PROCUREMENT OF FOREST RESIDUES

1. Potential of forest residues
2. Fuel quality
3. Types and technology
4. Production chain
5. Estimation of costs of forest residues
6. Legislation and policies
7. Environmental aspects
The figures below show the potential and the actual use of biomass. It is evident from these graphs that the biggest potential to increase the use of biomass lies within forest residues and other biomass resources such as agrobiomass and fruit biomass.

The largest biomass reserves can be found in Finland, Sweden, Germany and France, but also Poland and Spain have substantial volumes available for energy production. The largest volumes of available felling residues (excluding stump wood) are in Sweden (15 million m³), Finland (11.4 million m³), France (8.6 million m³) and Germany (6 million m³). When stem wood from additional fellings of unutilized increment and felling residues from them are added, available felling residues are in these countries about 20 million m³, in Sweden nearly 25 million m³.

Forest residues utilization is still taking place on a very small scale. Up until now, large scale use of forest residues is limited due to a number of factors such as policies and regulations, emissions trading, availability of biomass and the logistics of feedstock supply, the development of technologies, and economic and social factors.

1. Potential of forest residues

Forest residues are an underexploited source of bioenergy. The maximum potential of forest fuels in the EU covers 543 millions m³ (94.6 Mtoe) of which logging residues make up 251 millions m³ (43.73 Mtoe). However, the use of this potential depends on various factors and biomass fuels conditions such as EU and national policies and regulations, emissions trading, availability of biomass and the logistics of feedstock supply, the development of technologies, and economic and social factors.

Harvestable potential

For environmental and biodiversity reasons, not all maximum potential of forest residues is to be exploited. The harvestable forest residues potential can be counted as follows:

- 45 % of thinnings
- 20 % of stumps from final fellings
- 25 % of the additional fellings (i.e. fellings of the unutilised increment or roundwood balance)

Therefore, volume of technically available forest fuels in EU-25 accounts for 140 million m³, (65-66 % of the maximum forest residues potential) of which 72 million m³ are felling residues from current fellings and 68 million m³ are roundwood and felling residues from unutilized increment or roundwood balance. This includes 13 million m³ of stump wood. However, also ecological impacts of whole tree biomass harvesting should be taken into the consideration when available biomass for energy use is estimated. Stands with poor soils where nutrient losses in balances could result, steep slopes endangered by erosion and avalanches, and other sensitive sites should be excluded from such calculations.

However, only less than 5% of the technically available potential is used, mainly in Scandinavian countries. The figures below show the potential and the actual use of biomass.
3 Types and Technology

Generally, the value of forest residues might be less than the cost of collection, transportation, and processing for energy production. However, through advanced technologies including the whole fuel supply and logistics chain, forest residues such as logging residues, small trees, stumps and roots can become a new resource for solid biofuels - efficiently used in the form of forest chips (like in Finland and Sweden). This new resource could contribute to BAP goals and avoid possible environmental problems. But the right technology is a key element here as otherwise the cost of collection becomes higher than resource itself and environmental impact is not reduced as the technology can produce secondary residues, which requires careful management.

Forest fuel can be collected from young stands, short rotation forests thinnings and from final fellings - so-called logging residues including harvesting the stumps and roots.

Forest residues from thinnings

Young forests sometimes get too dense. Thinning these forests helps the trees to grow into more valuable and better quality forest. The thinning process can be carried out manually or automatically with wood collectors. The whole tree received from the

CEN committee prepared the specifications of properties for biomass fuels including the properties of forest residues.

<table>
<thead>
<tr>
<th>Forest residues fuel</th>
<th>Net calorific value</th>
<th>Moisture (Mar)</th>
<th>Bulk density (BD)</th>
<th>Net calorific value as received (Q_{net,ar})</th>
<th>Energy density as received (E_{ar})</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>[GJ/t]</td>
<td>[%]</td>
<td>[kg/m3]</td>
<td>[GJ/t]</td>
<td>[GJ/m3] based</td>
</tr>
<tr>
<td>Chips – final fellings</td>
<td>18.5 - 20.0</td>
<td>50.0 – 60.0</td>
<td>250 - 400</td>
<td>6.0 – 9.0</td>
<td>250 - 400</td>
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<td>2.5 – 3.2</td>
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<tr>
<td>Chips – thinnings</td>
<td>18.5 – 20.0</td>
<td>50.0 – 60.0</td>
<td>250 - 400</td>
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<td>2.5 – 3.2</td>
</tr>
<tr>
<td>Chips – detested small sized trees</td>
<td>18.5 – 20.0</td>
<td>50.0 – 60.0</td>
<td>250 - 400</td>
<td>6.0 – 9.0</td>
<td>250 - 400</td>
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<td>2.5 – 3.2</td>
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</tbody>
</table>

Main properties of forest residues, source: Alakangas 2000, CEN/TS 14961

Volumes of available felling residues and stump/root biomass in top 10 EU countries having highest available potential.
optimized so that the load capacity of the transport equipment can be fully utilised.

