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Changes, challenges and opportunities in the wood energy supply chain

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Abstract. One of the biggest challenges in using bioenergy has been the problem of logistics; that is how, in many cases, to process and transport these low density and bulky raw materials. Finnish forestry technology is advanced and the same machinery which is used in timber harvesting is often used in energy wood harvesting.

A change in the forest industry has however caused some new expectations concerning the wood energy supply chain. One of the basic requirements for woodchips is low moisture content. In the transportation of wood chips high moisture content, and therefore a high weight, may limit the carrying capacity of vehicles and roads. Also in syngas and charcoal production dry raw material is needed to be able to control the combustion process.

The reduction of moisture content under natural drying conditions means an extended storage time. With Finnish climate conditions this normally means a storage period of at least one year. The various types of energy wood: stems, whole tree harvested stems, logging residues or stumps are piled in storage sites and covered. The raw material is chipped or crushed at these intermediate storage sites and after that transported to bio-refineries.

In the measurement of the energy wood's quality and quantity there are some differences compared to timber measurements. Normally the timber measurements are based on solid volume in cubic metres. The forest harvesters are equipped with on-line measurement systems. This on-line measurement is more complicated to carry out in the case of energy wood. Especially difficult are the volume measurements in whole tree and stump harvesting. A new method used in the measurement of energy wood is weight.

Key words: Wood energy, moisture content, drying, logistics, weight measurements, transport.

INTRODUCTION

The structure of the Finnish forest industry is changing rapidly. The traditional pulp and paper industry is partly giving way to bio-refineries, which produce for example: liquid fuels or bio-based chemicals. There exist however hindrances which may be critical for the new businesses both upstream and downstream of bio-refineries.

In downstream operations in Chambosts and Stuarts (2007) research, the longer-term competitive advantage of companies implementing the bio-refinery concept is unlikely to be related only simply to technology, but rather, related to the unique supply chain that companies put in place; coupled with manufacturing flexibility.

The forest bio-refinery offers a business strategy that potential forestry companies are seriously considering for improving the overall financial performance of the sector; however, there are considerable technological and business risks related to its implementation. These risks can be mitigated to a great extent by using systematic product and process design tools for analysing bio-refinery strategies. (Chambost & Stuart, 2007).

The use of wood as fuel has a long tradition in Finland where forest energy is the most important source of bioenergy. In 2007 the final energy consumption of renewable energy in Finland was 28.5% of the total energy usage. The aim of the European Union Commission is to increase renewable energy usage in Finland to 38% by the year 2020 and the Finnish Government has promised to abide by that target. (Government Programme… 2007; Energy.eu. 2010).

Renewable energy is expected to play an essential part in preventing climate change. It is necessary to increase the use of forest energy substantially so that the goal of the European Union can be met. However, the above-mentioned target is very challenging for the technology of today. New innovations and bioenergy sources are needed (Laurila & Lauhanen, 2011).

Upstream of wood energy supply the properties and the treatment of the wood is expected to meet more precise quality requirements than ever before. The main hypothesis in the Seinäjoki University of Applied Sciences research has been that the future use of energy wood requires chips with low moisture content (30–40% wb.). This results in a need to dry the wood under Finnish conditions and this normally means one year storage time. Because of the disadvantages of natural drying, artificial drying methods such as thermal drying are also used. However, the energy consumption of thermal drying is quite high and therefore the method is not so cost effective. Both artificial drying and drying under natural conditions should be taken into account.

The measurement of the amount of energy wood can be based on volume (m^3), weight (kg) or energy content (MWh). All of these units of measurement are being used today. However, measuring wood is problematic. Physically the measuring can be made: in the forest, at the roadside storage site or at the heating plant. However during storage the wood moisture content reduces. Nowadays crane scale weighing in the forest is the most commonly used technique. (Laurila & Lauhanen, 2011).

MATERIALS AND METHODS

In Pasilas (2004) research a new harvesting method was introduced where bast fibre plants were harvested in early spring time the year after they were planted. Early spring was a favourable time for harvesting due to the very low air humidity and moderately high temperature. Both winter frost and the repeated temperature changes above and below zero were beneficial to the later processability of the bast fibre material (Pasila, 2004). This earlier information encouraged us to carry out further research with energy wood.

