Methodology report

Real potential for changes in growth and use of EU forests

EUwood

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EUwood team

University of Hamburg – Centre of Wood Science	**Udo Mantau** Head of Centre of wood science and project coordinator – Expert in wood resource monitoring, balance and assessment **Ulrike Saal** Research Assistant – Industrial wood residues
UNECE/ FAO – Forestry and Timber Section	**Kit Prins** Former Chief of Section – Forest policy expert **Florian Steierer** Research Assistant – Wood energy data specialist
EFI – European Forest Institute	**Marcus Lindner** Head of Programme Forest Ecology and Management **Hans Verkerk** Researcher – Forest resources modelling specialist **Jeannette Eggers** Researcher – Forest resources modelling specialist
Probos – The Dutch Institute for Forestry and Forest Products	**Nico Leek** Senior Consultant – Wood Market **Jan Oldenburger** Consultant - Forest Products and Statistics
METLA – Finnish Forest Research Institute	**Antti Asikainen** Researcher – Forest Technology specialist **Perttu Anttila** Researcher – Forest technology and forest biomass specialist

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Parts of Methodology report

Mantau, U. 2010: Method of the Wood Resource Balance. pp 14-29. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Mantau, U., Saal, U.; 2010: Material use. pp 31-50. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Jonsson, R. 2010: Modelling wood products demand, supply and trade. pp 33-45 in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Steierer, F. 2010: Energy use. pp 52-69. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

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Oldenburger, J. 2010: Landscape care wood. pp 98-111. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Leek, N. 2010: Short rotation plantation. pp 112-118. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Leek, N. 2010: Post-consumer wood. pp 119-123. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Saal, U. 2010: Industrial wood residues. pp 124-145. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

Prins, K. 2010: Strategies and recommendations for a sustainable wood mobilisation. pp 147-165. in: EUwood - Methodology report. Hamburg/Germany, June 2010. 165 p.

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EQUATIONS

Abbreviations

Btl	Biomass to liquid
CAP	Common Agriculture Policy
CEEC	Central and Eastern Europe
CEI-BOIS	Confederation of the European wood working industries
CN	Combined Nomenclature
DG ENV	European Commission Directorate General Environment
DG TREN	European Commission Directorate General Transport and Energy
Dm	Dry matter
EFISCEN	European Forest Information SCENario model
FAO	Food and Agriculture Organisation of the United Nations
FAWS	Forest area available for wood supply
FRA	Forest Resource Assessment
FTP	Forest Technology Platform
GAK	Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz (Multi-stakeholder Task Group for improved competitiveness of the agriculture and costal protection)
GDP	Gross Domestic Product
GIEC	Gross inland energy consumption
HS	Harmonised System
HWP	Harvested Wood Products
IEA	International Energy Agency
IEE	Intelligent Energy Europe
ISIC	International Standard Industrial Classification
ITTO	International Tropical Timber Organisation
JFSQ	Joint Forest Sector Questionnaire
JWEE	Joint Wood Energy Enquiry
LCW	Landscape care wood
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NACE	Statistical classification of economic activities in the European Community
NFI	National Forest Inventory
NFP	National Forest Programme
PCW	Post-consumer wood
R&D	Research and Development
RES	Renewable Energy Sources
SFC-WGII	Standing Forestry Committee by the ad hoc Working Group II on mobilisation and efficient use of wood and wood residues for energy generation
SITC	Standard International Trade Classification
SRC	Short Rotation Coppice
UNECE	Unites Nations Economic Commission for Europe
VAT	Value Added Tax

Prefixes

K	Kilo	(10^3)
M	Mega	(10^6)
G	Giga	(10^9)
T	Tera	(10^{12})
P	Peta	(10^{15})
E	Exa	(10^{18})

Units

m^3 ob	m^3 overbark
Mtoe	Million Tonnes Oil Equivalent
dmt	Dry matter tonnes
odt	Oven dry tonnes
swe	Solid wood equivalent
rwe	Roundwood equivalent

Abbreviations of the Wood Resource Balance

HI	High – refers to high mobilisation scenario
ME	Medium – refers to medium mobilisation scenario
LO	Low – refers to low mobilisation scenario
TH	Theoretical – refers to theoretical availability
POT	Potential – refers to “real” availability under given constraints
DEM	Demand – refers to modelled or assumed demand
DIS	Disposed – refers to potential that is currently disposed
USE	Use – refers to potential that is or will be used
C	Coniferous wood - softwood
NC	Non-coniferous wood - hardwood

Chapter 1

Method of the Wood Resource Balance

Author: Udo Mantau

Content

1 Method of the Wood Resource Balance

1.1 Why do we need a new calculation system for woody biomass?

In the beginning of the 21st century, the global forest products market is affected by strong changes. The use of wood for energy generation is no longer only limited to heating homes' fireplaces, but clearly becomes a new industry branch. Moreover, wood is newly discovered as raw material for chemical products. Scarcities on the supply side cause a differentiation of the choice of raw materials. Hence recycling products, e.g. post-consumer recovered wood, gain importance and new raw material sources, e.g. landscape care wood, are demanded.

Thus, the evaluation of economic and forest policy decisions become more difficult due to a more complex forest products market. Especially in view of the achievements of energy policy targets a solid data basis is urgently needed. Traditional statistics give only partly information about supply and demand of raw materials. A framework which presents the entity of sectors and their interactions is significantly necessary. The Wood Resource Balance can serve as the tool to close this gap.

The balance can either be roughly and straight forward calculated in a first step or based on a highly differentiated structure of markets and trade flows. It is graphic as well as easy to read and understand. In other words, it is a tool to quickly uncover missing information. Further, it easily integrates information and developments from the forestry and energy sector and functions as a tool to control all wood flows on national and international level. Consequently, it is a consistency check of national wood flows that counterchecks the sums of all sources of wood materials against the balance sheet total of the consumption side. In order to assess the real size of the gaps thoroughly empirical research on the national level is crucial.

International timber production and trade statistics (e.g. Joint Forest Sector Questionnaire of the UNECE/FAO/Eurostat/ITTO) provide best internationally available data on wood removals, trade and production. Inherent to their structure, these statistics are consistent within them and subtitles always sum up to the main heading. Definitions and classifications of the commodities are bound to international production and trade (SITC[1] and HS[2]) definitions and classifications.

Hence, they cover economically important activities of the wood and timber markets to a great extent. Nevertheless, trade statistics are not able to cover informal trade wood residues (e.g. wood use by private households) and waste recovery streams (e.g. black liquor, post-consumer recovered wood). For a long time this information deficiency on minor wood fibre sources did not matter, as overall sufficient wood resources were readily available and sustainable forest management was a matter of course.

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[1] SITC – Standard International Trade Classification (United National Statistical Commission)

[2] HS – Harmonized Commodity Description and Coding System (World Customs Organization)

Pace keeping with fast changing markets requires a more holistic assessment method for wood volumes and flows. The Wood Resource Balance easily integrates cross-sectoral information, going far beyond existing trade and production classifications of the forest based sector.

In a first step the wood resource market can be segmented into the four sectors forestry resources, other woody biomass, material uses and energy uses.

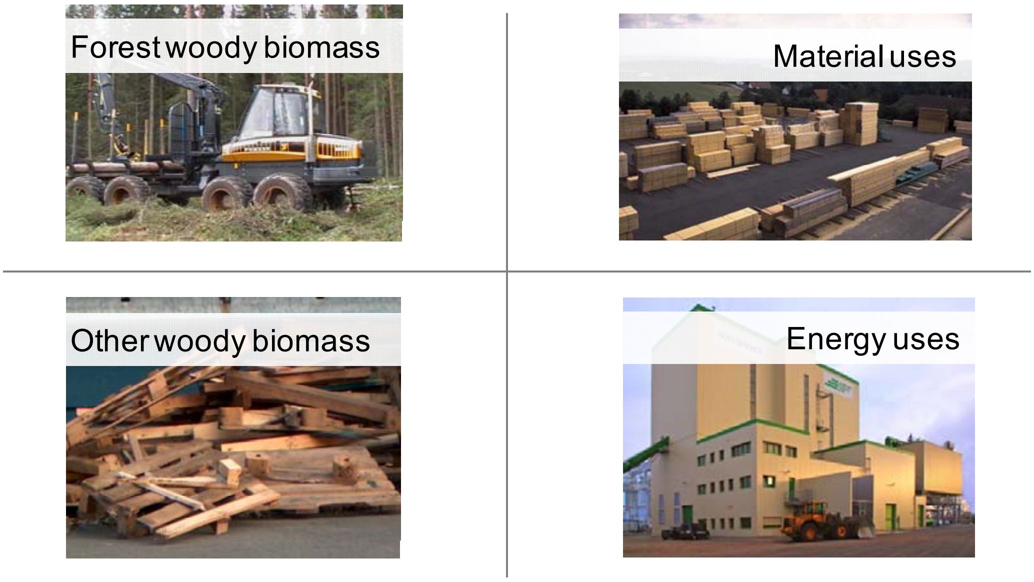

Figure 1-1: Basic sectors of the Wood Resource Balance

Before assessing the future real potential for sustainable woody biomass supply from European forests, it is required to draw a very precise picture of the current situation. Future developments and potentials can only be correctly projected, if the starting point is known precisely enough.

Previous work by some members of the EUwood project[3] was done for the year 2005 in cooperation with the UNECE Forestry and Timber Section. The EUwood project decided to start the assessment with a revised Wood Resource Balance referenced to 2007 (STEIERER) enabling a more precise assessment of the current situation of wood flow pattern between different wood fibre sources and uses at national level in the EU/EFTA member states.

1.2 First steps to a Wood Resource Balance

The approach goes beyond commodities defined by international trade classifications (e.g. harmonised system) and includes logging residues, post-consumer recovered wood, locally exchanged fuel wood or even black liquor. The used terms and calculated sectors in the Wood Resource Balance are shown in Figure 1-2. However, the structure of the wood resource biomass is not fixed. If new sources or users occur they can easily be added. While calculating the first European Wood Resource Balance STEIERER (in MANTAU et al. 2007) it became increasingly important to include the energy products and energy product producers as it no longer was applicable to integrate those in sawmill by-products. It may occur that the importance of a certain sector increases (e.g. Btl) and thus be differentiated by technology or end users of

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[3] UNECE/FAO wood resource balances 2005

different assortments. Consequently, the balance approach is very flexible and sectors can be added or differentiated, depending on the focus, as long as any action is counterbalanced on each side.

Furthermore, the Wood Resource Balance can flexibly be adapted to specific country conditions as well as to the access to certain data. In this regard and due to survey factors, the German Wood Resource Balance divided biomass power plants originally into those either below or above 1 MW (megawatt). The latter were measured separately by location and capacity. Hence, the last survey of 2008 recorded 481 plants according to location and capacity making regional analysis possible, too, which are estimated through declaration statistic and random sample. The survey of the year 2009 for biomass power plants below 1 MW assessed 43,000 plants in communities and in the industry.

Depending on the level of details in resource statistics, partial Wood Resource Balances can be derived. The chosen structure of the Wood Resource Balance for the EUwood project is shown in the following figure.

woody biomass			
sources		uses	
forest woody biomass	**stemwood, C**	**saw mill industry**	wood industry
	stemwood, NC	**veneer and plywood ind.**	
	forest residues, C+NC	**pulp industry**	
	bark	**panel industry**	
other primary woody biomass	**landscape care wood**	**other traditional uses**	
	short rotation plantations	***other innovative uses***	
industrial residues	**saw mill by-products**	**pellets and other**	producer of solid fuels
	other solid industrial restwood	**forest sect. intern. energy use**	energy end user
	black liquor	**energy biomass power plants**	
solid wood fuels	**pellets and other**	**private households (pellets)**	
recycled woody biomass	**post consumer wood**	**private households (other)**	
		liquid biofuels	refineries
total			total

Figure 1-2: Woody biomass terms and sectors

Source: MANTAU, U.: Wood Resource Balance methodology, June 2010

1.2.1 Supply and demand segments of woody biomass

Potential resources: In the current stage of the Wood Resource Balance on the left hand side the potential resources in a specific year are calculated, yet, not the actual supply. For a specific year in the past it can be calculated, as it was done for the balances for the years 2005 and 2007as in that case it is known in most of the sectors how big the real supply was., However, this is not the case for the future and the resource mix of the different sectors in the states of the EU 27 is not known. Nonetheless, with respect to the target of the availability of resources the potential resources are a sufficient for the calculation.

The analyses of supply and demand of woody biomass should be done in specific segments because each of the following segments has its own specific market and industrial structure and therefore its own way of analysing biomass quantities. The following segments have proven to be relevant and specific.

The differentiation in the forest sector follows the method of the EFISCEN-model. The forestry sector is differentiated into stemwood coniferous (C) and non-coniferous (NC). This is also the case in the EFISCEN-model for forest residues and for bark.. However, forest residues and bark are summed up to one position in the Wood Resource Balance.

Other primary woody biomass includes woody biomass from other wooded land (OWL), trees outside the forest (ToF) and horticulture. Landscape care wood sources are: maintenance operations; tree-cut activities in the horticulture industry; other landscape care or arboricultural activity in parks; cemeteries etc.; trees along roadsides and boundary ridges, rail- and waterways and gardens.

Short rotation plantations a raw material source which is often discussed these days. The current availability with 30,000 ha (LEEK) and circa 0.5 M m³ in Europe is, however, quite low. The estimates for the potential land area which is available for bio-energy crops in Europe differentiate highly between 10 M and 50 M ha and almost no analyses is available concerning the difference between agricultural and forestry crops. Thus, the EUwood-team has taken the decision to exclude short rotation plantations quantitatively in the balance because that would be highly speculative and would look at it qualitatively as part of the solution for the scarcity situation. On the right hand side of the balance a similar speculative sector was excluded from the quantitative calculations.

Industrial residues depend in their quantitative volume directly on the wood industry sector. Sawmill by-products are differently treated in the balance form other industrial residues out of several reasons. Sawmill by-products are primary biomass and have their origin directly in the first production process. Other industrial residues include a broad variety of different production processes of semi-finished products and end use sectors. Black liquor is a specific woody biomass not only due to its liquid consistency, but also because of its specific internal use in the forest industry.

Solid wood fuels are produced in a second production process out of sawdust or wood chips or from stem wood itself. If it is left out of the balance, it is assumed that sawdust is directly taken into account into any energy use. By including it in the balance it becomes obvious that it is a special market with significant volumes.

Finally, the left hand side of the balance includes post-consumer wood which comprises all wood which has already been in use and is included in the resource stream again via the disposal system or directly, e.g. households. There may occur some overlapping with the sector of other industrial residues because they do not enter any consumer directly but through the disposal system and then it is post-consumer wood by definition. However, no empirical information is available how much that might be. In a calculation based on studies in Germany EUwood roughly calculated that the overlapping amounts to 20%. Therefore the potential of other industrial residues have been reduced by 20%.

Potential demand: The potential demand is calculated on the basis of the econometric modelling (Future Forest, Jonsson, 2010) for the material uses and on the basis of policy targets of the European Directive on the on the promotion of the use of energy from renewable sources (Steierer, 2010). Thus, the right hand side of the balance can be considered as potential demand based on these assumptions.

The first forest sector on the right hand side of the balance is the sawmill industry which is differentiated by coniferous and non-coniferous logs. The plywood and veneer industry is as well consuming coniferous and non-coniferous logs. The pulp industry is segmented in mechanical and chemical pulp (bleached and unbleached) because of the different effects on black liquor and the different input of wood resources. The panel sector is also a segmented sector (particle board, fibre board and oriented strand boards). Due to the different density, the calculation for resource consumption is done differently for each sector.

The sector “other material uses” is differentiated into traditional other material uses and new innovative “other material uses”. Traditional other material uses include dissolving pulp, mulch, other industrial roundwood sorted for special purposes (e.g. poles and sleeper). Many new innovative products made out of wood fibber are on its way to market relevance. Wooden fibres tend currently to conquer the textile market. Wood is already an important raw material for the chemical industry. The incremental development towards bio-refineries indicates an increasing significance of wood as raw material in the chemical and food industry. Wood plastic components have already entered the market of terrace boards. Improvements of the plastic moldability lead to further expectations of plastic applications. Wind engines based on wood constructions offer further a substitute for biomass in regenerative energies. Although the raw material consumption of this field amounts already to a couple of millions cubic meters today, the quantitative calculations of the Wood Resource Balance do not take this aspect into considerations. On the one hand, there is only little reliable, empirical material in such quantities. On the other hand, the development is highly speculative. Last but not least, this constitutes a counter weight to the unconsidered short rotation plantations of the supply side.

As mentioned before the solid fuels have a special function in the balance. The domestic production is incorporated into the sources of woody biomass as a processed fuel (pellets). They have the same volume. However, the use of pellets in private households will grow higher in the future. The gap must be covered by imports. They are not included on the resource side, because they are part of the solution to fill the gap.

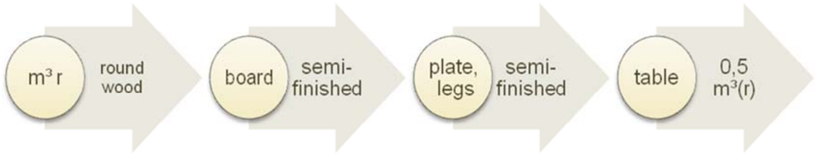
The area of energy end user is segmented in sector forest sector internal use, energy biomass power plants, private households (pellets and other) and liquid biofuels. The forest sector internal use consists of solid biofuels, mainly residues directly used for heat production and the use of black liquor as well as mainly for heat production. The sector households is furthermore segmented in the use of pellets and in wood burned in traditional fireplaces. The liquid biofuels are separately calculated by Steierer (2010) for cellulose based liquid biofuels by bio-chemical conversion (ethanol) and cellulose based liquid biofuels by pyrolysis/gasification (Btl). In the Wood Resource Balance, on the contrary, they are summed up. This is an interesting position to demonstrate the functionality of the Wood Resource Balance. As long as these biofuels are used for energy consumption in other sectors (transport) they leave the balance sheet. As long as innovative “other wood material uses” are not part of the balance, they are not counterbalanced with pyrolysis oil on the left hand side. However, this may change in a couple of years when this area becomes more relevant.

1.2.2 Wood balances and Wood Resource Balances

Wood balances have been made since the late fifties. To give an overview of all wooden products in one calculation system via roundwood equivalents was the focus during that time. The balance was used to determine consumption as a rest calculation of more or less available statistics. For policy reasons different supply rates were calculated (e.g. to determine the dependence of imports). In the course of time, special topics have been analysed (separate paper and wood balances, tropical wood balance etc.).

The most important statistical source is the import and export statistic. All wooden products like logs and pulpwood, semi-finished products and finished products are calculated on the basis of roundwood equivalents. Additionally, recorded cuttings are included as well as available data on used paper and used wood. If data on stocks are available, they are included, too. To calculate the consumption correspondingly as the balance gap is one of the main targets of the traditional wood balance. The basic measures in the wood balances, which focus on consumption, are roundwood equivalents. A roundwood equivalent calculates the input of roundwood for an end product. In order to present a table, for example, several processes (sawn wood, panel, table board and leg) are undertaken which may add up to half a cubic meter roundwood that was needed for the production.

Round wood equivalent:
How much roundwood is originally needed to produce one unit of a wooden product (table)?



Solid wood equivalent:
How much solid cubic meter of wood is transfered from one sector to another?

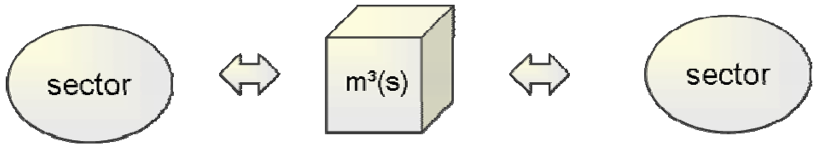


Figure 1-3: roundwood and solid wood equivalent

In a system of resources with cascade uses, this is problematic. For instance, to produce one m³ of sawmill by-products about three m³ of raw logs are needed. Obviously, this doesn't make sense. Therefore, in the system of "Wood Resource Balances" solid wood equivalents are used which only calculate the amount of a cubic meter wood that is transferred from one sector to another.

Among the different sectors different units used from bulk m³ to air dry tonnes or energy measures exist, which are all calculated in solid wood equivalents. In the first production steps the roundwood and the solid wood equivalents are the same. The roundwood equivalents are only calculated in one direction over several processes from roundwood to the final product. In contrast, the solid wood equivalent only calculates the roundwood from one sector to another forward and backward.

The conversion factor from a solid wood equivalent into air dry tonnes can vary between 0.45 metric tonnes/m³ and 0.55 metric tonnes/m³ depending on the specific gravity of different species However, most calculations show that an average of 0.5 metric tonnes/m³ is a good approximation.

For the conversion of energy units (Joules) into solid wood equivalents a theoretical calculation came to 8.72 GJ per 1,000 m³ or 8.72 PJ per M m³ (see chapter 3.5). For better comparability of results, the following Table 1-1 gives an overview of applied conversion factors.

Table 1-1: Common wood resources conversion factors

From/to	**Mm³**	**Modt**	**PJ**	**Mtoe**
Mm³	1	0.50	8.72	0.21
Modt	2.00	1	18.18	0.44
PJ	0.11	0.055	1	0.024
Mtoe	4.76	2.26	41.87	1

Source: EUwood 2010

1.2.3 Cascaded use

Wood is a highly versatile material being used and reused in many different processes. By-products of the wood-processing industry (chips from sawmill industry) are an important raw material for further processing. They can easily be used directly in on-site integrated processes (e.g. black liquor for energy generation or pellets production by sawmills). On top, they are sold to trader and/or producer using the fibres for subordinated processing (e.g. chips from sawmill used for pulp production, sawdust for panel production, etc.). Wood fibres reappearing as “secondary” raw material increase the overall wood availability on the market. This kind of cascade use can be documented by the Wood Resource Balance.

It is sometimes regarded as “double-counting” but this kind of cascade use is a typical advantage of wood resources. On the other hand, without including cascade use, the Wood Resource Balance would be incomplete. However, it is always possible to set up special Wood Resource Balances for forest resources, industrial rest wood, post-consumer wood or others. This is already done in the flow chart models of the wood resources balance in Germany where sufficient empirical data are available. In this case, the Wood Resource Balance is not set up on its own but is the sum of the flow charts models of all resources. When reporting properly all wood fibber supplies and uses, cascade-counting does not introduce a systematic over- or underestimation of either the wood supply or wood use but enlarges the balance sheet total on both sides.

The following example helps understanding the cascade consumption. The sawmill industry buys 100 M m³ roundwood form a forest enterprise of which roughly 60 M m³ is sawn wood and 40 M m³ are sawmill by-products. While sawn wood is dropped out of calculation area in the Wood Resource Balance, the sawmill by-products are registered again on the left hand side as resource.

They are used as a resource by the panel and pulp industry as well as for the wood fuel industry for the production of pellets.. The pulp industry produces the by-product black liquor which is a resource for forest sector internal liquid biofuel. The sawdust used for pellet production enters the balance sheet again as a resource consumed in private households or commercial power plants. The overall cascade factor in this example is 1.53 which means the 100 M m³ that entered the balance sheet have been used roughly one and a half time.

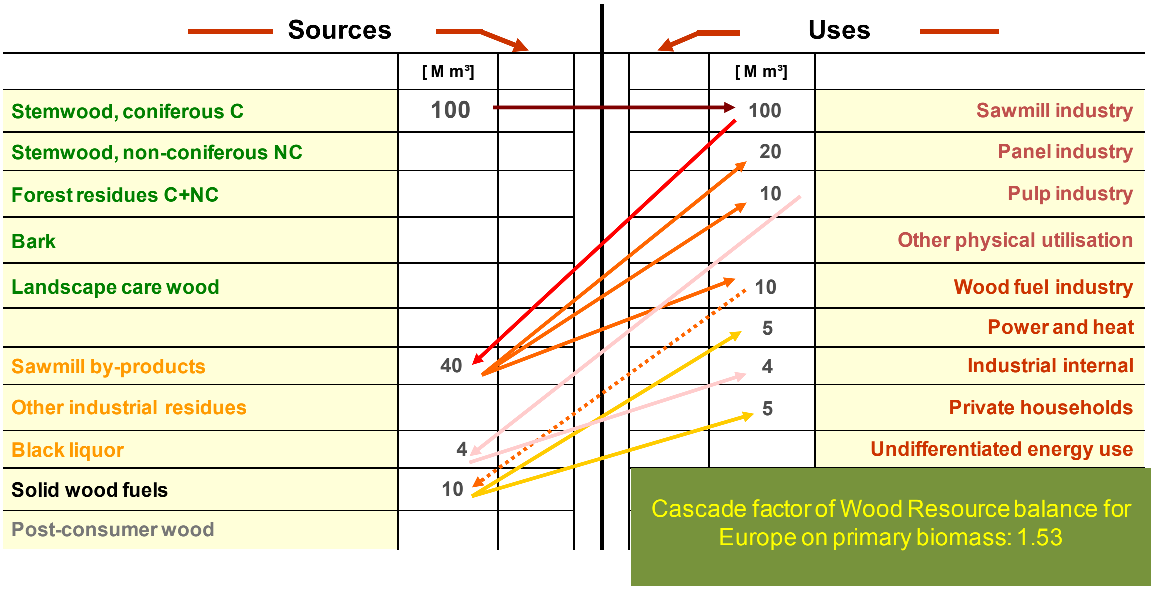


Figure 1-4: Cascade uses in the Wood Resource Balance

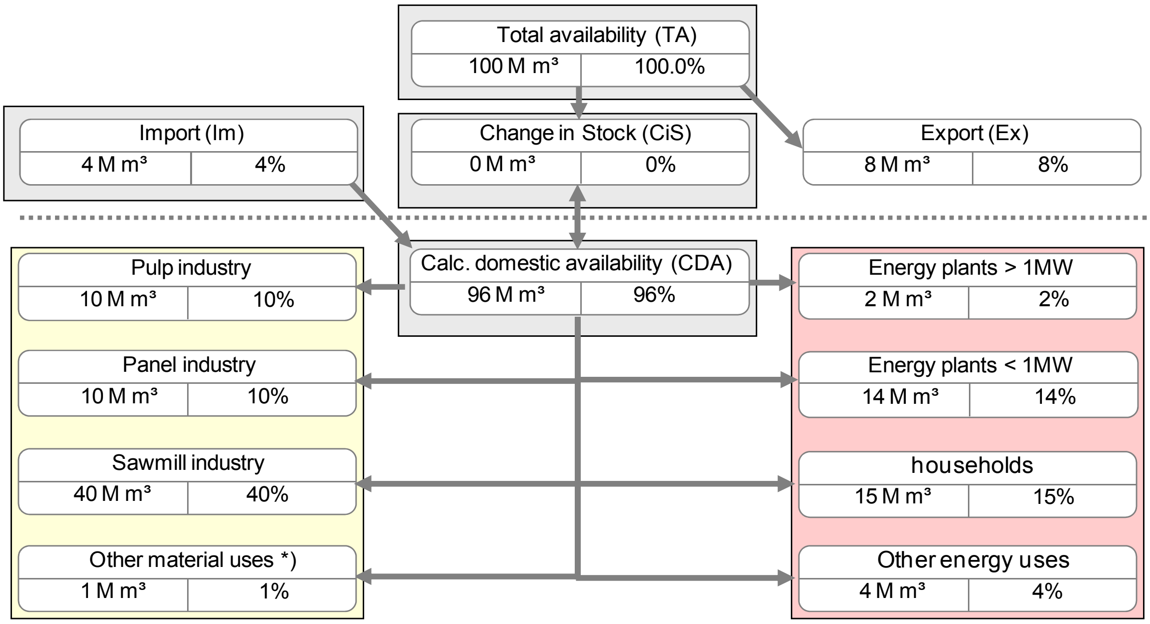
Source: MANTAU, U.: Wood Resource Balance methodology, June 2010

In a time of resource scarcity, an ideal consumption of raw material is increasingly important. For that reason, the wood resources balance is on top an excellent instrument in order to measure the cascade consumption quantitatively.

1.2.4 Sector resource balance

One of the major problems while establishing a Wood Resource Balance is surely the availability of data. Calculations within the EUwood project focus on the potential resources and potential demand. Taking this into account, crucial questions concerning wood availability are clarified. As a next step, however, the actual supply has to be further determined. Consequently, more detailed information about the raw material mix of different consumer types is necessary. In case of the wood industry, some data are available. Yet, the actual amount of forest residues, post-consumer wood or stemwood used by biomass power plants is unknown in most countries. With the monitoring studies in Germany, however, most of the data are gathered. In this case balances for specific sectors can be calculated.

Every single woody resource is subdivided into demand areas. First, the domestic availability is determined. Secondly, the domestic supply is extended by imports and reduced by exports. Inventory modifications also affect the domestic availability. Unfortunately, only few data are available about stock levels. The amount of the domestically available wood raw materials is finally assigned to the demand sectors. The information confirming this is asserted in the interviews. For this purpose, the distribution structure and/or the procurement structure is asked in the questionnaire. Figure 1-5 shows a theoretical example (stemwood).



TA = CDA + (Ex – Im) + ΔCiS; Consumption (CDA) = RA + (Im – Ex) + ΔCiS where (RA = production/felling when all quantities are included in production/felling statistics)

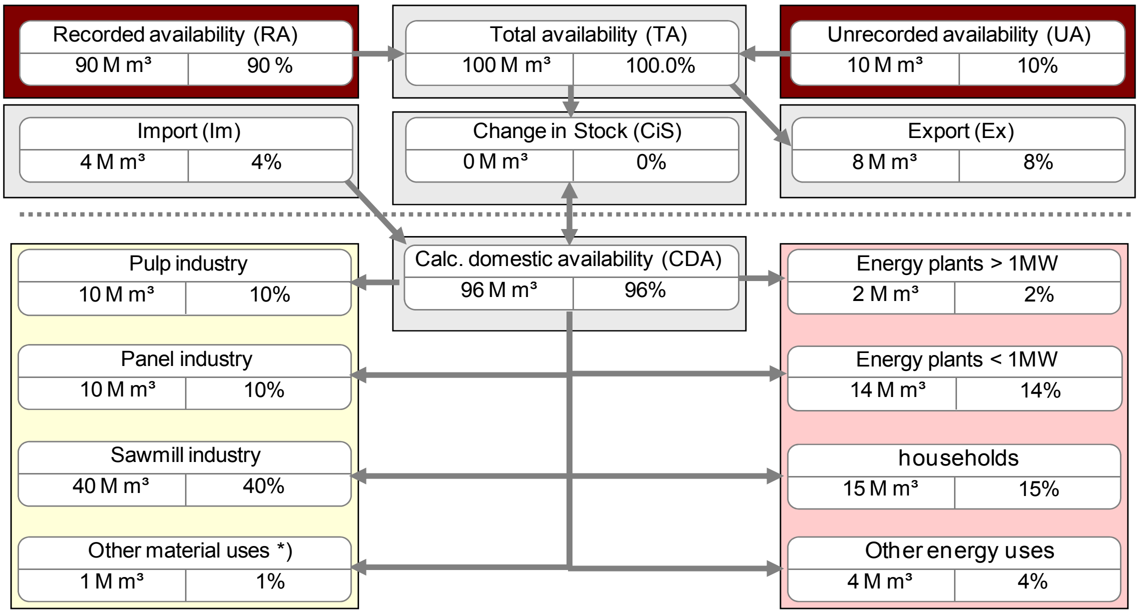
Figure 1-5: Flow chart of resource in the Wood Resource Balance

Similar to the sawmill by-product sector all other sectors are analysed and quantified.

In case of post-consumer wood, it turns out that all consumers use more waste wood than the investigation of the disposal enterprises revealed. This does not have to be a contradiction because there are other ways of purchase (e.g. direct supply). Private households use for example also post-consumer wood as firewood which is then never available in the disposal system. The difference between consumption and registered waste wood within the disposal branch is assigned to the domestic supply within the category „other offerer“ or “unregistered uses”.

“Domestic supply” is the sum of all sources of a resource. From this amount disposal and/or storage is withdrawn as well as exports. By adding the imports to that result, the “domestic availability” is determined. This amount is distributed to the different users. If the total availability is higher than the recorded availability “unrecorded availability” is the amount resulting from other sources in the market. This is a very important indicator in the case of unrecorded fellings. It is a normal phenomenon that small quantities of wood are not always registered. As well as in official statistics small producer are seldom registered. However, in the case of forestry this may add up to significant volumes. If more wood is already harvested than registered, the available resource of woody biomass is smaller.

On the grounds of these calculations, more efforts were undertaken in Germany in order to estimate the unregistered quantities. Furthermore, the registered fellings of circa 20% are meanwhile only half the amount. The comparison of the forest inventories 2002 and 2008 (Polley) depict a striking consistency between the estimated recorded and unrecorded fellings in the Wood Resource Balance and the actual outflow between the inventories. For that reason, the Wood Resource Balance is additionally a method to estimate the unregistered quantities in the field of application, too. This is possible since the Wood Resource Balance applies a bottom up approach which first assumes the applications and then counts back to the raw material. Yet, precise information about the different raw material compositions among the fields of consumption needs to be acquired.



TA = CDA + (Ex – Im) + ΔCiS; UA = TA – RA; Consumption (CDA) = (RA + UA) + (Im – Ex) + ΔCiS where (RA = production when UA = 0)

Figure 1-6: Mass flow diagrams are the basis of Wood Resource Balance calculations

Source: MANTAU, U. EUwood 2010

As already clearly pointed out, the availability of empirical data is an indispensable condition for most calculations of the Wood Resource Balance. Under particular circumstances the measures are certainly also transferable from one country to another. At the moment, however, there is too little information available for Europe-wide calculations. In order to stress this crucial aspect once more, the following example explains how sectors can be registered, even if there is no empirical information available in official statistics by monitoring the resource with primary data collection (Weimar & Mantau, 2004).

1.2.5 Questionnaires

The most important basic methodological principle of field research is the questionnaire. Questions have to be expressed in a way that the respondents can relate to the question within their daily acquaintance and so that the answers do not absorb too much time. Hence, the questionnaires were reduced to essential aspects. On location oriented surveys one has to consider some distinctions. The most important aspect of a location oriented survey is a return which is as high as possible. Therefore, the following is done to ease the return.

1. Response can be given optionally by fax or mail

2. The length of a questionnaire is restricted to one side, which eases the response by fax at the same time
3. If possible, an association, which enjoys confidence within the branch, should be attracted to become partner of the enquiry
4. The address of the questioned enterprise is printed directly so that it only has to be adjusted
5. The final report is offered as an incentive. This is, concerning investigations within industrial branches, the most important incentive and cost-saving at the same time. After all, it creates confidence because one can experience what is done with the responses
6. Confidence is important in general. It can be accomplished only after several investigations and if one affirms the consents made (send incentive, not to hand on individual data).
7. Due to the fact that even enterprises, which are actually not qualified for the questionnaire, are included within every dataset though, one has to provide a response-option for these enterprises so that they can be excluded from the dataset of potential addresses.
8. Finally, there are enterprises with district offices. Therefore, it is important to emphasise that the statements are only to be given for the enterprise addressed. Otherwise, the risk of double entries would be too high and the locations would be evaluated falsely.

The following first part of the questionnaire on disposal companies contains all of these elements. The questionnaire was separated within another investigation. Everyone was asked to answer all the questions of the first part of the questionnaire; the second part could be answered voluntarily. Since the main objective was to assess capacities, this approach did not cause any problems concerning the objectives of the investigation. Besides, the capacity already supplies an option to extrapolate the structural data. Yet, it turned out that almost everyone had filled out the complete questionnaire. This could be an alternative to raise the return concerning more sensitive questions.

Answer by Fax to +49-40 42891-2665	For **Window envelope:** address field on the back.

Universität Hamburg

„Quantity of recovered wood
and its consumption“

BAV

Bundesverband der
Altholzaufbereiter und –verwerter e.V.

Universität Hamburg, Zentrum Holzwirtschaft, Ökonomie
Prof. Dr. Udo Mantau, Leuschnerstr. 91, D - 21031 Hamburg

Address 1
Address 2
(Name, Contact)
Street
Zip code & City

Please correct your address if necessary:

____

____

____

Internetaddress, if applicable:__________________

☐ Please send me a free report

Please send the questionnaire back in any case.

Please make the following statements only for the production/processing site mentioned in the address field above. In case that further production/processing sites belonging to your company collect recovered wood, please specify the zip code and city of each of them. (To be filled out in question 9).

---

1. How much recovered wood have you collected in your company in 2001?

Annually 1/ ________________ **tonnes (air-dry)** of recovered wood

If none, because, …?

0/1 ☐ no recovered wood in this processing site
0/2 ☐ company not working anymore
0/3 ☐ other: ....
(please, fill in)

Within the second (additional - facultative) part of the questionnaire the structures are analysed more precisely.

---

2. How much of the annually collected quantity do you receive from other disposing companies?
(Including quantities from companies and processing sites belonging to your company)

2/1 _______ tonnes or
2/2 _______ % of the recovered wood

This question considers the circumstance that disposing companies strongly do business with each other. Therefore, it is very important to avoid double count.

3. How do you proceed with the accumulated recovered wood?

1. It is sold/distributed (processed or unprocessed)	3/ _______	%
2. Consumption in the company (it is used in this production site)	4/ _______	%
	100 %	

To estimate the market potential correctly, it is also important to elevate the energy consumption. The energy consumption of disposing companies is not very large, but it can be considerable regarding wood processing residues.

4. How do you use the recovered wood, which you consume in your company? (Quantity from 3b)?

material utilisation 5/ ________ %
energy generation 6/ ________ %
disposal 7/ ________ %
other: .... 8/ ________ %
100 %

If internal consumption is of relevance, the form of usage is important, if final statements about the shares of material and energetic usage are to be made. This aspect is considerably more eminent on wood processing residues than on waste wood.

5. If you do sell the recovered wood, how much of this quantity (3a) do you deliver

a. directly to final-consumers 9/ _______ %
(e.g. particleboard- or heating plants)
b. to other recovered wood-processors 10/ _______ %
(other recovered wood disposal companies)
100 %

Due to the fact that the trade between disposal companies is of great importance, it was measured on purchase and on sale. However, the differences between the extrapolated amounts can be considerable. Experience has shown that the sale quantities tend to be more valid.

