Available Potentials of Forest Biomasses for a Biorefinery in Kokkola

The sufficiency of forest raw material is of key importance when new biorefining facilities are planned. As a case study, the available potentials of various forest biomass assortments were estimated for a potential biorefinery in Kokkola, Finland. A theoretical procurement area was created using the existing road network, and the biomass potentials within this area were quantified. Harvesting and transport costs of each biomass assortment were also estimated. The full harvestable potentials were considered in contrast to the currently unused potentials.

Methods

The available potentials of pulpwood, small-diameter thinning wood (delimbed and whole-tree), logging residues and stumps were estimated from the 10^{th} national forest inventory (NFI) data and roundwood harvesting statistics. The full harvestable potentials of the biomass assortments were estimated considering harvesting restrictions for each assortment. The current use and regional distribution (in the year 2011) of small-diameter thinning wood, logging residues and stumps was estimated (Anttila et al 2013). The used volumes of these assortments were extracted from the full harvestable potentials to derive an estimate of the volume of unused forest biomass resources. The unused potential of pulpwood was estimated by extracting the actual harvested volumes (in 2011) from the full harvestable potential obtained from the NFI data.

A GIS analysis of the available resources to a facility location set in Kokkola was performed using the Network Analyst tool in ArcGIS 10.1. The potentials of the biomass assortments were divided into a point grid (5x5 km) and the existing road network was used to calculate the transport distance from each point to the facility. The cumulative biomass potentials were calculated for 25 km intervals from the facility up to a maximum distance of 200 km (along the road network). Procurement costs (€/m^3) for each biomass assortment were estimated using harvesting, comminution and transport cost values from earlier studies. The facility type or the production capacity of the biorefinery were not considered in this analysis.

Results

By far the largest harvestable biomass potential is in pulpwood in the studied procurement area (Table 1). Small-diameter thinning wood also forms a large potential, especially if it is harvested as whole-tree biomass. Stumps and logging residues from clear-cuts together exceed the potential of whole-tree thinning wood. However, almost solely spruce stumps and logging residues are currently extracted and their potential is much smaller than when all the tree species are considered.

The unused potentials in the studied procurement area are much smaller for each assortment (Table 2). Particularly striking is the scarcity of spruce stumps and logging residues close to the facility. Small-diameter thinning wood becomes a more important raw material source when the unused potentials are considered.

The procurement costs of each biomass assortment increase with increasing transport distance. The larger the needed volume of the raw material is, the further away from the facility the procurement area must be extended. Therefore, the unit costs are also increased by increased procurement volumes (Figures 2-4).

