Biomassa-upstream stuurgroep

Memo: **Report on bus ticket no. D15a**
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The harvest of forest residues in Europe

1. Problem

The Dutch forest owners reacted very reserved on the question whether they would be willing to harvest forest residues (tops and branches) from their forests. In other European countries, such as Sweden and Finland, forest residues to some extend are being harvested. The harvest of forest residues represents a large biomass potential which at present is hardly used.

2. Questions

1. Which European countries do harvest forest residues?
2. Is there any opposition against this harvest?
3. Has research been performed to determine the consequences of harvesting forest residues (e.g. soil fertility, sustainability)? If yes, what are the results?
4. What is the technical potential within the EU-25?

3. Approach

In order to answer the questions above a literature study has been done.

4. Results

4.1 Harvesting forest residues

Before answering the questions mentioned above some backgrounds of the harvest of forest residues are presented in this paragraph. Forest residues can be defined as all above-ground biomass left on the ground after timber harvesting operations (e.g. branches, tops, small unmarketable logs and undergrowth trees). On average 10 to 15 % of the total above ground biomass is left behind as forest residues during regular harvesting activities (20–30% in the first commercial thinning but only 4–5% in the final cutting). It should be kept in mind that these figures are from countries with forests mainly consisting of coniferous species and are for this reason related to coniferous species.
Forest residues have a great biomass potential. Especially in Europe where due to the high degree of utilization of industrial wood processing residues sources, of woody biomass for energy purposes are becoming scarce. Forestry residues than come into the picture.

Usually, high costs are involved in the procurement of forest residues from the forest. For this reason a number of technologies have been developed and should be further optimized in order to reduce the costs of harvesting forest residues. Also a number of logistical supply chains have been developed to remove the residues from the forest and transport them to the energy plant. Four logistical supply chains are commonly used: the terrain chipping method, the chipping in road side-method, the bundling method and the loose residues method. Which method and technologies should or can be used depends on ecosystem conditions, infrastructure, forestry traditions and the desired level of integration of the regular harvest system with the harvest of forest residues.

The four forest residue supply chains:

1. the terrain chipping method: residues chipped inside the forest stand – transported by truck to the energy plant
2. the chipping at roadside method: forest residues pilled up at the roadside – chipping at the roadside – transported by truck to the energy plant
3. the bundling method (figure 1): bundling the forest residues inside the forest stand– bundles pilled along the forest road – bundles transported to the energy plant – chipping at the energy plant
4. the loose residue method: extract forest residues from the forest stand – forest residues pilled up along the forest road – transport the forest residues to the power plant - chipping at the energy plant

A problem with the use of forest residues for energy purposes is the presence of needles (and in some cases of leaves). Needles burn better than wood, but they contain chlorine. Chlorine increases the possibility of corrosion inside the combustion chamber also dioxides are produced. The disadvantage of leaves is that they burn less well than wood. This problem can be solved by leaving the forest residues in the forest for a while to dry. Furthermore, most of the needles and leaves will be shed off during the harvesting operation.

Figure 1. The bundling method the most recent developed method to extract forest residues from the forest stands (Alakangas, VTT)

4.2 Countries that do harvest forest residues

The Scandinavian countries are the leading countries in the use of forest residues for energy production. Especially Finland and Sweden use large amounts of forest residues. Countries like the United Kingdom, Ireland and Germany are increasing their use of forest residues for energy purposes.
The views of several Dutch experts on the situation in the Netherlands regarding the harvest of energy wood and forest residues are presented in a recent article by Juijn that has been published in the "Vakblad Natuur Bos Landschap" January 2005, which is attached as an annex to this report. The article concludes that some energy wood is being harvested in the Netherlands, but forest residues are not harvested during regular thinnings. Only in those cases that clearfellings are performed forest residues are being harvested. Clearfellings are not common forest management practice in the Netherlands, but are sometimes performed if a piece of forest has to be cut e.g. to develop a building site. Most energy wood from forestry in the Netherlands comes from pre-commercial thinnings. The removal of forest residues after regular thinning is too expensive.

<u>Sweden</u>

The utilization of fuel chips from forest residues has been going on for some 30 years in Sweden. This utilization is ever increasing: some sources claim that it's growing by an annual 10 % and will continue to grow at the same rate for the upcoming years. Bio-energy from forest residues is an important part of the Swedish energy system, and Sweden is a world leader in this field. Most of the residues (>71%) are derived from final fellings.
Sweden has a theoretical potential of 20 million m^3/a of forest residues when ecological and technical constraints are applied (Richardson *et. al.*, 2002). Applying economical constraints will further reduce this theoretical potential.

