Cost and sensitive analysis tools for forest energy procurement chains

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Abstract. The primary aim of Excel based cost calculators is to familiarize the user with the various ways that different factors affect the cost of forest chip production within each working stage of the procurement system. The calculator enables the user to investigate how changes in processed material or in the productivity and hourly cost of machines influence the procurement cost of the whole system. Procurement chains are based on chipping at the roadside landing, in the terrain, at the terminal or at the end use facility. Procurement cost at end use facility is expressed as either €/m³ (solid cubic meter) or €/MWh. The herein reported Excel based cost calculator programmes were originally developed to serve research needs, but they are also suitable for energy wood procurement companies, contractors and teaching purposes.

Key words: logging residues, stumps, thinning wood, procurement costs, decision support, forest energy

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Introduction

At present Finland is the leading country in the utilization of renewable energy sources. Wood based fuels, including process residues from forest industries, represent 20% of total energy consumption in Finland (Hakkila, 2004). The utilization of wood energy has been supported by strong research and development work, including The National Wood Energy Technology Programme (1998–2003) which concentrated on the development of harvesting technology for forest chips (Hakkila, 2004). The production of bioenergy from forest fuels is also a growing trend in Europe, especially in the Baltic Sea Region. An increasing demand of forest fuels calls for means to transfer valuable research and development knowledge into practice.

Cost calculators for the procurement of small sized thinning wood, delimbed energy wood, logging residues and stumps for energy are based on the following National Wood Energy Technology Programme projects and subprojects results: “Cost factors and large scale procurement of logging residues” (Asikainen et al., 2001; Ranta, 2002), “Development of chip production from young forests” (Laitila et al., 2004), “Harvesting alternatives and cost factors of delimbed energy wood” (Heikkilä et al., 2005) and “Harvesting of stumps and processing of forest energy wood” (Laitila & Asikainen, 2004). The funding for the research projects has mainly come from TEKES (National Technology Agency), but also from the machine and appliance manufacturers, forestry and energy companies and the Trade Association of Finnish Forestry and Earth Moving Contractors.

The main purpose of the forest fuel procurement cost calculators, developed in the
The Finnish Forest Research Institute (METLA), is to familiarize the user with the various ways different factors affect the cost of forest chip production within each working stage of the procurement system. The user can review, for instance, how changes in materials’ heating value or in the productivity and hourly cost of machines influence the procurement cost of the whole system.

In the cost calculators forest chip procurement procedures are estimated at a stand level. The analysis of the supply chains starts with organizing the procurement activities, continuing to the harvesting and transportation and finally to delivering the forest fuels to the end users. The comparison includes each step of the procurement chain. Costs are expressed as either €/m³ (solid cubic meter) or €/MWh. Procurement chains are based on chipping at the roadside landing, in the terrain, at the terminal or at the end use facility. The purpose when creating these calculators was their easy usability and clear illustration of different phases of calculation and dependency relations.

The structure of cost calculators

Procurement costs on the basis of the stand data
The model calculates the forest chip procurement costs according to the stand data and harvesting machines productivity models (Asikainen et al., 2001; Ranta, 2002; Laitila & Asikainen, 2004; Laitila et al., 2004; Heikkilä et al., 2005; Laitila & Asikainen, 2006). In the stand data sheet, the user can insert specific information about forwarding and transporting distances, accumulation of energy wood per hectare by tree species, recovery rate of fresh and brown logging residue, area of the stand, moisture content of energy wood, seasoning time at roadside storage, seasoning loss at roadside storage, stem volume and recovery rate of logging residues etc (Figure 1). The data sheet is protected, except the feeding cells, so accidental changes are minimized.

| Area, ha | 2.0 |
| Forwarding distance, m | 200 |
| Transporting distance, km | 40 |
| Accumulation of small sized energy wood, m³/ha | 60 |
| Pine, % of accumulation | 33% |
| Spruce, % of accumulation | 2% |
| Birch, % of accumulation | 60% |
| Others, % of accumulation | 5% |
| Stem volume of whole-tree (with branches), dm³ | 30 |

<table>
<thead>
<tr>
<th>Moisture of fresh whole tree, %</th>
<th>Set value</th>
<th>Presumed value</th>
<th>Model uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture of seasoned whole tree, %</td>
<td>35%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Loss of seasoning, %</td>
<td>5%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Seasoning time at roadside storage, months</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Interest of capital, %</td>
<td>6%</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Overview from the stand data sheet in the cost calculator for whole tree chips procurement.
In the logging residue chip and stump wood chip calculators the accumulation of logging residues and stump wood is derived from the collection of commercial timber. In the whole tree chip and the delimbed energy wood calculators the user can input the accumulation of energy wood per hectare and the medium volume of the harvested trees (Figure 1). To help the estimation of the medium volume of the harvested trees there is a separate cell, where the volume of different tree species, delimbed or as whole tree, can be calculated by the DBH and length. The accumulation of crown mass (1991) and stump wood (1976) is calculated according to Hakkila’s biomass models and the stem volume in thinnings is calculated by the equations which are developed by Laasasenaho (1982). Forest chips energy content is calculated as a function of moisture content and fuel woods heating values (Hakkila, 1978; Nurmi, 2000).

