bio hub INFOSHEET

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Transportation Costs from Forest to Industry

Cost competitive forest biomass is important in the shift to a bioeconomy. A large part of the cost for forest biomass comes from transportation and handling, and these costs are therefore important to reduce. In this infosheet the transportation cost in the Swedish part of the Botnia-Atlantica region for different assortments from forest to terminal and from terminal to industry is estimated.

COST EFFECTIVE TRANSPORTATION IS NEEDED

It is essential to attain competitive costs for biomass to transition from a fossil based to a bio-based economy. Costs for handling and transporting forest biomass make up a large part of the total cost of a biomass supply chain. It is therefore important to find the most cost-effective options for these operations.

One way to reduce the transportation costs is to use different types of terminals where the material can be stored but also refined before transportation to end-user. It is also possible to use more effective transportation options from terminal to end-user, which is particular important for long distance transportation.

However, the cost for transportation from forest to terminal and from terminal to industry are also important as they affect the optimal number and optimal location of terminals. These costs are therefore important to consider when deciding the location of new terminals.

In this study, we attempt to assess these transportation costs for different assortments for the Botnia Atlantica region of Northern Sweden.

TRANSPORTATION FROM FOREST TO TERMINAL

Transportation options

Three different options for transportation of logging residues (branches and tops) and one for transportation of energy wood from the forest to a biomass terminal were investigated.

Logging residues were assumed to be transported either loose with logging residue trucks or comminuted with chipper trucks or chip trucks. Energy wood was assumed to be transported with roundwood trucks.

Logging residue transportation costs

The cost for truck transportation from forests to terminals was calculated per bone dry ton (BDt) with the Excel based calculation tool FLIS (von Hofsten et al. 2005), but all trucks were assumed to have variable speed depending on traveling distance (Ranta 2002). All trucks were also assumed to have a maximum gross weight of 60 t. Table 1 shows the costs for each cost category

Only the cost for comminuted logging residues at terminal was calculated. Logging residue trucks were assumed to be loaded and unloaded with their own cranes. The cost for comminution of logging residues at terminal was assumed to be 121 SEK/BDt.

	Assortments	Transport options
From forest to terminal	Logging residues from final fellingsw	Loose with logging residue truck
		Comminuted with chipper truck
		Comminuted with chip truck
	Energywood from final fellings	Roundwood truck
	Energy wood from thinningsw	
From terminal to industry	Logging residue chips	Trucks with 60 ton gross weight
	Energywood	Trucks with 74 ton gross weight
	Energywood chips	Trains

Table 1. Cost for different cost categories and time consumption of different work elements.

	Truck type			
	Logging residue	Chipper	Chip	Round wood
Fixed cost (SEK/year) [1]	745 085	1 171 361	513 436	726 442
Personal cost (SEK/year) [2]	849 256	849 256	849 256	849 256
Variable cost (SEK/10 km) [3]	95	82	93.4	96.4
Variable cost (SEK/BDt)	-	10	-	-
Load time (min)	47.5	99	77.6	34
Cost loading (SEK/h)	135.3	647.8	126.5	126.5
Unload time (min)	20	20	16.6	17
Cost unloading (SEK/h) [4]	96.3	50	50	87.5
Waiting time (min)	9.5	15	30	15
Load capacity (BDt)	11.5	15.4	19.4	19

1) Costs that do not vary depending on how much the truck is used (e.g. deprecition insurance, interests on loans), 2) costs for truck drivers, 3) costs for fuel, truck maintenance wear on tires etc., 4) wear on crane, cost of fuel, wear on bunk etc.

The chip trucks were assumed to be directly loaded by chippers at the landings, and the cost for chipping was assumed to be 171 SEK/BDt. Both the chipper trucks and the chip trucks were assumed to tip the material on the ground at the terminals and wheel loaders were assumed to push the material into stacks. The cost for stacking chips was assumed to be 18 SEK/BDt. Compensation to land owners (182 SEK/BDt) and the cost for forwarding (182 SEK/BDt) was also included in the analysis.

