Biomass Terminals in the Feedstock Supply Chain for Biorefining

Biomass terminals could be considered in the feedstock supply chain of a biorefinery, if it is not possible to procure raw material directly to a biorefining facility or if there simply is not enough desired biomasses surrounding the facility location. In this study, five potential terminal locations supplying a biorefinery in Kokkola were evaluated. Specifically, the availability of forest biomasses to each location was considered as well as the procurement costs of chosen biomass assortments. Theoretical procurement areas for each terminal location were created using the existing road network, and the biomass potentials within these areas were quantified.

Methods

Potential terminal locations were selected from locations of existing wood fuel consuming facilities. It was assumed that each of these facility locations are capable of storing and handling significant quantities of woody biomasses. Five terminal locations were chosen by weighing the surrounding volume of availabe forest biomasses of each location (Figure 1). GIS analyses of the available forest biomasses to the terminal locations were 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 terminal. The cumulative biomass potentials were calculated for 25 km intervals from the terminals up to a maximum distance of 100 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 costs were calculated for the terminal locations independently, but also the transport costs of comminuted material from the terminals to the biorefinery in Kokkola were considered. The facility type or the production capacity of the biorefinery were not considered in this analysis.

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 its 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.

RESULTS

When the harvestable biomass potentials were considered, some differences between the terminal locations were found (Tables 1 and 2). This is due to the uneven geographical disribution of forest biomass reserves and the regional differences in the rate of use of woody biomasses.

Compared to direct procurement of raw material to the facility in Kokkola, using the terminals was more expensive in terms of unit cost (Figures 2-4.) For instance, although there is a shortage of unused stumps in the surrounding areas of Kokkola, it is still more feasible to transport them directly to Kokkola from longer distances than to use a terminal e.g. in Keuruu, where the stump potential is much larger.

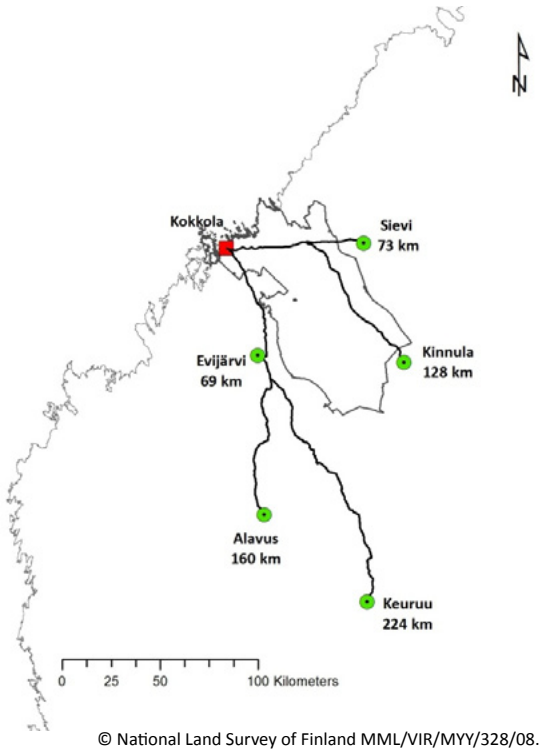

Figure 1. Alternative terminal locations and their distances from the facility via road.

Transport costs of these biomass assortments form a significant share of the total procurement costs. Therefore the overall costs of procurement tend to cumulate when the material has to be transported to the terminal and then transported again to the facility itself. From this perspective, these terminal locations would make an sensible option only if procurement directly to the facility was not possible for some reason.

Table 1. Potentials (m^3) of forest biomass assortments for alternative terminal locations.