**Bundling technology**

After being bundled, the slash logs are transported with standard forwarders from the forest to the road side where they can be stored temporarily or transported to the power plant by standard timber trucks. The slash logs are usually crushed at the power plant or terminal inventory.

When comparing bundles and loose residues from the stand-point of transport, bundles is the most cost effective alternative but not for short distances.

**Forest residues from stumps and roots**

Stumps and roots are a major unexploited resource of forest logging residues. It consist more than 20% of a harvestable dry mass of a tree. In regeneration cuttings the full yield from stumps has turned to be as high as from above ground residues. The stump harvesting, handling and crushing technology is becoming cost competitive and the quality of these chips meets the requirements set for fluidized bed boilers. Forestry works related to removing stumps are becoming easier to handle and cost-effective.

**Stump and root technology**

Stumps are pulled using excavators equipped with a special stump rake. Wheeled stump forwarders, which carry out both uprooting and off-road transport. When pulled, the stumps are torn to pieces –

**Thinning technology - Accumulative Felling head**

Beside a simple wood harvester, a new technology is available such as accumulative felling head adapted to harvest young trees from early thinning. The accumulation principle is a part of this technology which enables one to cut and bundle several trees at once and in a standing position instead of having to lay them on the ground. Depending on the tree species, up to ten trees can be accumulated before the "felling head" needs to be emptied. This increases harvesting capacity as well as harvesting efficiency due to lesser manoeuvre moves.

**Forest residues from final fellings**

Logging residues or so called forest slash are either a waste left on the ground after the logging operations have taken place (wood harvesting) or the excesses of production that have not been used. In most countries forest slash is still not used whereas in Finland, Sweden and a couple of other countries this energy resource is largely utilised. These residues are the main source of forest fuels from final fellings. At the felling areas for every m³ of solid industrial wood, the residual biomass generated amounts from 35 to 45%. Forest slash mainly consist of the tops of trunks, stems, branches, leaves, stumps and roots and when discharged can cause environmental problems and the loss of a natural resource. Logging residues can be effectively used with a new bundling technology.

**Bundling Technology for logging residues**

In the bundling method the forest residue or slash is collected and fed into the bundler that produces compact slash logs or bundles.

The length of slash logs is approximately 3 meters and about 60-70 cm in diameter. They weight about 550 kg and kept tight with a cord. Each bundle contains about 1MWh of energy depending of species and moisture content.

The machine picks up the tops and branches and places them into the feed mechanism. One hectare felling area yields about 100 -150 bundles with a productivity rate of 20 to 30 bundles per hour (in Sweden and Finland). The length of the bundle is 6-7 meters.
of available forest residues in the EU member states but only 6 M m³ are harvested. The thermal value of the logging residues collected within the rotation period of wood is about 160 MWh which in thermal value corresponds to 14 tons of domestic heating oil. Logging residues can be harvested either immediately after felling or during the summer season. In seasoned case a significant part of residues are left in the felling area but the quality of wood fuels is higher due to a lower content of moisture. Also the harvesting technology in the seasoned case is easier to manage especially in northern countries of the EU. Recovery of logging residues can reach 75–85 % in winter (Sweden and Finland) and about 45 % in summer. Recovery also depends on the chosen site to harvest, more precisely on tree species, the amount of timber, the size and branch density of a tree and terrain characteristics. For example, spruce stands the amount of logging residues is much bigger than that for pine or birch stands. Although, a part of residues, usually 20-30 %, should be left on the ground for fertilizing purposes. If the recovery rate is significantly lower than 50 %, it means that the site has been poorly chosen or the work on the site has been careless.

A good harvesting site (Alakangas et al, 1999):
- As much spruce as possible; good recovery rate and productivity
- Enough fertile soils only
- A sufficiently large felling site or a concentration of stands
- Easily traversed, well bearing ground
- No undergrowth which hinders logging
- Short terrain transport distance
- A spacious roadside storage area for long distance transport.

Production chain and comminution types
The position of the chipper or the crusher in whole production chain determines the state of the bio-

mass during transportation and also a key factor influencing the transportation costs.