Energy wood transportation costs

The cost for both comminuted and uncomminuted energy wood was calculated separately for thinnings and final fellings.

Round wood trucks were assumed to be loaded with their own cranes and unloaded by separate loaders. The cost for unloading was assumed to be 2 SEK/BDt. The cost for logging and forwarding was assumed to be 235 and 542 SEK/BDt in final fellings and thinnings, respectively. The compensation to the land owner and comminution at terminal was assumed to be 282 and 44 SEK/BDt, respectively.

ESTIMATIONS AND DISCUSSION

Best choice

Our results indicate that energy wood from final fellings would be the preferable source of biomass compared to other assortments when they have equal transportation distance. (Figure 1).

Other assortments become interesting as the demand and transportation distance increases. Loose logging residues become interesting at short transportation distances, while logging residues chipped with chipper trucks become interesting at longer transportation distances. Logging residues chipped with chippers and transported with chip trucks becomes interesting becomes interesting if logging residues are transported more than 50 km. Energy wood from thinnings are the last assortment that becomes interesting.

The above results correspond quite well to the current situation in Northern Sweden were mostly energy wood from final fellings is used and the use of logging residues is limited. However it is important to remember that part of the energy wood is interesting for the pulp industry so there might be a more fierce competition for that type of biomass, while logging residues does not have as strong competition from a well-established industry.

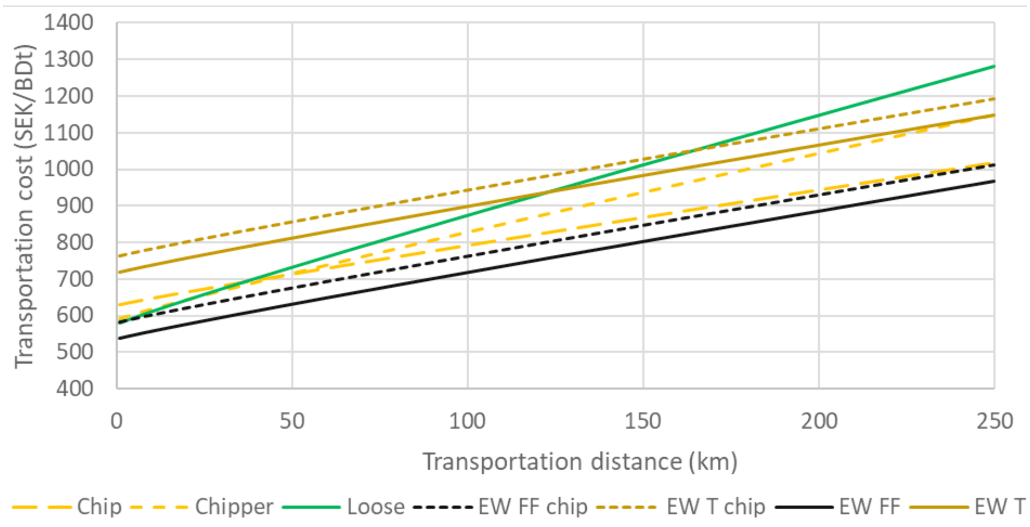

Figure 1. Transportation cost (SEK) per bone dry tone (BDt) for logging residue chips from final fellings depending on transportation distance (km) to terminal when the transportation was conducted by loose logging residues trucks (Loose), chipper trucks (Chipper) and chip trucks (Chip). The transportation cost depending on transportation distance for chip energy wood (EW chip) and uncomminuted energy wood (EW) from final fellings (FF) and thinnings (T) to terminal.

Comminuted material

Chipped energy wood from final fellings provide the lowest cost for almost every transportation distance, only loose logging residues at extremely short (<4 km) transportation distance had a lower cost.

Chipped energy wood from thinnings, on the other hand, had the highest cost except on long transportation distances (>165 km), where loose logging residues was the most costly option.