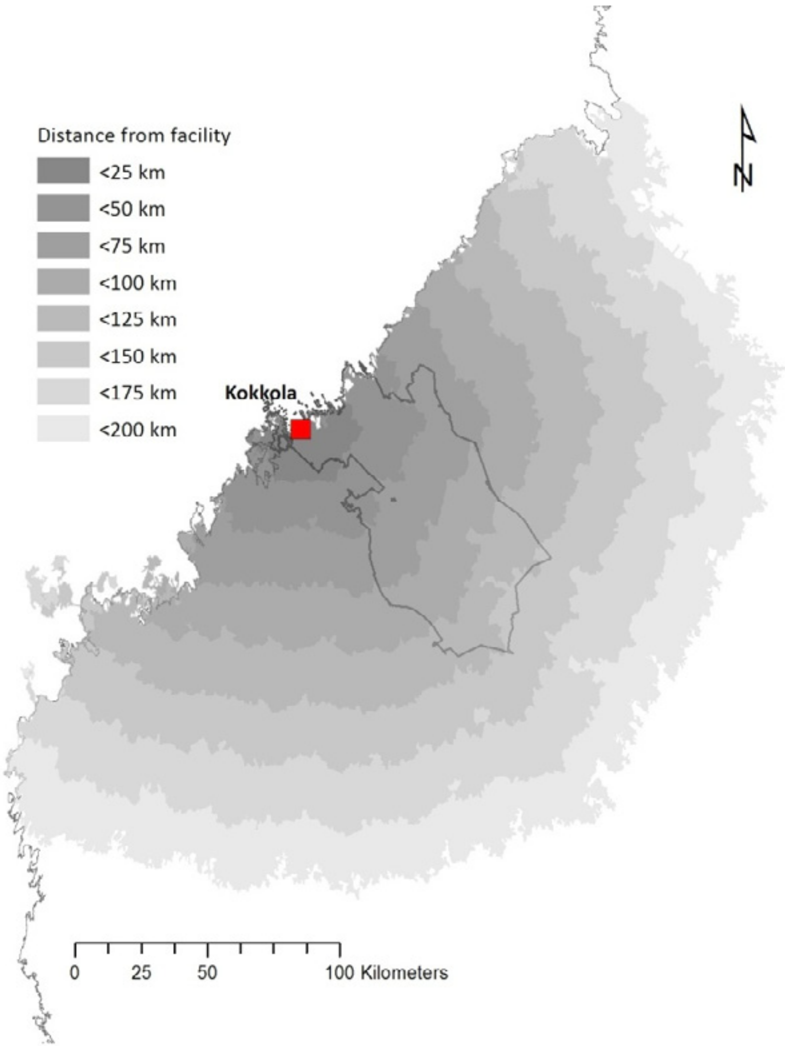

Figure 1. S tudied procurement area of a facility in Kokkola. The province of Central Osthrobotnia is outlined with a black line.

Table 1. Potentials (m^3/year) of forest biomass assortments for a facility located in Kokkola. Harvested pulpwood volume (bark included) is derived from harvesting statistics of 2011, whereas the full harvestable potential is estimated on the basis of the 10th NFI.

Max. distance from facility	Harvested pulpwood	Pulpwood, potential	Delimbed thinning wood	Whole-tree thinning wood	Stumps, all species	Spruce stumps	Logging residues, all species	Spruce logging residues
25 km	102 117	127 166	23 358	31 223	12 787	4 291	18 731	10 248
50 km	355 751	478 924	98 005	130 291	55 309	18 096	81 937	45 395
75 km	818 724	1 036 865	224 753	299 268	130 933	39 688	177 298	94 922
100 km	1 304 011	1 728 925	385 421	513 043	240 650	71 025	310 975	161 107
125 km	1 980 040	2 624 978	605 144	804 435	388 561	114 137	495 586	259 686
150 km	2 911 087	3 838 973	890 646	1 183 094	572 252	171 323	720 183	382 547
175 km	4 056 563	5 337 707	1 259 088	1 672 372	815 086	255 748	1 022 698	548 090
200 km	5 079 671	6 702 670	1 593 426	2 118 859	1 055 429	351 824	1 327 459	730 030

Table 2. Unused potentials (m³/year) of forest biomass assortments for a facility located in Kokkola. Unused pulpwood potential is calculated by extracting the harvested volume in the year 2011 from the full harvestable potential. The unused potentials of the other assortments were estimated by extracting the current use from the harvestable potentials presented in Table 1.

Max. distance from facility	Unused pulpwood	Delimbed thinning wood	Whole-tree thinning wood	Stumps, all species	Spruce stumps	Logging residues, all species	Spruce logging residues
25 km	24 998	5 569	11 683	3 194	0	3 445	0
50 km	123 173	32 510	61 866	14 179	0	15 753	154
75 km	218 140	86 032	158 498	33 768	92	37 389	2 001
100 km	424 914	156 225	283 957	60 391	388	81 575	16 922
125 km	644 938	248 137	449 237	101 936	2 078	158 084	46 502
150 km	927 885	379 588	677 964	173 543	13 488	245 612	78 144
175 km	1 281 144	567 296	993 883	287 144	42 670	361 715	125 496
200 km	1 622 999	747 158	1 296 382	415 045	86 800	498 955	195 065