Terminal location	Max. distance from terminal	Harvested pulpwood	Pulpwood, potential	Delimbed thinning wood	Whole-tree thinning wood	Stumps, all species	Spruce stumps	Logging residues, all species	Spruce logging residues
ALAVUS	25 km	85 085	127 689	22 334	30 368	26 814	8 130	31 267	13 733
	50 km	439 032	686 189	119 882	163 095	143 399	47 780	157 707	83 240
	75 km	962 373	1 428 016	267 944	363 903	302 844	106 869	332 563	186 722
	100 km	1 870 357	2 704 799	546 904	741 623	591 419	218 590	652 394	382 047
EVIJÄRVI	25 km	118 282	140 890	30 370	40 581	35 624	9 478	37 165	18 657
	50 km	536 263	626 990	145 892	195 595	113 516	31 407	128 729	64 304
	75 km	1 103 728	1 420 847	300 233	402 380	229 687	66 298	267 875	134 835
	100 km	1 748 890	2 286 154	489 079	655 560	382 426	113 117	436 004	223 032
KEURUU	25 km	140 032	176 992	43 578	58 358	42 630	21 744	54 842	38 433
	50 km	622 995	756 312	176 192	236 855	206 118	103 481	258 011	184 544
	75 km	1 305 630	1 628 164	360 317	485 525	448 992	222 872	557 880	399 745
	100 km	2 305 882	2 875 826	612 000	826 083	759 110	368 997	940 371	657 072
KINNULA	25 km	62 189	116 266	32 668	43 637	21 362	6 042	20 009	10 731
	50 km	390 037	520 611	142 263	189 853	90 254	28 316	96 816	53 935
	75 km	1 090 419	1 253 203	341 509	455 377	212 433	69 260	243 170	135 349
	100 km	2 227 192	2 441 901	648 664	865 425	405 183	141 962	490 204	280 337
SIEVI	25 km	110 830	155 743	38 234	50 473	21 361	5 385	28 298	13 477
	50 km	583 782	721 644	198 014	261 557	108 714	30 733	150 304	79 603
	75 km	1 355 209	1 562 062	411 745	544 208	212 761	61 370	295 068	156 235
	100 km	2 135 942	2 514 460	692 493	915 673	341 934	101 478	471 970	249 035

Table 2. Unused potentials (m^3) of forest biomass assortments for alternative terminal locations.

Terminal location	Max. distance from terminal	Unused pulpwood	Delimbed thinning wood	Whole-tree thinning wood	Stumps, all species	Spruce stumps	Logging residues, all species	Spruce logging residues
ALAVUS	25 km	42 605	3 196	11 734	3 151	951	792	290
	50 km	247 157	25 605	77 209	31 968	12 268	21 550	13 904
	75 km	465 343	70 948	192 798	86 901	35 913	76 576	50 203
	100 km	834 442	158 042	408 076	195 108	83 524	188 070	125 427
EVIJÄRVI	25 km	22 608	9 542	18 922	650	163	0	0
	50 km	90 727	59 489	110 935	1 570	385	87	27
	75 km	317 119	112 588	215 389	7 433	1 968	2 173	879
	100 km	537 264	188 363	357 152	37 933	11 807	28 434	15 847
KEURUU	25 km	36 960	11 874	30 204	20 203	10 308	27 081	18 971
	50 km	133 317	36 906	109 811	96 493	48 767	130 228	93 312
	75 km	322 534	67 279	210 457	202 291	102 394	274 893	199 496
	100 km	569 944	117 646	357 181	342 417	170 686	461 808	330 205
KINNULA	25 km	54 076	20 287	32 724	12 429	3 569	9 902	5 513
	50 km	130 574	87 743	140 872	46 644	15 647	51 229	30 203
	75 km	162 784	199 793	325 096	93 006	33 689	120 666	71 204
	100 km	214 709	358 713	592 969	163 895	67 778	238 252	145 705
SIEVI	25 km	44 913	17 209	30 014	0	0	7 934	3 877
	50 km	137 862	88 499	153 941	500	142	56 138	31 303
	75 km	206 853	190 079	324 898	3 958	1 330	108 261	60 587
	100 km	378 518	343 708	573 059	29 392	9 867	162 974	90 347