Finland
Finland is the world leader in utilization of bioenergy. The role of wood as a source of energy is more important than in any other industrialized country, as 20 % of the primary energy consumed is derived from wood-based fuels. The target of the Finnish energy and climate strategies is to raise the annual production of forest chips to 4.6 million m^3 or 37[1] PJ by 2010. In 2001 already 1,3 million m^3 of forest residues were used.
The total amount of stemwood residues (excluding crown mass) from annual logging operations in Finland is 4–5 million m^3, but as it is scattered over an area of 600 000 ha, the yield per site is too low to make the collection of these residues feasible. Profitable harvesting of forest residues for energy purposes requires higher yields. This can be achieved with simultaneous recovery of residual stemwood and crown mass.
In Finland the technical availability of logging residues from final harvests is about 40 PJ per annum (5 million m^3/a), of which 48–66 % (3 million m^3) is presently economically harvestable.

Denmark
In Denmark the importance of chips as a fuel has continued to increase over the past 20 years, and today approx. 200,000 m^3 of solid wood equivalent of forest residues is produced each year. Chip production equipment has been improved considerably in recent years, and this has helped to keep fuel prices at a reasonable level. Chips are mainly utilized for heat purposes, but the wood chips are also used in co-generation, district heating and CHP plants. In the 1990´s approx. 30 coal fired plants were converted into wood chip fired plants, in an effort to utilize a larger amount for CHP plants.
Denmark has a potential of 11 PJ/a of forest residues of which 75% is actually used (8.5 PJ/a or 1.1 million m^3) . This amount of forest residues comprises 23% of the total amount of biomass used for energy production.

United Kingdom
The total forest area in the United Kingdom has a technical potential of app. 2.2 million m^3 per annum of forest residues. This figure is an estimate of the annual sustainable production that can be made available taking account of technical and environmental constraints. Economic factors determine how much of it can be technically utilized.

Ireland
In 2000 Ireland had a technical potential of 43 PJ (6.9 million m^3) from forest residues.
The quantity of forest residues present in Ireland is given as 675,000 m^3, this was calculated as a percentage (20%) of the annual total of harvested timber in Ireland. Forest residues are not currently exploited as a biomass resource as they are considered to play an important part in the overall forest life cycle.

Germany
Germany has a potential of 178 PJ (22.2 million m^3) from forest residues. The use in 2000 was 55 PJ (6.9 million m^3) of forest residues; i.e. 28% of the total amount of biomass that is used for energy purposes.

4.3 Status of the harvest of forest residues: is there any discussion?
In general it can be said that there is little or no discussion about the removal of forest residues in countries where this removal is common practice. Especially in countries which start or are willing to start with this removal some doubts are expressed. The main question that is asked about the removal of forest residues is what the impact of this removal is or will be on soil fertility and on the sustainability of forest management? Paragraph 4.4 deals with the research that has been performed on this subject.

[1] Conversion factor: 1 PJ equals 0.125 million m^3 fresh wood chips

4.4 Performed research and results

Especially in Sweden and Finland a lot of research has been done into the subject of removing forest residues from the forest. In other countries research has not been done specifically on the subject of the removal of forest residues, but deals with the removal of forest products in general. The main findings of this research are presented here.

Compared with tree stems, crown material and particularly the foliage component, is rich in nutrients. Consequently, that crown mass removal increases the loss of nutrients from a forest ecosystem, if the removal of forest residues for energy purposes becomes a common practice in forest management. Certain restrictions and site specific management are needed to minimize the negative impacts of intensive harvesting on nutrient cycling and biodiversity.

Studies in many countries show that crown mass removal may endanger the sustainability of production capacity, depending on the site characteristics and amount and composition of removed biomass. However, field experiments usually incorporate uniform distribution of material after logging in control plots and complete removal of crown components from whole-tree logging plots. Since this degree of precision is impossible in operational forestry, experimental results tend to over-estimate the negative impact of forest residue removal on the growth potential of the site. No technology is able or intended to remove all crown mass from the site. For example, in Finland the salvage of logging residues from the final harvest, irrespective of the system applied, accounts for only some 70 % of the crown mass (Alakangas, 1999).