6. To which kind of final-consumers do you sell your recovered wood to? (Quantity from 5a)?

Domestic sale for:
material consumption in the
- panel board industry 11/ ________ %
- other (e.g. composting) 12/ ________ %

energy generation 13/ ________ %
disposal 14/ ________ %

Export for:
material consumption 15/ ________ %
energetic generation 16/ ________ %
disposal 17/ ________ %

Other:............................... 18/ ________ %
100 %

For the later demonstration of material flows, the structure of distribution is of high importance. Furthermore, it also gives information about the form of usage (material or energetic). Within this question one can also resolve the separation after domestic consumption and export. Another option could be found therein to ask internal and domestic consumption as well as export, first and then to partition the sectors apart. On the other hand, the coherence of the contents is more understandable for the questioned within the hereby elected way.

---

7. For the case that you export recovered wood, which are the countries?

Country ________________ to _______ %
Country ________________ to _______%

The direction of trade was temporarily of great interest in Germany, because one expected large exports to Italy. The question was not eligible concerning such specific aspects.

8. Is your plant a single company, or belongs it to a corporate group?

19/1 ☐ Single company
/2 ☐ Part of a corporate group (evtl. Name:____)
/3 ☐ Member of a union of companies
(evtl. Name: __________________________)

The combination of enterprises plays an important role within the disposal branch. With this question integrations or the forms of the co-operations can be identified. However, it is not relevant to determine the market quantitatively.

9. Specification of further production/processing sites:

Name_________________ Zip___________ City___________
Name_________________ Zip___________ City___________
Name_________________ Zip City

Latter is true as well for the last question. It is of great importance at the beginning of a total survey. The question gives information on other additional locations which might be unknown and can be investigated afterwards.

The displayed questionnaire is particularly suitable for the total survey of a branch. The scope of the wanted information is often much larger. In these cases a two-step process is of advantage. Thereby, the capacity of the enterprises is recorded by using a short questionnaire and the differentiated structure is recorded with a random sample afterwards. The latter can be structured by size-classes and then extrapolated by size-class to the capacity of the total enterprises.

1.2.6 Approaching the unknown universe

Besides, an identification of the individual participants of a business branch, the structure of assortments and the distribution of wood raw materials of the individual locations shall be converted into conversion rates by plant sizes for those who dodo not state any details. Beyond a purely quantitative regulation of the converted wood volume, this provides additional knowledge about the structure of supply sources and depicts likewise further necessary knowledge about the distribution channels of the wood raw material assortments. For reasons of a better processing of the complete project, the different forest product industries were examined separately as partial markets.

If the parent population is not known, the best sample cannot give any answers to market volumes and potentials. Mantau (2004a) developed a data collection method which is suitable to solve this problem for industrial branches. It can be subdivided into seven fundamental methodical steps:

1. Enquiry of all addresses and address sources
2. Consolidation of the address-/data stock
3. Development of a questionnaire as a location survey
4. Field work with mail questionnaire with only basic information
5. Telephonic and full survey of all the addresses which could not been reached
6. Detailed questionnaire after the parent population is evaluated
7. Projection from the partial return sample on the parent population

With these steps it should basically be possible to state the parent population of a business branch. In the course of the examination, single branch variations or even redundancies can arise. During the processing steps new information will almost certainly appear. This requires that processing steps which are already completed must be repeated (e.g. new address sources). In the following chapter, the course of the surveys shall be displayed in more detail for the individual branches of industry.

After recording the parent population, there are different possibilities to deepen the analysis by further surveys, e.g. by means of interviews. Whether one decides in favour of a sample examination or a full survey depends on the extent to which the examination can or must be carried out.

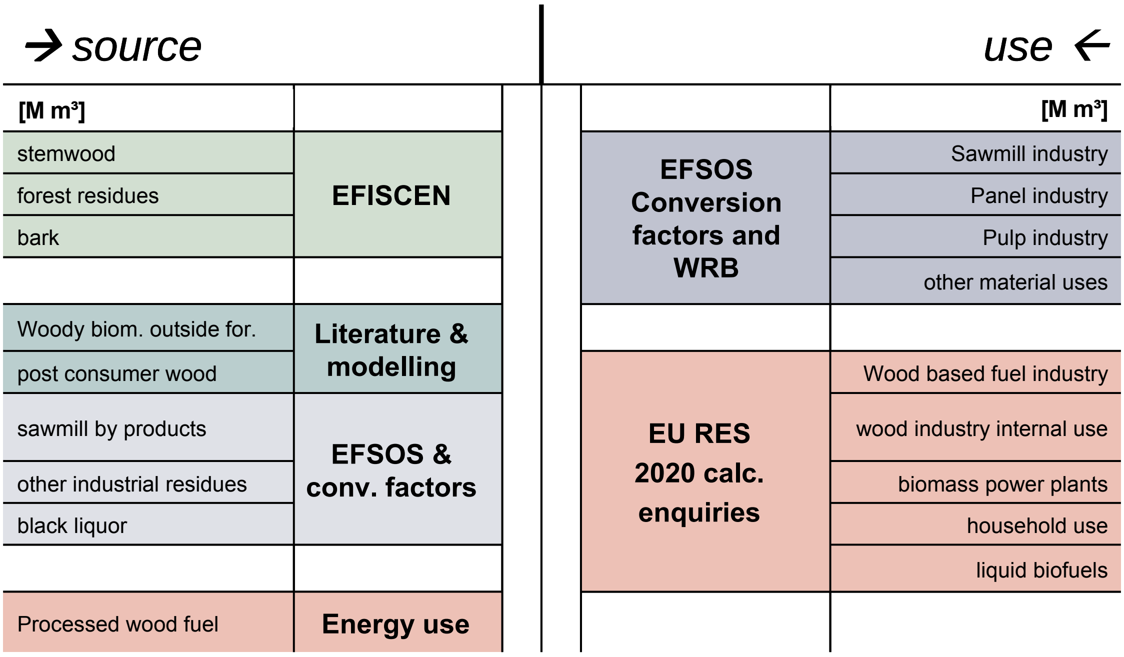
1.2.7 Methods used for scenarios in the Wood Resource Balance

The different sectors in the Wood Resource Balance need different approaches for projection because of their natural differences as well as their differences in data quality and modelling possibilities.

EFISCEN: A large-scale forest resource modelling system based on national forest inventories. The model was used to project the potential wood availability from forests under three different mobilisation scenarios.

Econometric modelling (Future Forest): The actualised GDP based econometric calculations by JONSSON and the core group members for the European Forest Sector Outlook Study of the FAO/UNECE was used to forecast the production of and wood consumption by the traditional wood industry sectors.

Other woody biomass: Because of poor data availability and large differences in their driving factors, the sectors of this part (e.g. post-consumer wood, landscape care wood, and short rotation plantations) will be projected sector by sector. Sectors with a strong linkage to industrial production (sawmill by-products) can be calculated by con-version factors.



→ source

[M m³]	
stemwood	EFISCEN
forest residues	
bark	
Woody biom. outside for.	Literature & modelling
post consumer wood	
sawmill by products	EFSOS & conv. factors
other industrial residues	
black liquor	
Processed wood fuel	Energy use

use ←

	[M m³]
EFSOS Conversion factors and WRB	Sawmill industry
	Panel industry
	Pulp industry
	other material uses
EU RES 2020 calc. enquiries	Wood based fuel industry
	wood industry internal use
	biomass power plants
	household use
	liquid biofuels

Figure 1-7: Framework of projections 2010 - 2030

Source: MANTAU, Wood Resource Balance, EUwood – team 2010. (VERKERK/LINDNER/ANTTILA/ASIKAINEN: EFISCEN forest resources and constraints; LEEK, N.: Post-consumer wood; OLDENBURGER J.: Landscape care wood; SAAL, U.: industrial residues; MANTAU/SAAL: Wood industry; PRINS, K.: Policy options; JONSSONS, R. econometric modelling (Future Forest))

Energy use of wood: The basis for the projections of the wood energy sector is the EU policy targets for renewable energy by 2020. The detailed National Renewable Energy Action Plans will not be available by the end of the EUwood project. It will hence use the country specific targets in combination with the current role of wood energy to project the future wood demand by the energy sector and assumes a 20% efficiency progress. Thus the driving factor behind these scenarios is not economic activity but the renewable energy targets. “How much wood is needed if Europe achieves these goals?”

The Wood Resource Balance will integrate all the different scenarios in one calculation system - three mobilisation scenarios in the natural production and the two IPCC scenarios in those sectors driven by economic developments. In this last step, the comparison of supply and demand under the assumed details of the scenarios will outline either reserves or gaps for future wood supply situation.

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Chapter 2
Wood demand for material use

Authors:

Chapters 2.1, 2.2, 2.5 and 2.6: Udo Mantau [1]

Chapters 2.3 and 2.4 Ragnar Jonsson [2]

[1] University of Hamburg, Germany

[2] Växjö University, Future Forests, Sweden

Content

2 Wood demand for material use

2.1 Introduction

The objective of the EUwood project is the determination of the wood consumption among the different sectors. In the field of material consumption this is based on the econometric modelling (Future Forest) (see below). The EFOSOS-Model calculates the quantities of produced goods (sawnwood, pulp, panels) in m³ and in tons. However, these are m³ and tonnes of semi-finished products but do not exactly rely on m³ wood resource biomass. In each production process there are by-products or residues and perhaps possible losses. Thus, conversion factors are needed to transfer product volumes into cubic meter of roundwood or in case of other woody biomass into a solid wood equivalent.

Conversion factors may differ significantly between products and countries. The reasons for this are among many others different production techniques and different species with different density. In the course of a further differentiation of the wood market and the application of the Wood Resource Balance as general record system, the need of conversion factors increased significantly. For that reason, the UNECE Timer Committee employed a working group in order to determine conversion factors which resulted in an excellent piece of work on conversion factors led by Fonseca with the contribution of country correspondents.

For further utilisation in the Wood Resource Balance, the conversion factors have partially been amended and adjusted (SAAL, 2010). A detailed description of industrial residues is presented in chapter 5.4.3. At this point, only an example of this approach shall be illustrated.

In order to produce one cubic meter softwood lumber 1.667 m³ of roundwood is needed. In other words, one m³ roundwood obtains 0.60 m³ sawnwood. However, this factor varies among European countries between 0.49 (Sweden) and 0.62 (France). Some publications use the term "efficiency factor". Yet, this is to a great extend misleading. The reason for the differences in the above mentioned countries depends rather on the small diameter of roundwood in Sweden than on technical efficiency. This is even worse if so called efficiency factors are calculated for panels' or countries' total roundwood consumption and total output of wooden products Buongiorno (1978). In this case, it is overlooked that particle board production contains post-consumer wood as a resource input as well. Furthermore, the felling statistics in some countries are not well developed. If a country counts only two third of its real cutting, the overall efficiency calculated on the basis of fellings as input and products as output are very low. Thus, the term "efficiency factor" should be used very carefully. The term "recovery factor" is much more neutral as well as the use of the term "conversion factor".

The calculations of the Wood Resource Balance calculate the total amount of solid wood equivalents. Only in case of sawnwood production this corresponds to roundwood or stemwood consumption. However, this is often not the case in the particle board production as this process can use stemwood, sawmill by-products and post-consumer wood as well. Thus, in a second step the overall solid wood equivalents are segmented into the different resources.

2.2 IPCC Scenarios

The scenarios used by EUwood are based on the IPCC scenarios (International Panel of Climate Change), as developed for the forest sector by EFORWOOD. The scenarios may be briefly characterised as follows (PRINS, EUwood State of the Art Report, 2009):

Scenario **A1** describes an open world with steady economic growth, slow population growth, fast technical development in industry, but slow in environment, strong rises in global trade, but less in intra-EU trade, rising consumption, including wood products, faster urbanisation, mill size, road transport, and long distance tourism. It also sees increased profitability of wood based industries (but not forest owners), and drop in numbers of mills, combined with a stable share of wood in construction, environmental awareness and nature conservation. Conversion of agricultural land to forest is forecast to rise and employment in the countryside to fall.

Scenario A1 is generally spoken the growth scenario in an open world. The population growth is slow as well as the environmental progress. Technical development in industry is fast and global trade rises strong. Wood industry develops prosperous; the concentration in the industry proceeds and wood has a stable market share in end use sectors.

Scenario **B2** describes a less global, more environmentally aware future, with slower GDP growth, but higher growth in population, strong increases in the “knowledge society” and technical developments for environment. General consumption would grow more slowly than in scenario A1, but wood consumption for materials and energy would grow faster. Urbanisation and the size of mills would progress more slowly. The number of mills in Europe would not fall and multi-functionality would increase, as would the area of nature reserves. Profitability of wood based industries would grow slower than in scenario A1, but profitability of forest owners would grow (unlike in Scenario A1), as would rural employment. There would be a smaller increase in conversion of agricultural land to forest, while rural employment would grow slightly.

Scenario B2 describes a less global, more environmentally aware future with slower GDP growth but higher growth in population, strong increases in the “knowledge society” and technical developments for environment. General consumption would grow more slowly than in scenario A1, but wood consumption, for materials and energy, would grow faster.

The scenario developments are broken down into GDP growth rates shown in the graph (see Figure 2-1). These growth rates are the basis for the econometric modelling (Future Forest, Jonsson) which forecast the wood industry semi-finished products sawnwood, pulp, panel and others. These are the basis for the resource consumption calculations in the EUwood-project.

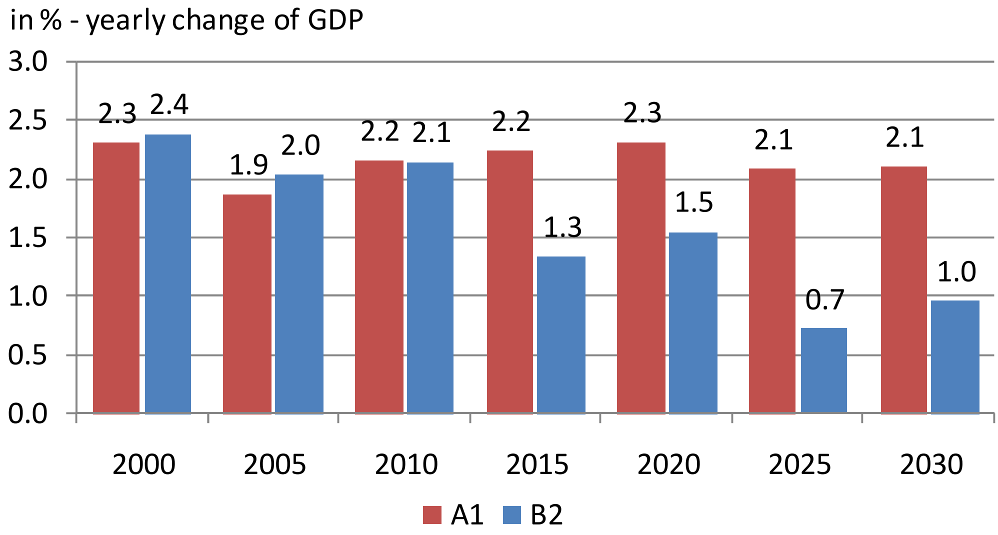

Figure 2-1: GDP growth in IPCC scenarios A1 and B2

Source: International Panel for Climate Change (IPCC)

Where is the financial crisis in the graph? One word to the actuality of the forecasts: the IPCC-Scenarios have been created in the middle of the 90th. The quality of a forecast depends very much on the base year. Could this be a realistic assumption for the economic development after the financial crisis? One could as well ask: Could more recent forecasts that were available at the beginning of the EUwood project in early 2009 have been a better basis?

The assumptions taken in the econometric modelling (Future Forest, Jonsson, 2010) are as follows: The average production volume of the last five years (2003-2007) is the starting point and from there on the IPCC GDP growth rates are assumed. Including the development of the financial crisis, it could not have been a better starting point because we are 2010 right there and if we look at the growth rates we have with A_1 a more “business as usual” development with growth rates between 2.0% and 2.5% and with B_2 a development where economic growth slows down around 1.0%. These scenarios might capture all economic developments so that we can assume right now under realistic conditions.

2.3 Modelling wood products demand, supply and trade

The current study provides a description of an econometric analysis of the forest sector in Europe and how the resulting models (henceforth market models), together with assumptions regarding economic growth and price and cost developments, are used to produce country specific projections of consumption, production and trade of wood products.

The methodology of Kangas and Baudin (2003) is applied for providing projections of supply, demand and trade as regards processed wood products. The benefit of this approach is that it covers all aspects of consumption, production, imports and exports (Kangas and Baudin, 2003). Subject to the market characteristics of the country in question, two different econometric approaches are used:

i. A multiple equations approach for demand (two equations) and supply (one equation) are applied for countries which are important in demand and/or supply terms for the product in question (see Kangas and Baudin (2003) for details). The functional form is log-linear, allowing for direct interpretation of estimated coefficients as elasticities.

ii. A time series cross-sectional model for consumption for countries and products where either a) only short time series are available and/or the country in question is insignificant in demand and/or supply terms. Again, the functional form is log-linear.

2.3.1 Scope

2.3.1.1 Country coverage and grouping

Major markets and producers are analysed individually, using the multiple equation approach (Group I in Table 2-1). The second group consists of countries that are traditional market economies, with minor production of forest products and/or relatively low consumption (Group II). The purpose of the grouping into IIa and IIb (Table 2-1) is to obtain relatively homogeneous groups of countries. The countries that have recently become market economies (countries with economies in transition) constitute group III with two subgroups (IIIa and IIIb), essentially formed from practical considerations such as size and importance.

From Table 2-1 it is obvious that in Group III, the larger (in terms of production and/or consumption of forest products) countries form their own group (IIIa), but they are also included in IIIb. The reason for this overlapping is the lack of stability of results for group IIIb if the countries in Group IIIa would not have been included. Attempts have been carried out with several alternative groupings among countries, but the classification above is the one providing the most stable results.

Table 2-1: Country grouping

Group I:			
Multiple equation approach: Demand, supply and trade models estimated			
Austria	Finland	France	Germany
Italy	Spain	Sweden	United Kingdom
Group II: Time Series Cross Section approach: Demand models estimated			
Group II a:		***Group II b:***	
Belgium		Greece	
Denmark		Ireland	
Luxembourg		Portugal	
Netherlands			
Group III:			
Time Series Cross Section approach: Demand models estimated			
Group III a:		***Group III b:***	
Czech Republic		Bulgaria	
Estonia		Czech Republic	
Latvia		Estonia	
Hungary		Hungary	
Poland		Latvia	
Poland		Lithuania	
Romania		Poland	
		Romania	
		Slovakia	
		Slovenia	

Source: Future forest

2.3.1.2 Product coverage

The products analysed in this study are:

- i. Sawnwood – coniferous and non-coniferous.
- ii. Wood-based panels – plywood, particle board, and fibreboard.
- iii. Paper and paperboard – newsprint, printing and writing paper, and other paper + paperboard.

For wood pulp, other fibre pulp, and recovered paper, consumption is not analysed but derived for projection purposes from the projected production of paper using conversion factors, indicating the input of raw material needed. However, for countries which are important importers and/or exporters of a specific raw material, imports (or, in some instances, domestic demand) and/or exports are analysed for projection purposes in the same vein as for final products. Further, demand and supply of veneer sheets are not analysed. It is assumed that demand and supply elasticities of veneer are the same as those for plywood for the country in question.

2.3.2 Materials and method

2.3.2.1 Data

The FAOSTAT database is the main source of data as to production, imports, exports as well as value of imports and exports of commodities. Based on this information, import and export unit values (in US$) are calculated and subsequently deflated to provide estimates of real (constant) import and export prices. Trade flows were assessed in the UNECE and UN COMTRADE database.

Historical macroeconomic data, gross domestic product (GDP) in constant US$ and deflators, was collected from the FAO database. For GDP projection purposes, IMF projections were used until 2010, thereafter the IPCC Special Report on Emissions Scenarios (SRES) A_1 and B_2 scenarios were used (source: CIESIN, 2002). For the A_1 as well as B_2 scenario, the price and production costs developments of the A_1 and B_2 reference futures as compiled/calculated within EFORWOOD was used. These baseline scenarios were chosen since they are considered to provide sufficient contrast as regards economic growth rates - a high growth and low growth scenario respectively. Added benefits are that using the same scenarios as the ones used in the EFORWOOD programme make comparisons and the achievement of project synergies possible.

2.3.2.2 The multiple-equations approach

For the multiple equations approach (see Table 2-1 above), the following set of equations is defined:

Equation 2-1: Multiple equations approach (1)

$$Q^D_D = f(P_d, P_m, D^D)$$

Equation 2-2: Multiple equations approach (3)

$$Q^M = f(P_d, P_m, D^M)$$

Equation 2-3: Multiple equations approach (3)

$$Q^D_s = f(P_d, P_x, Costs, S^D)$$

Equation 2-4: Multiple equations approach (4)

$$Q^X = f(P_d, P_x, Costs, S^X)$$

where Q^D_D = demand for domestically produced goods, Q^M = import demand, $Q^D s$ = supply to domestic markets ($QDs = Q^D_D$), Q^X = supply to export markets, Pd = the real price in domestic markets, Pm = real import price, Px = real export price, D^D = demand shifters for the domestic market, D^M = demand shifters for import demand, Costs= cost factors, S^D = supply shifters for the domestic market and S^X = supply shifters for the export market. Real gross domestic product (GDP), in constant US$, is used as demand shifter in equations 2-1 and 2-2 for paper and paperboard as well as for solid wood products, thus differing from Kangas and Baudin (2003). In the latter study an end-use index was used as demand shifter for solid wood products. Following the approach of Kangas and Baudin (2003), the activity of export markets, described by a population-weighted index, S^X, of real GDP in France, Germany, Italy and the United Kingdom, is used as supply shifter in equation 2-4.

In equation 2-1 the domestic price is expected to have a negative sign, whereas the sign of the import price can be either positive or negative depending on whether imports substitute for or complement domestic products. Analogously, in equation 2-2 the import price should be negative, and the domestic price can have either a positive (substitution) or negative (complement) sign. Equations 2-3 and 2-4 indicate that export and domestic markets are alternative destinations for the production. Negative cross-price elasticity signifies substitution. Hence, the expected sign for export price is negative in equation 2-3 and positive in equation 2-4 and vice versa for the domestic price.

Since domestic prices were not readily available, real export prices are used as proxies for domestic real prices in equations 2-1 and 2-2 when the country is a net exporter of the product in question. Otherwise, real import prices only are used in equations 2-1 and 2-2. Similarly, real import prices are used as proxies for domestic real prices in equations 2-3 and 2-4 whenever the country is a net importer. Otherwise, real export prices only are used in equations 2-3 and 2-4. The cost factors used in the supply equations 2-3 and 2-4 are raw material costs: log prices, chip prices, recovered paper prices and pulp prices, all in constant US$. All prices are based on deflated import and export unit values.

The four equations represent an over-identified system for projection purposes. Along with import demand and export supply (assuming both trade flows occur), only one equation must be estimated for the domestic market to fully-define production and consumption. For most countries and products, the domestic market quantity is estimated as a demand equation (Equation 2-1). Data for demand prices and demand shifters is generally better than corresponding data necessary to estimate coefficients in supply equations. Furthermore, since studies, e.g. Kangas and Baudin (2003) show that the differences between a systems approach (two-stage or three-stage least squares) and ordinary least squares (OLS) regression are only marginal; OLS is used throughout the study as the estimation method. OLS is a technique for estimating the unknown parameters in a linear regression model. This method minimises the sum of squared residuals, i.e., the sum of squared distances between the observed values and the values provided by the regression model.

2.3.2.3 The time series cross sectional approach

For the time series cross-sectional approach (see Table 2-1), total (apparent) consumption is explained using price and GDP.

The following equation is used:

Equation 2-5: Total (apparent) consumption

$$QT = f(P, GDP)$$

Where QT is apparent consumption, P is real export unit prices or real import unit prices, the larger of the trade flows determine which of the two price series are used. GDP is the real gross domestic product. Again, prices and GDP are in constant US$.

The estimation procedure is a time series cross-section (TSXS) approach. The methodology, described in Buongiorno (1977, 1978) and in Baudin and Lundberg (1987), is further developed in Baudin and Brooks (1995).

2.3.3 Results and discussion

The elasticities used are updated and revised from the ones used for market projections in the State of the World's forests 2009 (FAO, 2009). The circumstance that there are significant differences in elasticities between countries support the use of the multiple equation approach, provided, of course, that sufficiently long time series are at hand. The results are generally in accordance with economic theory. Supply and demand equations yield expected signs for the income coefficients, i.e., demand increases along with increasing income. Rising real domestic prices tend to decrease demand for domestically produced goods and increase imports. Analogously, increasing import prices generally increase demand for domestically produced goods and reduce imports. Thus the results tend to imply substitution between imports and domestic production in consumption. On the supply side, increasing domestic price lead to decreasing exports while increasing export price has a positive impact on exports. Increasing raw material costs tend to decrease production. In addition, trade models generally have higher elasticities than do domestic models, indicating that, in an individual country, trade is generally more price and income sensitive than are domestic production and consumption. There are, however, instances when elasticities do not exhibit the expected sign, e.g., in some instances the export price elasticity in the export models is negative. This could mean that the export model in question in those instances do not reflect export supply, but rather the demand for exports.

The sign and magnitude of income elasticities are of interest in the light of the discussion concerning structural changes in forest products markets. Hence, Hetemäki and Nilsson (2005) report that information and communication technology has had a fundamental impact on the forest products sector. According to their results, long-run income elasticity for newsprint consumption in the USA turned negative after 1987, consistent with the findings of Hetemäki and Obersteiner, 2001. This clearly indicates that structural change in mass media consumption patterns has taken place in the USA. However, historic data for Europe do not indicate a clear trend toward lower income elasticities for newsprint demand, exemplified by Figure 2-2 below, depicting income (i.e., GDP) elasticities for newsprint in the five largest economies of the European Union.

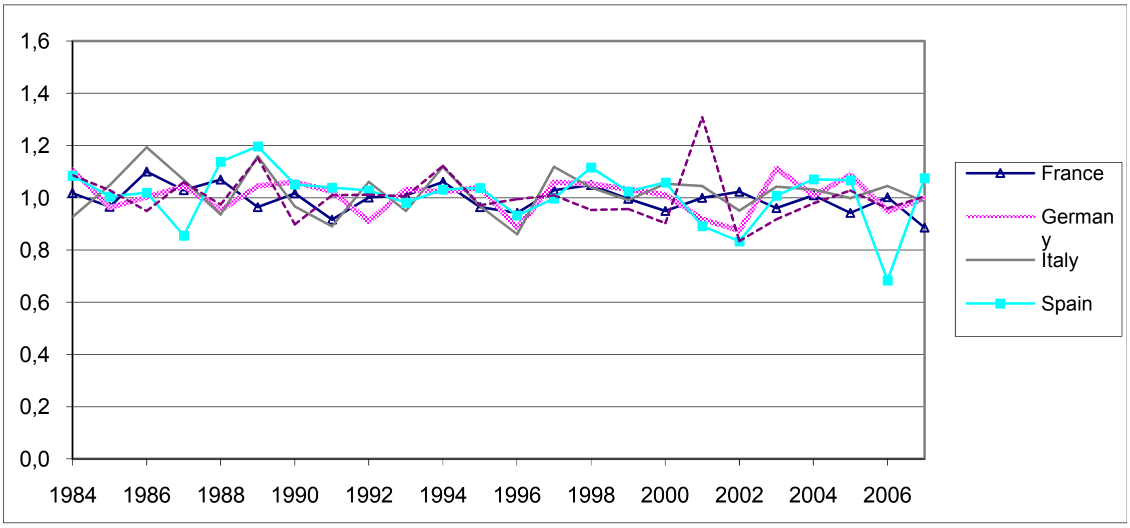

Figure 2-2: Newsprint - income-demand elasticities

Source: Data: FAOSTAT and FAO database, illustration: future forest

2.4 Projections of demand, supply and trade of wood products

2.4.1.1 Summary

In economic projections, information from the past is combined with current knowledge and judgement in order to make statements about plausible future developments. The projections of material use are prepared based on econometric models and forecasts of economic growth in forty European countries Econometric models examine the relationships between the economic factors that prevailed in the past. In projections, the functional relationships are assumed to remain the same. The essential relationships examined are the response to growth in GDP or changes to product price of a particular wood product. Combining the information on these relationships with the assumed development in GDP and prices, EUwood can produce projections.

The long term projections are intended to give insights into plausible developments of demand, supply and trade of wood products in Europe, given different sets of assumptions. Here, the methods and assumptions applied in preparing the projections are presented. Projections are provided for sawnwood (coniferous and non-coniferous), panels (plywood, particleboard, fibreboard), paper and paperboard (newsprint, printing and writing paper, other paper and paperboard), pulp for paper (mechanical wood pulp and chemical and semi-chemical wood pulp), other fibre pulp and recovered paper in forty European countries in three sub-regions. Projections are provided up to the year 2030.

2.4.1.2 Two baselines/reference futures: A1 and B2

Market projections of the econometric modelling under the Swedish Future Forest project are based on the IPCC scenarios A1 and B2. According to the IPCC story lines (for more comprehensive scenario descriptions, please see http://www.grida.no/publications/other/ipcc_sr/?src=/Climate/ipcc/emission/025.htm):

- The **A1** storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. In general, public awareness concerning environmental issues is low. A1 is a consumer oriented world with diluted national governance and highly developed global trading system. International best practices are adopted quickly and global standards emerge for many products and services.
- The **B2** storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 storyline. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels. International institutions decline in importance, with a shift towards local and regional decision-making structures and institutions. Human welfare, equality, environmental protections has high quality, and is addressed through community-based social solutions. Compared with A1, there is more emphasis to social cohesion and maintaining environmental integrity, as well as a greater effectiveness of global institutions. Solutions are found locally: within Europe, while North-South differences remain high.

These baseline scenarios, or reference futures, were chosen since they are considered to provide sufficient contrast as regards economic growth rates - a high growth and low growth scenario respectively. Added benefits are that using these well-known scenarios makes comparisons possible with other future studies, such as, e.g., EFORWOOD (for details see http://87.192.2.62/eforwood/Home/tabid/36/Default.aspx)

2.4.1.3 General conclusions

Overall consumption of all wood products is increasing in both of the reference futures, but the rate of growth is, of course, considerably higher in the A1 than in the B2 scenario. In general, consumption of wood products is growing slower than the economy as a whole, the characteristic of necessity goods. In the long run, an expected decrease in the European population does not support higher growth rates for the consumption of wood products.

In the B2 reference future, production and consumption growth rates are slowing down over the outlook period, with the exception of sawnwood consumption. This slowing down of consumption growth is most pronounced for paper products and wood pulp (mechanical pulp in particular). This is consistent with a future world characterised by heightened environmental concern, where, e.g., a higher demand for bio-energy drives up the prices of inputs for the wood-based panels and pulp & paper industry, while at the same time the sawnwood industry will mainly benefit from this development through a growing demand for energy-efficient and renewable construction materials and higher prices for the by-products, chips and particles with very limited competition from bio-energy markets as regards raw materials (see, e.g., Engelbrecht, 2006).

In A1, in contrast to the B2 reference future, production and consumption growth is increasing for all wood products over the outlook period, with the exception of paper and paperboard. The circumstance that paper & paperboard production and consumption growth are slowing down in the A1 reference future could mainly be understood in the light of progress in information and communication technology (see, e.g., Hetemäki and Nilsson, 2005).

According to the projections, the eastern parts of the Europe will increase in importance over the next two decades. Hence, the countries of Group III in Table 2-1 will take a larger share of the production and consumption of solid wood as well as pulp & paper products, in both of the reference futures. The importance of the East European countries will be highest in the A1 scenario, which is in accordance with the A1 theme of economic convergence among regions.

2.4.2 Projection approach for processed wood products

For a given country and product an estimated (domestic or import) demand model is given as

Equation 2-6: Domestic or import demand

$$lnY_t = a + b*lnGDP_t + d*lnP_t$$

For a given country and product an estimated export supply model is given as

Equation 2-7: Export supply

$$lnX_t = g + h*ln\ S^X{}_t + k*lnP_t + l*lnc_t$$

where Y_t *is* domestic consumption (or import) in time period t

ln denotes natural logarithms

GDP_t is real GDP in time period t

P_t is real product price

t is a time index; t=1 for 1961, t=2 for 1962 etc and

X_t is exports in time period t

$S^X{}_t$ is a population weighted index of the GDP of the four main economies and export destinations; France, Germany, Italy and UK

c_t is real cost of wood raw material and a, b, and d g, h, k and l are estimated elasticities.

The projection method is as follows:

1. With data to year 2007, a base-year value for *Y* at the centre of the last observed five year period, 2005 is given as a five-year average:

Equation 2-8: Five year average

$$Y_{05} = (Y_{03} + Y_{04} + Y_{05} + Y_{06} + Y_{07})/5$$

The rationale for using this average as a starting value is the objective to provide long term projections. This means that initial values for projections should, as much as possible, not reflect short term fluctuations (such as business cycles). A five-year average is expected to cancel major effects of business cycle variations, which means that it is expected to be 'on the trend line'. Considering the recent economic downturn, which did not begin to manifest itself until mid-2008, projections for 2010 could be higher than what will actually be observed. However, provided that the economic downturn is not reflecting a major change in the trend, projections should provide reasonably accurate reflections of longer term developments. The annual growth rate of consumption from 2005 to 2010 is defined as:

Equation 2-9: The annual growth rate of consumption from 2005 to 2010

$$Y_{05-10} = b*GDP_{05-10} + d*P_{05-10}$$

2. The projection for 2010 then is:

Equation 2-10: Projection for 2010

$$Y_{10} = Y_{05} * (1+b*GDP_{05-10} + d*P_{05-10})^5$$

Where GDP_{05-10} and P_{05-10} denote annual rates of growth for GDP and price respectively. For countries with short available time series, a three year average (for the years 2005, 2006 and 2007) is used when calculating the base year for projections. Hence, the centre year is 2006 and the initial projection value in this instance is obtained as:

Equation 2-11: Initial projection value

$$Y_{10} = Y_{06} * (1+b*GDP_{05-10} + d*P_{05-10})^4$$

3. Projections for year 2015 are obtained as above with the 2010 projection as the starting point. The procedure from year 2020 should be obvious
4. Projections for export supply are performed using the same methodology as above. In some instances when the export model produces unrealistic results, due to, e.g., highly variable export data, production was modelled instead using the same model as for exports.
5. Projections are provided for years 2010, 2015, 2020, 2025 and 2030. Values for intermediate years are given by linear interpolation.

6. Putting together import demand and domestic demand (for a given product and country); apparent consumption is obtained, total production is derived by putting together domestic demand and export supply.
7. The approach presented here also applies to the time series cross section demand models. In instances when only demand models are estimated, it is assumed that production is a constant share of consumption (self-sufficiency ratio) and that imports is a constant share of consumption. The ratio used is the five year average centred around 2005 or, for countries with short available time series, a three year average centred around 2006. Export is calculated from these quantities.

2.4.3 Intermediate products

For wood pulp, other fibre pulp and recovered paper, consumption is derived for projection purposes from the projected production of paper and paperboard using conversion factors, indicating the input of raw material needed.

2.4.3.1 Recovered paper

When preparing projections for the production and consumption of recovered paper, historical trends in wastepaper recovery rate (defined as recovered paper production divided by total paper and board consumption) and recovered paper utilisation rate (defined as consumption of recovered paper divided by total fibre-furnish) were analysed. There are technical limits to both of these variables, e.g., some types of paper are difficult to recover (e.g., tissue paper), whereas some types of paper are difficult to manufacture from recycled paper.

The projection of recovery and utilisation rates are based on extrapolation of past trends, subject to the limitations related above. When there is no discernible trend or in instances where the recovery rates were already high (70-80 percent), the average rate for the three last years were used. Production projections are then calculated as the product of the recovery rate and the projected total paper and board consumption for the country in question. Consumption projections are subsequently given as the product of the utilisation rate, projected total paper and board production and the fibre-furnish input ratio (total fibre-furnish consumption divided by total paper and board production).

The fibre-furnish input ratio is assumed to remain constant over the outlook period. As already noted, for countries which are important importers and/or exporters, imports (or domestic demand) and/or exports are analysed for projection purposes and projections are subsequently performed with the same method as for the forests products, related above. In other instances, it is assumed that imports are a constant share of consumption. The ratio used is a three year average centred around 2005. Export is subsequently calculated from production, imports and consumption quantities.

2.4.3.2 Wood pulp

Projections of the consumption of wood pulp are calculated by subtracting the projected consumption of recovered paper and other fibre pulp from the projected total fibre-furnish (the product of fibre-furnish input ratio and projected total paper and board production). In doing so, the other fibre pulp utilisation rate (other fibre pulp consumption divided by total fibre-furnish) is assumed to remain constant. Wood pulp consumption are subdivided into mechanical wood pulp and chemical wood pulp (in this instance comprising chemical and semi-chemical wood pulp) consumption by means of the historical shares of the different types of wood pulp. These shares are thus assumed to remain unchanged. Looking at Figure 2-3 below, displaying the situation in Western Europe, this assumption seems reasonable; though the share of mechanical wood pulp is lower than it was in 1980, it has been stable the last ten years:

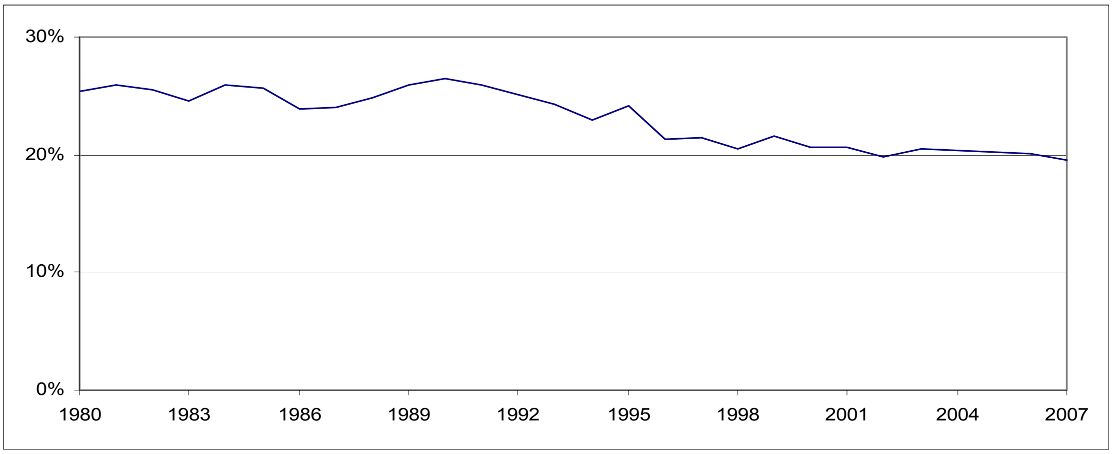

Figure 2-3: Mechanical pulp - share of total wood pulp (Western Europe).

