Supply Curves for Tree Sections and Long Tops

The supply of innovative assortments from forest to three biorefineries located in the project region was considered. Cost and energy use supply curves for tree sections and long tops were created and compared to the conventional supply of pulpwood and logging residues. The innovative supply of residues from long tops and tree sections delimbed in a terminal shows to have significantly lower cost than conventional supply of logging residues, while the energy demand is similar. The total potential amount of residues supplied from tree sections and long tops in thinnings and final fellings is ca. 20 % larger than the logging residues amount conventionally recovered in final fellings. By chipping the tree sections and long tops without delimbing-debarking is possible to supply wood chips at a lower cost than the ones obtained from a conventional separate supply of chips from pulpwood logs and logging residues.

Introduction

In the systems analysis sub-project of forest refine, we have calculated supply curves for novel forest feedstock assortments delivered to the cities of Storuman, Umeå and Örnsköldsvik. Supply curves show the amount of feedstock that can be offered to the market at a given market price. According to economic theory, the market price and the amount of goods supplied to the market depend on the supply curve and its interaction with the corresponding demand curve.

In the conventional Nordic forestry, harvesting is performed according to a cut-to-length system, where the trees are delimbed into the forest with a single grip harvester and the stem is cut into logs of appropriate length already at the harvest site. The logging residues – tree-tops and branches – can be collected with a forwarder after the harvesting in a separate operation. An alternative to using separate supply chains for stem-wood and residual biomass is to use systems that integrate the assortments at the harvesting site. Here, we consider two assortments from such integrated harvesting operations:

- Rough-delimbed tree sections from first thinnings, which are stems with 50 % of branches mass still attached, cut into 5-6 m long sections:
- Long tops from second thinnings and final fellings, which are the pulpwood suitable tree parts of the stems with the branches and tops still attached.

In this integrated supply, pulpwood logs can be separated from the residual biomass (branches and tops) in a terminal close to the industry by means of a chain-flail delimber-debarker.

Results

Figure 1 shows the supply cost curves and energy use for delivering residual assortments from rough-delimbed tree sections from 1st thinnings and long tops from 2nd thinnings and final fellings to the industry. The tops and branches are separated from pulpwood logs at a terminal close to the industry and the residual fraction is chipped.

The costs and energy use are calculated as the difference between the total cost for handling rough delimbed tree sections and long tops, including the delivery of pulpwood and residues, and the costs for delivering only pulpwood with conventional harvesting methods. Hence, the curves for tree sections and long tops in Figure 1 represent the additional costs and energy use for acquiring the residual assortments. The curves for a conventional supply of logging residues from final fellings are shown as a reference.

The supplied amounts are ranked by increasing supply cost and the supply cost curve thus forms a smooth, increasing line. The energy use is not exactly correlated to the supply cost and hence shows a rugged curve. However, it follows the same general trend, indicating that the more expensive parts of the supply also require more energy to acquire.

The supply cost curve for the innovative assortments are generally below the curve for conventional logging residues; a significant larger amount of residues can be potentially mobilized from the innovative systems when considering together thinnings and final fellings, instead in the conventional case logging residues are considered to be harvested in final fellings only. The dashed black curve in Figure 1 shows the supply cost for residual biomass from long tops harvested in final fellings only. This curve is initially lower than the one for the logging residues from the conventional system, but it has a steeper increase in costs, and lies above the conventional system curve towards the end.

The curves of energy use are similar for the conventional and the innovative systems. They show the same general increasing trend as the cost curves, ranging from approximately 2 % to 8 % of biomass energy content. The main part of the energy curves, however, stretch between 2 % and 6 %, which corresponds to 10-30 liters of diesel used per ODt of biomass delivered.