Negative ecological impacts can be reduced by careful planning and the adoption of appropriate technology. Examples of available methods are:

- the appropriate timing of operations
- minimizing the nutrient removals from the forest sites
  Summertime transpiration drying is an effective way of achieving the simultaneous reduction in moisture content and partial defoliation in small whole trees and logging residue heaps on the site. Most of the essential nutrients are stored in the needles and leaves. However, the flow of fuel from the logging site to the energy plants is slowed, and the recovery of biomass is reduced. An other way is the development of foliage trimming techniques
- recycling of ash from the combustion installation.
  By returning wood ash from the combustion installation to the forest the nutrient loss from the ecosystem is minimized

These methods will not completely compensate the nutrient loss, but will certainly reduce it. The removal of forest residues from poor sites should be avoided in all cases, because this would further reduce the nutrients availability in these already nutrient poor sites (Sikkema, 1998, van Belle and Temmerman, 2001, Burgers, 2002, Hakkila, 2002).

4.5 The technical potential within the EU-25

The theoretical energy potential of forest residues from logging and tending operations in the EU countries are estimated to amount to 1028 GJ. These residues are located primarily in Germany, France, Sweden and Finland. This potential can, of course, not be utilized entirely, since ecological, technical and economic barriers constrain its recovery (Richardson *et. al.*, 2000). Furthermore supply and demand do not always match geographically.

To illustrate what the potential impact of the use of the energy potential available in forest residues would be, the following assumptions are made. The use of one third (243 GJ) of the energy potential in forest residues would reduce CO2 emissions by 30 million tons annually. This is a reduction of 2-3% of the total CO2 emissions from power generation in the EU countries.

During a study performed by Ecofys, EFI and Probos the EFISCEN model was used to estimate the amounts of recoverable logging residues in the EU-15 member states. The results are shown in table 1. The amount was estimated by assuming a 15% recovery rate. The report on BUS ticket D15b will further deal with the technical potential of forest residues within the EU-25 member states and will be able to use different assumptions. For this reason this report will not further elaborate on the technical potential within the EU-25 countries.

Table 1 Amounts of logging residues potentially available for renewable energy when assuming a 15% recovery rate. Data for EU-15 Member States (Meuleman *et. al.*, 2005).

Member State	Recoverable logging residues (m^3)*
Austria	1,094,425
Belgium	239,061
Denmark	137,695
Finland	2,318,877
France	4,930,198
Germany	3,150,163
Greece	739
Ireland	206,577
Italy	1,318,613
Luxembourg	32,332
Netherlands	91,196
Portugal	282,945
Spain	853,388
Sweden	2,942,641
United Kingdom	745,361
Total EU-15	**18,344,231**

* m3 round wood equivalents
Source: EFISCEN-model

5. Conclusions

1. In general the harvest of forest residues is performed in clearfellings only and is less suitable for thinnings. The reason is that space to move around in the forest during thinning operations is limited which causes higher costs. Consequently the harvest of forest residues is mainly done in countries where clear- or final fellings are still performed.
   This is the main explanation for the huge gap between the technical potential of forest residues for energy purposes and the actual amount that is harvested in the EU.
2. A method that can be used during thinning operations is the full tree method in which the whole tree is extracted from the forest and chipped. This method is particularly suitable for young stands with small trees that do not have a commercial roundwood value (i.e. pre-commercial thinnings).
3. Logging residues should be harvested in an integrated harvesting system, where just as much attention is paid to the organization of the residues and to the organization of the timber harvested.
4. Residues, which are to be harvested for energy purposes, should not be used to drive on by harvesters and forwarders. Some of the branches can be used, but especially the tops should be put aside. (Residues are commonly used to drive on in order to prevent soil compaction.)
5. The availability of logging residue chips is, in practice, not as plentiful as suggested. Some of the logging sites are out of question due to small size, long distance, difficult terrain or ecological restrictions, and in all cases it is recommended that 30 % of logging residues are left at site. If residues are left to dry and shed part of the needles before haulage to road side, the yield of biomass is further reduced.
6. Although present research results show only a slight reduction in site production due to the removal of forest residues from forest stands if a large part of the foliage is left behind, it is not possible to draw the conclusion that the effect on the long term will be negligible. Long term biological research is needed inside permanent plots situated in intensively harvested forest stands in order to be able to determine the long term impacts of forest residue harvesting.

6. Follow up

A number of questions still remain unanswered:

- What is a realistic assumption for the percentage of forest residues that can be used for energy purposes in EU-25 states (modeling with EFISCEN)? Considering the ecological, technological and economical constraints.
- Which forest area in the Netherlands is not available/suitable for the harvest of forest residues? Where are these forest area's situated?
- What is the weakest or most expensive link in the forest residue supply chain in the Netherlands?
- Which logistical solutions can be found in order to make the harvest of forest residues from thinnings possible in the Netherlands? Develop the most promising solution into a field trial in order to see if it really works.

Literature

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Source: Pentti Hakkila, VTT Processes