The difference between energy wood from thinnings and final fellings was due to higher logging costs in thinnings. That the transportation of loose logging residues goes from least expensive to most expensive, is due to the logging residue trucks low load capacity and relatively capital low cost (Table 1).

Currently none of the logging cost is allocated to the logging residues as they mostly are seen as a by-product. This allocation could change in the future if the logging residues becomes more valuable.

Comparison of the different option for transportation of logging residues showed (Figure 1) that logging residue trucks, that has the most effective comminution at the terminal but the lowest load capacity, were the most cost effective option at short transportation distances (<20 km).

Chipper trucks than become the most cost effective option for medium transportation distances (20-50 km) as they had a higher load capacity than loose residue trucks. Chip trucks which had the highest load capacity became the most cost effective option on long transportation distances (>50 km). However scale effects (e.g. size of logging sites) has not been considered, which is important for chip trucks.

The cost difference between logging residue chips transported with chip trucks and energy wood chips from final fellings decreased with increasing transportation distance (Figure 1). This decrease was due to that chip trucks were assumed to have a higher load capacity than round wood trucks. However, round wood trucks commonly leave their crane to be able to load more logs on long transportation distance. This fact was not considered in the analysis, and the cost for energy wood chips could therefore be slightly over estimated.

Uncomminuted energy wood

The cost of uncomminuted energy wood is not directly comparable to the other assortments as it still requires chipping before use. However, the cost is still interesting as energy wood has better storage properties than chips and possibly a lower transportation cost, if the end user has the ability to comminute material at their site.

TRANSPORTATION FROM TERMINAL TO INDUSTRY

Three transportation options

Three transportation options between terminal and industry, 60 ton trucks, 74 ton trucks and train transportation, and three assortments, chipped logging residues (branches and tops), chipped energy wood (uncommercial round wood and pulpwood) and uncomminuted energy wood were analysed.

Logging residue chips were assumed to have a lower density than energy wood chips (table 2). The cost for truck transportation from terminal to industry was calculated per bone dry ton (BDt) with the Excel based calculation tool FLIS (von Hofsten et al. 2005), while the cost for train transportation was estimated according to Tahvanainen (2011). Table 3 shows the costs for each cost category for the trucks.

The cost for loading and unloading the trucks and trains was included in the analysis as well as the cost for comminution of energy wood at industry (table 2). Chip trucks were assumed to be loaded with wheel loaders and unloaded by tipping the material on the ground at the industrial facility.

Wheel loaders were then assumed to push the chips into a stack. Round wood trucks and trains were assumed to be loaded and unloaded with separate loaders. Chip trains were assumed to be loaded with wheel loaders and unloaded with a separate loader.

Trains for long distances

Trains are the most cost competitive options for medium and long distance transportation while trucks are most cost-effective on short transportation distances (figure 2 in page 6). 74 ton trucks are always more cost effective than 60 ton trucks (figure 2).

Train is the most cost effective option for chipped logging residues and energy wood chips at transportation distances above 50 km (figure 1). Trains are also the most cost effective option for transporting energy wood at transportation distances above 20 km (figure 1).

The cost function for the train transportation was mostly based on longer transportation distance so the cost for short distances might be uncertain. However, these re-

sults still indicate that train transportation form terminal to end-user often is the most cost effective option.

The cost for truck transportation of logging residue chips is 0.7 SEK/BDt higher than when transporting energy wood chips, regardless of truck and distance. Train transportation of logging residue chips is 3-10 SEK/BDt more expensive than that of energy wood chips.

The extra cost for transporting chips with 60 ton trucks instead of 74 ton trucks was 1-67 SEK/BDt depending on transportation distance. These differences are due to weight limitations that the trucks are subjected to which limits the load size.

Trains on the other hand, are limited by the bulk volume of the biomass, so the density difference between logging residue chips and energy wood chips had a more discernible impact on transportation cost.

It is difficult to assess and compare the total cost for forest biomass assortments as it depends on how the biomass has been transported and handled earlier in the supply chain, and there are many options for previous handling for the biomass studied here.