In Laurilas and Lauhanen´s (2010) research is described the harvesting of stumps after clear-cutting. This method is widely used in Finland. The data was collected during 2006–2009. Stump harvesting can result in a reduction of the infection rate of root rot fungus and is also a substitute for traditional soil preparation when reforesting. Therefore it also decreases the costs of reforestation (Procurement of forest… 2003; Saarinen 2006). The climate data (temperature, air humidity and precipitation) was obtained from the nearest Finnish Meteorological Institute weather station. The annual air humidity curve was calculated from the data. The climate data was compared to the moisture content in the stump piles during the year.

In other research Laurila and Lauhanen (2012) measured the weight of energy wood stems in the forest, roadside storages and at heating plants. The measurements were carried out using a Ponsse load optimiser and TB 3000 scales. The measurements at the roadside storage sites were carried out using frame volume to define the volume of the stacks. The results from the heating plants are based on declarations from the heating entrepreneurs or the receiver of the energy wood. The data included: the receiving time, the loose volume of the chips (m^3), the wood weight (kg), the energy content of the chips (MWh), the energy density of the chips (MWh $(m^3)^{-1}$) and the moisture content (%) of the wood.

Hakonen and Laurila (2011) have calculated the effects of the moisture content of wood chips on the transport capacity and fuel consumption of trucks. To find out the economic value of the wood chips at heating plants the heat value of the chips was also calculated.

In recent research Hakonen (2013) tested a complete wood supply chain computer program to evaluate the effect of, costs and capacity on the supply chain. Hakonen is using the Vensim PLE simulation program in his research. The simulation has been used earlier in time dependent processes because it enables you to take account of the time dependent costs (Harrington & Tumay, 2000).

RESULTS AND DISCUSSION

Under Finnish climate conditions the favourable time to use natural drying for any material occurs during April to June when the relative air humidity is at its lowest level 40–50% RH. Spring harvesting yielded bone dry material with a moisture content level 10% wb. The processability of the material was also favourable because of the fractionated structure of the plant stems. The slatted structure of the plant stems was caused by the repeated freezing and melting of the stems during winter (Pasila, 2004).

This fractionated structure was not expected to appear in wood stems because of their different structure when compared to bast fibre plants. However, the drying period from April to June was expected to be recorded in the stump and stem piles. This phenomenon could be clearly seen when the air humidity annual curves and stump pile moisture contents were compared (Laurila & Lauhanen, 2010).

The other information which could be seen on the annual temperature curves in Finland is the average below zero temperature from November to March which causes the soil to freeze. This freezing also facilitates wetland transportation during this period when energy use is at its highest. In Finnish climate conditions these two conditions: moderate air temperature and low air humidity could be integrated to produce lower moisture content wood chips which could be exploited in bio-refineries.

The weight of energy wood, which was measured with the harvester loader, was compared to the frame volume measurements at the roadside storage sites and they were in a high correlation. However the weight of the wood chips which was measured at the heating plants was lower. This measurement was carried out after the one year storage time. The reason for the weight loss was the drying of the energy wood (Laurila & Lauhanen, 2012). The moisture content change during the storage time increases the heat value of the wood chips at those heat plants where the convection process is not in use. The dry chips also give an advantage with transportation; however not as much as expected. A more important advantage however is the ability to exploit the full volume of the transport trucks. Wet wood chips result in an overload if the full volume of the transport trucks is used (Hakonen & Laurila, 2011).

In recent work Hakonen (2013) has applied the computer simulation program to transportation planning. The situation concerning, for example, one year storage time is complex. Storage time affects the moisture content of wood chips.

CONCLUSIONS

A major change in the wood energy supply chain is the long storage time needed for the wood. In future bio-refineries may also require dry raw material depending on the manufacturing process which is applied. The drying of energy wood under Finnish climate conditions requires normally a one year storage period which should include the April to June low RH period at least once.

A challenge in the future processes is the control of the roadside storage sites. The timing of the harvesting of stumps is dependent on the thawing of the soil. During winter time stump harvesting is not possible. The harvesting of early thinning areas in wetlands is possible only during wintertime when the soil is frozen. Also the consumption of wood chips at heating plants is highest during the winter time when the temperature is at its lowest.

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