The main chain of chip procurement is: cutting, off road transport from forest site to road site, comminution, secondary transport from roadside to mill, and receiving and handling at the plant (Hakkila, 2004). The most important phase is comminution as it has a crucial fact of the cost efficiency. Before combustion, the forest residues are comminuted, that is chopped or crushed. The comminution can take place in terrain, at landing, at terminal or at plant. Comminution in terrain

Terrain chipping is based on a single machine, called terrain chipper. Terrain chippers carry out several operations. It lifts the residues with its grapple loader and puts them into the feeder of the chopping device; residues then are chopped and bunched into 4-5 metres piles. They are left to dry over the next summer which improves the quality of the fuel. Comminution at roadside or landing

The comminution at landing is the traditional option for forest chip production. Logging residues are hauled by forwarers to the roadside landing all year round from the surroundings of the terminal and bunched into 4-5 metres piles. They are left to dry over the next summer which improves the quality of the fuel.
While it is true that this method “can be implement- ed more economically than in terrain or roadside”, this advantage is partly cancelled by the higher transpor tation costs of loose forest residues com- pared to the chips (because chips are more com- pact, the energy content of one truck-load is higher with chips than with un-chipped residues). If the residues are bundled before transportation, it improves the economy of transportation especially with longer distances.

5 Estimation of costs of forest residues

Solid biofuels from forest residues are usually pro- duced under very diverse conditions in Europe. The figure below shows the prices of forest residues in comparison with the price of industrial wood chips...
well all the operations featured in the picture “Supply chain” are organised together. Supply chain for large scale forest chips production In general, the production cost of forest residues largely depends on the following criteria: • comminution type • transportation distance • storage and drying • degree of mechanisation • steepness of the terrain • type and size of the machines used • labour costs in the country

Beside Finish and Polish examples, the cost can be counted as in the example of Austria.

6 Legislation and policies

Several political initiatives have been taken within the European Commission and the individual member states in order to ensure the sustainable energy production in Europe, to diminish the dependence on imported fuels and protect the environment. European Union has adopted various environmental agricultural and energy policies and measures to increase the use of renewables, however, the production of renewable energy using forest residues is the most affected by the national policies.

Example of national energy policy : case of Finland

Finish national energy and climate policy is based on National Climate Strategy which was adopted in 2001 and revised in 2003-2005. The objective of the Strategy is to increase the renewable energy share within total energy consumption by at least one fourth by 2015 and by at least 40% by 2025. The use of forest chips, agro-biomass fuels, biogas and small-scale use of wood are promoted through energy policy measures. The actions envisaged in the strategy aim to achieve the 65% renewables target by 2015 and 80% by 2025. The main tools to achieve these objectives are the technology development and financial support.

Finland was the first to impose a carbon-based environment tax in 1980 by introducing a CO2 tax on fossil fuels. In heat generation, solid biofuels, such as wood fuels, biogas and solid recovered fuels, are not taxed. A tax subsidy for electricity production from renewable energy sources was introduced in 1997.

In CHP, the tax was split into two: combined generation of electricity and heat production. The fuels used for heat generation are calculated considering the amount of heat produced. The consumption of heat fuels is calculated by multiplying the heat amount generated by the factor 0.8. The tax paid by the consumer on the electricity produced with wood-based fuel CHP (<40MVA) was refunded as a subsidy to the producer 4.2 EUR/MWh. Likewise, the support is given for electricity producers from forest residues and amounts for 6.9 EUR/MWh.

Subsidies granted for energy investments, development projects and energy conservation is an important part of the National Energy and Climate strategy. In 2004, the total amount of 31.2 million Euros was available for energy supports and 70% of the sum was granted to renewable energy investments.

Information dissemination and training is the key element to achieve the high renewable energy targets. The Finnish Ministry of Trade and Industry has channelled the main part of the funds to energy information through Motiva Oy. During 2008—2012, the proposed total funding for information dissemination and training in renewable energy sources and energy conservation is € 2.5 million annually. The support for information dissemination on energy and climate change was € 3.4 million in 2004. The support includes the promotion of network of energy agencies, training advisors in wood energy, training young people at schools, universities etc, pro-