The cost of uncomminuted energy wood is not directly comparable to that of the chipped assortments, as it includes chipping at the end-user. However, the cost is still interesting as energy wood has better storage properties than chips, and could therefore be interesting for some industries.

Table 2. Load capacity (bone dry ton, BDt), and cost for loading and unloading train wagons, 60 ton trucks and 74 ton trucks when transporting logging residue chips (LRC), energy wood chips (EWC) and energy wood (EW). Energy wood is assumed to be comminuted at the industry.

	Train			Truck, 60 t			Truck, 74 t		
	LRC	EWC	EW	LRC	EWC	EW	LRC	EWC	EW
Load capacity (BDt)	23.5	24.3	35.0	20.4	20.4	20.9	27.0	27.0	26.7
Loading (SEK/BDt)	13	12	7.3	13	12	7.3	13	12	7.3
Unloading (SEK/BDt)	8	7	4.3	8	7	4.3	8	7	4.3
Comminution (SEK/BDt)	-	-	41	-	-	41	-	-	41

- Indicates that the values were not relevant for the estimations

Table 3. *Cost for different cost categories and time consumption of different work elements for 60 and 74 ton trucks.*

	Truck type			
	Round wood		Chip	
	60 t	74 t	60 t	74 t
Fixed cost (SEK/year)	617 377	807 145	513 435	762 737
Personal cost (SEK/year)	849 256	849 256	849 256	849 256
Variable cost (SEK/10 km)	79.8	97.6	77.3	90.3
Load time (min/turn)	18.5	23.7	22.2	29.5
Cost loading (SEK/h)	87.5	87.5	87.5	87.5
Unload time (min/turn)	3.7	4.7	16.6	16.6
Cost unloading (SEK/h)	87.5	87.5	50.0	50.0
Waiting time (min/turn)	15	15	15	15
Velocity (km/h)	63	62	68	64

GENERAL COMMENTS

These cost estimations for the transportation between forest and terminal and terminal and industry are based on a literature review so they cannot estimate each specific situation correctly as much depends on which investment and maintenance cost that is assumed.

These costs will also vary depended on contractor and situation (e.g. road quality, productivity). However, the estimated cost still gives a reasonable estimate of potential costs.

It is also important to point out that fixed terminal costs are not included in the analysis.

CONCLUSIONS

The cost estimations presented in this infosheet, despite of being based on literature review, give a reasonable estimate of potential transportation costs from forest to terminal and terminal to industry, and can together with terminal handling costs give a good estimation of the total cost of forest biomass supply chain, and help in estimating if an investment in a terminal could be profitable.

When transporting logging residues from forests are logging residue trucks the most cost effective option for transportation on short distance, chipper trucks on medium distances and chip trucks on long distances. Energy wood basically have round wood trucks as the only option for transportation

When transporting material from terminals to industries trains are the most cost competitive options for medium and long distance transportation while trucks are most cost-effective on short transportation distances. 74 ton trucks are also always more cost effective than 60 ton trucks.