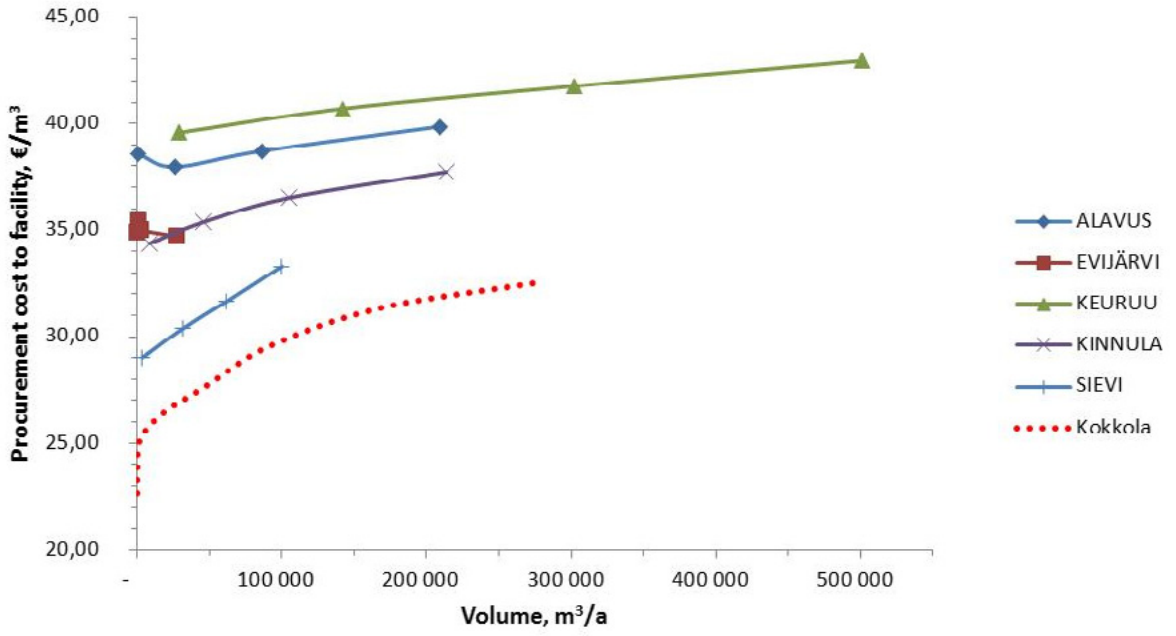

Figure 2. Procurement costs of stumps and logging residues to the facility using the terminal alternatives. The chipped (logging residues) and crushed (stumps) material is assumed to be transported from the terminal by a chip truck. Direct procurement cost to the facility location in Kokkola is shown as a reference.

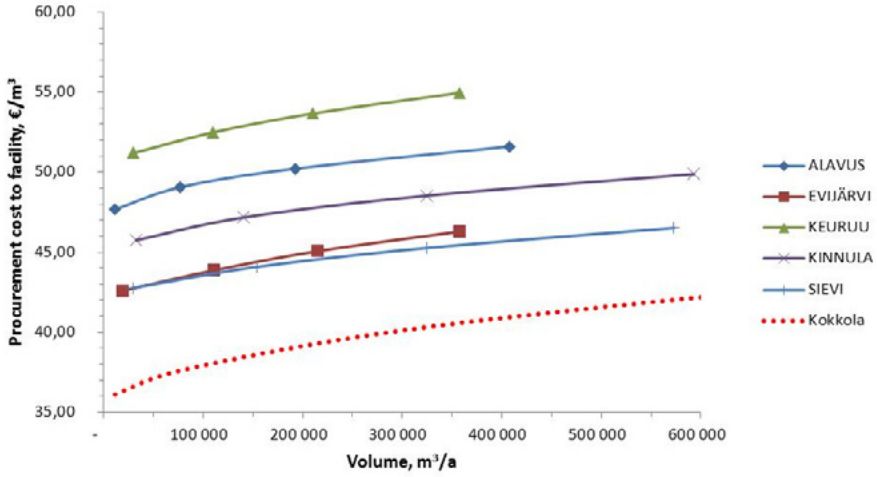

Figure 3. Procurement costs of whole-tree thinning wood to the facility using the terminal alternatives. The comminuted material is assumed to be transported from the terminal to the facility by a chip truck. Direct procurement cost to the facility location in Kokkola is shown as a reference.

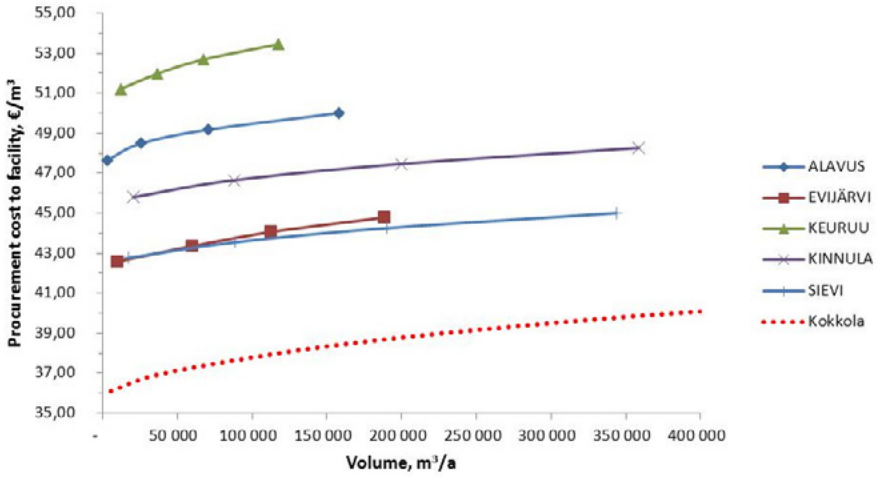

Figure 4. Procurement costs of delimbed thinning wood to facility using the terminal alternatives. The comminuted material is assumed to be transported from the terminal to the facility by a chip truck. Direct procurement cost to the facility location in Kokkola is shown as a reference.

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