Source: Data: FAOSTAT and FAO database, illustration: future forest

The same as for recovered paper, for important importers and/or exporters of the two different types of wood pulp defined above, imports (or domestic demand) and/or exports are analysed for projection purposes and projections are performed with the method already described. In other cases, production is assumed to be a constant share of consumption (self-sufficiency ratio) and imports a constant share of consumption. Export is calculated from these quantities. The ratio used is a three year average centred around 2005. Export is calculated from these quantities.

2.4.3.3 Other Fibre Pulp

Consumption projections for other fibre pulp are given as the product of the utilisation rate, projected total paper and board production and the fibre-furnish input ratio. The input ratio is assumed to remain constant. When projecting production and imports, it is assumed that the self-sufficiency ratio and the import/consumption quota are to remain unchanged.

2.4.4 Projection conditions

GDP growth rates, prices and costs are the variables used in the projection system. As for GDP, IMF forecasts were used until 2010, and thereafter the downscaled GDP projections from the IPCC Special Report on Emissions Scenarios (SRES) A1 and B2 scenarios (source: CIESIN, 2002).

Price and production costs developments of the A1 and B2 reference futures are the same as the ones used in the EFORWOOD program. The magnitude of the elasticities estimated from historical data is not changed over time. Income elasticities are notably stable over time (see, e.g., Perloff, 2008); hence it is difficult to identify a theoretically relevant argument for altering these figures.

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2.5 Calculation models

Before illustrating the calculations in detail, it is necessary to define some of the terms. In usual market models the terms ‘supply’ and ‘demand’ are used which is in line with the equilibrium models. The problematic fact that only the result of the supply and demand process is available for these models is not further expounded in this course. Since the EUwood project identifies different scenarios with the help of given development paths, the identified measures do not concern equilibriums. EFI prefers the terms potential supply and potential demand. The potential supply of stem wood is calculated on the basis of the EFISCEN-Model with assumptions for different mobilisation scenarios. It is not identical to the actual use of stem wood but represents the potential supply, which must be mobilised, under given conditions. The potential demand from sawmills is calculated based on econometric modelling by the Future Forest from Sweden. Thereby, it represents the potential demand under the assumption of gross domestic product and price developments of the wood industry sector. However, no equilibrium between stem wood from forests and stem wood used in sawmills is calculated because stem wood is used as well in many other sectors. Only if the resource mix of all sectors is known, the total stem wood demand can be calculated. The resource mix in many of the consumer sectors (private households, biomass power plants) is currently only in a few countries or sectors known. As long as this cannot be calculated, any kind of price related equilibrium model doesn’t make any sense.

On the demand side the calculations are based on the following general steps:

1. calculation of the total wood consumption
2. segmentation by resource assortments
3. calculation of industrial residues in the processing of semi-finished products
4. distribution into end-use-sectors
5. calculation of industrial residues in the processing of end-use-sectors

The following equations list the calculations for the coniferous sawnwood industry. Steps 4 and 5 are calculated in one step.

Equation 2-12: Coniferous sawnwood roundwood consumption

$$CSWWRT_{EU27} = \sum_{n=27}^{n=1} CSWPRN * CF_{csw}$$

CSWWRT = coniferous sawnwood wood resources total
CSWPRN = coniferous sawnwood production
CF_{csw} = conversion factor coniferous sawnwood

Equation 2-13: Coniferous sawnwood by-product

$$CSWCBP_{EU\,27} = \sum_{n=27}^{n=1} CSWWRT - CSWPRN$$

CSWCBP = coniferous sawnwood wood by-products gross value

Equation 2-14: Coniferous sawnwood by-product assortments - losses

$$CSWCBL_{EU\,27} = \sum_{n=27}^{n=1} CSWCBP * \sum_{n=27}^{n=1} CF_{CBL}$$

CSWCBP = coniferous sawnwood wood by-products - losses
CF_{CBL} = conversion factor coniferous sawnwood losses

Equation 2-15: Coniferous sawnwood by-product assortments – saw dust

$$CSWCBD_{EU\,27} = \sum_{n=27}^{n=1} CSWCBP * \sum_{n=27}^{n=1} CF_{CBD}$$

CSWCBP = coniferous sawnwood wood by-products - losses
CF_{CBL} = conversion factor coniferous sawnwood losses

Equation 2-16: Coniferous sawnwood by-product assortments - slabs

$$CSWCBS_{EU\,27} = \sum_{n=27}^{n=1} CSWCBP * CF_{CBS}$$

CSWCBS = coniferous sawnwood wood by-products - slabs
CF_{CBS} = conversion factor coniferous sawnwood - slabs

Equation 2-17: Coniferous sawnwood by-product assortments - chips

$$CSWCBC_{EU\,27} = \sum_{n=27}^{n=1} CSWCBP * CF_{CBC}$$

CSWCBP = coniferous sawnwood wood by-products - chips
CF_{CBL} = conversion factor coniferous sawnwood - chips

Equation 2-18: Coniferous sawnwood industrial residues from construction

$$CSWIRC_{EU\,27} = \sum_{n=27}^{n=1} CSWCBP * CSWMS_{CO} * CF_{IRT_{CO}}$$

CSWIRC = industrial residues from coniferous sawnwood in the construction industry
$CSWMS_{CO}$ = market share of coniferous sawnwood in the construction

industry
$CF_{IRT\ CO}$ = share of industrial residues in the use of sawnwood in the construction industry

Equation 2-19: Coniferous sawnwood industrial residues from furniture

$$CSWIRF_{EU27} = \sum_{n=27}^{n=1} CSWCBP * CSWMS_{FU} * CF_{IRT_{FU}}$$

CSWIRF = industrial residues from coniferous sawnwood in the furniture industry
$CSWMS_{FU}$ = market share of coniferous sawnwood in the furniture industry
$CF_{IRT\ FU}$ = share of industrial residues in the use of sawnwood in the furniture industry

Equation 2-20: Coniferous sawnwood industrial residues from packaging

$$CSWIRP_{EU27} = \sum_{n=27}^{n=1} CSWCBP * CSWMS_{PA} * CF_{IRT_{PA}}$$

CSWIRP = industrial residues from coniferous sawnwood in the packaging industry
$CSWMS_{PA}$ = market share of coniferous sawnwood in the packaging industry
$CF_{IRT\ PA}$ = share of industrial residues in the use of sawnwood in the packaging industry

Equation 2-21: Coniferous sawnwood industrial residues from other uses

$$CSWIRO_{EU27} = \sum_{n=27}^{n=1} CSWCBP * CSWMS_{OT} * CF_{IRT_{OT}}$$

CSWIRO = industrial residues from coniferous sawnwood in other industry
$CSWMS_{OT}$ = market share of coniferous sawnwood in other industry
$CF_{IRT\ OT}$ = share of industrial residues in the use of sawnwood in other industry

The calculations for the non-coniferous industry are the same (NSW). The calculations in the panel industry are slightly different. In contradiction to the sawmill industry the panel industry uses different resources. In the OSB-production only stemwood is used. In the MDF-production stemwood and sawmill-by-products are used and in the panel industry of stemwood and sawmill-by-products, post-consumer wood may be used additionally. Furthermore, in the production of panels industrial residues, instead of by-products, are calculated on the level of semi-finished products and on the level of end-use-products.

The pulp industry produces similar to the sawmill industry a special residue or by-product, the black liquor. In the case of pulp wood no industrial residues are calculated. In the panel and in the pulp wood industry stemwood is further segmented into coniferous and non-coniferous stemwood.

2.6 Other material uses

The sector “other material uses” is differentiated into traditional other material uses and new innovative “other material uses”. Traditional other material uses include dissolving pulp, mulch and other industrial roundwood sorted for special purposes (e.g. poles and sleeper). Many new innovative products made of wood fibber are on their way to win market relevance.

Traditional other material uses are not calculated in the econometric modelling (Future Forest). An expansion factor was calculated on the development of all projections under the econometric modelling (Future Forest) for solid wood consumption (sawnwood and panels) and applied to the sector other material uses.

No quantitative calculations have been undertaken for innovative wooden products. Yet, this does not mean that the relevance of this sector is low, but its development is highly speculative. It could be 20 M m^3 in 2030 or 100 M m^3 in 2030. So far only a few quantitative estimates are known, like the ones for wood plastics components, but real empirical data is lacking. In contrast, this sector has a high potential for rapid growth.

In the clothing industry cellulose is applied as regenerated cellulose fibres (viscose), for example made of beech wood, cotton and linen, respectively. In conjunction with additives functional textiles and increasingly also casual wear are produced. This combines excellently the marketing arguments sustainability and wellness and appeals thereby highly and with increasing success to the growing consumer group of the LOHAS (Lifestyle of Health and Sustainability).

Until now, liquid wood has only been used for high-quality household terrace building panels which do not have to be moulded. Another area which liquid wood application could be used in is in the engine compartment, with components such as the battery tray. Analyses have shown that the recyclability of liquid wood is excellent because the material can be reprocessed up to five times. Therefore, the overall CO_2 balance is almost neutral.

A further important field of application is the building material industry which uses cellulose derivates, like methyl cellulose, as an improver of flow properties in concrete and plaster, for instance. Besides, cellulose is the base material for the plastic known as cellophane, which is not only used in the food packaging industry but also in a novel transparent cigarette paper. Cellulose etherified to cellulose acetate can, working as a thermoplastic plastic material, be produced so transparent that it even can be applied as separating agent in LCD displays. On top, it is also used as car paint and to great amounts as raw material in cigarette filters for many years. Even silky textiles, which are especially crease-resistant and easy-care, are made of cellulose acetate. Moreover, the material lignin, conducive for the stabilisation of wood, becomes increasingly relevant. Remaining in great quantities as a by-product of the cellulose production, lignin as lingo-sulfonate can be used both as binder of dust in the building industry and as glue in animal food pellets in the agriculture. In form of PLA (poly lactic acid) it even functions as bio plastic and is used in the production of ball-pens, biodegradable packaging or shopping bags.

However, the problem of resource scarcity is equally true here, in case the material utilisation encounters the energetic one, whereby especially the segment of cellulose and lignin achieves a considerably higher added value.

Due to their rare emergence and an often constantly developing processing procedure, these components are substituted by oil, as resource for the material utilisation. Hence, they are often directly burned in the production plant in order to generate energy.

As the demonstrations above have shown, the field of new innovative products based on wood has huge growth potential. This ideally matches the trends of sustainability, CO_2 reduction, wellness and recycling. Likewise, this trend possibly enhances the traditional wood industry to gain higher added values with innovative instead of traditional products. While cost pressure increases on the raw material side, the wood industry will use its raw material competence to become an active participant in this field. Many of the stated methods and products have been known for more than 60 years – even the first film bases were made of cellulose acetate. However, many so-called bio plastics with their complex production process lost their importance as plastics made of oil emerged.

Due to the high scarcity of fossil raw material a lot of methods of the material utilisation of wood has been resumed and developed further with highly modern techniques, in order to become competitive again. By this, it equally aims to become a major substitute to fossil raw materials in the chemical industry. Evidently, the pulp and paper industry has already begun to complement their portfolio with bio-refinery plants and develop new basic material in the derived timber product industry. On top of this, completely new players enter the wood market, for instance the chemical industry which strives for a broader raw material supply and hence strongly focuses on renewable material.

In contrast, the field of material utilisation is as well likely to gain an increase in efficiency, both in existing production processes and totally new products such as honey comb boards or tubular chip board which need fewer raw materials per cubic meter board. Thus, the field of innovation on both counts (new raw material utilisation; increase in efficiency) is not quantitatively analysed here but left to qualitative considerations.

Chapter 3
Wood demand for energyl use

Author: Florian Steirerer

Content

3 Wood demand for energy use

3.1 Policies driving market developments

Wood energy is an integral and in many countries the most important single source of energy from renewable sources such as hydro, wind, geothermal, solar or other biomass and organic waste. The share of renewable energy has been increasing in recent years and will continue steady growth in the coming decade in the EU 27 member states if renewable energy policy targets remain in place. A number of different policies aiming at energy security, increased use of carbon neutral energies to mitigate climate change, rural and decentralised development will further boost wood energy in the coming years. The Directive on the on the promotion of the use of energy from renewable sources (called EU RES Directive hereafter) is likely to be the biggest driver of renewable energy in the period until 2020 and beyond. It sets ambitious targets for the role of renewable energy by 2020 in each member state and countries are requested to submit their national renewable energy action plans by the end of June 2010.

3.2 The overall energy framework

By means of legally binding targets for the consumption of renewable energy in each member state, the EU RES Directive provides precise guidance based on relative figures (as percentages of total primary energy consumption). However, it does not mention absolute figures. Hence, all of the targets depend crucially on the development of “Gross Inland Energy Consumption” which is the reference framework needed to calculate the future absolute amounts of Energy from Renewable Sources.

The EUwood project would have liked to use as much as possible, calculations and results of already existing and tested energy models. Another advantage of using existing models as starting point for the wood energy demand is the improved comparability between different projects. EUwood therefore intended to use the latest results of the PRIMES energy model, used for several large scale EU energy studies. EUwood contacted the PRIMES project leader, from Athens University. In the personal/informal communication he informed the EUwood project that *“the Energy and Transport Trends to 2030 (updated 2007) and the Impact assessment study with PRIMES for the Climate Action and Energy Policy Package (the 20-20-20) can be found at the European Commission site (in DG TREN and DG ENV sections respectively). However, both projections were made before the economic crisis and actually they are under revision; no publications are yet available however and so no information diffusion on the updates is possible at this stage.”*

A first quick assessment of these freely accessible (2007) PRIMES results with the latest data provided by member states on the transparency platform hosted by DG TREN indicates that realities seem to have changed quickly. 12 countries provided data on their expected Gross Inland Energy Consumption (AT, BE, EE, HU, IE, LV, PL, RO, SK, ES, SE, UK). Germany did provide an outlook, however, was excluded from the first assessment due to anomalous values (compared to any current and future data from any other source).

The result of the first assessment indicates that PRIMES data exceed countries projections of the Gross Inland Energy Consumption in 2020 by over 39% in the renewable energy scenario (Annex 4). Primes Annex 4 assumes only 10% energy savings compared to the baseline calculations (Primes Annex 1). Due to lack of better information, EUwood decided to use its own projections of future gross inland energy consumptions.

These projections are based on the development of energy consumption in past years with an added energy efficiency factor. EUwood projections differ from the national submissions by 13% on average and show maximum aberrations of -12% in Hungary to +54% in Estonia compared to the respective 12 national forecasts on the transparency platform of the European Commission (equalling 100% in Table 3-1).

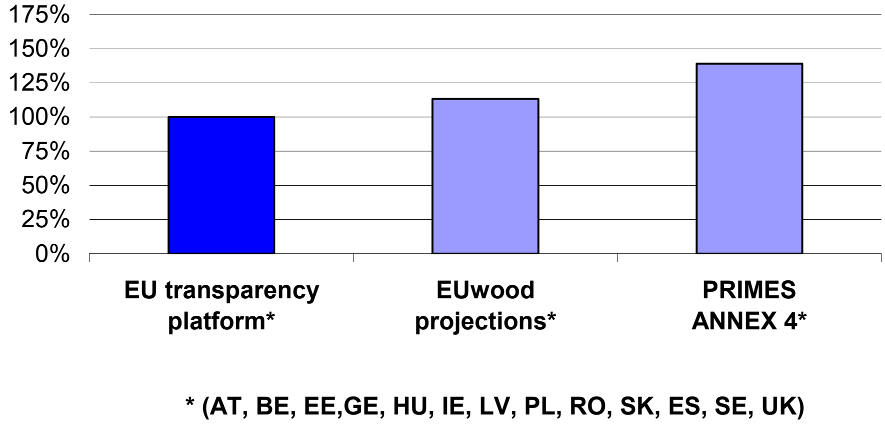

Figure 3-1: Gross inland energy consumption by 2020 - different projections

Source: Data: PRIMES energy model, country reports on the transparency platform on EU DG TREN, EUwood result. Illustration: EUwood

Results of the EUwood energy projections come close to the 12 member states' projections. EUwood values for the gross inland energy consumption in 2030 are lower than the results for the respective countries of the PRIMES Annex 4 scenario ("EC proposal with RES trading"). Unlike the PRIMES model, EUwood does not balance out the energy supply and consumption between countries as these data are only used as framework data to assess the absolute amount of renewable energy in the future.

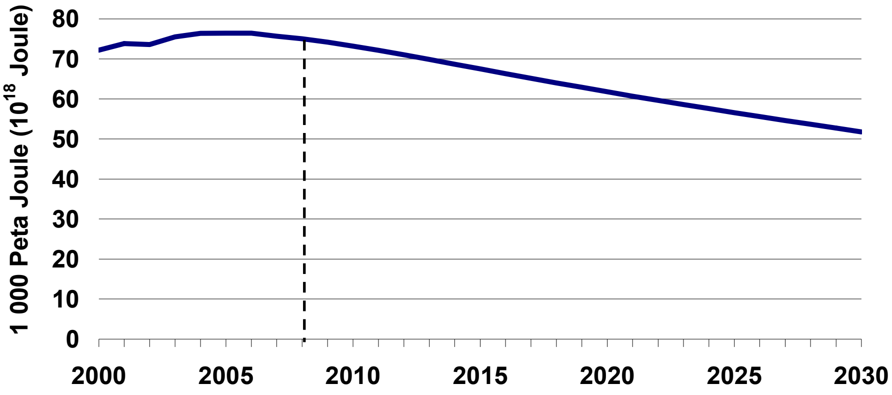

Figure 3-2: Gross inland energy consumption 2000 – 2030 (EU 27)

Source: EUwood

These data will need further checking and balancing once member countries submit their final data in their national renewable energy action plans their final dataset on how to achieve the 20% share of energy from renewable energy sources by the end of June 2010.

3.3 Energy efficiency gains

One important difference between the above described PRIMES datasets and the EUwood as well as the country specific projections is how they treat energy efficiency. Country projections, as well as the EUwood calculations consider energy efficiency as integral, given, legally binding part of the EU RES Directive.

In a personal/informal communication the leader of the PRIMES project motioned that *"(…) the 20-20-20 package(…) does not consider energy efficiency targets as mandatory; so energy efficiency improvement develops as needed to contribute to emission reduction but the volume of development depends on relative economic costs."* – This comment is of high importance as it outlines an important difference between the two projections (PRIMES and EUwood).

The EUwood project follows the majority of the country reports and statements made by the member states in assuming a 20% energy efficiency gain. Thus, the current calculations and absolute values represent the wood energy demand under *very* high energy efficiency gains. During the past few years before the financial and economic crisis, energy consumption within the EU 27 already decreased at regional level, but also in many countries. The past trend of less energy intensity in combination with higher gross domestic product (GDP) productivity was used to project the energy consumption separately for each member state.

Thus any of the statements made on the results of the EUwood project assume already that policy will successfully develop strong energy efficiency measures and tools that help achieving higher energy efficiency targets. The sensitivity assessment in chapter 3.7 assesses how this assumption may influence the future wood demand for energy.

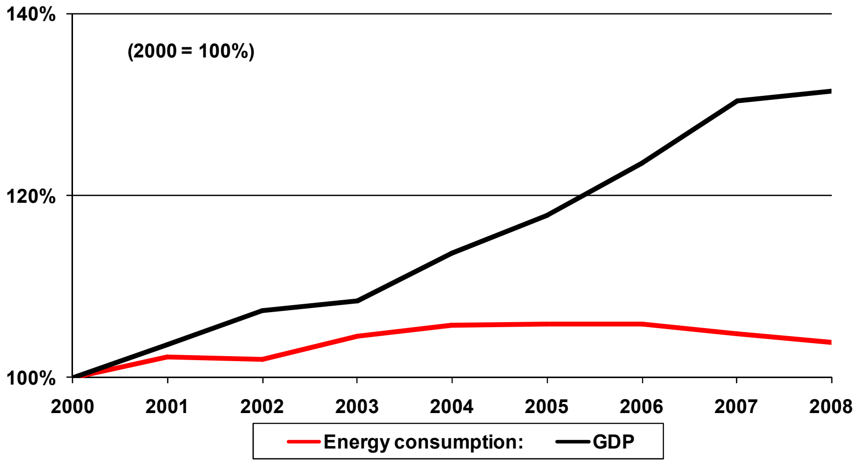

Figure 3-3: GDP and energy consumption (EU 27)

Source: Data Eurostat, illustration: EUwood

The calculations for the Gross Inland Energy Consumption as well as the trends of energy consumption per country are based on 2005 as reference year. Nevertheless, the calculation of the EUwood wood energy scenario uses Eurostat data until the year 2008. Generally, the EUwood energy scenario projects past developments of energy consumption between 2000 and 2008. The reason for using such a short period is that realities in energy consumption really started changing significantly in the first decade of the 21st century (Figure 3-3). Thus absolute values for Gross Inland Energy Consumption started decreasing in some of the most advanced countries. The calculation assumes a long term maximum drop of energy consumption of -1.75% annually (Table 3-1).

Countries with still increasing trends in energy consumption, notably new EU 27 member states such as Poland, Romania or Bulgaria show steep increases in energy consumption in the period prior to 2008. It was assumed that these countries will continue their increasing energy consumption in the coming years. However, it was also assumed that their trend of increased energy consumption called *“Default value for annual minimum improved energy efficiency (also to reverse trends)”* will be weakened by 0.5% per year. This value also applies to any country when energy savings at national level remained below that value.

Table 3-1: EUwood variables for the gross inland energy consumption

Reference year:	**2005**
Maximum average annual reduction in energy consumption (energy efficiency gains) - 2008-2020:	-1.75%
Maximum average annual reduction in energy consumption (energy efficiency gains) - 2020-2030:	-1.75%
Minimum annual reduction of energy consumption (e.g. to reverse trends):	-0. 50%
EUwood energy efficiency gain by 2020 (EU 27) (compared to reference year):	19.15%
EUwood energy efficiency gain by 2020 (EU 27) (compared to reference year):	32.24%

Source: EUwood

3.4 Future energy consumption from renewable sources

Once the future development of the Gross Inland Energy Consumption has been calculated, the development of energy consumption from Renewable Energy Source is outlined in very detail[4] by the "Table A" (Table 3-2 below) of the EU RES Directive:

"The starting point, the renewable energy potential and the energy mix of each Member State vary. It is therefore necessary to translate the Community 20 % target into individual targets for each Member State, with due regard to a fair and adequate allocation taking account of Member States' different starting points and potentials, including the existing level of energy from renewable sources and the energy mix. It is appropriate to do this by sharing the required total increase in the use of energy from renewable sources between Member States on the basis of an equal increase in each Member State's share weighted by their GDP, modulated to reflect their starting points, and by accounting in terms of gross final consumption of energy, with account being taken of Member States' past efforts with regard to the use of energy from renewable sources."

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[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF#page=31

Table 3-2: Country specific renewable energy targets (*"Table A"*)

Country	Share of energy from renewable sources in gross final consumption of energy, 2005 (S_{2005})	Target for share of energy from renewable sources in gross final consumption of energy, 2020 (S_{2020})
Austria	23.3 %	34 %
Belgium	2.2 %	13 %
Bulgaria	9.4 %	16 %
Cyprus	2.9 %	13 %
Czech Republic	6.1 %	13 %
Denmark	17.0 %	30 %
Estonia	18.0 %	25 %
Finland	28.5 %	38 %
France	10.3 %	23 %
Germany	5.8 %	18 %
Greece	6.9 %	18 %
Hungary	4.3 %	13 %
Ireland	3.1 %	16 %
Italy	5.2 %	17 %
Latvia	32.6 %	40 %
Lithuania	15.0 %	23 %
Luxembourg	0.9 %	11 %
Malta	0.0 %	10 %
Netherlands	2.4 %	14 %
Poland	7.2 %	15 %
Portugal	20.5 %	31 %
Romania	17.8 %	24 %
Slovak Republic	6.7 %	14 %
Slovenia	16.0 %	25 %
Spain	8.7 %	20 %
Sweden	39.8 %	49 %
United Kingdom	1.3 %	15 %

Source: EU RES Directive

Besides the starting and target point for each separate country, the EU RES Directive also provides very detailed guidance on the trajectory of how much of the final target should be achieved in every biennium term:

"Indicative trajectory

The indicative trajectory referred to in Article 3(2) shall consist of the following shares of energy from renewable sources:

$S_{2005} + 0.20 (S_{2020} – S_{2005})$*, as an average for the two-year period 2011 to 2012;*

$S_{2005} + 0.30 (S_{2020} – S_{2005})$*, as an average for the two-year period 2013 to 2014;*

$S_{2005} + 0.45 (S_{2020} – S_{2005})$*, as an average for the two-year period 2015 to 2016; and*

$S_{2005} + 0.65 (S_{2020} – S_{2005})$*, as an average for the two-year period 2017 to 2018, where*

S_{2005} *= the share for that Member State in 2005 as indicated in the table in part A, and*

S_{2020} *= the share for that Member State in 2020 as indicated in the table in part A."*

Table 3-3: Projected growth of RES share of GIEC as Δ 2020-2005 (EU 27)

	EU RES Directive	EUwood*
Ø 2011/2012:	20%	17% 22%
Ø 2013/2014:	30%	29% 36%
Ø 2015/2016:	45%	45% 55%
Ø 2017/2018:	65%	66% 77%
2019:		89%
2020:	100%	100%

Source: EU RES Directive

Despite this very detailed outline of how to develop the Renewable Energy Targets, the EUwood project applied a slightly different growth path than defined for the RES Directive (Table 3-3). The objective was to provide a moderate and equilibrated growth rate of the renewable energies over the entire time span. The inflection point (biggest annual growth rate) is to be found around 2018 in both, the EU RES Directive as well as the EUwood projection

The graph Figure 3-4 outlines the annual growth rates with and without energy efficiencies. This result underlines again the importance of effective and successful implementation of energy efficiency measures at country level. Energy efficiency gains could significantly attenuate the challenge of increasing the RES to its expected 20% share in 2020 by lowering required annually growth rates by -1% to -2% compared to a reality without such measures.

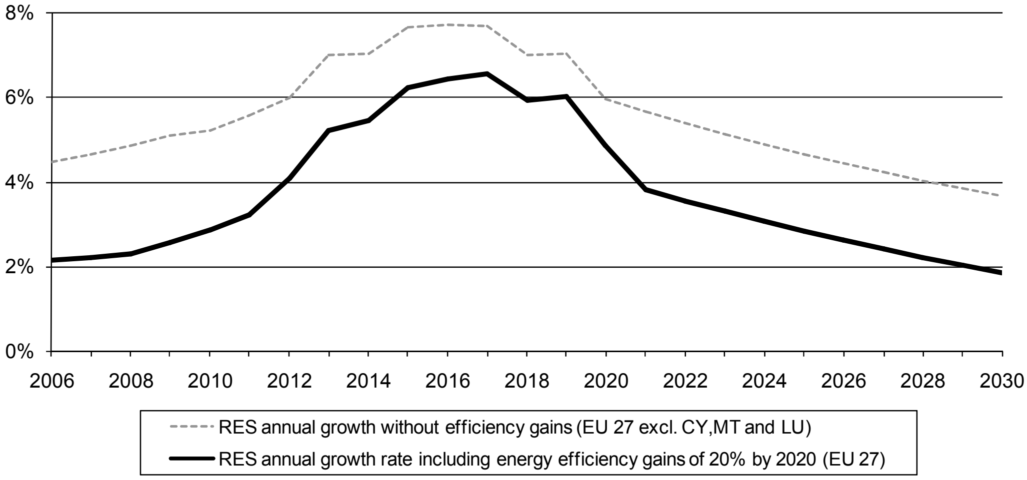

Figure 3-4: Projected average growth rates of renewable energy (EU 27)

Source: EUwood

It can be said, that energy consumption from renewable sources will increase from $7.2*10^{18}$Joules in 2010 to $12.2*10^{18}$Joules in 2020 and continues further growth to $16*10^{18}$Joules by 2030. However, to reach the targets, these values would have to be much higher if energy efficiencies were smaller than 20%:

Therefore the EUwood conclusions as regards demand for wood energy assume that Europe achieves energy efficiency gains of 20% by 2020. If this is not achieved, more wood would be necessary to reach the same target (see chapter 3.7).

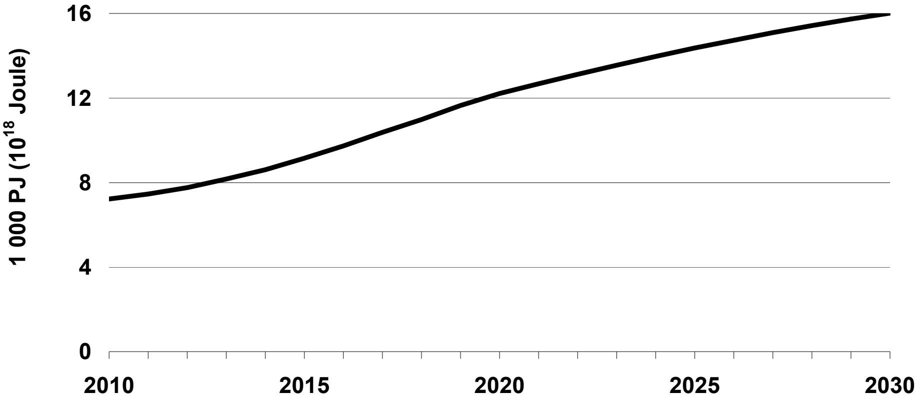

Figure 3-5: Gross inland consumption of renewable energy (EU 27)

Source: EUwood

3.5 Current and future role of wood energy

Eurostat as well as the UNECE/FAO Joint Wood Energy Enquiry provide data on energy supply and use of wood energy. The Joint Wood Energy Enquiry 2007 covers 12 of the 27 EU member countries. Its wood energy data are very valuable as they make it possible to link and compare energy and forestry statistics. The comparison of the 19 datasets of the JWEE 2005 and 2007 with the corresponding energy data from Eurostat on energy from wood and wood wastes resulted in 8.72 TJ / 1000 m³ as conversion factor between energy and forestry statistics. This conversion factor is used to convert the energy units (TJ) to forest units (m³) in those countries, which were not covered by the Joint Wood Energy Enquiry 2007.

It is important to note that this coefficient is a purely empirical value based on the intensive work on wood energy together with national correspondents at the UNECE/FAO Forestry and Timber Section in Geneva (JWEE 2005 & 2007). It is exclusively applicable to convert national energy statistics to wood units and can hence not be used for any conversion of the energy content in a piece of wood.

In a next step, EUwood used Eurostat data on energy from wood and wood waste to assess the current role of wood energy for each member country. Due to high variation from one year to another, the calculation was based on a five year average (2003-2008).

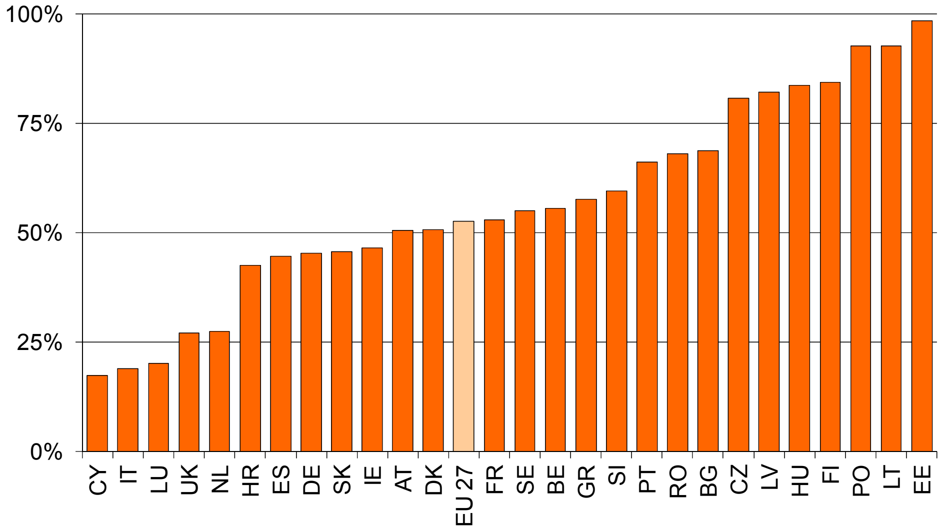

Figure 3-6: Wood energy's share in renewables total (EU 27)

Source: Data Eurostat & UNECE, illustration EUwood

The scenarios of the EUwood project assume that wood energy slightly decrease its share in energy from renewable sources to 40% in 2020. Chapter 3.7 discusses how a changing role of wood energy changes the demand in wood for energy generation.

The future total values of wood energy consumption per country per year were obtained by multiplying the future amounts of energy from renewable energy sources by the country specific average share of wood energy. The result in energy units (Joules) was then converted into m³ on the bases of 8.72 GJ/m³. This simplifying assumption may overestimate demand for wood energy, which at present is in many countries the dominant form of renewable energy. If as appears likely, newer forms of renewable energy (wind, solar, tide etc.) grow faster than wood, the share of wood would fall, and less wood would be needed to meet the renewable energy targets.

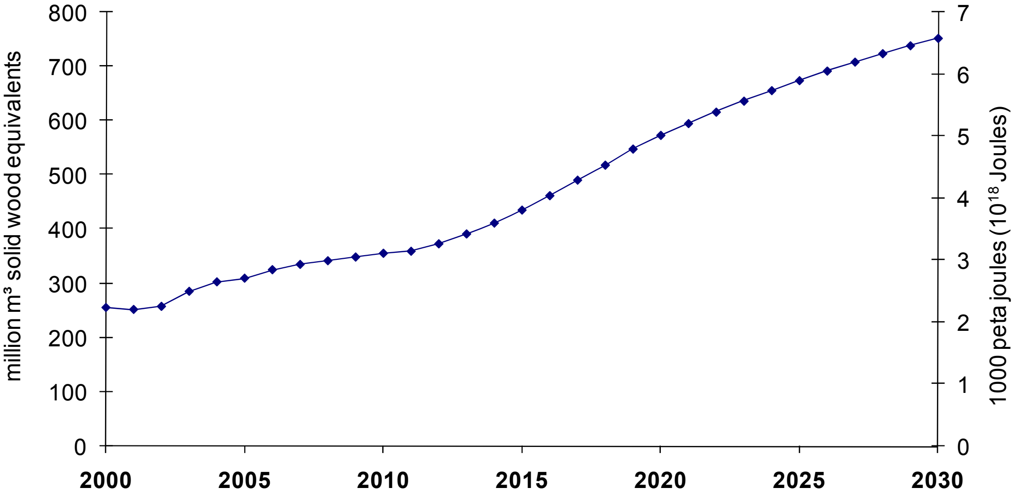

Figure 3-7: Current and future amounts of wood energy demand (EU 27)

Source: EUwood

3.6 Wood energy - sector specific development

EUwood considers variable incineration technologies and market developments of the different wood energy sectors and actors and modelled the different sectors separately (Table 3-4):

- households
- forest based sector internal
- main activity energy producer
- second generation biofuels

This approach aims to take into consideration the different evolution of the manifold energy applications and technologies with their very different pace in the future, based on the structure and experience of the UNECE/FAO Joint Wood Energy Enquiry, as well as FAO Unified Bioenergy Terminology[5] (UBET). EUwood calculated specific future developments for the following wood energy consumers:

The total needed to meet the renewable energy targets, estimated by the method outlined above, was distributed between the various wood energy users, with the residual assigned to a single use, biomass power plants.

Table 3-4: Sectors for the projection of future wood energy consumption

	Sector [1000 m³]	Sub-sector for detailed calculation [1000 m³]	Variable name
	Industry internal use for energy	energy - forest sector internal – liquid	EFL
		energy - forest sector internal – solid	EFS
+	Households	energy - private households – pellets and briquettes	EHP
		energy - private households – other	EHO
+	Commercial heat & power production	energy - biomass power plants (map – main activity producer)	EPP
+	Liquid biofuels	cellulose based liquid biofuels by biochemical conversion (ethanol)	LBC
		cellulose based liquid biofuels by thermochemical conversion (Btl, methanol)	LBP
=	Total	wood energy total	WET

Source: EUwood

3.6.1 Industry internal use of wood energy

Energy use in the forest based sector was split into energy from residues by the pulp and paper industries and the energy from solid residues from any other wood processing sector. Their development is based on the results of the sector

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[5] FAO 2004 http://www.fao.org/DOCREP/007/j4504E/j4504e00.htm

specific econometric modelling of the upcoming UNECE/FAO European Forest Sector Outlook Study.

3.6.1.1 Forest based industry internal energy use — liquid

The forest sector internal use of liquid residues (EFL) refers to the production of chemical and semi-chemical pulp. The amount as well as the composition of the liquid residues called “black liquor” depends highly on the specific pulping process as well as the tree species in each country (chapter 5.4.4). In many countries, chemical and semi-chemical pulp production represents the major energy producer and pulp mills are often the most important producer of electricity from biomass, today. Heat and power generated from these residues are mostly directly used to keep the pulping process running, notably for the recovery of the pulping chemicals.

EUwood’s calculations for the generation and use of black liquor imply that the efficiencies of different pulping processes will not change significantly in the future. The calculations therefore considered the input to output ratio, e.g. units of wood needed to produce one unit of pulp as constant. It is further assumed that any by-products of the puling process are entirely used for energy generation.

These assumptions may well be simplifications for the sake of easier calculation and better transparency of the process. However, it is clear to the authors that existing pulp mills could be modified to enlarge their product portfolio by wood-based bio-chemicals as well as wood based liquid biofuels- thus reducing the supply and use of black liquor. In this scenario, the lignin etc in black liquor would be put to higher value added uses and the energy if supplied would be generated from other sources, presumably from remaining internal sources and residues (bark etc.) or various other, externally purchased, fuels. Despite ongoing intensive research by the industries, EUwood assumes that the amounts of such products will remain very minor in comparison to the pulp production in the given timeframe.

