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Intermodal roundwood transport: Pre-carriage optimization ensuring economic and environmental benefits

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Abstract
Due to concentration processes in the European wood based industry and larger capacities in the installed units, the procurement radius has increased significantly over the last decade. Average transport distances today are approximately 150 km (one-way) and are likely to increase in the future. As a consequence transportation activities account for a substantial part of the total raw material costs at mill gate. Given the relatively dense rail and water way network in Central Europe it is claimed that the use of rail or ship for long distance roundwood transport is beneficial regarding both economic and environmental aspects in comparison to truck transport. Nevertheless this can only be realized by intermodal transport solutions as truck transport remains an inevitable component in roundwood transportation due to the remoteness of the constantly changing harvesting sites in the forest from logistic terminals. On the basis of case studies where long distance roundwood transport from the forest to the mill was carried out alternatively with trucks only and with intermodal systems (truck – rail – truck, truck – ship – truck) respectively, the comparison regarding total transport costs as well as energy efficiency and GHG emissions gives a more heterogeneous picture. The inevitable necessity for pre-carriage, detours and often additional onward-carriage risks to outweigh the potential benefits of intermodal transport solutions and requires rigorous observation and minimization of pre-carriage distances independently of the main carrier to ensure these economic and environmental advantages. The results can contribute to optimizing transport solutions and to avoid that opposing effects related to transport put the good ecological reputation of wood at stake.

Keywords: Intermodal transports, roundwood transportation, energy efficiency, economic and environmental assessment, transport optimization;

Introduction
The transport of roundwood from the place of origin (forest) to the point of first conversion (mill) is technically and economically challenging, given the fact, that the sources of origin are naturally much dispersed, constantly change over time and thus remote from logistic terminals and that roundwood is a bulky product with a relatively low weight / volume ratio. Wood transport is carried out with special trucks in most cases, which hampers the organization of back-haulage. The related costs as well as the environmental impacts (emissions, fossil energy consumption) are in conflict with an otherwise positive eco-profile of wood and wood products. Due to these reasons sawmills try to organize their roundwood supply in a way, that transport distances are minimized. In the southern part of Germany, average transport distance of sawmills ranges between 70-150 km (one way distance). Growing mill capacities in the last

decade generally lead to increased transport distances. Long distance transport is common already today, if it comes to “unplanned” roundwood supply due to large windthrow events, which became more and more frequent in the last decades. These catastrophic events result in big quantities of (lower priced) roundwood at the market. The surrounding mills are usually only capable to absorb a low percentage of this volume. Thus, in order to absorb these quantities, long distance transport of roundwood is organized, which can range between 300 and 1000 km, depending on the distance from the area affected by the windfall to the respective mill. Here transport by rail or ship is regularly being carried out as it is believed, that above a certain transport distance rail and ship are superior to truck transport regarding both economic and ecological aspects. Due to the remoteness and the constant source location change both rail and ship require pre-carriage from the forest to logistic terminals. Thus, speaking of transport by rail or ship in roundwood transportation needs to be regarded as intermodal transport.

Material

Case study Kyrill

The last big storm event in Germany, named Kyrill, blew down an estimated roundwood volume of about 37 million m^3 on 18th/19th January 2007, nearly 16 million m^3 of which on a cleared area of 30.000 ha in the federal state of North Rhine-Westphalia in the central west of Germany. A big sawmill X in southern Germany purchased a total of 57.000 m^3 from this area. The air-line distance between the windfall area and the sawmill was approximately 400 km.

As sawmill X is situated relatively close to a rail terminal and to a fluvial harbour, they organized the transport in a way, that 43.000 m^3 were transported by ship via channels and rivers and 14.000 m^3 by railway. All relevant data for these transports were recorded in detail.

Another sawmill Y in southern Germany, located far away from any river and railway line, had also purchased roundwood from the same windfall area, and organized their transport totally by trucks. Also for this transport alternative, the relevant figures were recorded as real data.

Methods

These two data sets allowed a comparative analysis. For sawmill X the (real) data for ship and railway transport were compared to a virtual truck transport of sawmill X, modelled with real data of sawmill Y.