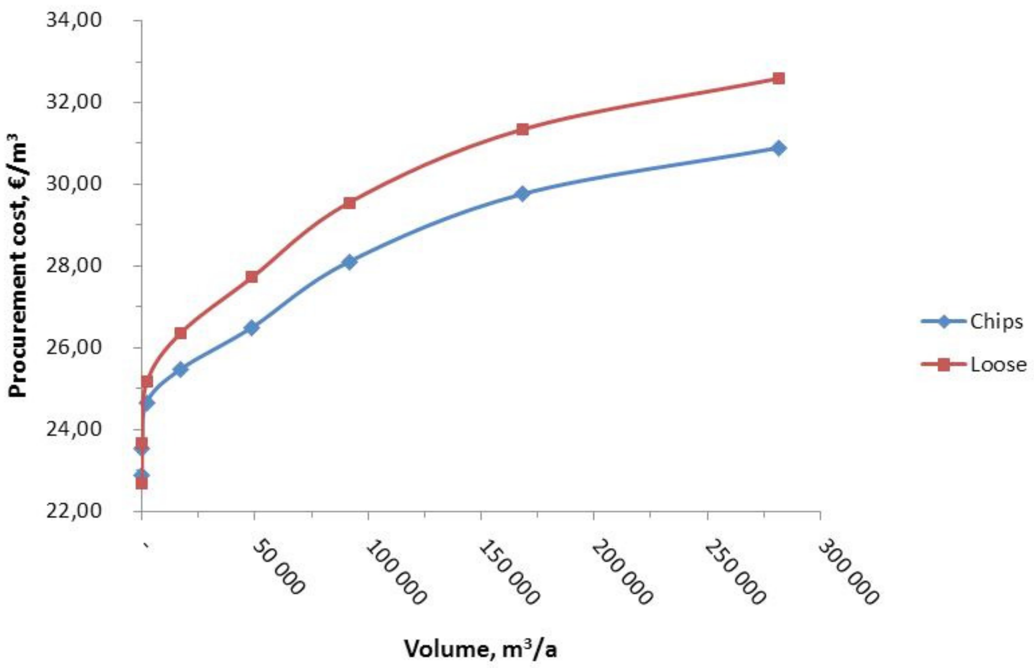

Figure 2. Procurement costs of stumps and logging residues in relation to the unused potential within the 200 km procurement area of a facility in Kokkola. Chips: logging residues are chipped at roadside; Loose: logging residues are transported uncomminuted and chipped at the facility. Stumps are transported as loose material and crushed at the facility.