3.6.1.2 Forest based industry internal energy use – solid (EFS)

Similarly, other wood processing industries such as sawmills and wood-based panel producer use wood internally for energy generation, notably for drying of their (semi-) finished products.

The Joint Wood Energy Enquiry of the UNECE/FAO Forestry and Timber Section, as well as empirical research from Hamburg University provide some rough indications on the share of wood that is used for such internal energy generation. Based on these first experiences, the EUwood calculation assumes the following shares of wood fibres are used for internal use:

Table 3-5: Solid wood energy consumption by forest based sector

0.16 m³	per m³ coniferous sawnwood produced for internal energy use
0.05 m³	per m³ non-coniferous sawnwood produced for internal energy use
0.02 m³	per m³ fibreboard production produced for internal energy use
0.05 m³	per m³ particle board production (including OSB) produced for internal energy use
0.15 m³	per m³ plywood and veneer produced for internal energy use

Source: EUwood

3.6.2 Households

3.6.2.1 Private households – other (EHO)

EUwood defines wood energy generated in traditional log stoves by private households from traditional from any source as “other”. It is difficult to obtain adequate, precise information on amounts of wood energy used by private households. Again, the Joint Wood Energy Enquiry of the UNECE/FAO Forestry and Timber Section provides unique information for fuelwood consumption by private households. 9 EU and UNECE member countries provided this detailed information in their response to the JWEE 2005 and 13 countries provided detailed data on wood energy consumption by private households to the JWEE 2007.

In the remaining 14 countries, where these data were not available, the calculation used an indicator based on “forest area (ha) / rural population”. The deeper assessment of the JWEE 2005 and 2007 results found this indicator to be quite relevant for the energy use in households. Thus it was used to estimate the energy use in private household. To differentiate the different structures of the countries, EUwood separated countries into three groups and attributed a specific factor to each of these.

Table 3-6: Fuelwood coefficient based on forest area and rural inhabitants

Forest area (ha) / rural inhabitant	Fuelwood use (m³) per rural inhabitant
< 0.5	0.10
0.5 - 1.12	0.97
> 1.12	2.66

Source: EUwood calculation based on UNECE/FAO Joint Wood Energy Enquiry

Results of empirical studies from Germany indicate a high correlation between the price of light heating oil and the use of wood energy. Since the EUwood study uses wood energy data up to 2007, it can be assumed that the volumes used for the projections are already at a quite high level. EUwood therefore assumes a continued slight growth of +5% in the period until 2015 (compared to 2010), +7.5% for the period until 2020 (compared to 2010) and +5% for the period until 2025 (compared to 2010). In 2030 it was assumed that fuelwood consumption will be back at the level of 2010.

In addition to projection of fuelwood application in private households it is expected, that wood pellets furnaces and stoves will replace some of the existing traditional wood stoves. Thus, the projection assumes that 10% of the pellets consumption will substitute traditional wood fuel. The projection subtracts these amounts from the projected volumes under the above described assumptions.

3.6.2.2 Private households – pellets and briquettes (EHP)

Additionally to the traditional fuelwood from a variety of origins, such as gardens, forests, trees outside forests, post-consumer wood, etc. wood pellets had their appearance as an entirely new form of fuel on the market about a decade ago. Wood pellets stoves are often automated and highly efficient in their combustion and hence cause much lower emissions of namely carbon monoxide as well as small particles (PM10 & PM2). EUwood calculated the development for wood pellets separately as their current and future market development can be considered significantly different from the development of traditional wood fuels.

Data on wood based pellets production, trade and consumption are scarce and there is no official long term dataset on production and trade of this commodity. The pellets@tlas[6] project under the Intelligent Energy for Europe improved significantly data availability and quality of European wood pellets production, export, import as well as data on apparent consumption for the years before 2009. This project is an important source of information to assess the fast evolving market of wood pellets for the period before this commodity was included in any of the international trade nomenclatures. This project phased out in December 2009 since the revision of the Combined Nomenclature (CN) included pellets as separate commodity since January 2009.

The EUwood project used the data on pellet production and consumption from the Pellets@tlas project. Table 3-7 shows the number of data sets next to the number of countries. In 14 out of 27 countries data for only one or two years were available (2007 and/or 2008). This could at least provide a starting point for the projections, but, did not allow any assessment of past trends and projections into the future development of these markets.

Table 3-7: Wood pellets consumption – data availability

Dataset covering … Years	Number of countries per dataset
1	6
2	8
3	2
…	0
6	1
7	1
8	5
12	1

Source: Pellets@tlas –illustration EUwood

Thus it is quite a challenge to project market developments based on this limited information. However, where possible and useful, EUwood used existing country specific data to project the future development (Austria, Belgium,

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[6] http://www.pelletsatlas.info/cms/site.aspx?p=9138

Denmark, Finland, Slovenia and Sweden). In other countries where data sets did not allow any projections on their own data the calculation uses the average growth rate of 29% for 2010 with a 10% decrease in growth in every subsequent year. For the period 2020 to 2030 it was assumed that reduced political support will halve the annual growth of wood pellets consumption.

The result indicates that wood pellets consumption by private households could grow up to 69 million m³ solid wood equivalent (about 35 million metric tonnes) in 2020 and up to 82 million m³ solid wood equivalent (about 41 million metric tonnes) in 2030.

This certainly is a steep evolution of the market of wood pellets in Europe. However, it remains significantly below the projection made by the European Biomass Association (AEBIOM) in their pellets roadmap (Aebiom 2008)[7]. AEBIOM "estimated that the use of pellets for heating purposes in the residential, services and industrial sectors might reach 50 Mt (million metric tonnes) in 2020" This figure is still excluding possible additional use of wood pellets for electricity production in co-firing or biomass only power plants.

3.6.3 Liquid biofuels

3.6.3.1 Introduction

The World Energy Outlook 2008 of the International Energy Agency states that *"Second-generation biofuels, based on ligno-cellulosic feedstock using enzyme hydrolysis of biomass-to-liquid gasification technologies, are expected to become commercially viable, but only make a minor contribution in the second half of the projected period (comment editor: 2020-2030)"* (page 173).

Nevertheless the IEA states that *"there is no consensus about when second-generation technologies will become commercially competitive, even with high oil prices. The key factors in achieving development are to prove the optimum technologies at a commercial scale, increase the scale of production, exploit the learning curve, and apply process optimisation and integration technologies"* (IEA 2009, page 175).

Despite this conservative view of future generation of cellulose based liquid biofuels, EUwood included a projection and followed the main line of the IEA reference scenario for OECD countries that *"second-generation biofuels are not expected to penetrate the market on a fully commercial scale before 2020"*(IEA 2009, page 176).

The IEA projects that the European Union could consume 16.6 Million tonnes of oil equivalent (Mtoe) of liquid biofuels in 2015 and 25.9 Mtoe in 2030. Between 2020 and 2030 consumption of liquid biofuels could increase by 6 Mtoe[8]. The EUwood calculation assumes that half of this additional consumption, 3 Mtoe could originate from second generation biofuels processes. EUwood further assumed that the raw material needed will come primarily from woody biomass

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[7] http://www.aebiom.org/wp/wp-content/uploads/file/Publications/BrochurePRME_LR.pdf

[8] WEO 2008 Table 7.2

even though other fibrous crops and grasses could be used for the process as well.

EUwood assumes that these amounts of second generation wood based biofuels will be produced within the region of the EU 27. Further EUwood attributes production of second generation biofuels, which will need very large plants with correspondingly large raw material procurement basins, only to countries with the biggest forest share (more than 5% of EU 27 forest area). This limitation leads to the result, that the total production of liquid biofuels from ligno-cellulosic raw material would be limited to seven member countries (Germany, Finland, France, Italy, Poland, Spain and Sweden).

EUwood followed the assumption of the IEA reference scenario, that about 80% of the second generation biofuels would be ethanol and 20% biodiesel.

EUwood presents its assumptions on liquid biofuels in an absolutely transparent way, in order to enable further discussion on the issue. In particular one could argue about the very simplified assumption used by EUwood for input/output efficiency.

Further it is likely, that the production of second generation liquid biofuels from wood will play only a minor role for both, the forest based sector, and the energy sector in Europe (about 10% of liquid biofuels derived from cellulose feedstock). It is expected that 90% of liquid biofuels consumed in the member states of the EU 27 in 2030 will be derived from other sources than wood or come from imports.

3.6.3.2 Liquid biofuels by biochemical conversion (ethanol)

Based on the IEA reference scenario as well as the above described assumption, EUwood considered that 2.4 Mtoe of liquid biofuels are derived from a biochemical conversion to ethanol in 2030.

Table 3-8: Wood consumption (2030) for ethanol production (EU 27)

Ethanol			Efficiency	Wood				
output		output	output/ input	input	h. heating value	input	spec. gravity	wood input
[Mtoe]	[GJ/ Mtoe]	[GJ]	%	[GJ]	[GJ/ dmt]	[dmt]	[dmt/ m³]	[m³ swe]
2.48	$42*10^{6}$	$104*10^{6}$	50	$208*10^{6}$	20	$10*10^{6}$	0.42	$24.7*10^{6}$

Source: EUwood calculation based on UNECE/FAO Joint Wood Energy Enquiry, Eurostat

3.6.3.3 Liquid biofuels by thermochemical conversion

Based on the IEA reference scenario as well as the above described assumption, EUwood considered that 0.5 Mtoe of liquid biofuels are derived from a bio-chemical conversion to ethanol.

Table 3-9: Wood consumption (2030) for Btl. production (EU 27)

Biomass to liquid			**Efficiency**	**Wood**				
output		output	output/ input	input	h. heating value	input	spec. gravity	wood input
[Mtoe]	[GJ/ Mtoe]	[GJ]	%	[GJ]	[GJ/ dmt]	[dmt]	[dmt/ m^3]	[m^3 swe]
0.5	$10*10^6$	$26*10^6$	50%	$52*10^6$	20	$2.6*10^6$	0.42	$6.2*10^6$

Source: EUwood calculation based on UNECE/FAO Joint Wood Energy Enquiry, Eurostat

3.6.4 Main activity producer

3.6.4.1 EPP: Energy - biomass power plants

Wood consumption for energy generation in biomass power plants comprises any heat and electricity producer whose main or sole activity is the production of energy for the market (i.e. similar installations producing heat or electricity for internal use by forest industries are not included). The International Energy Agency defines them also as “main activity producer”.

Due to lack of time and resources, the EUwood project did not differentiate the sector any further e.g. by different power plant types and sizes. Thus this sector sums together the future consumption of wood by co-firing in large scale coal plants, large scale biomass power plants with mid and small scale combined heat and power plants. Incineration plants for treated and contaminated wood are similarly included when producing heat and power for the market.

The amount of energy produced by the biomass power plants is calculated as the difference between the sum of wood energy generation from other sectors and the wood energy total (WET). Even though this approach represents rather an estimation method rather than a policy based sectoral projection, it may be a useful indicator for countries on the order of magnitude of wood based heat and power plants necessary to achieve their targets.

However, countries might emphasise one or other of the above described sectors, but the overall targets apply to renewable energies as whole. Increasing wood energy consumption by another sector will consequently decrease consumption of wood for energy by the main activity producer.

3.6.5 Wood energy total

Total wood energy consumption represents the overall framework of wood energy consumed in each country separately. It has been derived by assessing future development of renewable energy in total, multiplied with the share of wood energy from renewable sources. The conversion from energy to forestry units was done by multiplying the “TJ” of the energy statistics by 8.72 TJ/1,000 m^3.

3.7 Sensitivity analysis of assumptions

Any of the above presented results have been calculated on the basis of certain key assumptions. However, these constraints and assumptions may vary and change in the future. The sensitivity analysis of the assumptions outlines briefly, how changing realities might change future wood demands for energy use in 2020 and 2030.

Table 3-10: Sensitivity of EUwood assumptions – energy

Assumption (base scenario)	**Possible variation:**	**Effect on wood demand [million m^3 annually] (EU 27)**	
		2020	**2030**
Member states meet the energy efficiency targets (20%)	Member states miss these targets and energy efficiency remains at 2010 level	+ 85	+ 130
Wood energy contributes 40% to energy from renewable sources	Wood energy accounts for the same share in energy from renewables as in 2010 (50%)	+ 120	+ 167
	Others RES develop fasten than anticipated and wood energy decreases to 37,5% of RES	- 47	- 63
Constant energy yield of net calorific value / incineration efficiency	Each 1% decrease	+ 7.5	
	Each 1% increase	- 7.5	

Source: EUwood

The demand for wood for energy could increase dramatically if countries do not meet energy efficiency targets and expect a maintained strong role of wood energy with 50% share in energy from renewable sources in the future. These framework conditions could increase the demand for wood energy (as presented in the summary of the results of the Wood Resource Balance in chapter 1.5 in the final report of the EUwood project) by some additional 205 million m^3 in 2020 and in 2030 an even higher additional volume of 297 million m^3 would be required at the level of the EU 27.

The demand for wood energy could be further reduced if countries successfully implement energy efficiency measures and at the same time if other renewables develop faster than already anticipated. In case wood energy decreases its share in the renewable energy portfolio to 75% of its 2010 role (37.4% instead of 50%), wood demand could decrease by another 47 million m^3 in 2020 and by 63 million m^3 in 2030.

It also matters, how efficient wood burning facilities make use of the net calorific value of wood. Highly efficient incinerators will decrease the amounts of wood necessary to satisfy the future (wood) energy needs. The results from the EUwood calculations suggest that every increase of the burning efficiency by 1% could save up to 7.5 million m^3 at EU 27 level. Thus it does make a difference whether countries aim for huge electricity-only biomass power plants or whether policies favour highly efficient combined heat and power plants, or central municipal heating systems or extremely efficient pellet stoves in private households.

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Chapter 4

Potential biomass supply from forests 2010 - 2030

Author: Pieter J. Verkerk[1], Jeanette Eggers[1], Perttu Anttila[2], Marcus Lindner[1], Antti Asikainen[2]

[1]European Forest Institute, Finland

[2]Finnish Forest Research Institute (Metla), Finland

Content

4 Potential biomass supply from forests 2010 - 2030

4.1 General approach

The realisable potential for forest biomass supply was estimated for the period 2010 to 2030 in three steps. Firstly, EUwood estimated the maximum, theoretical availability of forest biomass in Europe using the large-scale European Forest Information SCENario model (EFISCEN) (Sallnäs, 1990; Schelhaas et al., 2007). These projections were based on recent, detailed National Forest Inventory (NFI) data on species and forest structure and provided the theoretical biomass potentials from broadleaved and coniferous tree species separately from (section 4.2):

- stemwood;
- logging residues (i.e. stem tops, branches and needles);
- stumps;
- early thinnings (thinning in very young stands; also referred to as pre-commercial thinnings).

Secondly, EUwood defined multiple environmental, technical, social and economical constraints that reduce the amount of biomass that can be extracted from forests. These constraints were quantified for three mobilisation scenarios (section 4.3). Thirdly, EUwood combined the theoretical potential according to EFISCEN with the constraints from the three mobilisation scenarios to assess the realisable biomass potential from European forests (section 4.4). To assess the effect of various assumptions that had to be made, a sensitivity analysis was performed (section 4.5).

4.2 Theoretical biomass supply from forests

4.2.1 EFISCEN modelling framework

EFISCEN is a large-scale forest scenario model that assesses the availability of wood and projects forest resource development on regional to European scale (Nabuurs et al., 2007; Eggers et al., 2008). A detailed model description is given by Schelhaas et al. (2007).

In EFISCEN, the state of the forest is described as an area distribution over age- and volume-classes in matrices, based on forest inventory data on the forest area available for wood supply. Transitions of area between matrix cells during simulation represent different natural processes and are influenced by management regimes and changes in forest area. Growth dynamics are simulated by shifting area proportions between matrix cells. In each 5-year time step, the area in each matrix cell moves up one age-class to simulate ageing. Part of the area of a cell also moves to a higher volume-class, thereby simulating volume increment. Growth dynamics are estimated by the model's growth functions whose coefficients are based on inventory data or yield tables.

Management scenarios are specified at two levels in the model. Firstly, a basic management regime defines the period during which thinnings can take place and a minimum age for final fellings. These regimes can be regarded as constraints on the total harvest level. Thinnings are implemented by moving area to a lower volume class. Final fellings are implemented by moving area outside the matrix to a bare-forest-land class, from where it can re-enter the matrix and thereby reflecting regeneration. Secondly, the demand for wood is specified for thinnings and for final felling separately and EFISCEN may fell the demanded wood volume if available.

To assess biomass in branches, coarse roots, fine roots and foliage, stemwood volumes are converted to stem biomass by using basic wood density (dry weight per green volume) and to whole-tree biomass using age- and species-specific biomass allocation functions.

During thinnings and final fellings logging residues are formed. These residues consist of stemwood harvest losses (e.g. stem tops), as well as branches and foliage that are separated from the harvested trees. In addition to these logging residues, stumps and coarse roots are formed. In the model, it is possible to define which share of the residues and stumps/coarse roots are removed from the forest during thinning and final fellings. Residues and stumps/roots that are left in the forest will decay eventually.

EFISCEN could not be applied for Cyprus, Greece and Malta, due to a lack of detailed inventory data (see section 4.2.2). Instead, EUwood applied a simple approach based on the average growth of the forest resources to assess the potential for stemwood. The potential from logging residues and stumps/roots was assessed in a similar manner as done in EFISCEN.

4.2.2 Data

The forest inventory data that were used in the EUwood study to initialise EFISCEN for 24 EU member states were collected by Schelhaas et al. (2006). Within this study, new inventory data have been collected from national forest agencies for Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Hungary, Ireland, Italy, Latvia, the Netherlands and Sweden (Table 4-1). The data consist of:

- forest area available for wood supply (ha), including temporarily unstocked areas;
- growing stock volume (m^3 overbark/ ha);
- net annual increment (m^3 overbark/ ha / a);

And the data was structured by:

- age-classes;
- tree species;
- geographic regions;
- ownership classes;
- site-classes.

Table 4-1: Forest inventory data sets used for EFISCEN model

Country	Year inventory	Forest area available for wood supply (1,000 ha)
Austria	2001-2002	3349
Belgium	1997–1999	587
Bulgaria	2000	3646
Czech Republic	2005	2667
Denmark	2000	473
Estonia	1999–2001	2048
Finland	2004-2008	18550
France	1988–2000	13872
Germany	2001-2002	10382
Hungary	2005	1859
Ireland	2004-2005	626
Italy	2005-2008	5408
Latvia	2004-2008	3141
Lithuania	2000	1939
Luxembourg	1989	71
Netherlands	2001-2005	360
Poland	1993	6309
Portugal	1997–1998	20267
Romania	1980s	6211
Slovak Republic	1994	1909
Slovenia	2000	1159
Spain	1986–1995	10476
Sweden	2004-2008	22647
United Kingdom	1995–2000	2202
Total	1980s-2008	140158

Source: Schelhaas et al. 2006; EUwood (New inventory data has been collected within this study for the countries indicated in bold)

To account for small differences in the forest area available for wood supply reported (FAWS) to MCPFE, UNECE and FAO (2007) and the area in the EFISCEN dataset, the forest area in each country was multiplied by the ratio between the reported FAWS and the forest area in the EFISCEN dataset.

The data included in the database represented forest inventories conducted between the 1980s and 2008. For countries where inventory data was available from before 2005, the structure of the forest resources in 2005 was estimated based on historical roundwood production (Sweden 2009; FAOSTAT 2009) converted to overbark volumes.

Detailed forest inventory data was not available for Cyprus, Greece and Malta. Instead, EUwood used aggregated data on forest area and net annual increment from MCPFE, UNECE and FAO (2007) and Meliadis et al. (2010).

During harvest operations more stemwood is felled than is removed from the forest in the form of logs. The proportion of volume from thinning or final fellings being removed from the forest in the form of logs was calculated at country level, distinguishing between coniferous and broadleaved species (UNECE-FAO, 2000). The proportion that is not removed as logs represents stemwood harvest losses and could be extracted as part of the logging residues.

Together with stemwood harvest losses other tree components (i.e. branches and stumps / coarse roots) could also be potentially extracted from the forest. To assess biomass in all tree components, species-specific growing stock data was converted to whole tree biomass. This was done using species-specific basic wood densities (IPCC, 2003), and age-dependent, species-specific biomass allocation factors for Austria, Finland, Germany, Ireland, Italy and Spain(Vilén et al., 2005; Romano et al et al., 2009; Mokany et al., 2006; Anderl et al. 2009). These allocation functions were also applied to other countries (Table 4-2). For Cyprus, Greece and Malta EUwood assumed average basic wood densities of 450 kg m^{-3} and 550 kg m^{-3} for coniferous and broadleaved species, respectively. Aboveground biomass was based on biomass allocation functions from Teobaldelli et al. (2009) and stump biomass was estimated based on data by Asikainen et al. (2008).

Table 4-2: Application of species and age-dependent biomass distribution factors to other countries in EFISCEN

Austria	Austria
Finland	Finland, Sweden
Germany	Belgium, Bulgaria, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Ireland (broadleaves), Latvia, Lithuania, the Netherlands, Poland, Romania, Slovenia, Slovakia, United Kingdom (broadleaves)
Ireland (conifers only)	Ireland, United Kingdom
Italy	Italy
Spain	Spain, Portugal

4.2.3 Model simulations and calculations

The EFISCEN model was used to assess iteratively the theoretical, long-term maximum stemwood harvest potential for the period 2010-2030 with five-year time-steps. This maximum potential was based on the average volume of wood that could be harvested over a 50 year period, taking into account increment, the age-structure, stocking level and harvesting losses. The maximum, average harvest level was re-estimated for every five year time-step for the following 50 years to take into account changes in forest area, structure, growth etc. (i.e.

2010-2060, 2015-2065 etc.). This approach provided direct estimations of the stemwood potentials from thinning and final fellings separately. For Cyprus, Greece and Malta, EUwood assumed that the theoretical stemwood harvest potential was based on the net annual increment, but corrected for harvesting losses.

Upon harvest, stem residues from harvest losses (e.g. stem tops) become potentially available, as well as branches, needles, stumps and coarse roots. The amount of biomass generated during harvest from these tree components were used to assess the theoretical potential of logging residues and stumps/roots from thinning and final fellings separately.

Direct model outputs do not include estimations for the potentials from early thinnings (i.e. thinning in very young stands; also referred to as pre-commercial thinnings). The theoretical potential from early thinnings was estimated by assuming 30% (cf Kofman 2006; Tapio 2007) removal of the stems, branches and needles of 1-10 year old forests. EUwood estimated the potential from early thinning from even-aged forests only; coppice and uneven-aged forests (MCPFE, UNECE and FAO 2007) were excluded.

Altogether, the following theoretical forest biomass potentials were estimated for coniferous and broadleaved forests separately:

- Stemwood from thinnings and final fellings;
- Logging residues from thinnings and final fellings;
- Stumps from thinnings and final fellings;
- Stem and crown biomass from early thinnings.

4.3 Constraints on biomass supply from forests

The theoretical forest biomass potentials estimated by EFISCEN are higher than what can actually be supplied from the forest due to various environmental, social, technical, and economic constraints. A review was made of important constraints (Mantau et al. 2009), based on literature, national biomass harvesting guidelines and recommendations to overcome constraints on wood supply. A long list of constraints was identified, but many of these constraints were correlated with each other, or were impossible to quantify. Through a scoping process, the number of constraints was reduced to the list shown in Table 4-3.

Table 4-3: Constraints on wood supply used in this study.

Constraint	Type	Explanation
Soil and water protection	Environmental	The nutritional impact of biomass extraction from forests is strongly influenced by the rate of extraction and the degree to which foliage and small branches are left on site. If soils are more productive, they can tolerate a higher degree of biomass extraction. Removal of forest biomass inevitably involves vehicle operations and soil disturbances. The extraction of forest residues increases the risk for erosion, especially on steep slopes. Therefore steeper slopes imply less biomass removal. Forests have an important role in the protection of

		watersheds. Intensive logging and residue extraction may result in the degradation of water quality. Using heavy machinery for extracting biomass can lead to soil compaction, particularly in wet soils.
Biodiversity protection	Environmental	To prevent loss of biodiversity a significant percentage of the European forest area is protected for conservation purposes with constraints on harvesting activities. In addition, a large share of the forests is certified and these schemes include restrictions on harvest in favour of biodiversity. An increase in protected area, or more restrictive harvest rules will reduce wood supply potential.
Recovery rate	Technical	Part of the woody biomass from forest is lost before reaching the point of utilisation due to, e.g., dropping off of foliage when drying and breaking of branches during harvesting. Technical recovery rate depends on the used harvesting technology.
Soil bearing capacity	Technical	On soft soils the bearing capacity of soil can reduce the amount of harvestable biomass. For instance, in soft peatlands the logging residues must be left on the forwarding trail to strengthen the bearing capacity of the soil.
Ownership structure	Social	In countries where the ownership structure is very fragmented and the forest holdings small, the owners may be difficult to reach and not necessarily motivated to sell wood as their forests may not be economically significant, and they have other management objectives than wood production, notably recreation, hunting, biodiversity etc. Forest with small holding size and absentee owners will tend to supply less wood.

Note: The constraints are partially overlapping with respect to the constraint type (environmental, social, technical, or economic). For simplicity, they have been assigned to a single type in the table. See Mantau et al. (2009) for details on each constraint.

In addition to these constraints, the availability of skilled labour and machinery and the procurement costs were identified as important constraints, but were not included in the overall assessment due to lack of data. The availability of skilled labour and machinery refers to the effort required to extract biomass from forests and may pose restrictions to the realistic biomass potential. However, it was out of the scope of this study to evaluate their future availability. Instead, an estimate was made of the required labour and machinery to harvest the potentials.

Procurement costs determine the amount of biomass that can be extracted at a given level of investment costs, operating costs of machinery and labour costs. The difference between wood price and procurement costs represents most of the owner’s profit. If it is small or negative, wood supply will drop or not occur at all. To assess the effect of procurement costs, EUwood conducted some case-studies for selected regions in Europe.

4.3.1 Mobilisation scenario storylines

In the mobilisation scenarios, the constraints were quantified based on assumption on their development over time in different futures. It is important to realise that the supply scenarios should be seen as the maximum amount of wood that can be supplied under given supply side conditions as described in the scenarios. Whether the wood will be harvested or not depends on the demand and EFISCEN does not attempt to produce an equilibrium.

The constraints on wood mobilisation applied in this study have been identified in different international processes, in which recommendations have been developed to overcome these constraints (e.g. SFC-WGII, 2008; UNECE/FAO, 2009; MCPFE, EC DG-Agri and UNECE/FAO 2010[9]). The recommendations defined in these processes serve as a starting point for the mobilisation scenarios defined in this study. The scenarios project different degrees of success of how the recommendations will be implemented. The scenarios are defined as follows:

- In the ***high mobilisation scenario*** there is a strong focus on the use of wood for producing energy and for other uses. Recommendations by the abovementioned processes have been successfully translated into measures that lead to an increased mobilisation of wood. This means that new forest owner associations or co-operations are established throughout Europe. Together with existing associations, these new associations lead to improved access of wood to markets. In addition, strong mechanisation is taking place across Europe and existing technologies are effectively shared between countries through improved information exchange. Biomass harvesting guidelines will become less restricting, because technologies are developed that are less harmful for the environment. Furthermore, possible negative environmental effects of intensified use of forest resources are considered less important than the negative effects of alternative sources of energy (i.e. oil, gas) or alternative building materials (e.g. steel and stone). Application of fertilizer is permitted to limit detrimental effects of logging residue and stump extraction on the soil.

- The ***medium mobilisation scenario*** builds on the idea that recommendations are not all fully implemented or do not have the desired effect. New forest owner associations or co-operations are established throughout Europe, but this does not lead to significant changes in the availability of wood from private forest owners. Biomass harvesting guidelines that have been developed in several countries are considered adequate and similar guidelines are implemented in other countries through improved information exchange. Mechanisation of harvesting is taking place, leading to a further shift of motor-manual harvesting to mechanised harvesting. To protect biodiversity forests are being protected, but with medium impacts on the harvests that can take place. Application of fertilizer is permitted to limited extent to limit detrimental effects of logging residue and stump extraction on the soil.

- In the ***low mobilisation scenario***, the recommendations do not have the desired effect, because the use of wood for producing energy and for other uses is subject to strong environmental concerns. Possible negative environmental effects of intensified use of wood are considered very important and lead to strict biomass harvesting guidelines.

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[9] The *Good practice guidance on the sustainable mobilisation of wood in Europe* has been issued in March 2010 and could not be fully included in the definition of the mobilisation scenarios.

Application of fertilizer to limit detrimental effects of logging residue and stump extraction on the soil is not permitted. Forests are set aside to protect biodiversity with strong limitations on harvest possibilities in these areas. Furthermore, forest owners have a negative attitude towards intensifying the use of their forests. Mechanisation of harvesting is taking place, leading to a shift of motor-manual harvesting to mechanised harvesting, but with little effect on the intensity of resource use.

4.3.2 Quantification of environmental and technical constraints

Each of the environmental and technical constraints was quantified separately for the type of biomass (i.e. stemwood, logging residues and stumps) and by type of felling activity (i.e. early thinning, thinnings and final felling).

For stemwood, the constraints were quantified by considering only stemwood coming from the forest area available for wood supply. The forest area available for wood supply refers to the “forests where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood” (MCPFE, UNECE and FAO 2007). Potentials from the forest area not available for wood supply (e.g. strictly protected forests) were excluded from the analysis in all scenarios. Furthermore, EUwood assumed that the FAWS area remained constant in the high and medium scenario, but in the low mobilisation scenarios EUwood assumed that 5% of the area was set aside for strict protection, without any harvest permitted.

For the other types of biomass, the potentials were limited as well to the forest area available for wood supply, because they depend on the extraction of stemwood. However, EUwood assumed that additional constraints were applicable. Several studies have developed recommendations on the extraction of logging residues and stumps. An overview of guidelines, recommendations and research concerning environmental and technical constraints of logging residue and stump extraction is given in Table 4-4.

Based on the guidelines and recommendations listed in Table 4-4, EUwood made general assumptions on the extraction rates of biomass from early thinnings, and logging residues and stumps from thinnings and final fellings. These assumptions are shown in Table 4-5. Based on these assumptions, EUwood quantified all constraints for the three mobilisation scenarios separately. The specific assumptions for each mobilisation scenario are shown in Annex I.

Table 4-4: Recommendations and limitations concerning logging residue and stump extraction as suggested by different studies.

Constraint	Residue removal	Stump removal
Soil productivity	Limited or no removal on poor soils (Äijälä et al. 2010; Forest Research 2009a)	Limited or no removal on poor soils (Äijälä et al. 2010)
Soil and water protection: slope	Only on slopes <35% (Fernholz et al. 2009)	Only on slopes <=20% (Forest Research 2009b) or <35% (Vasaitis et al. 2008, Fernholz et al. 2009)
Soil and water protection: soil surface texture	Not on coarse sandy soils or peatlands (Fernholz et al. 2009, Bradley & Thiffault 2009)	Not on coarse sandy soils or peatlands (Forest Research 2009b, Fernholz et al. 2009, Bradley & Thiffault 2009)
Soil and water protection: soil depth	Not on very shallow soils (<20cm soil depth), limited removal from shallow soils (20-50cm soil depth) (Fernholz et al. 2009, Bradley & Thiffault 2009)	Not on shallow soils of <50cm soil depth (Fernholz et al. 2009, Bradley & Thiffault 2009)
Soil and water protection: Soil compaction risk	No or limited removal on soils with high or very high susceptibility to compaction, because on these sites residues should be used as mats on forwarder routes (Forest Research 2009a)	Not on soil types with a high risk for ground damage (UK Forest Research 2009b)
Biodiversity protection	Not in protected forests (Fernholz et al. 2009, Fehrenbach et al. 2008)	Not in protected forests (Egnell 2007, Fehrenbach et al. 2008)
Recovery rate	Varies from 50 to 80% when using wheeled machines (Nurmi 2007, Peltola et al., 2009)	Minimum diameter for spruce roots 3-5 cm in Finland (Laitila, pers. comm.)
Soil bearing capacity	Not on soils with low bearing capacity (Driessen et al. 2001).	Not on soils with low bearing capacity (Driessen et al. 2001).

Table 4-5: Assumptions on constraints on biomass extraction from logging residue and stump and from early thinnings

Constraint	Assumptions
Site productivity	Biomass removal from forests is always associated with export of nutrients from the ecosystem. This can lead to a decrease in productivity on poor sites. Compensation fertilisation or wood ash recycling is possible mitigation measures. Whether these measures are permitted depends on the mobilisation scenario.
Soil and water protection: slope	We assumed that on a slope <35% residues could be extracted, but not when the slope exceeds 35%. Exceptions were made when cable crane systems are used in that case all or most logging residues are inevitably removed from the forest (see recovery rate).
Soil and water protection: soil surface texture	On peatlands, residues are usually not harvested because of the low accumulation of residues on peatlands (lower growth rate) and buffer zones around ditches. In addition the residues are used for increasing the soil bearing capacity.
Soil and water	Residue should not be extracted on sites with very low soil depth in

protection: soil depth	order to decrease erosion risk. EUwood therefore assumed that no residue or stump extraction would take place on very shallow soil types.
Soil and water protection: Soil compaction risk	We excluded soils with a very high compaction risk from residue removals, and reduced extraction for soils with high/medium compaction risk depending on scenario assumptions.
Biodiversity protection	A significant percentage of the European forest area is protected for conservation purposes by the Natura 2000 network. The legal constraints range from a total ban of management to no limitations for sustainable management (EC 2003). However, it can be assumed that where management is allowed under conservation designations, it is implemented as 'close-to-nature' or similar low-impact management (EEA 2007), with no or very limited residue or stump extraction. However, in fire prone areas, leaving residues in the forest could increase the forest fire risk. EUwood therefore assumed that residues could only be harvested in protected areas that have a high or very high fire risk.
Recovery rate	It was assumed that technically, almost all stem biomass and about two thirds of crown biomass from early thinnings could be extracted. About 70% of logging residues could technically be extracted, except when cable crane systems are applied in mountainous areas. Cable cranes are available in several countries (Karl Stampfer, pers. comm.). For stumps EUwood assumed no technical limitations, as all stump and coarse root biomass can technically be lifted.
Soil bearing capacity	The soils with low bearing capacity were excluded from the analysis. Exceptions are made for Sweden and Finland due to the possibility to harvest when soil is frozen.

To avoid overlap between all environmental and technical constraints, EUwood applied a spatially explicit approach to quantify these environmental and technical constraints. As a basis EUwood used the following spatial datasets:

- site productivity, soil surface texture, soil depth and soil bearing capacity: the 1km Raster version of the European Soil Database (v. 2.0) (European Soil Bureau Network & European Commission 2006)
- soil compaction risk: map of natural soil susceptibility to compaction (Houšková 2008)
- slope: GTOPO30 (1 km resolution; Earth Resources Observation and Science (EROS) Center 1996)
- biodiversity protection: Natura 2000 sites (European Commission, DG Environment 2009)
- biodiversity protection: fire weather index (data provided by Marco Moriondo, pers. comm.)

After collecting these datasets, all spatial datasets were combined with the relevant constraint values as defined in Annex II for the different mobilisation scenarios. In a subsequent step, a raster layer was created for each environmental or technical constraint with a resolution of 1x1 km^2. Finally, on a cell-by-cell basis, all relevant layers were combined and the minimum extraction rate was defined for each cell. This was done separately for the constraints on biomass from early thinnings and for logging residues and stumps from thinnings and final fellings. The resulting raster layers were then combined with the European forest map (Schuck et al. 2002; Päivinen et al. 2001; also on a

1x1 km^2 resolution) to calculate the weighted average restriction per EFISCEN region and country.

4.3.3 Quantification of social constraint

An effort was made to quantify the impact of forest holding size and forest ownership structure on the amount of wood that could be mobilised. The underlying assumption was that the availability of wood is lower from smaller private forest holdings than from the larger forest holdings, mainly because of owners' lower economic interest and higher procurement costs per unit (Straka et al. 1984). The effect of ownership structure on wood mobilisation was estimated by linking size-classes of privately-owned forest holdings with maximum extraction rates per size-class.

Data on size-classes of private forest holdings at the national level was obtained from an enquiry conducted by UNECE/FAO (Schmithüsen & Hirsch 2009), complemented by data from national reports for Denmark (Larsen & Johannsen 2002), Estonia (Metsakaitse- ja Metsauuenduskeskus 2007), Greece (KEPE 1976), Italy (ISTAT 2000), Lithuania (Kuliešis & Kulbokas 2009) and Spain (MARM 2009). For Greece, Italy and Spain the size classes related to all ownership categories (private and non-privately owned forests). For two countries no data were available; for Portugal EUwood used data from France, for Luxembourg EUwood used data from Belgium and Netherlands.

Although the relationship between wood supply and size of forest holdings is considered to be a general challenge in mobilising wood (Schmithüsen & Hirsch 2009; Straka et al. 1984; UNECE/FAO, 2009), there is no empirical data on this relationship for European countries. Hence, a relationship was assumed as shown in Figure 4-1 for the medium mobilisation scenario. For the high mobilisation scenario the assumed availability was raised by 5%-units (with 100% as a maximum) and for the low scenario lowered by 5%-units.