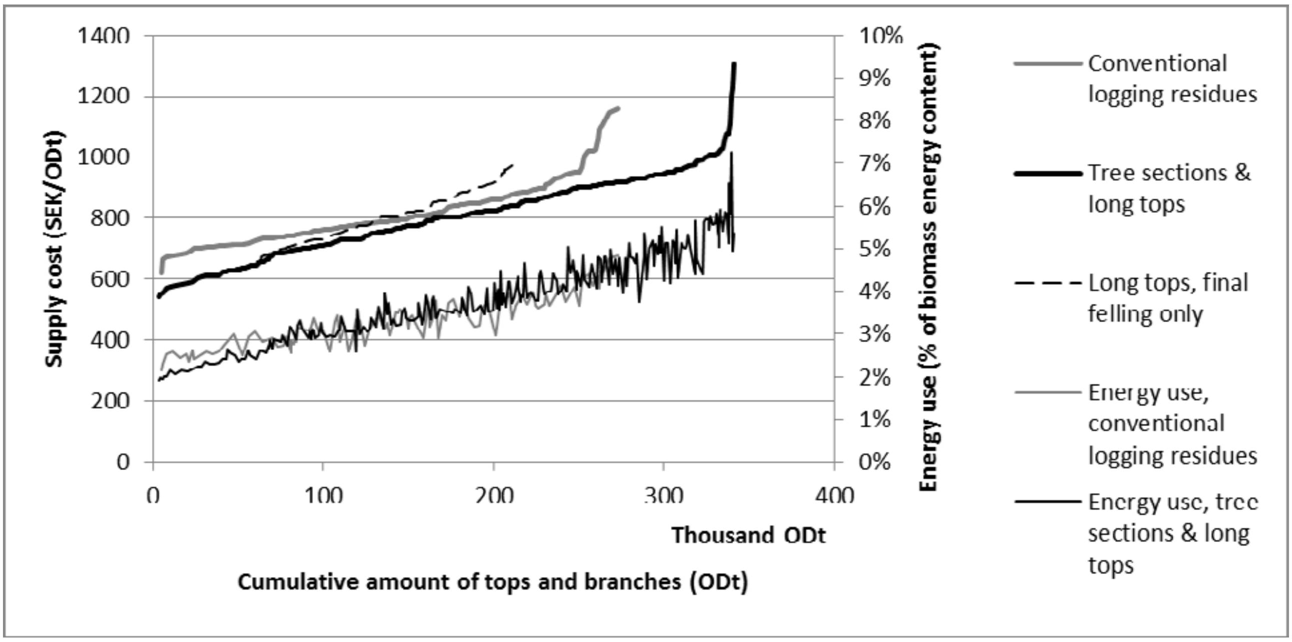

Figure 1. Supply cost and energy use for residual biomass from harvest of rough delimbed tree sections (at first thinning) and long tops (at second thinning and final felling) compared to conventional logging residue recovery (at final felling) based on the case study of Örnsköldsvik. Chipping at terminal and delivery to industry is included.

In Figure 2, results for the innovative system (grey curves) are shown in case of chipping the tree sections and long tops and as a whole (stemwood and residual biomass are chipped together) without prior delimbing-debarking in a terminal. In the conventional case (black curves) un-barked pulpwood and logging residues are considered both to be chipped and delivered as a joint assortment.

The supply cost for all chipped feedstock lies mainly in the 700-1000 SEK/ODt range. In this case, the innovative system has markedly lower supply cost per ODt biomass than the conventional one. Energy use figures lies around 2-4 % of biomass energy content.

The variation of the energy use is larger for the conventional case, which could be expected, since pulpwood and logging residues are handled independently and require different amounts of energy, whereas in the innovative system the stemwood and residual biomass are handled together.

Figure 3 shows the supply cost curves for chipped tree sections and long tops (c.f. fig. 2) for three locations. The characteristics of the supply cost and energy use curves are similar for Umeå, Örnsköldsvik and Storuman. The main difference is the total amount of feedstock available within the studied 120 km radius. The amounts, including residues and stemwood are about 600 000, 1 000 000 and 800 000 ODt/year for Umeå, Örnsköldsvik and Storuman, respectively. For delivery of chipped residues only (c.f. fig. 1), corresponding amounts are 270 000, 340 000 and 200 000 ODt/year.

