

## FEEDSTOCK FOR BIOFUEL PRODUCTION:

# Residues from the forest

*Main forestry products are timber and pulpwood, but residues from forestry, such as tops, branches and stumps can be harvested for energy purposes. Currently, the major part of the harvested residues is used in heat plants and combined heat and power plants. However, forest residues also have a large potential as a feedstock to produce biofuels. By gasification and further treatment residues can be used to produce e.g. methanol, ethanol, DME, hydrogen, Fischer-Tropsch diesel and substitute natural gas (SNG). By pre-treatment and fermentation, forest residues can be utilised for ethanol production. Another potential lies in the different high-value products that can be co-produced when forest residues are utilized in so called biorefineries.*

### Forest management

In Sweden, the productive forest area is around 22 million hectares. The dominating forest type is conifer (spruce and pine), but also broadleaved and mixed forest types are common. A rotation period can vary from 50 years in southern Sweden to over 100 years in the north. Common practice is to plant seedlings, however natural sowing from seed trees can also be used. Thinning is done to concentrate the growth to fewer trees in order to achieve better timber quality. There is a large energy potential in collecting forest residues from thinning, even though this is not currently done in any considerable scale in Sweden, mainly due to practical problems of transporting the trees out of the forest without damaging the remaining trees. Final felling is in Sweden often done as clear-cutting.

### Tops and branches

Tops and branches is the part of the biomass left in the forest after final felling. The tops of the trees are cut, since this part is too small to be used as timber or pulpwood. Tops and branches make up about 15-20% of the mass of the whole tree. During the felling, tops and branches are put in stacks, along with the timber and pulpwood. The stacks of tops and branches are left in the clearing to dry for a period of time and for the needles to fall off, since needles make a good forest nutrient. The semi-dried tops and branches are then taken out of the forest to be stored in windrows alongside the nearest road, before transport to user.

There are many different operational and logistic management options for handling of tops and branches. The residues are bulky; therefore they can be chipped in the forest with mobile chipping equipment before transportation, so that trucks can be effectively loaded. The bulky residues can also be transported to a central chipping facility, before the residues are distributed to heat plants. Storing of chipped wood can be problematic as it leads to dry matter losses. It also leads to heat development and risk for self-ignition. Storing wet wood chip can lead to molding, with risks of spreading spores that are unhealthy to inhale. Therefore long-time storage of wood chips is rarely recommended. This requires a balance between supply and demand, which is a logistical challenge.

### Stumps

At present almost all stumps are left in the forest after final felling in Sweden. With about 15-20% of the whole tree's energy contained in the stump, there is a large potential in using stumps for bioenergy. The Swedish research on stump harvesting and its consequences looks to e.g. Finland for experiences, where stump harvesting has already been in commercial operation for some time.

Stump harvesting can be done using an excavator with a harvesting head. There are two main type of harvesting heads, shearing or refractive heads. The shear head has a forked part, which is pressed against a wedge in order to split the stump before lifting. Each piece of the stump then has to be lifted individually.

A refractive head has prongs that are pressed under the stump and pulling it up until it comes loose. The stumps are generally contaminated with stones, sand etc, of which as much as possible needs to be shaken off before the stumps are hauled to a windrow at roadside.

From roadside, stumps can either be crushed at site with mobile crushing equipment or transported to a terminal for crushing. Crushing on site dramatically increases the pay load on each truck. After crushing, whether on site or at terminal, the stump fuel can be run through a drum sieve, to remove as much contaminants as possible, lowering the ash content to below 5%.

### Current production and potential

In 2010, residues from forestry in Sweden contributed with about 14 TWh of energy, with only a small part of this deriving from stumps. The residues are mainly used for heat and electricity production; there is currently no commercial production of biofuels from forest residues in Sweden. It is difficult to obtain statistics

on how many hectares the residues are collected from, which can be explained by the reporting routines. The forest owners are only obliged to report the intention to take out residues after final felling, but this intention is not always followed through. During 2010, 155 000 hectares of forest was reported as intended for harvesting of tops and branches, and about 7 600 hectares for harvesting of stumps.

The energy potential in residues from forestry is large, and the total theoretical potential, no restrictions applied, is calculated to 141 TWh annually. But for different reasons not all residues can be collected. For example harvesting should not at all be done on wetlands or steep grounds, stumps cannot be harvested during thinning, and a certain amount of the residues needs to be left in the forest for ecological reasons, especially in broadleaved forests. Including these restrictions, there is an estimated total potential of 16 TWh per year in tops and branches, and 21 TWh in stumps for residues after final felling. Including residues from thinning will increase the potential, but removing residues from thinning is connected with practical and economic difficulties.

### Chemical properties

These are the chemical properties for tops, branches and stumps. The table shows mean value and range. Regarding lignin content, the numbers refer to spruce, in other cases they are not defined.

	Tops and branches	Stumps
Lower heating value (MJ/kg <sub>dm</sub> )*	19.9 (18.8-20.1)	19.5 (19.1-20.6)
Ash content (%)	2.7 (1.3-4.7)	1.5 (1.4-18)
Lignin content (%)	21.5 (15.6-27.4)	19.5

\* dm = Dry Matter. Source: Värmeforsk (Bränslehandboken 2012) and Forest Refine.