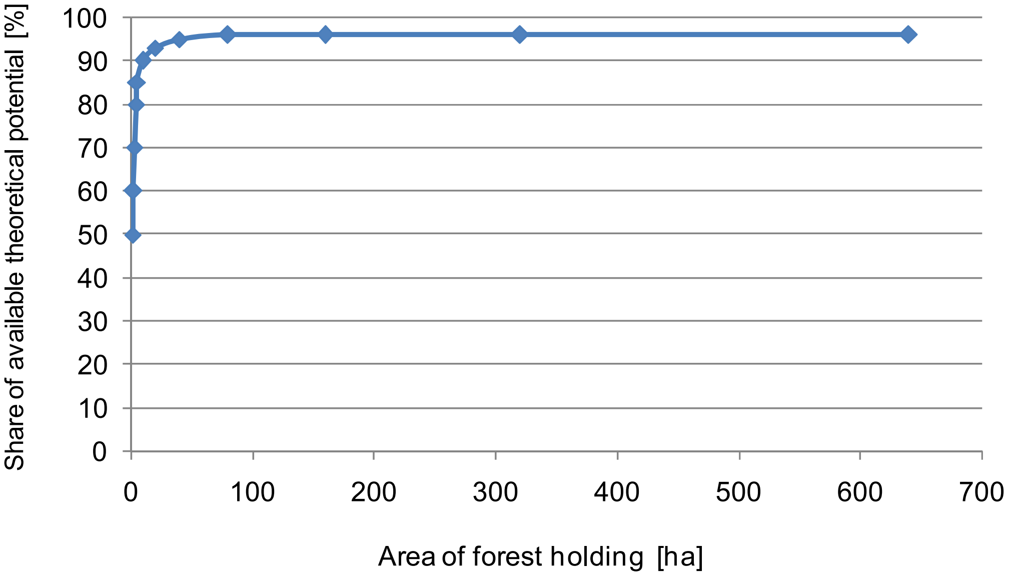

Figure 4-1: Extraction rate influence by private forest holdings' size

Assumed proportion of theoretical forest biomass potential that can be extracted from privately-owned forests based on the size of a forest holding for the medium mobilisation scenario

The percentage of woody biomass not constrained by forest holding size in privately owned forests was calculated by multiplying the area in each size class with the corresponding, assumed availability as shown in Figure 2.

Not all forests are privately owned. In non-privately owned forests, it was assumed that size of the forest holdings did not reduce the biomass potential (i.e. availability was assumed to be 100% regardless of the size of a forest holding). The availability from all ownership types was calculated using the proportions of private and public forests as weights (Schmithüsen & Hirsch, 2009; MCPFE 2007). The proportions for a country were calculated for FAWS. There was lack of data on ownership on FAWS in Lithuania, Netherlands and Denmark where the proportions were calculated of all forests and in Slovenia, Estonia, Italy, Luxembourg, Portugal and Spain where the proportions were calculated of forest and other wooded land. No data on ownership was available for Cyprus and Malta. Instead EUwood used the average availability from Greece.

4.4 Mobilisation scenario analysis

The theoretical forest biomass potential at the regional level, as estimated by EFISCEN, was combined with the average reduction factor for each region for environmental and technical constraints and for the constraint related to forest holding size. This step resulted realisable biomass potential from European forests at the regional level. In a next step, these regional estimates were aggregated to the national level.

The realisable biomass potential from all tree components for each mobilisation scenario was provided to the Wood Resource Balance. Within the Wood Resource Balance, bark was separated from the stemwood potential. Furthermore, the forest biomass potentials were further aggregated, as described in chapter 4.4.

The needed skilled labour and machinery, as well as the procurement costs of logging residues from final fellings was calculated based by combining the potentials from each scenario with the average machine capacity, costs etc. These results were not used in the Wood Resource Balance.

4.5 Sensitivity analysis

The realistic biomass potential from European forests was based on various assumptions made within the EFISCEN modelling framework, as well as in the quantification and definition of constraints. Sensitivity analyses were therefore performed to assess how sensitive the estimated potentials were to the EUwood specific assumptions. The sensitivity analyses also provide insight in which factors limit the supply of wood in Europe most strongly. In all sensitivity scenarios the medium mobilisation scenario was used as a reference. The results of these sensitivity analyses were not used in the Wood Resource Balance.

Firstly, sensitivity analyses were therefore performed in which the impacts of assumptions on growth changes due to environmental/climate change, and forest area changes were analysed. The background of these scenarios is given by Mantau et al. (2009). The following sensitivity scenarios were performed within EFISCEN and could affect the potentials from all biomass compartments:

- Continued forest area change: the forest area increased between 1990 and 2005 at the European level as a result of afforestation and natural forest area expansion (MCPFE, UNECE and FAO 2007). It was assumed that the average annual change in forest between 1990 and 2005 would be continued.
- Increased forest growth rates: as a result of climate change, forest growth was assumed to increase with 4% per decade compared to no climate change effects on growth in all countries;
- Decreased forest growth rates: as a result of climate change, forest growth was assumed to decrease with 4% per decade compared to no climate change effects on growth in all countries.

Secondly, sensitivity analyses were therefore performed in which the impact of assumptions on constraints were analysed. In the low and high mobilisation scenarios, all constraints were changed at the same time compared to the medium mobilisation scenario. However, to determine the effect of each constraint separately, each constraint value was changed individually to the high and low scenario in the sensitivity analyses. These sensitivity analyses were limited to the constraints on extracting logging residues and stumps only.

4.6 Additional calculations

The availability of skilled labour and machinery and the procurement costs were not included in the overall assessment of the impacts of various constraints on potential wood supply. Instead, required labour and machinery to harvest the potentials was calculated as well as the procurement costs of logging residues from final fellings for selected regions in Europe.

Required skilled labour and machinery

The required labour and machinery was estimated by combining the biomass potentials from the mobilisation scenarios with machine capacity and the labour need per machine.

Based on experiences in Finnish conditions, average capacities (m^3 / a) for the machinery were determined (Table 4-6). The calculations assume mechanised harvesting with no limitations for, e.g. mountainous or hardwood-dominated areas. The considered machinery is listed in Table x. The number of machines needed to harvest a potential of a certain biomass type was the potential divided by the capacity of the respective machine. For trucks higher capacities were assumed in Finland and Sweden than in other countries due to higher allowable truck weight.

The labour need for each machine type was estimated by multiplying the number of machines by the labour need per machine. The average labour need per machine was again based on Finnish practice and the minimum and maximum represented the range at the EU level. The minimum labour need for a machine is naturally one person, whereas two working shifts were assumed to be the maximum.

Table 4-6: Minimum, average and maximum capacities for the machines and the respective labour needs per machine

Machine type	Annual capacity, M. m^3			Labour need per machine		
	min	avg	max	min	avg	max
Harvester	0.025	0.035	0.045	1	1.5	2
Forwarder	0.02	0.03	0.04	1	1.5	2
Feller-buncher	0.007	0.01	0.013	1	1.5	2
Excavator	0.01	0.014	0.02	1	1.3	2
Chipper/crusher	0.02	0.03	0.05	1	1.5	2
Timber truck, FI/SWE	0.03	0.04	0.05	1	2	2
Timber truck, others	0.023	0.33	0.043	1	1.5	2
Chip truck, FI/SWE	0.025	0.032	0.04	1	2	2
Chip truck, others	0.02	0.027	0.035	1	1.5	2

Table 4-7: The machinery considered for each biomass type

Machine type	Residues	Whole trees	Stumps	Stemwood
Harvester				x
Forwarder	x	x	x	x
Feller-buncher		x		
Excavator			x	
Chipper/crusher	x	x	x	
Timber truck				x
Chip truck,	x	x	x	

It should be noted that the required labour and machinery was based on average Finnish conditions with a high level of mechanisation. However, the level of mechanisation differs strongly between European countries (Asikainen et al. 2008). The calculations are indicative only and are based on the main idea that increasing amounts of forest biomass cannot be harvested manually, but more productive mechanised systems are needed.

Procurement costs

Almost all the environmental and technical constraints can also be considered as economic constraints, as the environmental and technical constraints assume certain, existing or likely, forest management and harvesting technology. With more expensive solutions more wood could be mobilised. E.g. with cable cranes wood can be harvested even on steep slopes, although the harvesting cost is higher than with wheeled machines. The primary economic constraint for wood supply is, however, profitability, i.e. the ratio between prices (determined by the market, including the price of wood imported from far away) and costs, of which “procurement costs” also known as harvesting and transport costs, are the major element. In fact, with the forest owner's profit which has to compensate him for the effort over the whole cycle, they are the main, significant part of costs.

To reliably estimate procurement costs, spatially explicit data on supply (forests), demand (points of utilisation) and infrastructure (transportation networks) would be needed regionally over the whole EU. This task is far beyond what could be done within this study. As an example of the effect of procurement costs on the potentials, region-level cost-supply curves were estimated for logging residues from final fellings in regions where enough background data was available.

The methodology for estimating the cost-supply curves is based on the work by Asikainen et al. (2008). Region-level curves were calculated for countries representing different conditions, namely Finland, Germany, Poland and Spain. If a country was divided to regions in EFISCEN, the regions with lowest, highest and average region-level potential (after applying environmental, technical and social constraints) per region area were selected. The curves were estimated for logging residues from final fellings assuming chipping of residues at the roadside and further transportation of chips by truck.

The estimation was started by calculating hourly costs of machines (Harstela 1993). The costs were calculated for a forwarder, a chipper and a truck. The hourly rates account for

- labour costs (wages including side costs and contractor's profit margins)
- operating costs (fuel and lubricant costs, maintenance and repair costs, and insurance and administrative costs) and
- capital costs (depreciation of machines and interest on capital).

Labour costs were taken from Eurostat (2010a, 2010b) and updated to 2010. For chipper operator, the average hourly costs of industry (sections C-F in NACE Rev. 1.1) and for forwarder or truck driver, the average hourly costs of transport, storage and communication (section I) were used. Fuel costs were obtained from Finnish Oil and Gas Federation (2010). Other data was assumed to be invariable between the countries (Table 4-8).

Table 4-8: Basic data for machine cost calculations

	Forwarder	Chipper	Truck / trailer
Purchase price, €	242,000	400,000	240,000
Operating hours	2,026	2,700	3,000
Service time, years	8	6	5.1 / 7.7
Depreciation rate, %	22	20	-*
Interest rate, %	6	6	5

Note: * reselling value of 40% assumed

Next the hourly costs along with variables describing typical harvesting conditions in a region were input to a cost calculator (Laitila 2006). Table 4-9 shows the variables that EUwood assumed to be the same between the regions.

Table 4-9: Fixed variables in cost calculations

Variable	Value	Unit
Hauling distance	300	m
Recovery rate	67	%
Distance between skidding trails	15	m
Interest of capital	6	%
Piling compensation	0.3	€/m³
Overhead costs (2009)	3.51	€/m³
Load capacity of forwarder	7.8	m³
Gross effective/ effective time ratio (forwarder)	1.2	
Transferring costs	0	€/turn
Productivity of operational hour (chipper)	70	bulk-m³
Unloading time (truck)	0.50	h
Auxiliary time (truck)	0.30	h

The density of logging residues within a region (m^3 / km), removal of logging residues on a typical final felling stand (m^3 /ha) and truck load space (lbulk-m^3) and overhead costs were allowed to change between regions. The overhead costs in 2010 were estimated based on the overhead costs in harvesting and transport of wood in 2008 in Finland and the country-level hourly labour costs for transport, storage and communication (Kariniemi, 2009, Eurostat 2010a). Other conditions (e.g. slope) affecting the costs of supply could not be taken into account because of lack of data. Furthermore, Nordic style mechanised harvesting was assumed for all the regions although the actual technology at the moment might be different. However, the conditions and harvesting techniques differ strongly between European countries (Asikainen et al. 2008). The calculations are therefore indicative only. Finally cost-supply curves were determined by calculating procurement costs over a range of transportation distances.

Above-mentioned general cost-supply curves do not take the size-distribution of plants into account. Implicitly the curves assume that there would be one large plant in the middle of a region consuming all the forest chips. Consequently, the transport distances are long rising the procurement costs. In reality there are several plants consuming different amounts of forest chips and, thus, having different transport distances and procurement costs. Therefore, the effect of users of different sizes was estimated with the following, rough approach:

1. Plants were divided to three categories according to present use of forest chips
2. For each category, the share of total use in the region was calculated
3. The potential from Medium mobilisation scenario was distributed to the categories assuming the present shares of the categories
4. Maximum transport distance for each category was determined
5. Marginal procurement cost for each category was taken from the general cost-supply curve

6. By combining procurement costs with the supplied amounts, the curve was drawn again.

Taking plant size distribution into account is a step toward more realistic cost-supply curve. The inclusion of plants of various sizes lowers procurement costs. However, no competition between plants was assumed. In practice the supply regions of the plants overlap increasing procurement costs.

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Annex I

Table I.1: Maximum extraction rates for extracting stem biomass during early thinnings

Type of constraint	Current (2010) and medium mobilisation	High mobilisation	Low mobilisation
Site productivity	Not a constraining factor	Not a constraining factor	Not a constraining factor
Soil and water protection: Slope	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0% on slopes over 35%; not a constraining factor on slopes up to 35%
Soil and water protection: Soil depth	Not a constraining factor	Not a constraining factor	Not a constraining factor
Soil and water protection: Soil surface texture	Not a constraining factor	Not a constraining factor	Not a constraining factor
Soil and water protection: Soil compaction risk	Not a constraining factor	Not a constraining factor	Not a constraining factor
Biodiversity: protected forest areas	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk
Recovery rate	95%	95%	95%
Soil bearing capacity	Not a constraining factor	Not a constraining factor	Not a constraining factor

Table I.2: Maximum extraction rates for extracting crown biomass during early thinnings

Type of constraint	Current (2010) and medium mobilisation	High mobilisation	Low mobilisation
Site productivity	0% on poor soils; 70% on other soils	Not a constraining factor	0% on poor soils; 20% on other soils
Soil and water protection: Slope	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0% on slopes over 35%; not a constraining factor on slopes up to 35%
Soil and water protection: Soil depth	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0% on Rendzina, Lithosol and Ranker (very low soil depth)
Soil and water protection: Soil surface texture	35% on peatlands	40% on peatlands	0% on peatlands
Soil and water protection: Soil compaction risk	0% on soils with very high compaction risk; 25% on soils with high compaction risk	0% on soils with very high compaction risk; 50% on soils with high compaction risk	0% on soils with very high and high compaction risk
Biodiversity: protected forest areas	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk
Recovery rate	80%	80%	80%
Soil bearing capacity	0% on Histosols, Fluvisols, Gleysols and Andosols; not a constraining factor in Finland and Sweden	0% on Histosols, Fluvisols, Gleysols and Andosols; not a constraining factor in Finland and Sweden	0% on Histosols, Fluvisols, Gleysols and Andosols

Table I.3: Maximum extraction rates for extracting logging residues from final fellings

Type of constraint	**Current (2010) and medium mobilisation**	**High mobilisation**	**Low mobilisation**
Site productivity	Not a constraining factor	Not a constraining factor	35% extraction rate on poor soils; not a constraining factor on other soils
Soil and water protection: Slope	Not a constraining factor on slopes up to 35%; 0% on slopes over 35%, unless cable-crane systems are used	Not a constraining factor on slopes up to 35%; 0% on slopes over 35%, unless cable-crane systems are used	Not a constraining factor on slopes up to 35%; 0% on slopes over 35%, unless cable-crane systems are used
Soil and water protection: Soil depth	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0% on Rendzina, Lithosol and Ranker (very low soil depth)
Soil and water protection: Soil surface texture	0% on peatlands	33% on peatlands	0% on peatlands
Soil and water protection: Soil compaction risk	0% on soils with very high compaction risk; 25% on soils with high compaction risk	0% on soils with very high compaction risk; 50% on soils with high compaction risk	0% on soils with high or very high compaction risk; 50% on soils with medium compaction risk
Biodiversity: protected forest areas	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk
Recovery rate	67% on slopes up to 35%; 0% on slopes over 35%, but 67% if cable-crane systems are used Cable cranes are applied in Austria, Italy, France, Germany, Czech Republic, Slovakia, Slovenia, Romania[10]	67% on slopes up to 35%; 0% on slopes over 35%, but 67% if cable-crane systems are used Cable cranes are applied in Austria, Italy, France, Germany, Czech Republic, Slovakia, Slovenia, Romania, Bulgaria	67% on slopes up to 35%; 0% on slopes over 35%, but 67% if cable-crane systems are used Cable cranes are applied in Austria, Italy, France, Germany, Czech Republic, Slovakia, Slovenia, Romania
Soil bearing capacity	0% on Histosols, Fluvisols, Gleysols and Andosols	0% on Histosols, Fluvisols, Gleysols and Andosols; not a constraining factor in Finland and Sweden	0% on Histosols, Fluvisols, Gleysols and Andosols

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[10] Based on personal communication with Karl Stampfer

Table I.4: Maximum extraction rates for extracting logging residues from thinnings

Type of constraint	Current (2010) and medium mobilisation	High mobilisation	Low mobilisation
Site productivity	0% on poor soils; 33% on other soils	67%	0%
Soil and water protection: Slope	Not a constraining factor on slopes up to 35%; 0% on slopes over 35%, unless cable-crane systems are used	Not a constraining factor on slopes up to 35%; 0% on slopes over 35%, unless cable-crane systems are used	0%
Soil and water protection: Soil depth	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0% on Rendzina, Lithosol and Ranker (very low soil depth)	0%
Soil and water protection: Soil surface texture	0% on peatlands	33% on peatlands	0%
Soil and water protection: Soil compaction risk	0% on soils with high compaction risk; 25% on soils with high compaction risk	0% on soils with very high compaction risk; 50% on soils with high compaction risk	0%
Biodiversity: protected forest areas	0%; not a constraining factor in areas with high or very high fire risk	0%; not a constraining factor in areas with high or very high fire risk	0%
Recovery rate	67% on slopes up to 35%; 0% on slopes over 35%, but 47% if cable-crane systems are used Cable cranes are applied in Austria, Italy, France, Germany, Czech Republic, Slovakia, Slovenia, Romania[11]	67% on slopes up to 35%; 0% on slopes over 35%, but 47% if cable-crane systems are used Cable cranes are applied in Austria, Italy, France, Germany, Czech Republic, Slovakia, Slovenia, Romania, Bulgaria	0%
Soil bearing capacity	0% on Histosols, Fluvisols, Gleysols and Andosols	0% on Histosols, Fluvisols, Gleysols and Andosols ,not a constraint in Fennoscandia	0%

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[11] Based on personal communication with Karl Stampfer

Table I.5: Maximum extraction rates for extracting stumps from final fellings

Type of constraint	Current (2010) and medium mobilisation	High mobilisation	Low mobilisation
Countries	Finland, Sweden, UK	All	0%
Species	Conifers	All	0%
Site productivity	15% on poor soils; 33% on other soils	33% on poor soils; 67% on other soils	0%
Soil and water protection: Slope	0% on slopes over 20%; not a constraining factor on slopes up to 20%	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0%
Soil and water protection: Soil surface texture	0% on peatlands	33% on peatlands	0%
Soil and water protection: Soil depth	0% on soils < 40 cm (including Rendzina, Lithosol and Ranker); 33% on soils >40 cm	0% on soils < 40 cm (including Rendzina, Lithosol and Ranker); 67% on soils >40 cm	0%
Soil and water protection: Soil compaction risk	0% on soils with very high compaction risk; 15% on soils with high compaction risk	0% on soils with very high compaction risk; 33% on soils with high compaction risk	0%
Biodiversity: protected forest areas	0%	0%	0%
Recovery rate	Not a constraining factor	Not a constraining factor	0%
Soil bearing capacity	0% on Histosols, Fluvisols, Gleysols and Andosols	0% on Histosols, Fluvisols, Gleysols and Andosols; not a constraint in Finland and Sweden	0%

Table I.6: Maximum extraction rates for extracting stumps from thinnings.

Type of constraint	Current (2010) and medium mobilisation	High mobilisation	Low mobilisation
Countries	0%	All	0%
Species	0%	All	0%
Site productivity	0%	33% on poor soils; 67% on other soils	0%
Soil and water protection: Slope	0%	0% on slopes over 35%; not a constraining factor on slopes up to 35%	0%
Soil and water protection: Soil surface texture	0%	33% on peatlands	0%
Soil and water protection: Soil depth	0%	0% on soils < 40 cm (including Rendzina, Lithosol and Ranker); 67% on soils >40 cm	0%
Soil and water protection: Soil compaction risk	0%	0% on soils with very high compaction risk; 33% on soils with high compaction risk	0%
Biodiversity: protected forest areas	0%	0%	0%
Recovery rate	0%	Not a constraining factor	0%
Soil bearing capacity	0%	0% on Histosols, Fluvisols, Gleysols and Andosols; not a constraint in Finland and Sweden	0%

Chapter 5
Biomass from other sources

Authors:

Chapter 5.1 Jan Oldenburger [1]

Chapter 5.2 and 5.3 Nico Leek [1]

Chapter 5.4 Ulrike Saal [2]

[1]*Probos, Wageningen, Netherlands*

[2]*University of Hamburg, Germany*

Content

5 Biomass from other sources

5.1 Landscape care wood

5.1.1 Defining wood from trees outside the forests (Landscape care wood)

Harvesting wood from outside the forest most often takes place as a result of management activities that are performed in order to keep the plantings in the desired state and not in order to produce wood. Consequently the biomass is most often considered and/or treated as waste and not as a product. The material is in many European countries referred to as landscape care wood. For this reason primary woody biomass from trees outside forests will in this study be called “landscape care wood”. All fresh wood (e.g. roundwood, chips and branches) that is harvested from other sources than forests is included. It doesn’t refer to post-consumer wood or wood processing residues.

Within the context of international reporting on forests and other sources of roundwood and woody biomass two categories are defined that both can be considered as sources of landscape care wood. These categories are “other wooded land” (OWL)[12] and “trees outside the forest” (ToF)[13] and are defined by FAO. Table 5-1 gives an overview of the different segments that are included in the two FAO categories other wooded land and trees outside the forest.

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[12] Other wooded land definition by FAO: “land not classified as forest, spanning more than 0.5 hectares; with trees higher than 5 metres and a canopy cover of 5–10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.”

[13] Trees outside the forest definition of FAO: “Trees on land other than forest or other wooded land.” It refers to: (a) groups of trees covering an area of less than 0.5 ha, including lines and shelterbelts along infrastructure features and agricultural fields; (b) scattered trees in agricultural landscapes; (c) tree plantations mainly for other purposes than wood, such as fruit orchards and palm plantations; and (d) trees in parks and gardens and around buildings.

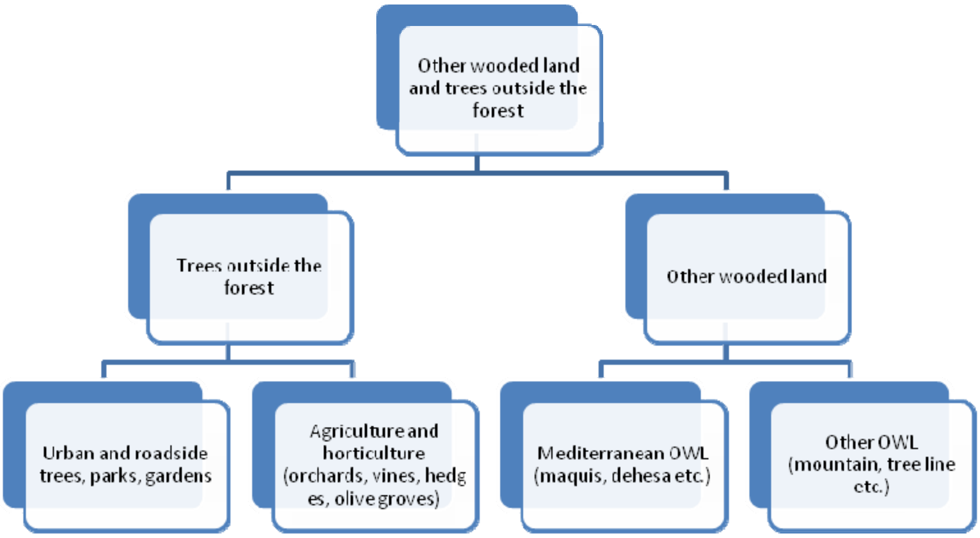

Figure 5-1: Segments defining landscape care wood

Source: Prins, 2010

To define the sources of Landscape Care Wood (LCW) the definition from the German renewable Energy Act is used. The definition in the German renewable Energy Act for “landscape care wood” is as follows:

Landscape care wood comprehends plants or plant components, which accumulate within landscape care activities. It refers to woody residues from landscape care such as:

- Maintenance operations, tree-cut activities in agriculture and horticulture industry
- Other landscape care or horticultural activity in parks, cemeteries
- Maintenance along roadsides and boundary ridges, rail- and waterways, orchards and
- Gardens

Wood-based solid fuels from agriculture such as from short rotation plantations are not considered.

If the definition for landscape care wood and its sources is compared to the segments in the FAO categories trees outside the forest and other wooded land (see Table 5-1) it can be concluded that this definition of landscape care wood does not contain the area in the category other wooded land. For this reason this very important category is treated separately. The other wooded land within a country can be substantial. For instance the Mediterranean maquis/shrub in Greece, France and Spain can cover large areas. Just as the dehesas in Spain, the mountain tree belts and scattered trees in the boreal region.

5.1.2 Calculating the Landscape care wood potential

5.1.2.1 Segment approach

In this study different approaches were analysed before achieving the most applicable methodology to calculate the landscape care wood potential. The first most promising approach to calculate the theoretical potential of landscape care wood was based on calculating the potential for each segment of landscape care wood. These potentials per segment could in the end be added up to result in the total theoretical potential of landscape care wood in the EU 27 in 2007 (sources approach).

These segments are

- wood from urban areas (e.g. wood from gardens, parks, roadside trees etc.)
- wood from horticulture (e.g. prunings and roundwood from vineyards, orchards and olive trees) and
- wood from trees outside the forest (ToF) (e.g. solitary or patches of trees, linear features such as hedgerows and roadside trees in the countryside).

For this reason the attempt was made to calculate the amount of wood that can be potentially harvested from each segment by using data from Eurostat and country specific data. This approach was successful for estimating the potential for wood from horticulture (orchards, vineyards and olive tree plantations) and the potential for wood from urban areas. However, it appeared not to be possible to determine the potential of woody biomass from patches of trees, individual trees, windbreaks etc. in the landscape. This is caused by the fact that in most of the EU 27 countries the land cover and extent of this source of landscape care wood is not known. Moreover, statistics concerning the current harvest of wood and management of these stands or plantings are not available. For this reason another approach was used to calculate the landscape care wood potential.

The calculated potentials for wood from horticulture and wood from urban areas were used during the final approach and for this reason the method used to calculate these potentials is presented in the paragraphs below.

5.1.2.1.1 Wood from horticulture

One of the sources of landscape care wood is wood from agricultural systems such as orchards and tree nurseries. These systems are not established for wood production, but wood becomes available during regular management and reestablishment of orchards and tree nurseries. Main sources are plantations of fruit trees, olive trees and vineyards.

Data on the area of these cultivations are derived from Eurostat agriculture statistics. Data for increment and annual amount of woody residues in these cultivations are obtained by looking at country studies and by acquiring country specific data through an enquiry performed during the EUwood project. This enquiry was send to all national correspondents for the UNECE/FAO/EU/ITTO Joint forest sector questionnaire (JFSQ) and the UNECE/FAO/IEA Joint Wood Energy Enquiry (JWEE). Based on the available results from both the country studies and the enquiry, default values were established for those EU 27 countries for which no data were available. With these default values the increment within the EU 27 is calculated (see Annex 1**)**.

It is assumed that 75% of the increment is harvested each year in order to be able to calculate the total harvest per country and the EU 27. This total harvest is not used to calculate the total potential of landscape care wood in the EU 27, but some country results are used to calculate the total landscape care wood potential within those countries.

5.1.2.2 Wood from urban areas

Several studies have been performed (e.g. in the Netherlands, Flanders and Germany) to determine the amount of prunings (incl. small logs and sometimes stumps) from urban areas. Most of these studies aimed to determine the biomass potential in a certain country area (e.g. local community or province). Table 5-1 gives an overview of the average amount of prunings per inhabitant that has been calculated per country, for which data were available. The prunings from households and municipalities are separated. Prunings from households are most often delivered to the municipality's waste stations or are collected a number of times per year by the municipality itself. Prunings from the management of parks and trees along roads in municipalities (arboricultural arisings) are in some cases brought to the same waste stations or other communal yards if the management activities are performed by the municipality itself. If a contractor is performing the management the contractor is most often responsible for the removal of the prunings and they are than brought to waste companies. Especially the stem wood from households is most often used as fuelwood by the households themselves or is provided to other private users. This internal use by households is not included in the presented default values and total volumes.

Table 5-1: Woody biomass from prunings in gardens and parks

	Amount in kg per inhabitant per year	
Country or country area	Households	Arboricultural arisings
Netherlands average	23	23
Flanders average (2004-2007) (BE)	23	n.a.
Flanders (2015) (BE)	23	n.a.
Bayern (DE)	n.a.	22
Community Vilsbiburg (DE)	n.a.	20
Total average	23	22

Source: Feil and Frederiks, 2006; Voskuilen et. al., 2008; Weterings et.al. 1999; Dobers and Opitz, 2007 and OVAM, 2008

Note: [$\text{kg}_{\text{fresh weight}}$/ inhabitant]

Based on the results from the different studies consulted the average amount of woody biomass that becomes available from households and from municipalities are 23 kg and 22 kg per inhabitants per year respectively. This results in a total amount of 45 kg woody biomass per inhabitant per year, which becomes available from urban areas. This value is used as a default value for countries of which no data are available. Based on these default values the potentials of woody biomass from urban areas in all EU 27 countries have been calculated (see Annex 2). Spatial differences within countries caused by differences in population densities are included in the calculated averages.

It is realised that the Netherlands, Belgium and Germany have very good waste collecting systems and waste infrastructures in place. Garden waste is collected separately from other waste and can also be brought to waste stations in which there is an area situated where only garden waste may be disposed. In other EU 27 countries this waste infrastructure is probably less developed and consequently the accessibility of the woody biomass from urban areas will be lower. This should be considered while using these country data in future studies. For the EUwood project it does not have consequences, since data for only two countries were applied.

5.1.2.3 Woody biomass potential studies

Instead of calculating the potential for each segment in a country separately (segment approach) it was decided to calculate the potential for landscape care wood as a whole. To make this possible data from (woody) biomass potential studies including landscape care wood were used. These studies were available for Slovenia, France, Germany (Bavaria and Schleswig-Holstein), Netherlands and the United Kingdom. It is realised that the definitions for landscape care wood and the assumptions used in these country studies differ from each other. The effect of these difference are unknown, but these studies give at least a better estimate for the landscape care wood potential in these specific countries than could be given by using general data. The studies cover the biomass that is actually removed from the plantings after management operations, the amount that is left behind in the plantings and to a lesser extend the amount that could become available if management would be performed in plantings that are currently not or under managed.

As already mentioned in chapter 5.1.1 the definition of landscape care wood that is used in this study is derived from the German definition. The definitions used in the other countries differ from the German, because they do not include one or two of the different components. The missing components were wood from households and/or wood from orchards (horticulture). However, it was possible to adjust the values by adding the calculated potential for one or both segments by using the values that were calculated during the segment approach (see annex 1 and 2).

The total potential amount of landscape care wood for each of these five countries is used to obtain a coefficient of landscape care wood per hectare of non-forested land area (excl. inland water bodies). This coefficient is used to extrapolate values for EU 27 countries that were not covered by a biomass potential study yet. The results of this calculation can be found from Table 5-2. The average of the calculated landscape care wood potential (0.32 m^3/ha of non-forested land) per hectare could be used to calculate the landscape care wood potential in the other 22 countries of the EU 27. However by using the average, differences in country characteristics are not accounted for.

Table 5-2: Country specific data from biomass potential studies

Country	Non-forest land area in 2005 [1,000 ha]	Potential of LCW [m³]	Potential/ area of non-forest land [m³/ha]
France	23.789	18,370,441	0.38
Germany	9.138	7,267,402	0.31
Netherlands	3.011	971.177	0.32
Slovenia	750	256.214	0.34
United Kingdom	21.243	5,295,271	0.25
Average			**0.32**

Source: EUwood calculations based on: AGRESTE, 2005, CIBE, 2007, Bauer et al., 2006, Drigo and Vaselič, 2006, McKay et al., 2003, de Vries et al., 2008, Dobers, 2007, MCPFE, 2007

To account for differences in country characteristics a possible relationship between a certain country characteristic and the amount of landscape care wood was searched for. This resulted in the assumption that if there is a larger share of non-forested land area compared to the share of the forest area available for wood supply (FAWS) in a country the landscape care wood fellings will also have a larger share compared to the FAWS fellings. Equation 5-3 illustrates this relationship.

Equation 5-1: Relationship between the non-forest land area / FAWS area and fellings on FAWS / landscape care wood fellings

$$\frac{Nonforestlandarea}{FAWS_{area}} = \frac{LCW_{fellings}}{FAWS_{fellings}}$$

Table 5-3: Coefficients of wood available from forests and outside forests

Country	Relation non-forest land area and FAWS area [%]	Share of LCW fellings in FAWS fellings [%]
France	324	32
Germany	217	12
Netherlands	1021	63
Slovenia	65	8
United Kingdom	894	53

Source: EUwood calculation

The application of the assumption resulted in a linear relationship for the 5 countries. Figure 5-2 shows the resulting graph; data can be found in Table 5-3. Based on the linear relationship it is possible to estimate the landscape care wood potential in the other EU 27 countries by calculating the share of landscape care wood fellings in the FAWS fellings. Furthermore it allows calculating the landscape care wood potential per ha of non-forest land area. This resulted in a wide range of the landscape care wood potential per ha, from 0.01 to 0.62 m³/ha, in the EU 27 (see Annex 3 column 7).

The country characteristics of the 5 countries used to establish the relationship are not comparable (The Netherlands and United Kingdom have very low forest covers compared to Germany and Slovenia), but still the variance in the landscape care wood potential per hectare of non-forest land area in the 5 countries is rather small (between 0.25 and 0.38 m³/ha, Table 5-2). For this reason the large variance for the other 22 countries does not make sense.

To reduce the variance within the calculated values for the other 22 EU 27 countries it is decided to limit the range of possible landscape care wood potentials per ha of non-forested land. The lowest value for the amount of landscape care wood per ha of non-forested land (0.25 m³/ha) is used as a lower boundary and the highest value (0.38 m³/ha) is used as a maximum boundary (see Annex 3 column 8). The landscape care wood potential in the EU 27 is calculated by using these adjusted country values.

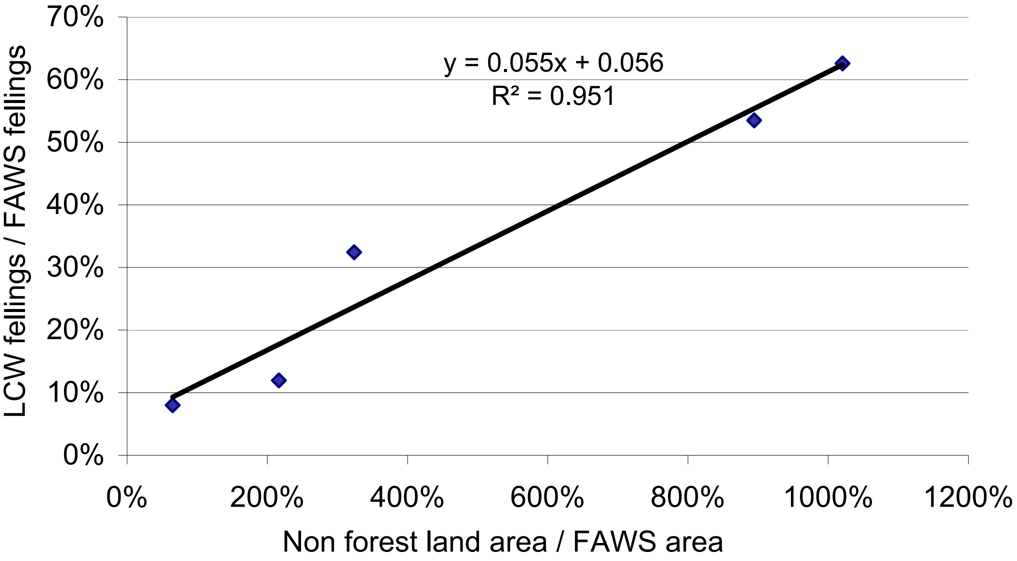

Figure 5-2: Coefficient of landscape care wood removals

Note: Forests available for wood supply (FAWS) area as share of the non-forest land area in relation to the landscape care wood fellings' share of the FAWS fellings

5.1.3 Other wooded land

As mentioned in chapter 5.1.1, other wooded land is not included in the definition used for landscape care wood. For this reason the potential of other woody biomass from these sources within the EU 27 has to be determined separately. Recent information concerning the area of other wooded land in the EU 27 is derived from the State of Europe's Forest 2007 (MCPFE, 2007). Data on increment, fellings and removals on the other wooded land area are derived from the TBFRA 2000 database (FAO, 2000). These are from the 1990's, but no more recent data are available.

In order to obtain a better understanding of what is included in the reported other wooded land area, the background data from the TBFRA2000 were studied. Country comments in particular offered valuable information about the characteristics of the other wooded land area in most of the countries that were covered by the TBFRA 2000. The conclusion is that most of the reported other wooded land area consists of areas with low or no economic driven activities and with low production such as areas stocked with mountain pine (*Pinus* *mugo*), sub or high alpine forest, trees on swamps and peat land, bush lands, Mediterranean maquis/ dehesa, riparian formations etc. On the other hand the reported area by other counties is already included in the above described analysis for landscape care wood.

Based on the analyses of the country comments it is decided to only include the reported fellings on the other wooded land areas of countries that have reported a substantial area of other wooded land in 2005. These countries are: Greece (2.8 M. ha), France (1.7 M ha), Spain (10.3 M ha), Italy (1.0 M ha), Finland (1.2 M ha) and Sweden (3.1 M ha).

The reason for selecting countries with a substantial other wooded land area only is based on the fact that removals from these areas might be substantial although the site productivity and the management intensity might be low. Next to this these removals are not included in the calculated landscape care wood potential. The country comments support the assumption that for the other EU 27 countries the removals on other wooded land are negligible or already covered by the calculated landscape care wood potential. Information on the 6 countries with a substantial other wooded land area can be found from Annex 4.

5.1.4 Estimating the current use of landscape care wood and wood from other wooded land

Estimating the current use of the calculated landscape care wood potential appeared to be rather difficult. Statistics on the actual use of the landscape care wood that becomes available within the EU 27 or individual countries are not widely available. This is probably caused by the fact that landscape care wood in most countries is treated as waste or is not marketed; large volumes are internally used as fuelwood by private households. Of course the volumes of waste can be derived from Eurostat, but it is difficult to derive the share of landscape care wood within the total waste volumes.