The first objective was to analyse and compare both economic and environmental parameters for an alternative rail/ship/truck transport from the windfall area to mill X. In a second step the inevitable trucking part within intermodal transport has been minimized to analyse the effect on the overall performance of the different transport solutions and the choice of the main carrier.

The following criteria were selected: transport distances for the different means of transportation, total transport costs at mill gate, energy consumption and the related total CO_2 and NO_X emissions for the alternative chains. The reference unit was one m^3 roundwood. Included into the system boundaries were all transport costs and the direct energy consumption and emissions related to the means of transportation. For all truck transport phases empty back-haulage was included whereas rail and ship transport were calculated for the one-way distances. Also the energy consumption and emissions of the pre-chains to produce diesel for trucks, ships and railway and electricity for railway were included. Not included were material and energy input for construction and maintenance of the transport means as well as the energy input, emissions and costs for traffic infrastructure (building, maintenance and management of roads, railway lines, rivers and fluvial channels).

Volumes and tonnage of the transported roundwood, conversion factors from volume to weight of roundwood, distances, costs and fuel consumption of the trucks were directly collected at mill X and Y respectively. Standard data from environmental data bases (EcoTransIT, HBEFA) were used to calculate the energy consumption of ship and railway and the emissions of CO_2 and NO_X related to all three means of transportation. Also for the conversion between the different forms of energy standard conversion factors were used. To provide a comprehensive and comparable analysis of all three process chains, the three alternatives were modelled using the event driven process chain concept (EPC).
For the transport optimization the volumes were assigned to the nearest terminal independent of its nature as port or rail terminal.

Results
The transport distances showed no big differences between direct truck transport and ship but shorter distances for rail transport. This was due to the empty back-haulage on the one hand and fairly high detour factors for ship transport including longer pre-carriage distances compared to the rail transport.
The results of the cost analysis show that under the given circumstances, the costs of direct truck transport and of transport by ship are nearly equivalent. The cheaper main transport phase by ship is partly outweighed by long and expensive pre-carriage to the harbour. Transport by rail was cheaper, which was mainly due to the fact that the pre-carriage distance and cost, from the forest to the rail station, was lower.
Regarding the specific energy consumption, rail and ship are by far more energy efficient than truck transport.
The CO_2 emissions follow the pattern of primary energy consumption. Truck transport nearly has double CO_2 emissions compared to rail and ship.
The relative high CO_2 emissions from railway transport is due to the fact, that the electricity mix for railway transport includes a substantial part of electricity produced by brown coal. In other countries or regions, where the electricity is produced primarily with e.g. hydro power, the railway may benefit from this fact. An additional reason is the dependence on diesel engines on the secondary lines of the rail network that are characteristic to rail roundwood transportation
The picture is different regarding the NO_X emissions. Ship and truck are both fuelled by diesel and therefore have a clear disadvantage compared to rail with the largest share being electric traction.

Conclusions
The results show clearly, that the cost advantages and environmental benefits of ship and rail transport phases, are partly outweighed by the necessity of pre-carriage - the roundwood has to be transported from the forest to the nearest port / rail terminal by truck - and that even big mills do not always have direct access to fluvial / railway lines, which makes onward-carriage necessary - again by truck. Loading between the different carriers also causes higher lead times and additional costs.
Pre-carriage constituted a substantial expense factor but is inevitable in intermodal roundwood transport. Minimizing this by assigning the volume of each pile to the nearest terminal independent of the main carrier, a strong shift towards more rail transport could be observed. This is only practical if the terminals capability is high enough.
A consequence would be, that the (dense) railway network in Central Europe, and especially in Germany should provide more stations which technically allow the loading of roundwood on the railway. Sawmills and other wood industries should be connected directly to railway and/or should have close fluvial access to be able to make full use of the cost benefits and the

environmental advantage of long distance transport by alternative transport means (ship and railway).

In the case study, bottlenecks at the loading stations (railway loading stations and harbours) were quite common during the hot phase of the windfall logging campaign. Consequently the pre-transport distance was not always optimal. An alternative calculation using the optimal distances from the respective forest location to the next harbour / railway station resulted in a substantial decrease of the pre-chain distances. This shows that a very careful logistic planning of the wood flow can contribute to lower transport distances and the related cost and environmental impacts especially in the case of catastrophic events.

Literature

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