Austrian Research Promotion Agency (FFG), coordinated by the Institute for industrial Ecology A- St. Pölten, the Institute of Wood Science and Technology (Prof. Dr. Teischinger) A- Vienna and the Institute for Paper, Pulp and Fibre Technology (Prof. W. Bauer) A- Graz.

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