In the end a study of the Comité Interprofessionnel du Bois Energie (CIBE) (2007) from France is used to get an estimation of the use of the potential in 2007. In France 45% of the potential is used as fuelwood, 20% is treated as waste and goes to composting and 35% is not used and left behind or is burned at the felling location. A drawback of these figures is that they refer to the volume of landscape care wood that actually becomes available during management activities. It does not refer to the potential that could become available if not or under managed plantings (standing potential) will be fully managed in the future. The current use is for this reason an overestimation, but it is not possible to come to a better estimate, because the share of this standing potential within the total landscape care wood potential is not known.

The share of the landscape care wood potential within each category of use in the year 2030 is estimated by assuming a gradual increase in the use and as a consequence a decrease in the volume that is composted or unused. Three different scenarios (low, medium and high) are used to account for different levels of demand. Table 5-4 gives an overview of the different percentages used.

Table 5-4: Landscape care wood potentials (2010 and 2030)

Treatment	Share of treatment			
	2010*	2030		
		Low	medium	High
Energy and material use used	45	60	70	80
Composting	20	15	15	10
Unused	35	25	15	10

*Source: CIBE, 2007

Note: Distribution of the landscape care wood potential over the different categories for the year 2010 and the tree scenarios low medium and high

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Annex 1

Table 1-1: Woody biomass potential from horticulture in the EU 27

Country	Area (in 1,000 ha)			Annual level of increment in m^3 per ha			Total annual increment in 1,000 m^3				Total annual harvest in 1,000 m^3 (75% of increment harvested)			
	Orchards	Vineyards	Olive trees	Orchards	Vine-yards	Olive trees	Orchards	Vine-yards	Olive trees	Total	Orchards	Vineyards	Olive trees	Total
Austria	7.8	44.2	0.0	2.2	1.5	0.0	17	66	0	83	13	50	0	63
Belgium	16.6	0.0	0.0	3.0	0.0	0.0	50	0	0	50	37	0	0	37
Bulgaria	63.2	120.3	0.0	2.2	1.5	0.0	139	180	0	319	104	135	0	240
Cyprus	14.3	8.2	11.6	1.5	1.0	2.5	21	8	29	59	16	6	22	44
Czech Republic	10.6	17.0	0.0	2.2	1.5	0.0	23	26	0	49	17	19	0	37
Denmark	0.0	0.0	0.0	3.0	0.0	0.0	0	0	0	0	0	0	0	0
Estonia	1.2	0.0	0.0	1.5	0.0	0.0	2	0	0	2	1	0	0	1
Finland	0.6	0.0	0.0	1.5	0.0	0.0	1	0	0	1	1	0	0	1
France	155.4	861.6	18.9	1.5	1.0	2.5	233	862	47	1,142	175	646	35	856
Germany	47.9	98.8	0.0	3.0	1.0	0.0	144	99	0	243	108	74	0	182
Greece	182.2	108.0	806.6	1.5	1.0	2.5	273	108	2,017	2,398	205	81	1,512	1,798
Hungary	90.2	82.4	0.0	2.2	1.5	0.0	198	124	0	322	149	93	0	242
Ireland	0.0	0.0	0.0	3.0	0.0	0.0	0	0	0	0	0	0	0	0
Italy	614.5	782.2	1,161.3	3.0	1.5	1.5	1,844	1,173	1,742	4,759	1,383	880	1,306	3,569
Latvia	9.2	0.0	0.0	1.4	0.0	0.0	13	0	0	13	10	0	0	10
Lithuania	16.8	0.0	0.0	1.4	0.0	0.0	24	0	0	24	18	0	0	18
Luxemburg	2.1	1.4	0.0	3.0	1.5	0.0	6	2	0	8	5	2	0	6
Malta	0.0	0.0	0.0	3.0	0.0	1.5	0	0	0	0	0	0	0	0
Netherlands	17.8	0.1	0.0	3.0	0.0	0.0	53	0	0	53	40	0	0	40
Poland	286.8	0.4	0.0	2.2	1.5	0.0	631	1	0	632	473	0	0	474
Portugal	154.4	222.7	379.6	1.5	1.0	2.5	232	223	949	1,403	174	167	712	1,052
Romania	155.9	187.6	0.0	2.2	1.5	0.0	343	281	0	624	257	211	0	468
Slovakia	5.1	11.5	0.0	2.2	1.5	0.0	11	17	0	28	8	13	0	21
Slovenia	4.0	16.1	0.8	1.2	1.2	1.2	5	19	1	25	4	14	1	19
Spain	1,139.2	1,130.7	2,470.2	1.5	1.0	2.5	1,709	1,131	6,176	9,015	1,282	848	4,632	6,761
Sweden	1.4	0.0	0.0	1.5	0.0	0.0	2	0	0	2	2	0	0	2
United Kingdom	17.8	0.0	0.0	3.0	0.0	0.0	53	0	0	53	40	0	0	40
Total EU 27	**3,015**	**3,693**	**4,849**				**6,027**	**4,320**	**10,960**	**21,307**	**4,521**	**3,240**	**8,220**	**15,981**

Sources: Eurostat database. Statistics on the production of crop products. (http://ec.europa.eu/eurostat)

Default values from country enquiries: Lithuania (Darius Vizlenskas), Slovakia (Roman Svitok) and Finland (Perttu Anttila).

Annex 2

Table 2-1: Woody biomass potential from urban areas within the EU 27

Country	Population in 2007	Households (garden waste) (in m³) 23 kg per inhabitant	Arboricultural arisings (in m³) 22 kg per inhabitant	
Austria	8,282,984	188,604	180,403	
Belgium	10,584,534	241,010	230,531	
Bulgaria	7,679,290	174,857	167,255	
Cyprus	778,684	17,731	16,960	
Czech Republic	10,287,189	234,239	224,055	
Denmark	5,447,084	124,030	118,637	
Estonia	1,342,409	30,567	29,238	
Finland	5,276,955	120,156	114,932	
France	63,623,209	1,448,700	1,385,713	
Germany	82,314,906	1,874,310	1,792,819	
Greece	11,171,740	254,381	243,320	
Hungary	10,066,158	229,206	219,241	
Ireland	4,312,526	98,196	93,927	
Italy	59,131,287	1,346,419	1,287,879	
Latvia	2,281,305	51,945	49,687	
Lithuania	3,384,879	77,074	73,723	
Luxemburg	476,187	10,843	10,371	
Malta	407,810	9,286	8,882	
Netherlands	16,357,992	372,471	356,277	
Poland	38,125,479	868,117	830,373	
Portugal	10,599,095	241,341	230,848	
Romania	21,565,119	491,038	469,688	
Slovakia	5,393,637	122,813	117,473	
Slovenia	2,010,377	45,776	43,786	
Spain	44,474,631	1,012,687	968,657	
Sweden	9,113,257	207,509	198,487	
United Kingdom	60,781,352	1,383,991	1,323,818	
EU 27	**495,270,075**	**11,277,300**	**10,786,982**	**22,064,282**

Source: Eurostat database. Statistics on the population in Europe. (http://ec.europa.eu/eurostat)

Annex 3

Table 3-1: Calculated potential for landscape care wood in the EU27 countries

Country	Country characteristics in 2007 unless stated otherwise					Results for landscape care wood	
	Total Land area excl. inland water bodies [1,000 ha][1]	**Forest area in 2005 [1,000 ha)][1]**	**Forest Available for wood supply [1,000 ha][1]**	**Non-forest land area [in 1000 ha][1]**	**Fellings in FAWS [1,000 m^3][1]**	**Calculated potential per ha of non-forest land area based on the relationship [m^3/ha]**	**Potential per ha of other land area after applying the upper and lower boundaries [m^3/ha]**
Austria	8,321	3,862	3,354	4,459	18,797	0.55	0.38
Belgium	3,033	672	667	2,361	4,475	0.48	0.38
Bulgaria	11,063	3,651	2,561	7,412	5,768	0.17	0.25
Cyprus	924	174	43	750	6.4	0.01	0.25
Czech Republic	7,725	2,647	2,518	5,078	17,190	0.57	0.38
Denmark	4,243	500	385	3,743	1,837	0.29	0.29
Estonia	4,239	2,264	2,090	1,975	5,730	0.32	0.32
Finland	30,447	22,130	20,004	8,317	64,526	0.62	0.38
France	63,283	15,554	14,743	47,729	56,623	0.38	0.38
Germany	34,865	11,076	10,984	23,789	60,770	0.31	0.31
Greece	12,890	3,752	3,456	9,138	1,842	0.04	0.25
Hungary	9,211	1,948	1,684	7,263	7,167	0.29	0.29
Ireland	6,839	669	656	6,170	2,741	0.26	0.26
Italy	29,411	9,979	8,922	19,432	10,105	0.09	0.25
Latvia	6,229	3,035	2,844	3,194	11,290	0.42	0.38
Lithuania	6,288	2,121	1,835	4,167	7,238	0.32	0.32
Luxemburg	259	87	86	172	249	0.24	0.25
Malta	32	0	0	31	0	0.32	0.32
Netherlands	3,376	365	295	3,011	1,552	0.32	0.32
Poland	30,629	9,200	8,417	21,429	37,156	0.34	0.34
Portugal	9,150	3,783	2,009	5,367	10,590	0.41	0.38
Romania	22,997	6,391	4,628	16,607	15,900	0.25	0.25
Slovakia	4,808	1,932	1,751	2,876	8,962	0.46	0.38
Slovenia	2,014	1,264	1,155	750	3,203	0.34	0.34
Spain	49,944	17,915	10,479	32,029	19,093	0.14	0.25
Sweden	41,034	27,871	21,235	13,163	78,127	0.54	0.38
United Kingdom	24,088	2,845	2,375	21,243	9,900	0.25	0.25
EU 27	**427,341**	**155,686**	**129,175**	**271,655**	**460,837**	**0.32**	**0.32**

Source: MCPFE. FAO and UNECE, 2007

Annex 4

Table 4-1: Characteristics of countries with a substantial Other wooded land area

Country	Area (1,000 ha)		Increment [1,000 m^3 ob]	Fellings [1,000 m^3 ob]	Removals [1,000 m^3 ob]	Increment per ha [1,000 m^3 ob]	Removals per ha [1,000 m^3 ob]	Share of increment felled in 1990 [1,000 m^3 ob]	Calculated removals for the year 2005 [1,000 m^3 ob]	Remarks
	1990	2005	1990	1990	1990	1990	1990	1990	2005	
Finland	923	1,181	282	0	0	0.31	0.00	0%	0	Peat lands and other poor sites not fulfilling the forest criteria/definition.
France	2,087	1,708	1,179	-	648	0.56	0.31	55%	531	Less than 10% of the total area is represented by wooded areas. The total area refers to peatland in the sense of land use survey. and is defined as "Formations generally of large extent. Grassy vegetation most often makes up the bulk of the plant life. but 25% at least of the ground cover consists of woody or semi-woody plants such as ferns. heather. broom and gorse. Also including maquis - garrigues.
Greece	3,212	2,780	75	0	0	0.02	0			
Italy	880	1,047	524	0	115	0.60	0.13		137	Natural wooded lands having a cover density of at least 20%. composed by trees and shrubs species. Not managed for economic purposes. - Riparian formations: can be composed by trees species or shrubs species growing in particularly difficult areas. - Shrubs formations: mainly composed by shrub species.
Spain	12,447	10,299	15,000	3,224	1,554	1.21	0.12	10%	1,286	Mainly dehesas
Sweden	3,217	3,059	991	528	336	0.31	0.10	34%	319	Non productive forest. e.g. swamp. subalpine coniferous forest and high mountain
Total	**22,766**	**20,074**	**18,051**	**3,752**	**2,654**	**0.60**		**22%**		

Source: FAO, 2000

5.2 Short rotation plantations

5.2.1 Sector definition

Short rotation plantations are defined as plantings established and managed under short rotation intensive culture practices. They can be established with fast growing tree species like poplar, willow, black locust (Robinia pseudoacacia) and eucalypt having rotations of 10 to 15 years or can be managed as a coppice system with 2 to 4 year rotation. Plantations with rotations of 10 to 15 years are mainly used for fibre production for the pulp and paper industry. This management system includes replanting. For energy purposes short rotations of 2 to 4 year with coppice management are more in favour. In the EUwood study the focus is on the future perspectives of short rotation coppice (SRC).

5.2.2 Existing area of short rotation coppice

Basically, no data are available for the area of short rotation plantations (rotation 10 to15 years) in the EU countries. These plantations are either registered as forest area or are part of trees outside the forest (and not registered) (see chapter 5.1.1). Existing wood production is included in those categories.

An exception can be made for the area of short rotation coppice, especially because these plantations are more or less established as an energy producing crop system. A first analysis of available literature showed that the area of SRC is estimated about 30,000 hectares.

Table 5-5: Area of short rotation coppice (EU 27)

Country	SRC area [ha]	Species	Reference date	Remark
Austria	915		2007	
Denmark	1,600			
Baltic countries	1,000	Willow	2006	
Germany	500		2007	
Ireland	100			
Netherlands	50	Willow	2008/2009	Estimate, no commercial exploitation
Poland	1,600	Willow	2008/2009	
Slovakia	500		2010	
Sweden	16,000	Willow	2008/2009	10,000 ha being commercially exploited
United Kingdom	5,700	Willow	2007	

Sources: Statistik Austria, 2008; National Non-Food Crops Centre for the UK, 2009; Vetter, 2010; Hepperle und von Teuffel, 2007; Biopros, 2006 .

Only Sweden and UK have a substantial area of SRC, while countries like Poland, Austria and Denmark exploit 1,000 to 1,500 hectares. In the other countries there is none or only smaller areas, which are trial plantations to estimate local or regional productivity. Recently the foresters in Germany experimented with the planting of black locust (Robinia pseudoacacia) for SRC in forest areas damaged by the Kyrill hurricane (Bündnis Pro Wald NRW, 2009).

Therefore, assuming a mean productivity of 8.0 tonnes dry matter per hectare for EUwood, the special SRC plantations can produce about 240,000 tonnes dry matter of wood in the EU 27 annually. For now, the volume has a relatively small contribution to the total woody biomass supply.

5.2.3 Studies on potential land area for bio-energy crops in the EU 27

The establishment of short-rotation coppice is only one option to increase the feedstock for renewable energy. Other energy crops such as oilseed, sugar beet, starch or other cellulosic plants (miscanthus etc) are alternatives. In fact, the main uncertainty at the moment is not what kind of bio-energy crops should be planted, but how much land will be devoted to energy production.

During the last years different studies were done for the European Commission on modelling the future area of bio-fuel crops in Europe. The results of these studies show great variations, that is to say there are studies with clear perspectives in Europe for woody crops and on the other hand studies show a bright future for agricultural crops.

An example of a study with positive outcomes for woody crops is the study “Biomass production potentials in Central and Eastern Europe under different scenarios” (van Dam et al., 2007). In this study a methodology for the assessment of biomass potentials was developed and applied to Central and Eastern European countries (Estonia, Latvia, Lithuania, Poland, Slovakia, Hungary, Czech Republic, Romania and Bulgaria):

> *“Biomass resources considered were agricultural residues, forestry residues, and wood from surplus forest and biomass from energy crops. Only land that is not needed for food and feed production is considered as available for the production of energy crops. Five scenarios were built to depict the influences of different factors on biomass potentials and costs. Scenarios, with a domination of current level of agricultural production or ecological production systems, show the smallest biomass potentials of 2-5 EJ for all CEEC. Highest potentials can reach up to 11.7 EJ (85% from energy crops, 12% and 3% from surplus forest wood) if 44 million ha of agricultural land were to become available for energy crop production. This potential is, however, only realizable under high input production systems and most advanced production technology, best allocation of crop production over all CEEC and by choosing willow as energy crop. The production of lignocellulosic crops and willow in particular, best combines high biomass production potentials and low biomass production costs. Production costs for willow biomass range from 1.6 to 8.0 €/GJ HHV in the scenario with the highest agricultural productivity and 1.0-4.5 €/GJ HHV in the scenario reflection the current status of agricultural production. Generally the highest biomass production costs are experienced when ecological agriculture is prevailing and on land with lower quality. In most CEEC, the production potentials are larger than the current energy use in the more favourable scenarios. Bulk of the biomass potential could be produced at costs lower than 2 €/GJ. High potentials combined with the low costs levels gives CEEC major export opportunities”*

Another more recent study by Fischer et al., (2009) from IIASA and other European research institutes on biofuel production potentials in Europe concluded that by 2030 some 22.4 to 45.7 million hectares of agricultural land could be used for bio-energy feedstock production in the EU 27. For the EU 15 these figures are 2.7 to 16.4 million hectares and for the EU 12 19.7 to 29.3 million hectares. These outcomes were based on three land conversion scenarios:

(i) A base scenario, that reflects developments under current policy settings and respects current trends in nature conservation and organic farming practices, by assuming moderate overall yield increases;

(ii) an environment oriented scenario with higher emphasis on sustainable farming practices and maintenance of biodiversity; and

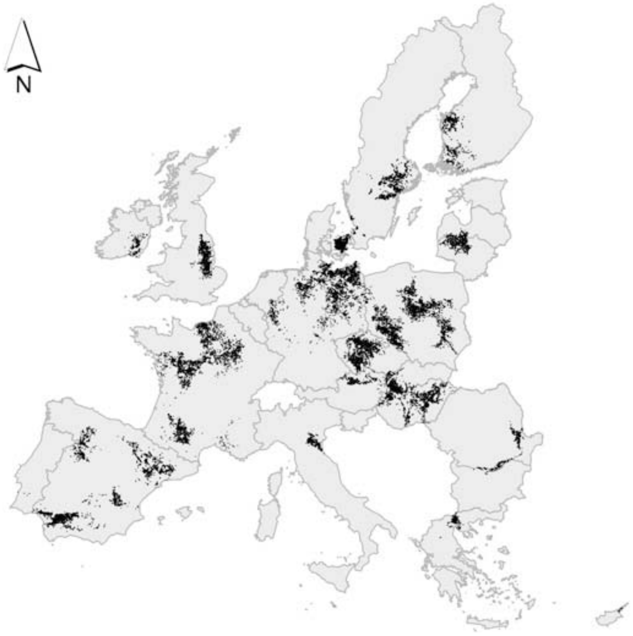
(iii) an energy oriented scenario considering more substantial land use conversions including the use of pasture land.

The results show that available land is foremost to be found in Eastern Europe where substantial cultivated areas can be freed up through sustainable gains in yield in the food and feed sector.

A third study from the Copernicus Institute of Sustainable Development and Innovation (de Wit and Faaij, 2009) assessed the European (EU 27^+ and Ukraine) cost and supply potentials for biomass resources. Their results indicated that the total available land for bio-energy crop production – following the ’food first’ paradigm –could amount to 41.0 to 90.0 million hectares by 2030. Three scenarios were constructed that take into account different development directions and rates of change, mainly for the agricultural productivity of food production. Feedstock supply of dedicated bio-energy crop estimates varies between 1.7 and 12.8 EJ/a. In addition, agricultural residues and forestry residues can potentially add to this 3.1 to 3.9 EJ/a and 1.4 to 5.4 EJ/a respectively. First generation feedstock supply is available at production costs of 5 to15 €/ GJ compared to 1.5 to 4.5 € / GJ for second generation feedstock. Costs for agricultural residues are 1 to 7 € / GJ and forestry residues 2 to 4 € /GJ. Large variation exists in biomass production potential and costs between 280 European regions . Regions that stand out with respect to high potential and low costs are large parts of Poland, the Baltic States, Romania, Bulgaria and Ukraine. In Western Europe, France, Spain and Italy are moderately attractive following the low cost high potential criterion.

Faaij (2009) stated in his presentation “Development of the energy potential of the forestry sector and wood energy in a sustainable way” during the UNECE/FAO Policy Forum “The Forest Sector in the Green Economy” held in Geneva in October 2009, that the energy yield of perennials is 3 times higher than the energy yield of agricultural crops. Moreover, lignocellulosic biomass (perennials, residues) offer excellent perspectives for sustainable energy.

An example of a study, which favours the agricultural crops for bio-fuels is the study “Spatially explicit modelling of biofuel crops in Europe” by Hellmann and Verburg (2008). They described a methodology to explore the future spatial distribution of bio-fuel crops in Europe. A multi-scale, multi-model approach is used in which bio-fuel crops are allocated over the period 2000-2030. The area of bio-fuel crops at national level is determined by a macro economic model. A spatially explicit land use model is used to allocate the bio-fuel crops within the EU countries. Figure 5-3 shows the locations where biodiesel/bio-ethanol crops (oilseed, cereals and starch excluding ligno-cellulosic crops) are allocated.



Source: Hellmann and Verburg (2008)

Figure 5-3: European hotspots biodiesel / bio-ethanol crops

They also made calculations for the allocation of ligno-cellulosic crops (willow, poplar, miscanthus etc.). The hotspots of the ligno-cellulosic crops clearly overlapped with the biodiesel / bio-ethanol crops.

Due to commercial production of bio-fuels from ligno-cellulosic crops did not yet occur. A validation or calibration of the allocation of ligno-cellulosic crops was not possible. Moreover, the future scale of production was difficult to determine as these bio-fuel crops can be processed through different techniques.

In another EU project Verburg made new calculations for DG Environment with the same models based on the EU RES Directive for bio-fuels from the Commission. The results show a rather small area for woody bio-fuel crops (Table 5-6). A reason for that seems to be the growing agricultural production in the EU, due to the termination of the 'set-aside' regulation by the European Commission in 2008. Another reason is the lack of information on the management of woody biomass crops (short rotation coppice) and the processing of bio-fuels. For the year 2030 the calculations within the model resulted in 20,161,000 hectares with arable plants for bio-fuels and only 7,910 hectares for woody perennials for bio-fuels.

Table 5-6: Estimated area with biofuel crops in the EU 27

	Area arable biofuels [ha]	Area perennial biofuels [ha]
2000	12,228,000	2,380
2010	11,401,000	2,800
2020	18,329,000	7,180
2030	20,161,000	7,910

Source: Verburg, 2009

Another example is a study made from inside the forest sector. The UNECE/FAO study “Potential Sustainable Wood Supply in Europe” (Hetsch, 2009) presents the useful estimates and quantitative analysis for wood resources in Europe. Short rotation plantations were just one of them.

Data on fallow and set-aside land were derived from Eurostat agriculture statistics (2005). In this study only “set-aside areas under incentive schemes: Fallow land with no economic use” are used as a basis for calculation. An increment of 15 m^3 per year and hectare was assumed as default value. This value has to be adapted according to national or local conditions, in order to obtain better estimates for wood supply from short rotation plantations.

Assuming that 100% of the fallow land under incentive schemes with no economic use in the EU 27 are afforested (4.3 million hectares with tree species producing 15 m^3/ha / a), additional 65 million m^3 wood could become available. The theoretical potential of afforestation of fallow land without subsidies (4.2 million hectares) is 63 million m^3, adding up to 127 million m^3.

To maintain a conservative estimate, the UNECE/FAO study by Hetsch (2009) did not consider fallow land without subsidies. For the means of discussion an afforestation rate of 35% was assumed, and applied on fallow land only under incentive schemes with no economic use. This would result in an additional wood supply of 22.8 million m^3 in the EU 27.

5.2.4 Agricultural area available for energy crops

Short-rotation plantations on agricultural land are officially considered as forests under the Forest Resource Assessment (FRA) definition. However, in many countries, these areas are legally not considered as forests, because these plantations are in principle temporary and are not governed by national forest laws.

In the existing studies and from other reports quite different area figures for energy crop production in Europe are presented:

- Study by van Dam et al. (2006): the highest potential for sustainable energy in the CEEC can be reached when 44.0 million ha of agricultural land become available for energy crop production. This 90% of the total agricultural area in the CEEC (49,282,000 ha).
- Study by Fischer et al. (2009): by 2030 about 22.4 to 45.7 million hectares of agricultural land could be used for bio-energy feedstock production in the EU 27. For the EU 15 these figures are 2.7 to 16.4 million hectares and for the EU 12 19.7 to 29.3 million hectares.
- Study by de Wit and Faaij (2009): the total available land for bio-energy crop production – following the ’food first’ paradigm –could amount 41.0 to 90.0 million hectares by 2030 (EU 27^+ and Ukraine).
- Study by Hellmann and Verburg (2008): 20,161,000 ha could become available for arable crops and 8,000 ha for woody crops for the production of bio-fuels in Europe. Basically the calculated 20.0 million ha could also become available for wood energy crops as a raw material for second generation bio-fuels.

- The study by Hetsch (2009) derived the area of fallow land with no economic use (set-aside areas under incentive schemes) from the European statistics 2005: 4.3 million ha and fallow land without subsidies was 4.2 million ha. In total 8.5 million ha in potential available.
- A study from the European Environmental Agency announced that about 16.0 million ha could be “freed up” for energy crop biomass production (EEA, 2007).
- The European Commission (Anonymous, 2009a) stated in a German wood energy conference that Europe needs 26.0 million ha agricultural land for energy crops.
- The German ministry of Environment (BMU) has stated in one of its studies that 450,000 ha of SRC plantations will be needed in 2020 in Germany to meet the climate goals (Anonymous, 2009b).
- The Biomass Action Plan from the German government (BMU und BMELV, 2009) demands 1.3 million ha to become available for energy crops. This area would equal 7.7% of the total German agricultural area and 11% of total arable land in Germany.
- The Energy Agency (Anonymous, 2010) from North Rhine Westphalia (Germany) presented its potentials: 13% of agricultural land could become available for energy crops.
- Bemmann et al. (2010) see a potential for wood energy plantations on arable land of about 10% of the total annual wood harvest from the German forests. Their calculation is based on an area for SRC of 400,000 to 500,000 ha.

These studies show quite different estimations on the future contribution of energy crops and even more outspoken over the future area SRC in Europe. As already stated by Hetsch (2009) the perspectives of short rotation coppice, are strongly influenced by agricultural policies in the EU as well as on the competition between woody biomass and agricultural crops.

5.2.5 Area of SRC needed to meet the renewable energy targets

The outcomes of the studies for area potentials for bio-energy crops in the EU 27 differ so much, that the future contribution of SRC to the energy demand in 2030 is highly speculative. The EUwood project group decided therefore not to include future potentials for SRC into the Wood Resource Balances.

A main challenge of the EUwood project is to estimate the potentials based on already existing data on woody biomass. Confronting these potential supplies of woody biomass with the estimated demand for woody materials and for energy in 2030 the project will present area data for the future contribution of short rotation coppice in the total woody biomass supply in the EU 27.

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5.3 Post-consumer wood

5.3.1 Sector definition

Post-consumer wood (PCW) includes all kinds of wooden material that is available at the end of its use as a wooden product ("post-consumer" or "post-use" wood). Post-consumer recovered wood mainly comprises packaging materials, demolition wood, and timber from building sites and fractions of used wood from residential (municipal waste), industrial and commercial activities.

5.3.2 The volume of post-consumer wood in 2007

To make an estimation of the volume of post-consumer wood that is expected to be generated in the EU 27 in the year 2030 it is first of all, necessary to start with the most reliable data for the present situation.

A first step in the analysis was to detect the best values for post-consumer wood in 2007. PCW data files from COST E31, COST E44, JWEE 2007 and also the Eurostat data for waste wood for 2006 were included in the analysis.

For the preparation of the final Wood Resource Balance 2007 in the EUwood state of the art report (Steierer, 2009) made an analysis based on data from COST and Eurostat and also on the results from studies in the Netherlands and Germany (BioXchange, 2005) which presented values for post-consumer wood production in kg per capita. The results from this analysis are presented in EUwood State of the Art report (EUwood, 2009).

Finally these results are used as basic values for the amount of post-consumer wood in 2007 for the most European countries. For Belgium, Estonia, Finland and Sweden the data were corrected. For UK (Wrap, 2009) and the Netherlands (Leek, 2009) new studies for the year 2008 were published and included in the dataset for 2007.

The data in Table 5-7 in the column post-consumer wood total in m^3 are used for further calculations and predictions for the years 2010, 2015, 2020, 2025 and 2030.

Table 5-7: Basic values for post-consumer wood in 2007 in m³ per country

Country	PCW total [m³]	PCW recovered [m³]	PCW energy [m³]	PCW disposed [m³]
Austria	1.117.230	502.754	469.237	145.240
Belgium	1.564.790	1.032.761	344.254	187.775
Bulgaria	434.200	108.550	151.970	173.680
Cyprus	88.510	18.370	8.350	61.790
Czech Republic	768.200	76.820	76.820	614.560
Denmark	1.133.930	113.393	963.841	56.697
Estonia	195.390	29.309	19.539	146.543
Finland	1.254.170	602.002	639.627	12.542
France	6.731.770	4.712.239	1.009.766	1.009.766

Germany	10.285.530	1.542.830	7.199.871	1.542.830
Greece	769.870	107.782	7.699	654.390
Hungary	561.120	28.056	56.112	476.952
Ireland	619.570	278.807	30.979	309.785
Italy	6.524.690	2.609.876	1.631.173	2.283.642
Latvia	265.530	26.553	13.277	225.701
Lithuania	337.340	50.601	33.734	253.005
Luxembourg	61.790	40.164	12.358	9.269
Malta	18.370	3.674	1.837	12.859
Netherlands	2.479.950	1.214.424	1.265.025	50.601
Poland	4.113.210	164.528	41.132	3.907.550
Portugal	684.700	82.164	6.847	595.689
Romania	1.903.800	266.532	19.038	1.618.230
Slovakia	255.510	102.204	25.551	127.755
Slovenia	185.370	14.830	124.198	46.343
Spain	4.121.560	1.648.624	82.431	2.390.505
Sweden	1.309.280	65.464	1.178.352	65.464
United Kingdom	7.636.910	2.672.919	1.527.382	3.436.610
Total EU 27	55.422.290	18.116.227	16.940.397	20.415.767

Source: EUwood , 2009; COST E31

The next step was to analyse how post-consumer wood is used nowadays in the EU 27 countries. Based on information from COST E31 for 17 countries national experts gave their best professional judgement on how recovered wood is used for the production of panels and for energy purposes. Moreover, non-use of post-consumer wood was estimated, especially for landfill and for incineration.

This information was not available for the countries Cyprus, Czech Republic, Denmark, Estonia, Latvia, Lithuania, Luxembourg, Malta, Romania and Slovakia. For these countries estimates were made for use and non-use of post-consumer wood in relation with neighbouring COST-countries. In southern and eastern EU countries landfill is still a major way to dispose of waste.

Table 5-8: Share of different uses of post-consumer wood (EU 27)

Country	Recovered for raw material	Used for energy	Not used
Austria	0.45	0.42	0.13
Belgium	0.66	0.22	0.12
Bulgaria	0.25	0.35	0.40
Cyprus*)	0.20	0.10	0.70
Czech Republic*)	0.10	0.10	0.80
Denmark*)	0.10	0.85	0.05
Estonia*)	0.15	0.10	0.75

Finland	0.48	0.51	0.01
France	0.70	0.15	0.15
Germany	0.15	0.70	0.15
Greece	0.14	0.01	0.85
Hungary	0.05	0.10	0.85
Ireland	0.45	0.05	0.50
Italy	0.40	0.25	0.35
Latvia*)	0.10	0.05	0.85
Lithuania*)	0.15	0.10	0.75
Luxembourg*)	0.65	0.20	0.15
Malta*)	0.20	0.10	0.70
Netherlands	0.48	0.50	0.02
Poland	0.04	0.01	0.95
Portugal	0.12	0.01	0.87
Romania*)	0.14	0.01	0.85
Slovakia*)	0.40	0.10	0.50
Slovenia	0.08	0.67	0.25
Spain	0.40	0.02	0.58
Sweden	0.05	0.90	0.05
United Kingdom	0.35	0.20	0.45

Source: country data from COST E31. *) Estimated in relation with COST E31 data.

There is a huge variation between countries where most post-consumer wood is used and those where the great majority is wasted / not used / landfilled. This can be considered as a crucial reserve. Although the waste sector calculates in weight (ton) data were transferred in to volumes (m^3) with the conversion factor of 1.67 for the Wood Resource Balance.

5.3.3 Modelling the volume of post-consumer wood for 2030

The COST E31 group made an analysis of different country characteristics like land area, number of inhabitants, GDP, primary energy consumption and consumption of roundwood in relation to the generation of post-consumer wood. Basic idea behind was to find relations for presenting better estimates for those countries with low quality data.

An examination of these national economic and geographic parameters indicated that it was difficult to find correlations between them and the amounts of post-consumer wood per country.

In this project some additional relations were studied:

- kg post-consumer wood per capita and m^3 solid wood consumption per capita,
- kg post-consumer wood per capita and m^3 sawn wood consumption per capita,

- kg post-consumer wood per capita and the share of post-consumer wood in total wood consumption.

Moreover, the results of regression analysis for these equations were also not satisfying.

To predict the future supply of post-consumer wood in the EU 27 two approaches were considered. The first approach is based on kg post-consumer wood per capita for countries with reliable post-consumer wood data and translates them to the other countries. This way of calculation has not been followed, since it demanded data for future developments.

The second approach is based on the relation between wood consumption per capita and the share of post-consumer wood in the total wood consumption in 2007 for each country. By grouping high wood consuming countries versus low wood consuming countries different figures were found for the share of post-consumer wood in total wood consumption. Relations and shares are shown in Table 5-9.

Table 5-9: Share of post-consumer wood in total wood consumption (2007)

Country groups	Solid wood / capita [m³]	Share of PCW in total wood consumption
High wood consuming countries (7)*)	1 (0.75 – 1.3)**)	0.2
Middle wood consuming countries (11)	0.45 (0.3 – 0.6)	0.3
Low wood consuming countries (9)	0.2 (0.1 – 0.3)	0.45

*) number of countries. **) between brackets is variation

Source: EUwood

It is interesting to see that in high wood consuming countries (1.0 m^3 of wood per capita) the share of post-consumer wood in the total national wood consumption is only 0.2 while the low wood consuming countries (0.2 m^3 wood per capita) show a share of post-consumer wood in the national wood consumption of 0.45. The most reasonable explanation for this relation is that high wood consuming countries have a greater export of different wood products.

This relation was used for the prediction of the future post-consumer wood supply in the EU 27. For each country the share of post-consumer wood in total national solid wood consumption was calculated for 2007. The national solid wood consumption was calculated for the years 2010, 2015, 2020, 2025 and 2030 from the econometric modelling data sets (see chapter 2.3) both for scenario A1 and B2 (solid wood consumption = sawn wood consumption and panel consumption).

The next step was to calculate for each EU country the volume of post-consumer wood in m³ for the years up to 2030 based on the following equation:

Equation 5-2: Volume of post-consumer wood until 2030

$$\text{PCW}_{2010,\,2015,\,2020,\,2025,\,2030} = (\text{PCW}_{2007} * \text{solid wood consumption}_{2010,\,2015,\,2020,\,2025,\,2030}) / \text{solid wood consumption}_{2007}$$

Further, the volumes of post-consumer wood for the EU 27 countries in 2030 are calculated (in the Wood Resource Balance presented as PCW (POT)). It is interesting to see how much post-consumer wood is estimated to be available in the coming 20 years up to 2030. The distribution of post-consumer wood is known for 2007. Compare Table 5-7 for the existing post-consumer wood volumes for material use and energy use and volumes disposed (land filled and incinerated).

The EU Landfill Directive (1999) stimulates the member countries to decrease their share of landfill. It is reasonable to assume that in 2030 land filling is nearly coming to zero. On the other hand a certain share of wood inside the municipal waste streams will not be extracted and will be incinerated. In the calculations it is assumed that the volumes of post-consumer wood in landfills for each country will be halved each period from 2007-2015, 2015-2020 and 2020-2030 and will not drop under the 5% level (= 5% of total post-consumer wood volume).

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5.4 Industrial wood residues – a source that grows with production

5.4.1 General approach

Assessing and calculating the volumes of industrial wood residues (IWR), which are produced and available in the EU 27 countries, is based on the general structure of forest industries. Modelling approaches for the respective sectors are based on production processes in the sawmill industry, the wood-based panel industry and the pulp and paper industry. Moreover, the branches of further processing industry are analysed basing estimates of arising volumes of industrial wood residues on the consumption of sawnwood and wood-based panels.

Industrial wood residues as a considerable volume of a “unit’s” Wood Resource Balance is part of the total of wood raw material sources – seen as input but also output. Legal frameworks[14] and definitions complicate the clear allocation of industrial wood residues to only one source. Thus, the analysis and modelling is based on raw material input not further differentiated. Moreover, industrial wood residue volumes calculated are considered as residues from industrial production or consumption.

Figure 5-4 gives an overview of the general structure, which is applied for modelling volumes of industrial wood residues. Generally, the analysis is based on existing forest industry segments. Further, the three forest products segments form the basis of the detailed analysis. Expected results of industrial wood residues cover the volumes of sawmill by-products, other industrial wood residues and black liquor.

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[14] E.g. German KrW-/AbfG - Kreislaufwirtschafts- und Abfallgesetz (Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal, BMU, 2010) and AltholzV (Waste Wood Ordinance, BMU, 2010)

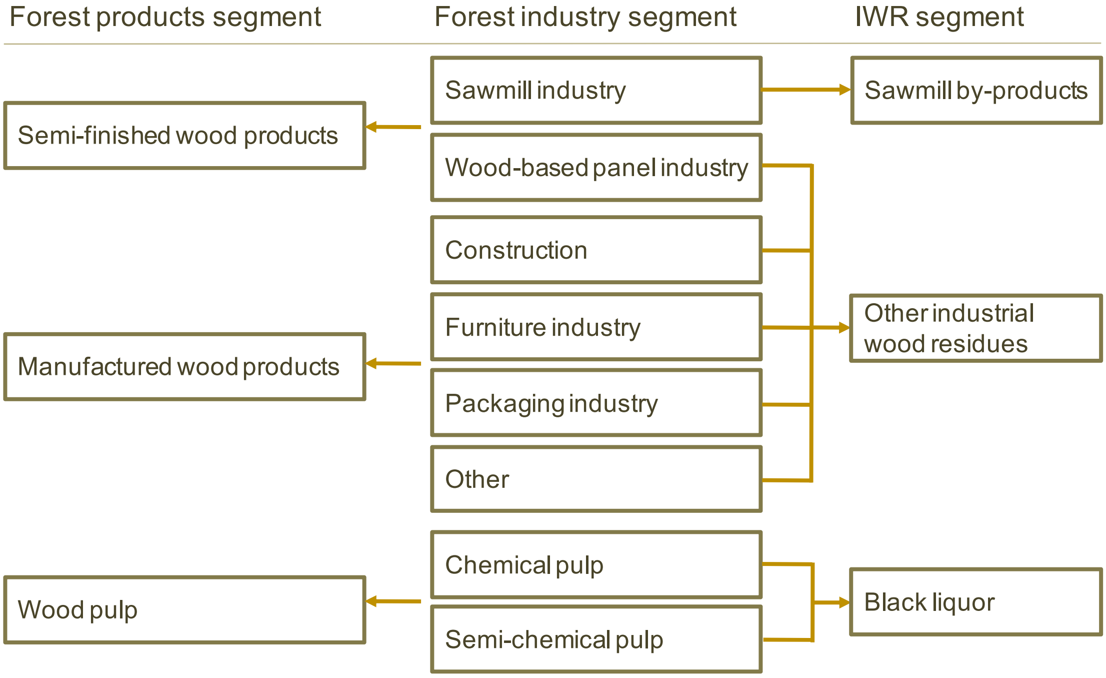

Figure 5-4: Analysed elements of research area

Modelling volumes of industrial wood residues based on available data mainly implies focusing on FAOSTAT available data. Production data of forest products are (relatively) reliable and complete. However, FAOSTAT data reach limits. Valuable, empirical studies conducted in the German forest industry provide necessary modelling bases. The challenge for EUwood is to not apply the pattern of the German forest industry production, effects and results on all EU 27 countries, in all cases. Rather, it is to ascertain structures of the significantly differing forest industry structures in the EU 27.