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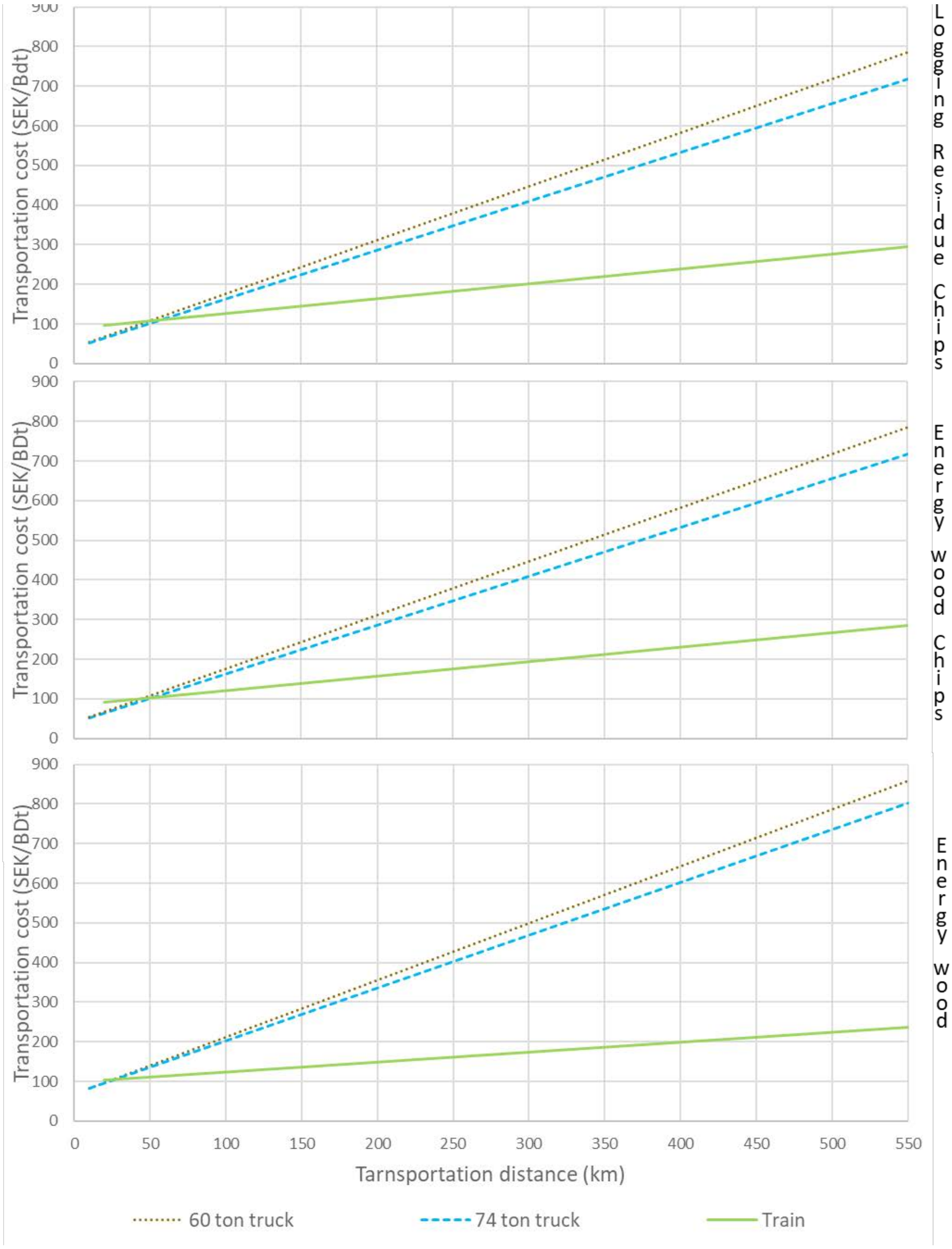

Figure 1. *Transportation cost (SEK) per bone dry tone (BDt) depending on transportation distance (km) between terminal and industry for logging residue chips, energy wood chips and energy wood transported with either 60 ton trucks (60 ton), 74 ton trucks (74 ton) or trains (Train).*

References:

[1] Ranta, T. 2002. 'Logging residues from regeneration fellings for biofuel production – a GIS-based availability and cost supply analysis. Lappeenranta University of Technology. Finland', Lappeenranta University of Technology

[2] Tahvanainen, T., Anttila, P. 2011. 'Supply chain cost analysis of long-distance transportation of energy wood in Finland', Biomass and Bioenergy, 35: 3360-75 L4.

[3] von Hofsten, H., Lundström, H., Nordén, B., Thor, M. 2005. "System för uttag av skogsbränsle - analyser av sju slutavverkningssytem och fyra galringssytem." In Arbetsrapport. Uppsala: Skogforsk. [In Swedish].