<table>
<thead>
<tr>
<th>Directive/communication</th>
<th>Date of publication</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>Directive 2001/77/EC on electricity production from renewable energy sources</td>
<td>Published on 27 September 2001</td>
<td>The aim is to increase the share of renewable electricity from 14% to 22% by 2010</td>
</tr>
<tr>
<td>Directive 2002/91/EC on the energy performance in buildings</td>
<td>Published on 16 December 2002</td>
<td>Measures on the energy performance in buildings and the use of renewable energy</td>
</tr>
<tr>
<td>Biomass Action plan COM (2005) 628 final (BAP)</td>
<td>This Commission communication was adopted 7 December 2005</td>
<td>Designed to increase the use of energy from forestry, agriculture and waste materials in three sectors: heating, electricity and transport.</td>
</tr>
<tr>
<td>Directive 2004/8/EC (CHP)</td>
<td>Published on 11 February 2004</td>
<td>Directive has the aim to promote cogeneration based on a needed heat demand in the internal energy market.</td>
</tr>
<tr>
<td>Renewables roadmap (within the Energy package)</td>
<td>Published on 10 January 2007 and accepted by the European Spring Council on 9-5 March 2007</td>
<td>The aim is to increase the share of renewables in the current energy mix to 20% by 2020.</td>
</tr>
</tbody>
</table>

Implementation of the Energy and Climate Change Strategy calls for financial support measures. Technology R&D and the introduction of new technologies are the main measures aiming at economically competitive solutions within the open market.

Implementation of the Energy and Climate Change Strategy

Forest residues bundling, source: UPM

That is why, the focus of Finish Funding Agency for Technology and Innovation (Tekes) is on sustainable development solutions with 15.5 million (in 2004) Euros reserved for the funding of renewable energy R&D. The total funding for renewable energy and climate change technology has been 60–70 million Euros annually.
Energy and Climate Change Strategy

The Act on the Financing of Sustainable Forestry entitles non-industrial, private forest owners to seek governmental grants for the afforestation of understocked areas, prescribed burning, the tending of young stands, the harvesting of energy wood, forest recovery, fertilisation etc. Loans can be granted for joint ventures involving improvement ditching and forest road construction.

The state supports the harvesting costs of thinnings from young stands. In year 2006, the total public support for the harvesting of energy wood from young stands amounted to € 4.7 million. The support to forest owners for forestry operations ranges between 210.5—294.7 €/ha when the harvesting services are outsourced and when a farm has a forestry plan, and 168.4—252.6 €/ha, if the forest owner does not have a forest plan. Support for wood fuel harvesting is 3.5 €/m³ and forest transport 0.5 €/m³, the total support being 7 €/m³ about 1 €/GJ. In 1999, the subsidisation of harvesting and use of fuel wood was improved. At the end of the year 1999, a new support scheme was introduced by the Ministry of Agriculture and Forestry to cover also the chipping costs. This “chipping support” (1.7 €/m³, about 0.6 €/GJ) is paid for chips produced from trees harvested from young stands and to the organisation or the farm delivering the chips to the plant. In the new Energy and Climate Change Strategy this support is planned to be € 6 million annually during the period 2008—2012.

Procurement of forest residues

In order to ensure the environmentally friendly way of harvesting logging residues, the following key elements have to be taken into account:

- **Soil degradation**
  - In order to avoid the degradation of the soil, it is important to leave a considerable amount of nutrients on the ground. Different parts of the trees contain different amount of nutrients. Generally wood (including bark), branches and leaves/needles contain respectively 1:2:4 parts of nutrients. This implies that the soil degradation can be prevented by leaving needles and a considerable amount of branches in the forest.
  - For environmental and economical reasons, the trees or branches that are less than four centimetres in diameter should be left in the forest.

- **Dry biomass harvesting**
  - In order to ensure that the necessary for the soil nutrition stays in the forest, the biomass should be left on the ground for a certain period of time after the harvesting processes have taken place. It allows the needles and branches to dry and fall down. The collection of the remaining wood without leaves and needles can now be delivered dry and, therefore, transformed into more valuable and better suited for storage chips. Furthermore, due to the decreased amount of leaves and needles, the burning of dry residues produces a lower amount of ashes and release less emissions.
About the project

RESTMAC project 'Creating Markets for Renewable Energy Technologies - EU RES technology marketing campaign' aims at developing and implementing a concise, well-targeted and thematic approach to ensure the dissemination and uptake of selected RES technologies in the market. In other words the consortium works towards establishing a technology marketing campaign for the different RE technologies involved. So far R&D formed a good basis for the outstanding industry development in the Renewable Energy area. Nevertheless, the market uptake of these R&D results is not always happening in the best possible way and therefore needs to be improved. Lack of information and limited use of synergies between various stakeholders (industries, governments, investors...) are still the key critical barriers towards Renewable Energy Technologies.

The renewable energy sectors to be marketed include: PV (photovoltaic), SHP (Small Hydro Power), Biomass, Geothermal, Solar Thermal and Wind Power.

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