5.4.2 Sawmill by-products

5.4.2.1 Description of the segment and sawmill by-products assortments

The segment of sawmill by-products comprises wood residues that originate from the production of sawnwood. It includes wood chips, sawdust and particles, as well as sawmill rejects, slabs, edgings and trimmings. The assortments are suitable for material uses such as pulping, particleboard and fibreboard production as well as for energy use. sawmill by-products exclude wood chips made either directly in the forest from roundwood or made from forest residues (i.e. already counted as pulpwood, round and split or wood chips and particles).

According to Mombächer (2003), wood chips are wood pieces, cut diagonal to the wood fibre. Wood chips accumulate as by-products in the sawnwood production. Wood particles of cubical or fibrous form accumulate as by-products during sawing processes. Slabs are pieces cut off at both sides of the stem, produced during sawnwood production. Edgings and trimmings are produced during edging of boards.

5.4.2.2 Modelling approach

Generally, volumes of sawmill by-products of a considered unit (sawmill, region or country) differ considerably. The amount of sawmill by-products is dependent on factors describing the material balance as well as other influencing factors. The material balance mainly comprises the recovery rate and sawn species (coniferous / non-coniferous).

Modelling sawmill by-products volumes and assortments in particular, the recovery rate comes to the fore. The recovery rate describes the ratio of roundwood input – and sawnwood output of the considered unit. Influencing parameters are the sawn species, sawmill size and technology applied. Considering larger units such as a country, the recovery rate is also dependent on the country's sawmill size structure. Further, special characteristics of vegetation respectively roundwood characteristics (e.g. log dimensions, shape and species composition) and product traditions have an influence on the product output. Product traditions refer to local or traditional markets with specialised product portfolios or national standards.

In addition, the share of SPB assortments (dust, slabs and chips) are also influenced by the mentioned factors. The produced volumes of sawmill by-products assortments, especially slabs and chips differ considerably, mainly dependent on sawn species and sawmill technology applied. Further, the sawmill size has an important effect on the particular share of chips and slaps (see Table 5-10and Table 5-11).

Hence, assessing the volumes of sawmill by-products and respective shares of sawmill by-products assortments of the EU 27 countries demands comprehensive data for each country, which enables to structure the EU 27 national sawmill industries.

At present the availability of described data for assessing sawmill by-products volumes country wise e.g. by national sawmill industry studies is limited. Data are available on annual sawnwood production separated into coniferous and non-coniferous sawnwood. Country specific data on recovery rates, sawmill sizes and sawmill size structures are partly available.

In addition to country specific information related assumptions based on available data and information are needed to assign a recovery rate as well as to classify each country according to a particular sawmill size structure.

5.4.2.3 Assumptions

Technology and log dimensions

Based on the development of sawnwood production volumes a country's sawmill industry development and growth can be evaluated. It is to be assumed that a growth in production volumes indicates recent investments into capacity and therewith (modern) technology. Considered time spans are 1995 to 2000 and 2000 to 2007.

Chipper / chipper canter sawing lines usually have lower recovery rates due to sawnwood production from small-size timber and characteristic cutting geometry. The effect of chipper / chipper canter sawing lines on the different sawmill by-product assortments are: a) a high share of chips and b) a low share of slabs (almost 0%, see Table 5-10). The resulting share of dust is similar to frame saw lines.

Frame / band sawing technology usually results in higher recovery rates due to larger dimensions cut and sawing patterns, which are better adjusted to the actual geometry of the stemwood. The effect of frame saws on the results of SPB assortments are a high share of slabs and a lower share of chips. The share of dust is independent of the sawing technology applied.

Generally, recovery rates are higher in non-coniferous sawnwood production due to larger stemwood dimensions and application of frame / band saw technology.

Vegetation characteristics

Concerning vegetation characteristics it is assumed that stemwood in the boreal forest zone is of small dimensions whereas stemwood in temperate forests is of larger dimensions. Since the shape of the log influences the recovery rate, too, it is assumed that especially crooked and small size orchard trees in southern European regions lower the recovery rate.

Countries with high shares of coniferous species mainly produce coniferous sawnwood – resulting in generally lower recovery rates.

Comparison

Information describing regional differences such as vegetation, forest/ species composition, geography or socioeconomic criteria such as GDP, population, forest area/capita provide further evidence for classification and especially comparison of countries. Moreover, the combination of available country specific information allows using reference regions. It is most likely, that e.g. characteristics of countries in the boreal forest zone are similar.

Reference regions (e.g. by Fonseca, 2010)

- Northern Europe – Finland, Sweden, Ireland, Estonia, Latvia, Lithuania
- Central Europe – UK, Denmark, Netherlands, Belgium, Germany, France, Czech Republic, Slovakia, Austria
- Eastern Europe – Poland, Hungary, Bulgaria, Romania, Slovenia
- Southern Europe – Italy, Spain, Portugal, Greece, Malta, Cyprus

Sawmill sizes and structure

Since sawmill industry and according size structures differ considerably by country, different structures have to be assumed for modelling.

Generally, large size sawmills produce higher amounts of chips, whereas the share of slabs decreases with the (larger) size. A basic assumption on the sawmill size structure is the existence of sawmills larger than 500,000 m³ of annual cutting capacity. To achieve detailed results on the differing sawmill by-products assortment shares, different types of structure have to be assumed:

Type **A** – large and extra large mills with high production capacity are prevailing. Some sawmills have production capacity over 500,000 m³/a.

Type **B** – small, medium and large size sawmills form the structure, however, medium and large size sawmills prevail. There are no extra large sawmills.

Type **C** – small and medium size sawmills prevails. There are no extra-large mills; however, large mills have an important share of annual cutting.

5.4.2.4 Modelling and Calculation

Deduction and development of the model

By the means of country specific information a sawmill size structure and respective recovery rate can be assigned to each country. Data on production volumes of sawnwood are considered as the basis for calculations. The classification according to types A, B, C, however, is partly based on individual case decisions.

The modelling and further calculation of respective sawmill by-product volumes is based on a repeatedly conducted study of the German sawmill industry by Mantau et al., (2008, 2006 and 2004). The study provides data on coniferous and non-coniferous sawmills by sawmill sizes. The sawmill size indicates a sawmill's maximum annual cutting capacity. Moreover, the study gives detailed information on shares of sawmill by-products assortments and share of total cuttings per size. The composition and share of sawmill sizes in a country describe the national sawmill size structure (sawmill industry structure).

Separate modelling for coniferous and non-coniferous sawmill by-products

Due to the applied technology and available log sizes considerable differences in the share of sawmill by-product segments between coniferous and non-coniferous sawnwood are obvious. Volumes of slabs are significantly higher in non-coniferous sawnwood production than in coniferous sawnwood production. Volumes of chips are lower. Therefore the model is applied separately for coniferous and non-coniferous sawnwood. The FAO database provides detailed data on coniferous and non-coniferous sawnwood production.

Table 5-10and Table 5-11 show results of the German sawmill industry study for coniferous and non-coniferous sawmills.

Table 5-10: Share of sawmill by-products in German sawmill industry by size (C)

Sawmills size class	Max. annual capacity [m³ log input]	Share of total cuttings [%]	SBP assortments Dust [%]	Slabs [%]	Chips [%]
x-small sawmill	< 1,000	1.39	33.20	61.70	5.20
small sawmills I	1,000 - 2,500	3.97	34.27	57.23	8.51
small sawmills II	2,500 - 5,000	2.86	33.42	54.82	11.76
small sawmills III	5,000 - 10,000	7.52	33.85	28.84	37.31
medium size sawmills I	10,000 - 20,000	6.07	35.50	8.88	55.62
medium size sawmills II	20,000 - 50,000	7.56	38.73	1.82	59.46
large sawmills I	50,000 - 100,000	9.16	33.43	0.10	66.47
large sawmills II	100,000 - 500,000	34.38	35.20	0.40	64.40
x-large sawmills	> 500,000	27.09	31.40	1.00	67.60
Total		**100.00**	**34.33**	**23.87**	**41.81**

Source: Mantau and Hick, 2008

Table 5-11: Share of sawmill by-products in German sawmill industry by size (NC)

Sawmills size class	Max. annual capacity [m³ log input]	Share of total cuttings [%]	SBP assortments Dust [%]	Slabs [%]	Chips [%]
x-small sawmill	< 200	0.10	36.62	58.18	5.19
small sawmills I	200 - 500	1.64	36.81	57.67	5.60
small sawmills II	500 - 1000	1.15	35.40	48.61	15.98
small sawmills III	1000 - 2500	6.67	31.16	49.73	19.16
medium size sawmills I	2500 - 5000	7.38	30.47	51.80	17.80
medium size sawmills II	5000 - 10000	21.09	28.70	53.08	18.31
large sawmills I	10000 - 20000	29.98	39.86	39.86	20.30
large sawmills II	20000 - 50,000	15.70	27.38	36.03	36.59
x-large sawmills	> 50,000	16.29	24.30	36.00	39.70
Total		**100.00**	**32.30**	**47.89**	**19.85**

Source: Mantau and Hick, 2008

The results of the German study are very comprehensive. Due to low data availability on sawmill industry structure in the particular EU 27 countries the initial amount of nine sizes for the assessment of sawmill by-products is reduced to four classes (see Table 5-12 and Table 5-13). Based on weighed mean values, shares of sawmill by-products segments of compressed and new sizes are adjusted. Moreover, adjusted shares of each size on total cuttings result from compression.

Differences in the structure

Basically, modelling coniferous and non-coniferous sawmill by-products segments and volumes follows the same structure (size classes). However, the sizes differ: Sizes for non-coniferous sawmills range from <1,000 m³ to >50,000m³, whereas coniferous sawmills range from <1,000 m³ to >500,000 m³ of annual capacity. Differences in resulting sawmill by-product assortments and volumes mainly refer to the use of above described sawing technology. Large size mills predominantly use chipper / chipper canter saw lines, whereas small and medium size mills rather apply frame and band saw technology.

Table 5-12 and Table 5-13 display the reduced German sawmill size structures of coniferous and non-coniferous sawmills– consisting of 4 sizes (annual cutting capacity) and respective shares of sizes(share of sawmill size on annual cutting capacity/ on total number of sawmills). Results of sizes and respective share of each sawmill sizes are used as default values for modelling and represent Type A. The default values further serve for the definition of two further types (B and C) of sawmill size structures (compare chapter 5.4.2.3). Based on the default values, the shares of respective sizes are either decreased or increased.

Table 5-12: Reduced and adjusted sawmill sizes (C) – default values

Max. annual capacity [m³ log input]	Share of total cuttings [%]	SBP assortments		
		Dust [%]	Slabs [%]	Chips [%]
< 1,000 m³	**2.00**	0.66	1.23	0.10
1,000 - 19,999 m³	**20.00**	6.87	6.41	6.72
20,000 - 500,000 m³	**51.00**	18.06	0.28	32.66
> 500,000 m³	**27.00**	8.48	0.27	18.25
Total	100.00	34.07	8.20	57.73

Source: own calculations

Table 5-13: Reduced and adjusted sawmill sizes (NC) – default values

Max. annual capacity [m³ log input]	Share of total cuttings [%]	SBP assortments		
		Dust [%]	Slabs [%]	Chips [%]
< 1,000 m³	**3.00**	1.09	1.62	0.29
1,000 - 19,999 m³	**14.00**	4.31	7.11	2.58
20,000 - 50,000 m³	**67.00**	22.38	28.90	15.75
> 50,000 m³	**16.00**	3.89	5.76	6.35
Total	100.00	31.66	43.40	24.97

Source: own calculations

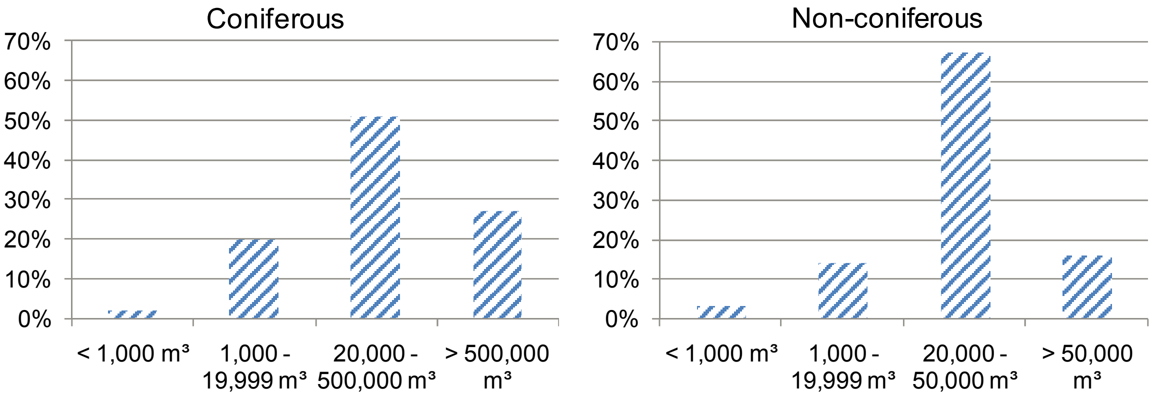

Figure 5-5: Default values/ shares of sawmill sizes on total cutting type A

The following Table 5-14 and Table 5-15 show the results of modelling three different types of sawmill industry respectively sawmill size structures. They are based on German default values and most common and reasonable sawmill industry structures. Types A, B and C represent the different compositions of sawmill sizes and differing share of the four sawmill sizes in a country. However, they are theoretical constructs and modelled flexible for individual adjustment.

Table 5-14: Types of sawmill size structure and shares of sawmill by-product assortments

Type	Max. annual capacity [m³]				SBP assortments		
	< 1,000 m³	1,000 - 19,999 m³	20,000 - 500,000 m³	> 500,000 m³	Dust [%]	Slabs [%]	Chips [%]
A	2.00	20.00	51.00	27.00	34.07	8.20	57.73
B	5.00	20.00	75.00	0.00	35.09	9.91	55.01
C	10.00	40.00	50.00	0.00	34.77	19.27	45.97

Source: own calculations

Allocation of capacities and sawmill by-products based on sawmill sector classification

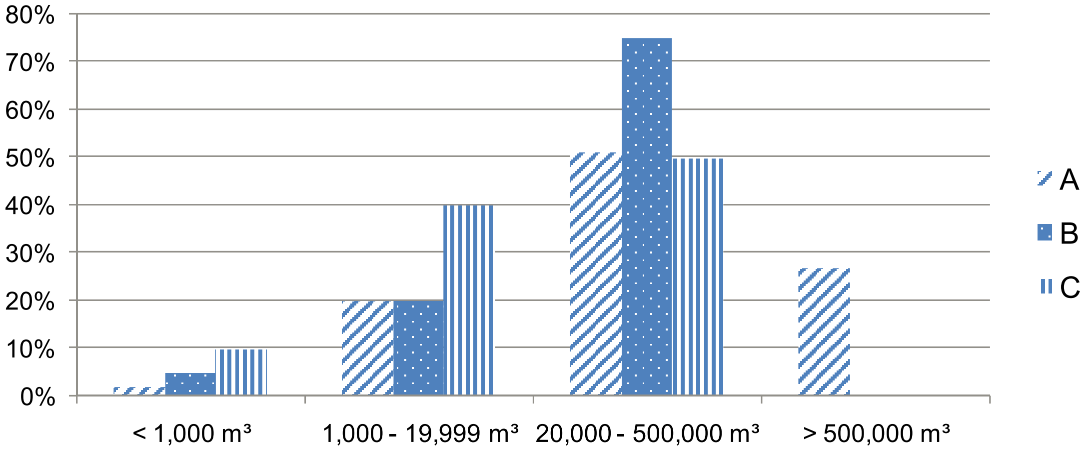

Figure 5-6: Share of sawmill size (C) on total cuttings [%] by type A, B or C

Table 5-15: Types of sawmill size structure (NC) and shares of SBP assortments

Type	Max. annual capacity [m³]				SBP assortments		
	< 1,000 m³	1,000 - 19,999 m³	20,000 - 50,000 m³	> 50,000 m³	Dust [%]	Slabs [%]	Chips [%]
A	3.00	14.00	67.00	16.00	31.66	43.40	24.97
B	10.00	60.00	30.00	0.00	32.12	48.84	19.09
C	40.00	60.00	0.00	0.00	32.97	52.12	14.96

Source: own calculations

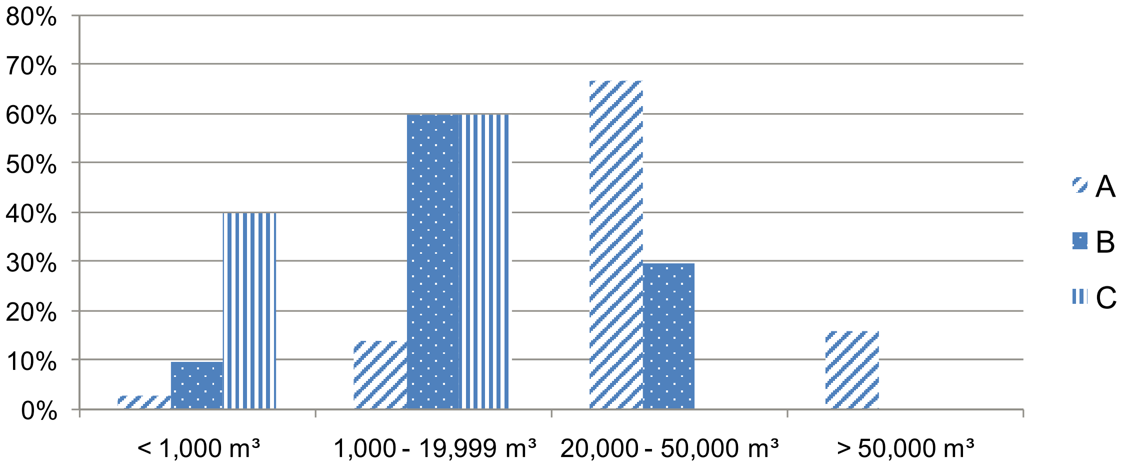

Figure 5-7: Share of sawmill size (NC) on total cuttings [%] by type A, B or C

Classification

As described in chapter 5.4.2.2 a recovery rate (sawnwood output as % of log input) has to be assigned to each country if not given by specific country information. Thus, the assignment of a recovery rate is partly based on comparison with reference regions and individual case decisions. In a first step, a range of recovery rates is assigned. The recovery rate ranges are consecutive, grouped into three ranges. Ranges for coniferous sawnwood production are 49-54%, 55-59% and 60-65%. Ranges of recovery rates for non-coniferous sawnwood production are 40-50%, 51-55% and 56-66%. Among other available background information, country specific information given by Fonseca (2010) were used to assign a definite recovery rate to each country based on comparison.

Further, each country is classified according to modelled types of sawmill size structures (A, B and C).

The existence of sawmills larger than 500,000m³ respectively 50,000m³ annual cutting capacity is done based on elimination.

Moreover, the classification is based on existing country data (e.g. Czech Republic) or described assumptions (compare 5.4.2.3). The following data sets and references support the classification.

- More or less up to date UNECE country reports present overall information on a country's forest industry, with partly detailed information on the national sawmill industry.
- Country specific data, which further describe the sawmill industry structure and give evidence for the industry's sizes can be found from the website 'The Sawmill database' (www.sawmilldatabase.org). The database is a constantly updated collection of available country specific information, useful for an overview and approach; however, it is not scientifically reliable.
- Comparable country specific sawmill industry studies with detailed information on sizes were available for the Czech Republic (Bomba, 2009) and Pražan and Přikasky, 2007, (in Czech language). Information on the Estonian sawmill industry, useful for comparison of Baltic countries is

given by Zirnhelt & Lesser (2003).

- A study by Kando and Buongiorno (2009) provides information on the efficiency of wood and fibre utilisation in some EU 27 countries ("Efficiency in wood and fibre utilisation in OECD countries"). The relevance of the study's results is limited due to its approach concerning data and calculation. However, the results may serve as important indicators.
- A discussion paper on forest products conversion factors for the UNECE region (Fonseca, 2010) provides important information on raw material input and output of wood-based forest products. Data cover country reported data and average values; however detailed data exist for few EU 27 countries only.

Calculation

FAOSTAT production data of coniferous and non-coniferous sawnwood form the basis of the calculation of volumes of sawmill by-products and the assortments dust, slabs and chips. However, volumes of sawmill by-products and assortments are calculated on the basis of the total cutting volume (roundwood input), which in turn is calculated based on the assigned recovery rate.

Equation 5-3: Sawmill by-products – total annual cutting

$$TAC = SW_{produced} / RR_{assigned}$$

Definition: TAC = total annual cutting volume, SW = sawnwood, RR=recovery rate,

An average share of 0.7% (coniferous) respectively 1.6% (non-coniferous) for losses is subtracted from the total cutting volume. Losses are considered as unrecovered volumes, which do not account for sawmill by-products or produced sawnwood (e.g. due to losses during transport).

Equation 5-4: Sawmill by-products – total volume

$$\text{Total SBP} = TAC / ((100\%-RR_{assigned}) - \text{losses}\%)$$

Definition: TAC = total annual cutting volume,

Finally, the share of the total volume of sawmill by-products can be calculated based on the difference of 100% - losses – recovery rate. Based on the results of previous classification the shares of the different sawmill by-products assortments are given by the types of sawmill size structure.

5.4.3 Other industrial wood residues

5.4.3.1 Semi-finished and manufactured wood products

The segment of other industrial wood residues (oIWR) comprehends wood residues accumulating during production of semi-finished wood products as well as during their processing (resawing, planing) and the production of manufactured wood products (construction, furniture, etc.). By origin, other industrial wood residues clearly have to be separated from sawmill by-products.

Particular assortments of other industrial wood residues are small fractions such as dust and shavings from planing, milling and drilling. Other assortments are trimmings, rejections, peeler cores or square-cuttings. Following, production of semi-finished wood products is analysed according to accumulating volumes of industrial wood residues.

5.4.3.2 Modelling other industrial wood residues from semi-finished wood products

Modelling of other industrial wood residues of wood-based panels is based on input - output calculations and respective material recovery. Volumes of raw material input are calculated based on conversion factors by Mantau & Bilitewski (2010) as well as Fonseca (2010) (compare Mantau & Saal, 2010).

Next to sawnwood production the segment of semi-finished wood products also covers production processes of wood-based panels (compare Figure 5-4). However, accumulating residues account for other industrial wood residues.

Coefficients and conversion factors

In a first step the production of wood-based panels (veneer sheets, plywood, particle board, OSB, MDF, hardboard and insulating board) is analysed according to accumulating wood residues per production process. Information for this analysis was provided by studies conducted at the University of Hamburg in recent years (Frings, 2004; Hartig, 2003). Results of this analysis could only be used for comparison and validation.

Relevant data on shares and material recovery rates for different wood-based panels is given by the updated life cycle analysis for wood products (Mantau & Bilitewski, 2010). Based on results of an empirical study on German wood-based panel industry and material flow analysis input – output ratios particular coefficients for other industrial wood residues or bark can be ascertained (determined). Concerning the composition of wood-based panels, the coefficients cover density differences of input raw material and output products by means of considered compression. Data by Mantau & Bilitewski (2007, 2010) are supplemented and combined with conversion factors by Fonseca (2010). Similar to available data of sawnwood material balances, data by Fonseca (2010) represent the results of a survey conducted by the UNECE among the EU 27 countries. Up to 11 countries of the EU 27 provided country specific data. Average volumes are used for calculations. Table 5-16 shows resulting coefficients and available conversion factors. In some cases, conversion factors by Fonseca (2010) are only used for comparison and validation.

Table 5-16: Coefficients for wood-based panels

Product	Factor m³rw/m³p (Mantau, 2010)	Factor m³rw/m³p (Fonseca, 2010)	Share wood residues
Particle board	1.48	1.51	3.94%
OSB	1.47	1.63	9.80%
MDF	1.80	1.68	9.61%
Hardboard		2.03	11.61%
Insulation board		0.83	4.75%
Veneer/ Plywood		1.87	45.00%

Source: Mantau, 2010, Fonseca, 2010, own calculations

Assumptions

Generally, production processes of the particular wood-based panel products are assumed to be similar throughout the EU 27 countries. Moreover, it is assumed that technology development and requirements regarding material and product quality are the same. Differences might occur in the composition of raw materials. However, conversion factors by Fonseca (2010) as well as data by Mantau & Bilitewski (2010) consider the composition of different species as raw material by specific gravity of product and raw material or independent compression factor. Coefficients result per production process and are applied for each EU 27 country.

Since data by Mantau (2010) do not provide particular raw material input coefficients for the production of hardboard and insulation board the production processes of hardboard and insulating board are assumed to be similar to the production of MDF. However, due to considerable differences in density of the two wood-based panel products, the shares of residues need to be adjusted (compare paragraph: Calculation of other industrial wood residue volumes of hardboard and insulating board).

Calculation

Similar to the calculation of sawmill by-products and respective assortments, the calculation of other industrial wood residue volumes is based on available production data (FAOSTAT, 2009). The initial raw material input is calculated based on given coefficients and conversion factors of the particular product. Volumes of bark and wood residues are included in the total volume of raw material input. Based on given shares of bark and other industrial wood residues the respective volumes are calculated.

The calculation based on coefficients by Mantau (2010) considers a compression factor, which represents density differences of input raw material and output product. Data by Fonseca (2010) provide additional information on the shares of moisture, bark and binders and fillers.

Calculation of other industrial wood residue volumes of hardboard and insulating board

The particular wood residue volumes of hardboard and insulating board are calculated based on available coefficients and conversion factor of MDF.

The input of raw material volumes for hardboard production is calculated on the basis of MDF. The calculation of raw material input in the production of insulating board is based on the conversion factor provided by Fonseca (2010).

The respective shares of wood residues of production of hardboard and insulating board are calculated based on the relation to MDF. The relation of raw material input of hardboard to that of MDF respectively insulating board to MDF (data given by Fonseca, 2010) results in a factor. Further, the share of other industrial wood residues of MDF is multiplied by the factor.

5.4.3.3 Modelling other industrial wood residues from manufactured wood products and further processing

The sector of manufactured wood products and further processing in forest industries can be described according to its branches (see Figure 5-4).

Other industrial wood residues from further processing derive from the utilisation of sawnwood and wood-based panels in construction, furniture industry, packaging and other processing of semi-finished wood products. Other industrial wood residues, which accumulate during further processing mainly cover dust, shavings, trimmings rejections or cuttings. Compared to the production of semi-finished wood products the share of wood residues is higher. Moreover, since the volumes of processed raw material input cover sawnwood and wood-based panels the output of other industrial wood residues in further processing is considerably higher.

Approach

Other industrial wood residue volumes derived from manufactured wood products and further processing are related to the total consumption of sawnwood and wood-based panels. Data by Mantau & Bilitewski (2010) provide detailed data on wood residue shares for four further processing industry branches: construction, furniture industry, packaging and further processing of other wood products. However, the consumption of raw material for further processing differs considerably by industry branch and country. Therefore, the consumption of sawnwood and wood-based panels has to be modelled based on factors describing the size of the different industry branches. The four further processing branches are assumed to be very applicable to describe the further processing industry structure of a unit (here EU 27 countries).

Assumptions

Data on turnover or the number of employees of an industry branch are useful indicators to describe the size and possibly also the volume of the considered branch. Compared to rather unifying assumptions to model residues from wood-based panel production (see 3.2.6.2) differences in the structure need to be considered when modelling wood consumption in the four branches. The different further processing industry branches consume different volumes of semi-finished wood products. Data on consumed volumes per branch are not available. Moreover, these volumes differ considerably by country due to different distinction and development of the branches. Thus, an approach to describe the structures of the respective national further processing industry has to be developed.

However, the technological development of the further processing industry is assumed to be similar throughout the EU 27 countries. This assumption makes it possible to use available data of the share of other industrial wood residues by branch (for Germany) for all EU 27 countries.

Data and modelling

Consumption

As already described, the modelling of other industrial wood residues from further processing is based on the total consumption of wood products – sawnwood and wood-based panels. Particular data on consumption are given by FAOSTAT.

Share of other industrial wood residues

Particular data on the share of accumulating wood residues per further processing branch are given by the results of the life-cycle assessment by Mantau and Bilitewski (2010). The results are based on an empirical study conducted within German forest industry companies. The following Table 5- 17 presents the different shares per industry branch. The given shares are applied for all EU 27 countries.

Table 5- 17: Shares of other industrial wood residues by further processing industry branch

Industry branch	Share of other industrial wood residues [%]
Construction	10.3
Furniture industry	18.4
Packaging industry	9.7
Other	13.0

Source: Mantau and Bilitewski, 2010

Consumption by branch and country

Data on the raw material consumption per industry branch and country are derived from data given by EUROSTAT. Based on the Statistical classification of economic activities in the European community (NACE[15], NACE rev. 1.1) the four considered industry branches are described by single economic activities. Table 5-18 shows, which industrial activities were used to describe the further processing branches. Economic indicators such as turnover of industrial activities and the number of employees per industry branch describe the size of the branch by monetary value / number of persons respectively.

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[15] NACE Nomenclature statistique des activités économiques (Eurostat, 2010)

Table 5-18: Further wood processing branches (NACE rev.1.1)

Industry branch	NACE rev.1.1	Classification of industrial activities	
Construction	DD	20.30.11	20.30.20.00
Packaging	DD	20.40.11.33	20.40.12.50
Other	DD	20.51.11.00	20.51.14.50
Furniture	DN	36.11.12.30	36.11.12.90
		36.11.14.10	
		36.12.12.30	36.12.13.00
e.g. Kitchen		36.13.10.50	36.13.10.90
		36.14.12.30	
		36.14.12.50	
		36.14.13.00	
		36.14.15.50	

Source: Eurostat, 2010

The according description of industrial activities classified by NACE rev. 1.1 can be found from Eurostat correspondence tables (Eurostat, 2010a). Based on available data two datasets for the EU 27 countries (2007) are generated. The datasets for industrial activities are filtered according to the economic indicators of turnover by industrial activity and the number of employees.

Up to that point, the datasets only reveal the size of the industry branches by monetary value or demand of employees. The results for the particular industry branches show, that the furniture industry registers the highest turnover and also the highest number of employees. Figure 5-8 shows the shares of each sector by turnover.

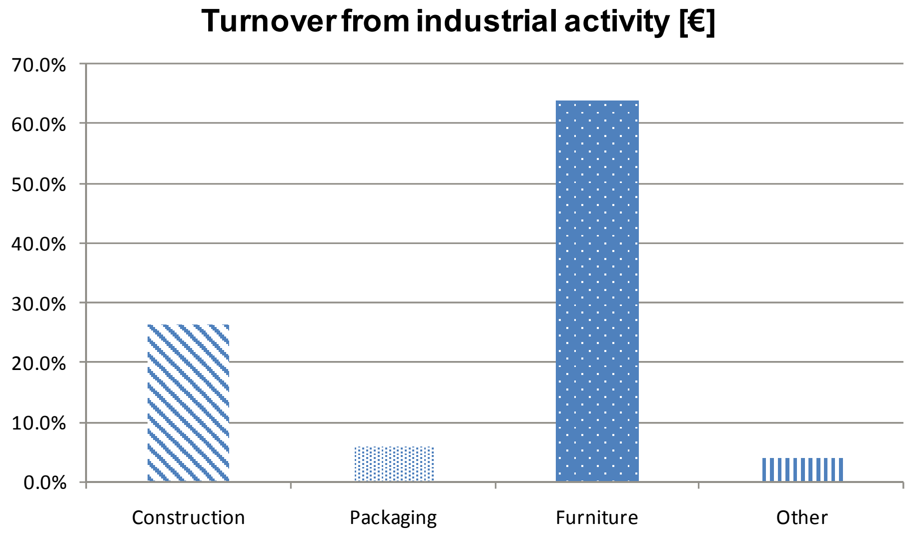

Figure 5-8: Share of industry branches by turnover on industrial activity [€]

Figure 5-9 shows the shares of each sector by the number of employees.

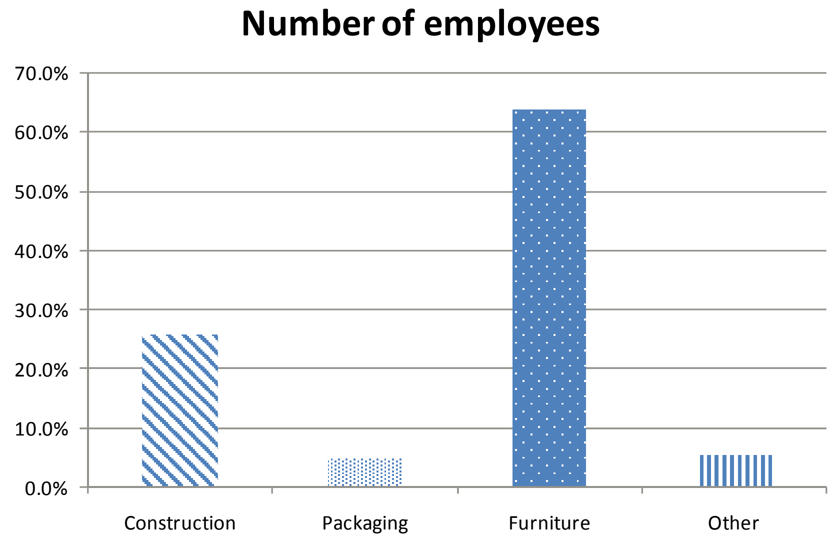

Figure 5-9: Share of industry branches by number of employees

However, regarding the reference numbers by Mantau and Bilitewski (2010) for Germany, it is obvious that the industry branch of construction has a higher raw material input (i.e. consumption of manufactured wood products) than the other branches. Therefore, an expansion factor has to be developed based on empirical data from the German forest industry sector to assess the size of the particular branch by the volume [m³] of consumed sawnwood and wood-based panels.

Based on given data for the absolute wood consumption in the single branches and the turnover values given by Eurostat (2010) for Germany (2007), an expansion factor for each industry branch can be generated. Table 5- 19 shows the generated expansion factors for consumption/ turnover and consumption / employee.

Table 5- 19: Expansion factors for consumption of wood

Industry branch	Construction [m³/100,000 €]	Consumption [m³/employee]
Construction	262.6	310.6
Furniture industry	43.3	72.2
Packaging industry	266.1	513.4
Other	115.7	115.0

Source: own calculations

Further, the factors serve as conversion factor for the calculation of consumed volumes of manufactured wood products in m³ consumed wood products. The shares of consumption in the four industry branches finally result from the calculation of turnover values respectively number of employees and applied coefficients/ expansion factors.

The application of the expansion factor for actual consumption of wood products results in reasonable shares of consumption. The comparison with basic data (Germany – Mantau & Bilitewski, 2010) approves the results. Generally, the consumption of wood based panels and sawnwood in construction is the highest among the four further processing branches. The following Figure 5-10 and Figure 5-11 show the shares of wood products consumption for the particular branches based on the application of the expansion factors.

Figure 5-10: Share of industry branches by turnover on industrial activity

Note: with applied expansion factors

Figure 5-11: Share of industry branches by number of employees

Note: with applied expansion factors

The results show that both approaches, based on turnover by industrial activity as well as the number of employees are reasonable to model the consumption of manufactured wood products in the four industry branches. However, even though assumed for modelling, that the conditions of production are similar, shares given by the number of employees have to be considered more critically. The efficiency of production regarding the number of employees still differs significantly within the countries of the EU 27.

5.4.4 Black liquor

5.4.4.1 Introduction

Black liquor is a by-product from the production of wood pulp for paper making. The pulping process residues mainly consist of lignin and hemicelluloses, cooking chemicals (for pulping) and water. Black liquor results from chemical pulping processes when wood is cooked with appropriate chemicals to separate cellulose fibres from lignin and other wood components.

Approximately 40 to 50% of the input wood raw material is recovered as usable fibre in the chemical pulping processes (Smook, 1992). The other "half" of the input wood along with an equal amount of spent caustic cooking chemicals, forms the black liquor.

Recovery process

The initial form of pulp process residue, weak black liquor has a content of solids of only 13 to 17% by weight. Since the share of solids is too low for combustion (Marklund, 2010), the black liquor is evaporated to raise the solid content in the liquor and burn it at a solids content of 60 and 80% (Smook, 1992). During evaporation and the reduction of the share of liquor the black liquor converts some of its chemical energy either by full recovery (boiler) or partial (gasifier) combustion. Further, the combustion yields in an inorganic smelt and gases.

Most of the chemicals in the smelt that leave the recovery unit are led back into the pulping process as green liquor respectively white liquor after several recovery processes (e.g. causticising) (Marklund, 2010).

Importance of black liquor

According to Smook (1992) the recovery of process chemicals, their reconstitution and especially the generation of energy from organic process residues are crucial for any pulp mill recovery process. Moreover, without the recovery cycle, the process would be both economically and environmentally impossible (Marklund, 2010).

Results of the 2005 Wood Resource Balance (Mantau, 2007) show an adequate volume of 72 million m³ or 432 PJ of black liquor production in the EU. The production is shared three-ways with Sweden, Finland and the remainder Europe in equal parts of about 144 PJ each. From 1965 up to present the total production has shown a steady increase, with on average about 3.8%/year, in line with the growth of chemical pulp production.