**Supply chains of the calculators**

In the “cost calculator for logging residue procurement”, the supply chains are based on chipping at the roadside landing, in the terrain or at the end use facility. When the chipping is performed at the plant, truck transportation of biomass takes place in the form of loose logging residues or compacted logging residue logs (Figure 2). In the “cost calculator for stump and root wood procurement”, stumps are uprooted and split by an excavator or harvesting is done by a special stump-harwarder. The comminution of the stump and root wood is done either in the end use facility or at the roadside storage (Figure 2).

In the “cost calculator for whole tree chips procurement”, forest fuel production system is based on chipping at the roadside storage or at the end use facility. Harvesting of whole trees is based on manual or mechanized felling or the whole trees are harvested by the harwarder method (Figure 2). In the “cost calculator for delimbed energy wood procurement”, the fuel production system is based on chipping at the roadside storage or at the terminal (Figure 2). The delimbed energy wood is harvested with a standard harvesting head, for example Timberjack 745 or Valmet 945, which are modified with accessories to enable multi-tree processing.

**Calculation values can be changed**

The supply chain information sheets are included default values, for example, for the over-head costs for each production method, covering the cost of energy wood at the roadside storage and stumpage price of the energy wood. Other default values are the hourly cost of machines and trucks, load capacity for forwarding and transporting, transferring cost of machines, loading and unloading time for transporting, chippers productivity and chipping cost (Figure 3).

In the supply chain information sheet the user can, if needed, change the default values (Figure 3). This is because in reality the machines and procurement systems calculations basics and situations can vary significantly. In the calculations the default values are average of normal costs. All the default cost basics are easily adjustable to accommodate each calculation situation. For example the effective productivity of the machines can changed to the operating productivity by the optional multiplier (Figure 3).

**Discussion and conclusions**

“The cost calculator for logging residue procurement” was first published in 2001. In 2003 the calculator was updated by changing Finnish Mark values to Euro values.
Figure 2: Supply chains of the calculators.

THE PROCUREMENT COSTS AT THE END USE FACILITY: € per solid cubic meter or € per MWh
“The cost calculator for the whole tree chips procurement” was finished in Spring 2004 and “The cost calculator for stump and root wood procurement” was finished in December 2004. The latest procurement cost calculator, finished in April 2005, is “The cost calculator for delimbed energy wood procurement”. All procurement cost calculators are available to the public, except for “The cost calculator for stump and root wood procurement”. They are available for free in Finnish and English at by contacting (e-mail: juha.laitila@metla.fi).

The cost calculators can be utilized in consulting organizations, research institutes, educational institutions, forest chips procurement companies and as well in the energy companies. The productivity functions of the different harvesting methods, gained from the several work and field studies, are revised into an easy-to-use form in the cost calculators. Forest fuel calculators are a unique and very useful tool to the user when comparing different supply chains or making sensitive analysis. Feedback from the users has been positive.

The herein reported forest fuel procurement cost calculators have been used also in the energy wood technology transfer projects. In the Climbus technology programmes project “The EU’s forest fuels resources, energy technology market and international bioenergy trade” the calculators were used to calculate the forest chips procurement costs in Poland (Leinonen, 2005). The cost calculators have also been modified to suit the conditions in Scotland, which is for the Northern WoodHeat project (Sikanen et al., 2005). Cost calculators and harvesting productivity functions will also adjust to be a part of the MOTTI (Hynynen et al., 2002) and MELA (Salminen et al., 2005) programs.

In the calculators the analysis is made at the stand level, which thus limits the amounts of cost factors and variables. The herein reported forest fuel procurement cost calculators are thus decision support programs for analyzing selected supply chains and work site conditions. The efficiency of the supply chain for forest fuels depends on a large number of factors. Therefore matching the right type of supply chain to the right site requires careful GIS-based availability studies and cost analysis.

The procurement of energy wood is a processing chain, where one step effects
the later step. The scale of operations, full employment of machinery and areal availability of forest fuels are the most important cost factors (Asikainen et al., 2001). Operating on a large scale enables the use of capital intensive and effective systems based on chipping at plant, whereas at the small/medium scale roadside chipping based technologies are most suitable.

In the calculators, the machines productivity is based on Finnish work site conditions. Despite that, stand conditions (terrain, tree species etc.) are comparable in Sweden, the Baltic States, North Poland and North West Russia and results are thus reliable. However it is necessary, that the calculation values, such as machine costs, payloads and stand factors, are adjusted to local levels.

References


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