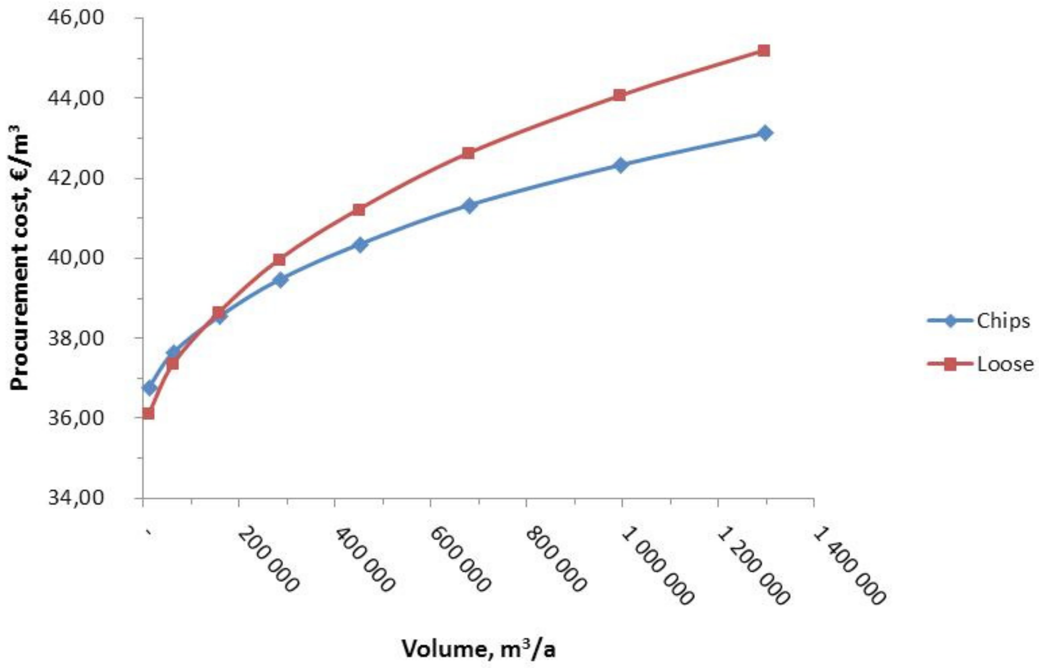

Figure 3. Procurement costs of whole-tree thinning wood in relation to the unused potential within the 200 km procurement area. Chips: thinning wood is chipped at roadside and transported with a chip truck: Loose: wood is transported as whole-trees and chipped at the facility.

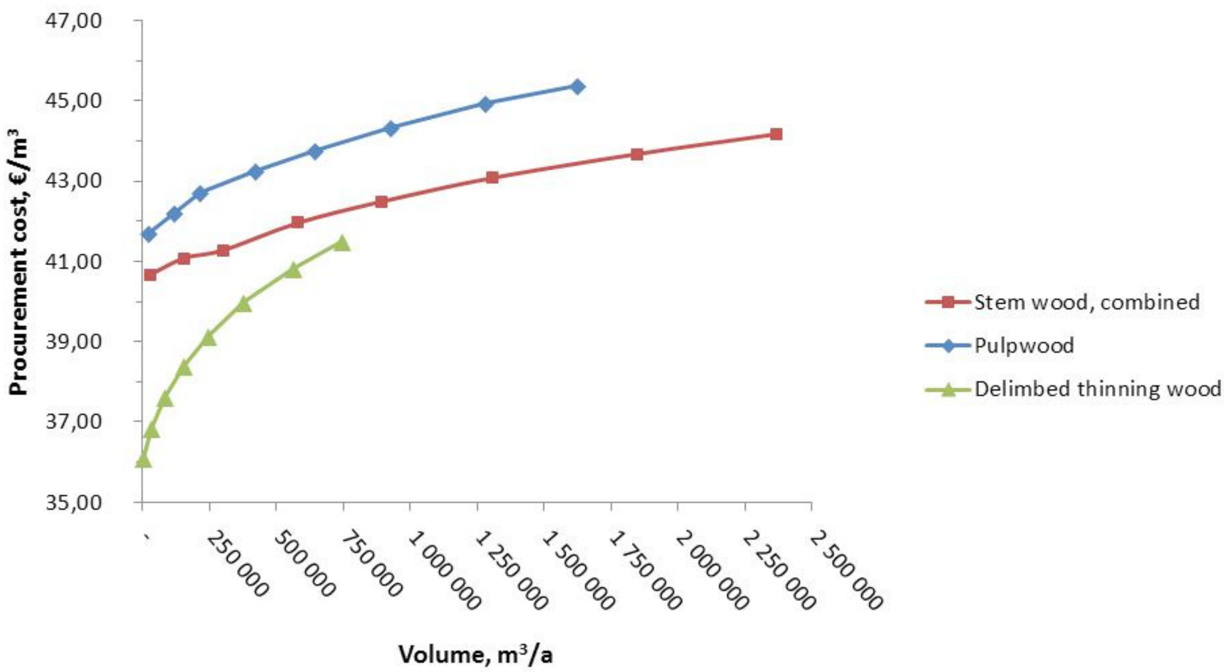

Figure 4. Procurement costs of stemwood in relation to the unused potential within the 200 km procurement area.

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