5.4.4.2 Modelling future black liquor volumes

Approach

Similar to modelling of industrial wood residues volumes derived from solid wood products, the modelling of black liquor volumes is based on production data available in FAOSTAT. For the present calculation of black liquor volumes, only volumes of pulp for paper products are considered relevant for modelling.

This includes chemical and semi-chemical pulp. Dissolving pulp is excluded from modelling.

Assumptions

Within the modelling of black liquor the industrial wood residues segment is assumed simplified as the balance between raw material input and product output. That implies that the solid content of black liquor is assumed as residue volume.

Equation 5-5: Available black liquor from pulp production

$$ABL\ [m^3\ swe] = (I_{raw\ material}\ [dmt] - O_{pulp}\ [dmt]) * swe$$

Definition: ABL = available black liquor, Iraw material = Raw material input, Opulp=pulp output, swe = solid wood equivalent based on species composition and specific gravity

Generally, it is assumed that the mass of black liquor is burnt completely. For the current study it is relevant to assume that all black liquor produced in the European pulp and paper industry is recovered in the pulp mills for energy production.

Technical features of pulp production and thus resulting volumes of black liquor are assumed to be similar throughout the EU 27 countries, which produce pulp.

The share of lignin differs by wood species, thus the mass of lignin in the black liquor volumes differ. Therefore the share of coniferous or non-coniferous roundwood input has to be considered. Based on the share of coniferous roundwood of the input raw material, specific gravity is assumed. For shares lower than 70% of coniferous roundwood an average gravity of 0.43 t/m³ for coniferous and non-coniferous species is assumed. For the share of coniferous roundwood higher than 70% a specific gravity of 0.4 t/m³ is applied.

Data

Basic data on the production of chemical and semi-chemical pulp are provided by FAOSTAT for the year 2007. Country reported data and average values by Fonseca (2010) provide basic factors for the conversion of production volumes to initial raw material input. Data on the share of coniferous roundwood for pulp production input for some pulp producing countries are provided by the Confederation of European paper industry (CEPI, 2007).

Calculation

Due to different conversion factors for the processes the calculation of volumes of black liquor is separated based on the two chemical pulping processes. Moreover, chemical pulp is separated according to its two product outputs – bleached and unbleached pulp. Table 5- 20 presents the different conversion factors by Fonseca (2010) necessary for calculations.

Table 5- 20: Conversion factors

Pulp products	Average
Semi-chemical	2.67
Chemical	4.49
Bleached	4.63
Unbleached	4.55

Source: Fonseca, 2010

In a first step the respective (average) conversion factors given by Fonseca (2010) for chemical and semi-chemical pulp as well as bleached and unbleached chemical pulp are reduced by the specific gravity (coniferous 0.4 and mix of coniferous and non-coniferous 0.43). The applied gravity value depends on the share of coniferous roundwood of raw material input.

Equation 5-6: Reduction of conversion factors

$$\text{Coefficient} = \text{Conversion factor } [m^3/mt] * sg\ [t/m^3]$$

mt = metric tonnes (dry matter)

Resulting factors are applied on the produced pulp volumes (FAOSTAT, 2009) for the calculation of roundwood input for pulp production. The volumes are given in tonnes dry matter.

Equation 5-7: Calculation of raw material input [t oven dry]

$$I_{\text{raw material}}\ [t] = O_{\text{pulp}}\ [dmt] * \text{coefficient}$$

According to Fonseca (2009), produced pulp given in “air dried metric ton” has a moisture content of 10%. This means that e.g. one air dried metric tonnes of pulp consists of 900kg oven dry fibre and 100kg water. Therefore the values for pulp have to be reduced by 10% moisture content.

Equation 5-8: Reduction of moisture content

$$O_{\text{pulp}}\ [odt] = O_{\text{pulp}}\ [dmt] * 0.9$$

Definition: reduced by 10% moisture

Given that black liquor is assumed simplified as the balance between raw material input and product output, the subtraction of the oven dry pulp volume from the total raw material input results in the volume of black liquor [oven dry t].

Equation 5-9: Calculation of black liquor volume

$$BL\ [odt] = I_{\text{raw material}}\ [t] - O_{\text{pulp}}\ [odt]$$

Definition: BL = Black liquor

Finally, for the integration into calculations of the Wood Resource Balance the volume of black liquor given in oven dry tonnes has to be converted into solid wood equivalent [m^3(swe)].

Equation 5-10: Conversion of black liquor volume

$$BL\ [m^3\ swe] = BL\ [odt] / sg\ [t/m^3]$$

Definition: BL = black liquor volume [m³ swe]

The results of the calculation confirm the results of the Wood Resource Balance 2005 by Mantau (2007). However the structure and share of the main producing countries differ. Results based on data from 2007 show that Sweden and Finland produce a share of approximately 60%. Spain and Portugal share the production of about 15% of black liquor volumes. The other 25% are produced mainly produced in the Central European countries (A, DE, FR, BE, PL and CZ). There is no unused black liquor as it arises and is used always within a single industrial process.

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Chapter 6

Strategies and recommendations for a sustainable wood mobilisation

Author: Kit Prins

Content

6 Strategies and recommendations for a sustainable wood mobilisation

This work package aims to build a link between the research results of the other work packages and the needs of policy makers. It is dependent on the other packages for input as regards the scenarios of future supply and demand for wood, and takes as its starting point the balance between supply and demand which emerges from the analysis under the other packages.

The work package consists of three main stages:

1. Identification of policies which influence supply and demand for wood, with estimation of their influence (i.e. whether they increase or decrease wood supply or demand)
2. Identification, on the basis of the Wood Resource Balance (WP6), of the desirable main strategic directions to achieve wood supply which is sustainable and achieve the realistic potential wood supply
3. On the basis of 1 and 2, as well as work done elsewhere and existing policy, propose recommendations for policies which will influence wood supply and demand in the desired directions.

Throughout, this Work Package considers all policies influencing wood supply and demand, whether or not they originate in the forest sector. Energy and environment policies clearly play a major role, but so do industry and rural development policies, as well as macroeconomic management, trade and fiscal policies. It is essential from the policy point of view to take a cross sectoral approach and this is reflected in the recommendations.

A distinction is made between polices specifically focused on achieving a desirable supply/demand balance for wood in Europe, and a number of “framework conditions” which are necessary conditions for achieving this target. Forest sector policy makers must be aware of these framework conditions, attempt to influence them to the extent possible, and take them explicitly into account in their own policy making

The main tool for stage 1 (identification of policies which influence supply and demand) was a matrix of policy measures and instruments with their influence on wood availability. This matrix (see following chapter 6.1) was constructed by the EUwood team and circulated to a number of experts for comment, but represents a relatively new approach for the sector, and may need further critical review. On the basis of this matrix, a partial enquiry was carried out of the status of application of the policy measures, concentrating on the EU level as there is no single source of information on forest sector policies and institutions. The policy measures were also sorted according to their influence on wood availability (direction and strength of influence, as estimated by the EUwood team).

Stage 2 was based on an in-depth analysis of the results of the Wood Resource Balance, taken as a whole, and in particular of the assumptions underlying the various scenarios.

Stage 3 was derived by bringing together stages 1 and 2, identifying those polices which would stimulate the implementation of the strategic directions identified in stage 2.

The strategies and recommendations were reviewed by the team and then by a meeting of stakeholders on 4 June 2010 in Brussels. The final strategies and recommendations take account of the opinion of the stakeholders.

Despite the widespread consultation, the EUwood team is fully responsible for its recommendations as regards a strategy and policy.

6.1 Influence of policy measures on wood availability

This table lists policy measures which influence wood availability, explaining briefly how they influence wood availability whether the influence mainly concerns supply or demand of wood, with a very rough estimate of the direction and strength of this influence: "+++" means a strong positive influence on supply or demand, "---" a strong negative influence.

	Policy measure	**Link to wood availability**	**Focus**	**Potential Effect**
1	CLIMATE CHANGE			
1.1	Promote carbon sequestration in forests	Would discourage harvests which would reduce carbon stocks in forests	Supply	-
1.2	Promote cascaded use of wood i.e. first as raw material, then energy	Would ensure most rational use of wood and thus increase competitivity, sustainability and demand for forest products	Demand	++
1.3	Promote carbon storage in harvested wood products (HWP)	Allowing accounting for HWP under the Kyoto Protocol would encourage use of wood as a material before use as energy source	Demand	+
1.4	Promote use of wood energy to replace non-renewable energy	Promoting the use of sustainable energy would make wood use more attractive economically and stimulate demand	Demand	+++
1.5	Promote use of forest products to replace non-renewable products	Promoting the use of sustainable materials would make wood use more attractive economically and stimulate demand	Demand	+++
1.6	Introduce a carbon tax	Would make wood from renewable sources advantageous compared to carbon intensive materials and energy which would be disadvantaged by a carbon tax.	Demand	++
1.7	Further develop emission trading for carbon	Creating a market for carbon should deliver advantages to raw materials and energy which are not carbon intensive, like wood, thereby improving the competitiveness of bioenergy and forest products	Demand	++
1.8	Adapt management of European forests to expected climate change	Adaptation measures often favour shorter rotation lengths (decreased susceptibility of forests to disturbances, increased opportunity to select tree species or provenances)[16] and more intensive management, thus raising harvest levels	Supply	+
2	ENERGY			

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[16] This does not take into consideration negative influence on wood supply of climate change e.g. by drought, fire or insects or the positive influence of better growing conditions, e.g. longer growing seasons, as these are not policy/management choices

2.1	Include wood energy in biomass action plans	Giving wood a prominent and ambitious role in national biomass action plans (with supportive measures) would encourage higher wood supply	Demand	+ ++
2.2	Promote renewable energies through pricing	If the measures, e.g. feed-in tariffs, quotas and/or subsidies for renewables are high enough, they will increase wood demand.	Demand	+++
2.3	Promote renewable energies by supporting R&D	Successful R&D programmes will increase wood demand if they improve competitivity of wood-based energy (e.g. second generation biofuels)	Demand	+ +
2.4	Promote renewable energies by supporting investment (e.g. in wood burning stoves)	Will tend to increase demand for wood energy as in several areas, the bottleneck to increased wood use is boiler capacity (private or communal).	Demand	+ +
2.5	Encourage energy efficiency	Reduces overall energy demand in the longer term, In the shorter term, demand for energy is expected to increase in absolute numbers in light of the targets.	Demand	- -
3	AGRICULTURE AND RURAL DEVELOPMENT			
3.1	Encourage afforestation	Increases wood supply (in long term)	Supply	+
3.2	Support rural incomes	Increased income for farmers (from non-forest sources) increases the price differential between agricultural and forest land, discouraging wood supply. There is evidence that the higher rural incomes are, the less farmers need income from forestry	Supply	-
3.3	Develop rural infrastructure	Normally a rural economy and community based on high quality infrastructure should make it easier to access and supply more wood. However in some cases, there may be tradeoffs: e.g. between wood supply and tourism or protection of water supply.	Supply	+
4	MACRO-ECONOMIC POLICY, INCLUDING INDUSTRIAL DEVELOPMENT			
4.1	Manage for long-term growth	High economic growth increases demand and disposable income which will in turn increase demand for wood.	Demand	+
4.2	Put in place stimulus measures influencing the forest sector	A few stimulus packages specifically target green measures, notably renewable energies, but also forest management. These measures will presumably increase wood supply. However, in most countries stimulus	Demand Supply	+ +

		measures have not targeted specific sectors.		
4.3	Implement regional policy (specifically through investment support for forest industry)	A large new plant will normally increase wood demand substantially	Demand	+ (locally can be +++)
5	TRADE			
5.1	Implement trade measures which protect domestic forest industries	Measures such as anti-dumping or limitations based on other concerns (e.g. social conditions in exporting countries) giving domestic forest industries a cost advantage, thus strengthening demand for wood raw material	Demand	+
5.2	Implement trade measure which reduce protection of domestic producers	Lower tariffs (where possible) or the removal of non-tariff barriers increases competition. It may weaken domestic industries or, if the tariff reductions are part of a mutual arrangement, give them access to wider markets	Demand	-
5.3	Implement trade measures which restrict imports of wood raw material or products	Measures restricting imports of wood raw material may be based on phytosanitary concerns or concerns related to sustainability of forest management in exporting countries. In both cases, domestic wood production becomes more competitive compared to imports	Supply	+
5.4	Promote exports of forest products	In forest sectors of export oriented countries, higher exports of products will increase local demand for wood	Demand	+
6	FISCAL			
6.1	Implement favourable fiscal treatment of income from wood sales	Depends on the form and intent of the regime chosen, but may have very significant effect[17]	Supply	+ +
6.2	Implement non-targeted measures giving fiscal advantages for forest owners (e.g. reduction of succession tax)	Favours forest ownership and wealth of forest owners, but unclear whether and how it influences wood supply: prosperous forest owners may harvest less wood if the fiscal conditions are favourable	Supply	-
6.3	Implement favourable fiscal treatment of certain management actions, e.g. stand establishment, thinning	Cost reduction for measures linked to wood production will encourage wood supply, although sometimes with long delays (e.g. stand establishment)	Supply	+

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[17] See recent experience in Finland

7	ENVIRONMENT			
7.1	Increase areas protected for biodiversity	Decreases wood supply (or at least prevents increase) as harvest is often forbidden or constrained in protected areas, to varying degrees, depending on the conservation regime. However protected areas are often situated where there is not much wood supply anyway (remote, steep etc.).[18]	Supply	-
7.2	Protect biodiversity in forests without specific protection status	Reduces wood supply by forbidding or limiting harvesting and/or residue extraction in certain spots (e.g. “key habitats”) or imposing more expensive harvesting methods.	Supply	-
7.3	Reduce immissions of pollutants to forests	Reduced air pollution should increase forest health, so reduced pollution => increased wood supply[19].	Supply	+
7.4	Promote “green building”	Insistence on the use of sustainable local building materials should favour wood use, assuming wood is classified as a sustainable material in the different schemes and adequately promoted to producers and consumers.	Demand	+ +
7.5	Promote recycling, improve waste disposal systems	High landfill taxes and other waste disposal measures strongly increase the attractivity of recycling/recovery based solutions, thereby encouraging more wood supply from industry residues and, above all from post-consumer waste (wood and paper)	Supply	+ +
7.6	Implement sustainability provisions in public procurement policies	Public procurement rules setting specific criteria for forest products (i.e. that they come from sustainable sources) may limit use of certain forest products in certain markets (while other materials do not face similar requirements). However, when sustainability criteria are also applied to competing materials, the renewable nature of forest products should be an advantage	Demand	+

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[18] Verkerk et al. Verkerk, P. J., Zanchi, G. & Lindner, M. (2008) Impacts of biological and landscape diversity protection on the wood supply in Europe. EFI Technical Report 27. European Forest Institute, Joensuu. estimated the impacts of biological and landscape diversity protection on the wood supply in Europe. They found that on average 48% of the theoretical potential supply in forests with biodiversity protection could not be harvested, while landscape protection resulted in felling restrictions of 40% on those areas. Consequently, 67.8 million m3 could not be felled from these protected areas (compared to maximum harvest with no constraints).

[19] However, some pollutants (N, CO_2) increase site productivity (within certain limits), so reduced pollution => reduced wood supply.

7.7	Protect soil and site fertility	Limits on extraction of nutrients from sites and on techniques which harm soil by compaction or influence watercourses will reduce availability especially of branches and stumps, and raise costs	Supply	- -
7.8	Limit emissions of micro-particles, notably from wood burning boilers	Will reduce demand for wood energy in the short term by increasing costs of equipment and forcing some installations out of service. May well be positive in the longer term, as confirming wood as a clean energy	Demand	-
7.9	Promote payment for ecosystem services	By providing income for non-wood supply functions, reduces incentive to supply wood	Supply	-
8	RESEARCH AND DEVELOPMENT, TRAINING			
8.1	Improve R&D funding to support competitiveness of the forest sector value chain	Competitive industries strengthen wood demand (and improve wood mobilisation), although the effect is quite long term. Major programmes like FTP involving many partners show the potential of this.	Demand	+ +
8.2	Improve education and training of workforce and forest owners	Without well qualified and skilled owners, managers, contractors and workforce, it is not realistic to expand wood supply. An under-skilled workforce could threaten present levels of wood supply	Supply	+
9	FOREST SECTOR			
9.1	Implement national forest programmes (NFPs)	NFPs aim at promoting the conservation and sustainable use of forest resources. They may increase wood supply by setting goals and enabling measures and coordinating national efforts	Supply	+
9.2	Provide support for forest owners	Small inactive forest owners and holdings are major obstacles to wood mobilisation. Possible measures are strengthening of associations and cooperatives, increasing size of management units through service agreements , land swapping, extension services, improved communication etc.	Supply	++
9.3	Provide support for improvement of forest and transport infrastructure	A frequent barrier to wood mobilisation is the cost of extraction and transport. Potential measures are intensification of forest road networks, removal of bottlenecks, changed technology (e.g. cable cranes on steep slopes) and increased permitted axle weights for trucks.	Supply	+
9.4	Provide support for forest management	A management plan is a prerequisite of more intensive forest	Supply	+

	planning	management, and typically leads to increased wood supply. Thus if governments support the creation of management plans, and if those plans foresee higher levels of wood supply, higher harvests could well be the result		
9.5	Provide support for silvicultural measures	Economic support and extension services can increase wood supply according to how they are applied and the levels of subsidy.	Supply	+
9.6	Provide support for improved organisation of wood raw material markets, better market information and coordination	In some roundwood markets, the bottleneck to expansion is inefficiencies in local or regional markets, arising from poor information flow, problems matching buyers and sellers etc. In these circumstances, improving market organisation will increase wood supply.	Supply	+
9.7	Promote the sound use of wood	Promotion efforts expand wood demand, which is transmitted up the supply chain	Demand	+
9.8	Regulate harvesting and transport methods (nutrients, compaction etc.)	Strongly influences availability of certain parts of the tree (stumps, branches) and acceptability of certain methods (skidding in fragile stands)	Supply	-
9.9	Prevent forest fires	Protects growing stock which may be harvested at maturity. Brush clearing to reduce fuel load generates local source of renewable energy	Supply	-
9.10	Communicate and educate on forest related issues	By correcting negative stereotypes, makes wood a more attractive material in public perception	Demand	+
9.11	Promote certification systems	Increases consumer trust in forest products	Demand	+ (may shift demand from one region to another)

6.2 Status of main policy instruments which influence wood availability

NB there are no comprehensive and organised data bases on forest sector policy instruments, so this list is only indicative, and shows examples.

	Policy measure	Instruments and status	
		EU level	**National examples**
1	CLIMATE CHANGE		
1.1	Promote carbon sequestration in forests	Carbon credits to forest owners under new AFOLU regime under discussion	Sweden: no policy in place Italy: economic incentives to enhance carbon sequestration in place
1.2	Promote cascaded use of wood i.e. first as raw material, then energy	Promotion and explanation, no specific policy instruments	
1.3	Promote carbon storage in harvested wood products (HWP),	Incorporation of accounting for HWPs into the Kyoto protocol second commitment period is under discussion	NA
1.4	Promote use of wood to replace non-renewable and energy	In the Kyoto Protocol accounting system, relevant measures penalise carbon intensive energy sources, rather than favouring renewable energies. Thus for substitution, there are no specific measures favouring wood consumption.	
1.5	Promote use of forest products to replace non-renewable products	In the Kyoto Protocol accounting system, relevant measures penalise carbon intensive materials, rather than favouring carbon poor materials. Thus for substitution, there are no specific measures favouring wood consumption.	
1.6	Introduce a carbon tax	Not yet implemented at EU level (proposed)	Carbon tax implemented in Sweden in 1991 (Naturvårdsverket, 2005), Carbon tax for cars implemented in Germany and several other European countries (http://www.co2-steuer.info/)
1.7	Develop emission trading for carbon	EU Emission Trading Scheme implemented, may be strengthened	Impact of EU-Emission trading scheme vary widely between countries, depending, among other things on how the emission permits are distributed (Sipilä et al. 2008)
1.8	Adapt management of European forests to expected climate change	Nothing in place	Many countries considering adaptation strategies, in the context of forest policy
2	ENERGY		

2.1	Include wood energy in biomass action plans	Biomass Action Plan	The German Biomass Action Plan (http://www.erneuerbare-energien.de/inhalt/43839/4593/, last accessed on 20090513), proposes a number of measures to increase the use of biomass in the energy sector.
2.2	Promote renewable energies through pricing	Directive on the Promotion of Electricity produced from Renewable Energy Sources (RES-E Directive)[20] Directive on the Promotion of the use of energy from renewable sources **(**2020 target)[21]	The RES-E Directive has driven most EU countries to set national targets for renewable electricity and establish specific feed-in tariffs for electricity from biomass. **Sweden** and **Italy**, among other countries, use quota and tradable certificates. Other countries, including **Germany** and **France**, use fixed feed-in tariffs (Sipilä *et al.*, 2008). **France**: reduced value added tax (VAT) rate to the supply of energy wood and biomass heat delivery (UNECE *et al.*, 2007b)
2.3	Promote renewable energies by supporting R&D	The EU 7th Framework Programme; The Intelligent Energy – Europe programme of the EU[22] The EU encourages the development of Technology Platforms, e.g. the industry-led Biofuel Technology Platform[23] and, above all the Forest Based Industry Technology Platform (FTP) at http://www.forestplatform.org/	**Germany**: The German government established a biomass research centre (http://www.dbfz.de/) in 2008, which is partly financed through the Federal Ministry of Food, Agriculture and Consumer Protection[24] The 5th Energy Research Programme entitled "Innovation and New Energy Technologies" finances research on and development of modern energy technologies.[25] **Sweden**: The Swedish energy agency supports research and development about the supply, conversion, distribution and use of energy, as well as the development of new technologies (http://www.energimyndigheten.se/en/Forskning/, last accessed on

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[20] Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market. The Directive sets a target for a 21 per cent share of electricity from renewable sources by 2010.

[21] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union, 5.6.2009 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF, last accessed on 20090617)

[22] http://ec.europa.eu/energy/intelligent/ (last accessed 20090601)

[23] Commission of the European Communities. (2006b) Communication from the Commission: An EU Strategy for Biofuels. COM(2006) 34 final. Brussels, 8.2.2006.

[24] http://www.bmelv.de/cln_044/nn_754188/DE/12-Presse/Pressemitteilungen/2007/126-BiomasseForschungszentrum.html__nnn=true (lass accessed on 20090601)

[25] http://www.foerderinfo.bund.de/de/316.php, last accessed on 20090515

			20090618).
2.4	Promote renewable energies by supporting investment (e.g. in wood burning stoves)	Rural development policy (Council of the European Union, 2005; Council of the European Union, 2009) can inter alia give support for installations/infrastructure for biomass energy	**Germany**: Act on heat from renewable energy[26] and the related Renewable Energy Incentive Program (Marktanreizprogramm), support measures for heat production from renewable sources, including biomass France: Calls for tenders of electricity production from biomass (UNECE *et al.*, 2007b)
2.5	Encourage energy efficiency		
3	AGRICULTURE AND RURAL DEVELOPMENT		
3.1	Encourage afforestation	Council regulation (EC) No 1698/2005[27] supports afforestation. MCPFE Guidelines for afforestation and reforestation provide “rules of the game”	Germany: GAK (support for afforestation) Several EU member states have adopted explicit policies to enlarge the forest area: Bulgaria, Cyprus, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Romania and the United Kingdom (MCPFE, 2007)
3.2	Support rural incomes	Support to rural incomes has always been a central part of the CAP and the rural development policy. Under the 2003 reform of the CAP, income support for farmers is no longer linked to the crops produced. Under Rural development regulation 1698/2005, Axis 1 (improving competitiveness of the agriculture and forestry sector) and Axis 3 (quality of life in rural areas and diversification of the rural economy) payments may be made to support rural incomes	Each member state develops its own rural development policy to implement the EU regulation. All contain support for rural incomes.
3.3	Develop rural infrastructure	Council regulation (EC) No 1698/2005[27], supporting measures such as afforestation, modernisation of agricultural and forestry holdings, and improving and developing infrastructure.	**France**: Rural development plan 2007-2013: adoption of a measure aiming at the modernisation of equipment and the improvement of the mechanisation of the forestry development companies with a view to developing the mobilisation of wood in compliance with safety at work and of environmental concerns (UNECE *et al.*, 2007b).

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[26] Erneuerbare-Energien-Wärmegesetz, http://www.erneuerbare-energien.de/inhalt/40512, last accessed on 20090513

[27] Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD).

4	MACRO-ECONOMIC POLICY, INCLUDING INDUSTRIAL DEVELOPMENT		
4.1	Manage for long-term growth	Many EU policy measures and institutions, including the European Central bank for the euro zone and the Maastricht criteria, influence the conditions of long term growth, but this remains an area where member states have the leading role.	All countries have extensive macro-economic policies for long term growth
4.2	Put in place stimulus measures influencing the forest sector	European Economic Recovery Plan[28], which includes the aim to speed up the shift towards a low carbon economy. Being implemented	Most European countries are implementing stimulus packages (and significant budget deficits which also stimulate demand). Few, if any, in Europe, include specific forest sector measures, but many target renewable energies.
4.3	Implement regional policy (specifically through investment support for forest industry)	EU regional development policy sometimes supports investment in the forest sector. In place	**France**: Investment aids for sawmills (UNECE *et al.*, 2007a) Germany: use of regional development funds for large sawmill in eastern Germany
5	TRADE		
5.1	Implement trade measures which protect domestic forest industries	EU Common Custom Tariffs[29] Council Directive 2000/29/EC[30] Commission Directive on wood packaging material[31]	Most trade measures are implemented at the Community level
5.2	Implement trade measure which reduce protection of domestic producers	EU Trade policy	
5.3	Implement trade measures which restrict imports of wood raw material or products	EU Trade policy, Sustainability criteria for biofuels FLEGT policy[32]	

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[28] Commission of the European Communities. (2008) Communication from the Commission to the European Council: A European Economic Recovery Plan. *COM(2008) 800 final*, Brussels.

[29] COMMISSION REGULATION (EC) No 1031/2008 of 19 September 2008 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff

[30] Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (OJ L 169, 10.7.2000)

[31] Commission Directive 2004/102/EC of 5 October 2004 amending Annexes II, III, IV and V to Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community

[32] Council Regulation (EC) No 2173/2005 of 20 December 2005 on the establishment of a FLEGT licensing scheme for imports of timber into the European Community

5.4	Promote exports of forest products	National level only	Most countries have export promotion services. In countries with major forest sectors, these programmes promote forest products exports.
6	FISCAL		
6.1	Implement favourable fiscal treatment of income from wood sales	National level only	Very varied situations: needs further investigation
6.2	Implement non-targeted measures giving fiscal advantages for forest owners (e.g. reduction of succession tax)	National level only	Very varied situations: needs further investigation
6.3	Implement favourable fiscal treatment of certain management actions e.g. stand establishment, thinning		
7	ENVIRONMENT		
7.1	Increase protected areas	Natura 2000 network[33]. Being implemented	**Germany:** Aim for 2020: increase the share of forest area without interventions to 5% of forest area[34] **Sweden**: A further 900,000 hectares of forest land of high conservation value will be excluded from forest production by the year 2010. Identified woodland key habitats shall be preserved within those 900,000 hectares. (Skogsstyrelsen, 2005) **Finland**: By 2016, the government aims to increase the area of privately owned forests with biodiversity protection by 82,000 to 173,000 ha in the context of the Metso programme[35]
7.2	Protect biodiversity in forests without specific protection	MCPFE resolutions H2 and V4 on biological diversity (EU being signatory to MCPFE	**Sweden**: By 2010, the volume of hard dead wood should increase by at least

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[33] Based on the Bird and Habitat directives: Council Directive 79/409/EEC on the conservation of wild birds, commonly referred to as the Birds Directive, Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

[34] Nationale Strategie zur biologischen Vielfalt, http://www.bmu.de/files/pdfs/allgemein/application/pdf/biolog_vielfalt_strategie_nov07.pdf,(last accessed 20090327)

[35] Government Resolution on the forest biodiversity programme for Southern Finland, 2008-2016 (METSO) of 27 March 2008

	status	process)[36] 2006 Biodiversity Communication and its Action Plan[37]	40% in the country as a whole, and considerably more in areas where biological diversity is especially at risk. (Skogsstyrelsen, 2005)
7.3	Limit air and water pollution, reducing immissions to forests	Many policy measures in place, e.g. on long range transboundary air pollution, ceilings for emissions and ambient air quality[38].	**Sweden**: Sulphur tax and nitrogen oxide charge (Naturvårdsverket, 2005) **Germany**: Federal Immission Control Act[39] **Spain**: Law 34/2007 on air quality and the protection of the atmosphere[40]
7.4	Promote "green building"		Programmes under development (France has just adopted a decree to increase the minimum level of wood in new buildings)
7.5	Promote recycling, improve waste disposal systems	Council Directive 1999/31/EC on the landfill of waste, aiming, inter alia, at the reduction of biodegradable waste (including paper and paperboard) going to landfills Directive 2000/76/EC on the incineration of waste sets air emission limits for waste incineration. Directive 2006/12/EC on waste, encouraging, inter alia, recycling of waste and	Most countries have specific waste disposal policies and strategies in place.

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[36] Helsinki Resolution 2, 1993: General Guidelines for the Conservation of the Biodiversity of European Forests, http://www.mcpfe.org/files/u1/helsinki_resolution_h2.pdf and Vienna Resolution 4, 2003: Conserving and enhancing forest biological diversity in Europe: http://www.mcpfe.org/files/u1/vienna_resolution_v4.pdf

[37] COM/2006/0216 final: Communication from the Commission - Halting the loss of biodiversity by 2010 - and beyond - Sustaining ecosystem services for human well-being. The Action Plan (Annex to the Communication) identifies several measures to safeguard biodiversity in forests, including the definition of measures to identify forest land of high value for biodiversity, implementing the MCPFE resolution on forest biodiversity (Vienna 2003), and strengthening the establishment and safeguarding of the Natura 2000 network.

[38] For instance:
Council Decision 81/462/EEC on the conclusion of the Convention on long-range transboundary air pollution;
Council Directive 85/203/EEC on air quality standards for nitrogen dioxide ;
Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants.
Directive 2008/50/EC on ambient air quality and cleaner air for Europe;
Directive 2000/25/EC on action to be taken against the emission of gaseous and particulate pollutants by engines intended to power agricultural or forestry tractors and amending Council Directive 74/150/EEC;

Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants

[39] http://www.bmu.de/files/pdfs/allgemein/application/pdf/bimschg_071023_en.pdf (last accessed on 20090618)

[40] http://www.todalaley.com/mostrarLey2214p1tn.htm (last accessed on 20090618)

		the use of waste as a source of energy	
7.6	Implement sustainability provisions in public procurement policies	Directive 2004/18/EC on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts provides the ground rules, but does not specifically mention rules for forest products	Several countries, including Denmark, France and the United Kingdom, have specific rules in place which determine criteria to be met by public agencies who procure forest products. Others are considering similar measures
7.7	Protect soil and site productivity		
7.8	Limit emissions of micro-particles, notably from wood burning boilers		
7.9	Promote payment for ecosystem services		
8	RESEARCH AND DEVELOPMENT, TRAINING		
8.1	Improve R&D funding to support competitiveness of the forest sector value chain	EU is major provider of research funding, notably under the sixth and seventh framework programmes (http://cordis.europa.eu/fp7/home_en.html)	National and private sector programmes are often coordinated with EU programmes. The Forest Based Sector Technology Platform coordinates private and public sector funding in the context of a Strategic Research Agenda (http://www.forestplatform.org)
8.2	Improve education and training of forest workforce	EU rural development policy supports inter alia vocational training and information actions, for persons engaged in the forestry sector, as well as setting up forestry advisory services (Council of the European Union, 2005)	All countries have ongoing education and training programmes and institutions. More research needed on specific situation for the forest sector
9	FOREST SECTOR[41]		
9.1	Implement national forest programmes (NFPs)	By signing the Vienna Resolution 1 of the MCPFE, the European Community endorsed and supports the MCPFE approach to NFPs in Europe.[42]	**Finland**: The aim of the NFP is to increase the annual harvesting of industrial roundwood (MCPFE, 2007) **Lithuania**: NFP includes a range of objectives aiming at strengthening economic viability of forestry activities (MCPFE, 2007) **France**: The NFP addresses inter alia

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[41] The Treaties on the European Union make no provision for a comprehensive common forest policy. Forestry measures are mainly implemented through environmental, rural development energy, enterprise and other policies at the EU level. There is however, a Forestry Action Plan

[42] MCPFE. (2003) Vienna Resolution 1: Strengthen synergies for sustainable forest management in Europe through cross-sectoral co-operation and national forest programmes. Fourth Ministerial Conference on the Protection of Forests in Europe, 28-30 April 2003, Vienna, Austria.

			the aim to increase wood use in construction and heating, cogeneration and biofuels, as well as possibilities for remuneration arising from the positive role of forests (carbon credits or domestic projects) (UNECE *et al.*, 2007b)
9.2	Provide support for forest owners	One of the key actions of the EU Forest Action Plan is to foster the cooperation between forest owners (Commission of the European Communities, 2006a)	**Germany**: GAK (supports forest owner associations and the mobilisation of wood) **Austria**: The National Programme for Rural Development promotes the establishment of forest owner associations (UNECE *et al.*, 2007a) **France**: The state supported the creation of the association "France Bois Forêts", which involves forestry owners and harvest and first transformation companies. The "DEFI travaux" programme (2006-2010) gives forest owners tax advantages for forestry work. (UNECE et al., 2007b)
9.3	Provide support for forest and transport infrastructure	See rural development policies	**Germany**: GAK **Italy**: Decree of the Government No 227/2001 on modernisation of the Forest Sector; Decree of the Ministry of Environment concerning "Guidelines for Forest Programming" (UNECE *et al.*, 2007b) **France**: A financial support scheme for forestry road network , support for mechanisation of forestry work (UNECE *et al.*, 2007a)
9.4	Provide support for forest management planning		Several European countries support forest management plans through subsidies or grants (MCPFE, 2007)
9.5	Provide support for silvicultural measures		**Finland**: support for energy wood harvesting from certain young stands and for wood chipping **Czech Republic**: wood chipping grants (Standing Forestry Committee ad hoc Working Group II, 2008) **France**: Tax incentives are available to carry out forestry work that will enable timber to be extracted (Standing Forestry Committee ad hoc Working Group II, 2008)
9.6	Provide support for improved organisation of roundwood markets, better market information and		**Ireland**: A core aim of the National Forest Plan is to increase national forest cover from the (sustainable) annual timber cut. Also **Finland, France, Hungary, Italy,**

	coordination		**Latvia, Slovenia and the Netherlands** have explicit policies to increase the use of wood, (UNECE et al., 2007b) **France**: aims to increase the market share of wood in construction by 25% until 2010, The Orientation Law on Forests from 9 July 2001 and the Communication in the Council of Ministers from 27 April 2005 on the forestry policy have the main objectives to develop forestry products and supply the secondary processing industries of wood, paper pulp and panel; to encourage employment and improve ergonomics and the forestry occupational safety of harvest, to improve the overall level of the results of the companies of the sector, to develop the mobilisation of wood through environmentally friendly techniques and to encourage the creation of local industries of energy-wood supply.(UNECE et al., 2007b)
9.7	Promote the sound use of wood		**Germany**: The Federal Government initiated a Wood Charter together with the directly affected stakeholders and interest groups, who committed themselves to an increased use of wood for construction, housing and energy purposes **Sweden**: During 2004-2005 a strategic programme for the forest-products industry was developed. Promotion of the sound and innovative use of wood was one of a number of priority issues. (MCPFE, 2007) UK wood.for.good campaign
9.8	Regulate harvesting and transport methods (nutrients, compaction etc.)		
9.9	Prevent forest fires	Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire Regulation (EC) No 2152/2003 of 17 November 2003 on the monitoring of forests and environmental interactions in the European Union (Forest Focus) European Parliament resolution on forest fires and floods (September 2006)(P6	

		TA (2006) 0349) LIFE+ Regulation (EC) No. 614/2007 on the Financial Instrument for the Environment (LIFE+) Commission Communication (COM(2008)130 final) on reinforcing the Union's disaster response capacity	
9.10	Communicate and educate on forest related issues		See 9.7
9.11	Promote certification systems		

7 EUwood glossary

Energy efficiency	Energy efficiency takes place when either energy inputs are reduced for a given level of service or there are increased or enhanced services for a given amount of energy inputs. Source: EIA: http://www.eia.doe.gov/emeu/efficiency/ee_gloss.htm.
Forest area available for wood supply	Forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. Includes: areas where, although there are no such restrictions, harvesting is not taking place, for example areas included in long-term utilisation plans or intentions (UNECE/FAO2000).
Growing stock	The living tree component of the standing volume (UNECE/FAO2000).
Gross Inland Energy Consumption	A measure of the energy inputs to the economy, calculated by adding total domestic energy production plus energy imports minus energy exports, plus net withdrawals from existing stocks. Source: EEA. 2001. Renewable energies: success stories. Copenhagen.
Main activity producer	Main Activity Plants refer to plants which are designed to produce electricity/CHP or Heat only. If one or more units of the plant is a CHP unit (and the inputs and outputs cannot be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Main activity supply undertakings generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the main activity grid. Source: IEA Balance builder 2007.
Net annual increment	Average annual volume over the given reference period of gross increment less that of natural losses on all trees to a minimum diameter of 0 cm (DBH.) (UNECE/FAO2000).
Recovery rate (forestry)	In procurement of logging residues: The share of utilised logging residues of the total amount of logging residues that are being generated in the forest as a result of a felling
Recovery rate (industry)	Describes the ratio of roundwood input – and product output in a forest industry production process (also of a considered unit)
RES Directive	EU Directive on the on the promotion of the use of energy from renewable sources
Soil bearing capacity	The capacity of soil to support the loads (e.g. forest machines) applied to the ground
Solid wood equivalent	A solid wood equivalent calculates the volume of solid wood transferred from one sector to another. The transfer can be carried out forward and backward.
Roundwood equivalent	A roundwood equivalent is calculated in one direction over several processes from roundwood to a specific stage of a product process (semi or final). It measures the total input of wood in a product along all production processes, including all losses and by-products.