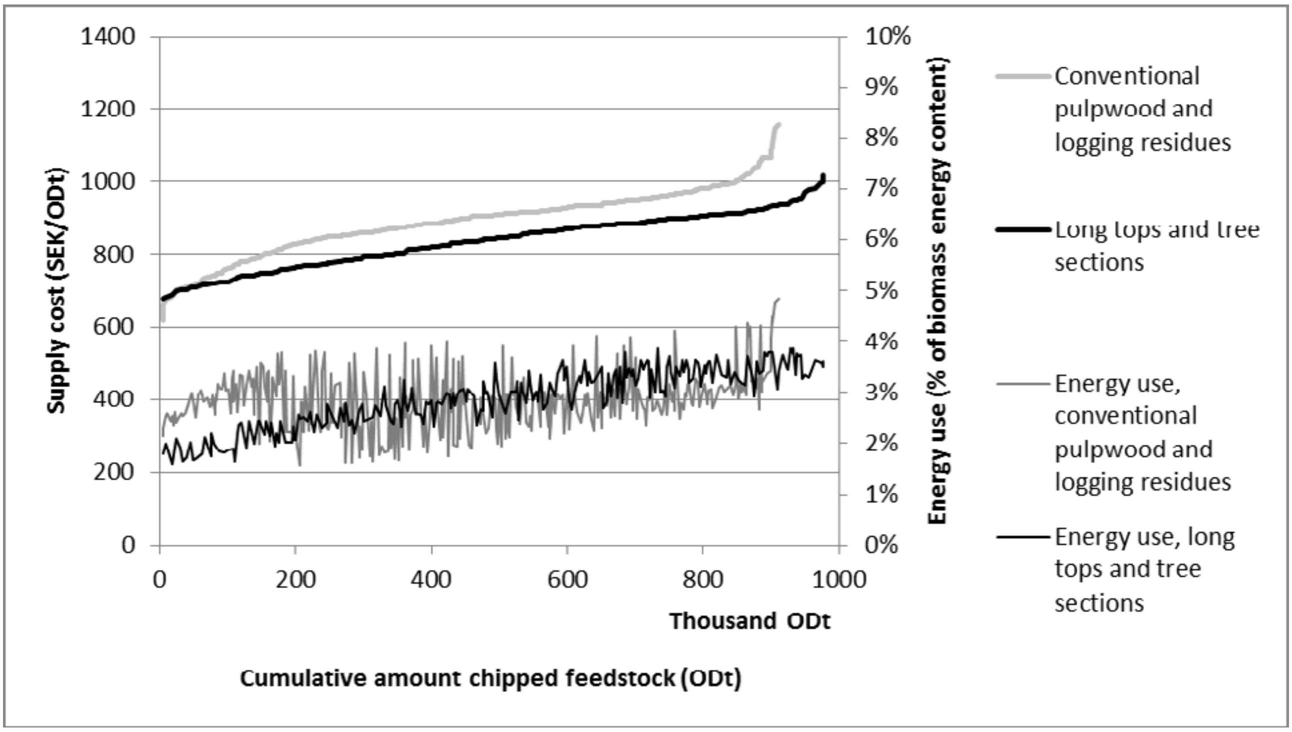

Figure 2. Supply cost and energy use for chipped feedstock with conventional systems and with innovative systems when stemwood, tops and branches are all chipped together. Based on the case study of Örnsköldsvik.

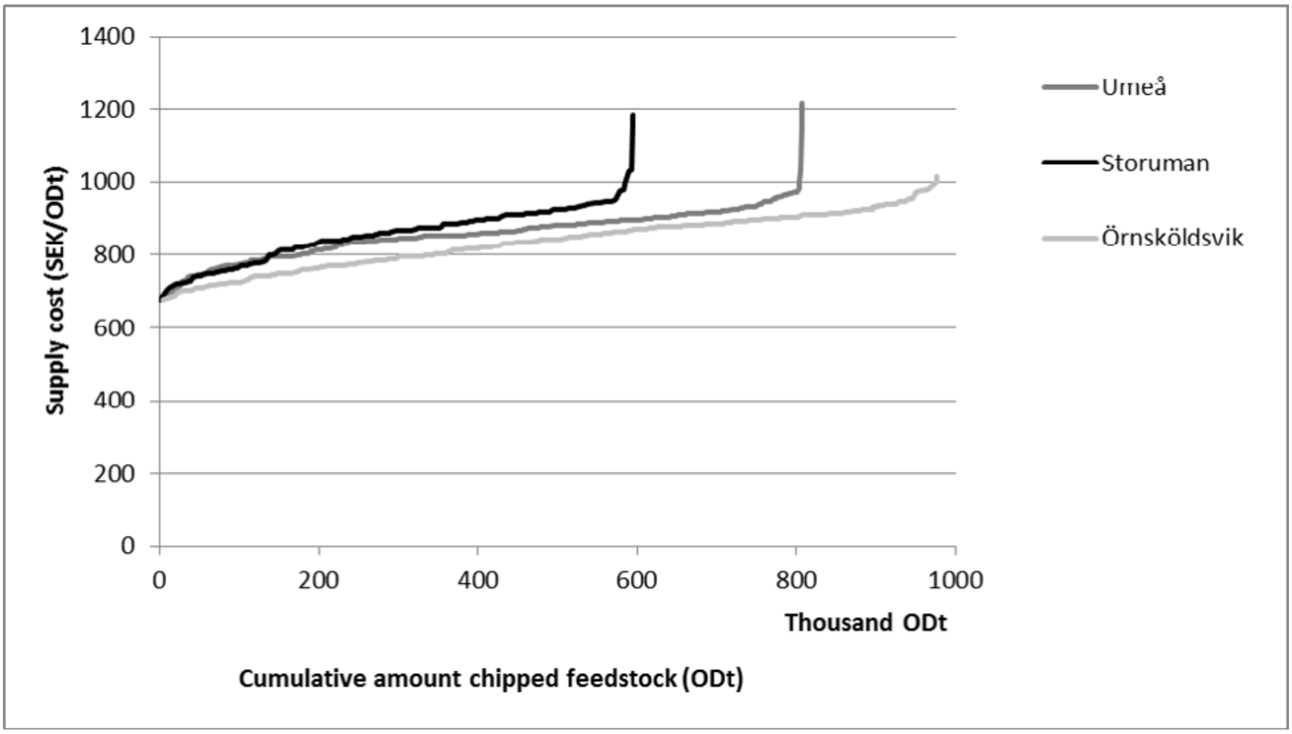

Figure 3. Supply cost for chipped feedstock with innovative systems when stemwood, tops and branches are all chipped together. Comparison of three locations results.

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