A EUROPEAN WOOD PROCESSING STRATEGY: FUTURE RESOURCES MATCHING PRODUCTS AND INNOVATIONS

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Preface

COST Action E44, *Wood Processing Strategy*, started in 2004 and is ending with this Final Conference organised in Milan, Italy.

During this period knowledge needed to create a Wood Processing Strategy for Europe was gathered and several outcomes are included in this book. The work required for achieving this aim was divided across three Working Groups: WG1 - Forestry-wood industry chain; WG2 - Solid wood products; and WG3 – Wood-based panels. The working groups have been active and produced a lot of data and information covering whole supply and demand chains – from the forest to the end products and vice versa.

Wood Processing Strategy means a road map towards the future considering all aspects of the Forestry-Wood Industry Chain.

By means of this book of proceedings of the Final Conference as well as with the compilation of country reports and the compiled information from earlier conferences and workshops during this COST Action it is the intention to disseminate to both national and European decision makers active in the field of forestry and wood processing topics. The more general target audience can be summarised as: researchers involved in Forestry-Wood Industry topics, representatives from industry and their service providers, but also regional planners and policy makers and the general public.

The Management Committee of COST Action E44 decided to organise a Final Conference on “A European wood processing strategy: future resources matching products and innovations” in Milan on May 30th and June 2nd-3rd to provide direct interaction with the target audience and the media. Linking with the Xylexpo New Fair 2008 was an excellent opportunity to do so. Both the presentation of key notes and the organisation of a discussion forum related to the country reports are tools to provide optimal dissemination.

The Final Conference has been organised by the Cost E44 Managing Committee, in cooperation with Acimall, Federlegno and DISTAF (Department of environment forest science and technology) of the University of Florence.

The organisers and editors would like to thank the speakers for their papers and the national experts for their contribution to the discussion in relation to country reports. We are sure that everyone involved in the conference from organiser to participant would like to thank COST for sponsoring this event.

Joris Van Acker and Marco Fioravanti
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Keywords: Forest management, sustainability, global environmental change, environmental services, low carbon society, wood requirements and supply, bio-energy

ABSTRACT

The paper is aimed to present an overview of forest resources, considering the actual extent, at the European and global scale, of forest characteristics (forest area, growing stock, biomass and carbon store) and functions (productive and socio-economic) as well as the perspectives of long-term trends for supply and demand of forest products. The analysis is carried out on the basis of existing studies and statistics such as the Forests Resources Assessment (FAO, 2005), the European Forest Sector Outlook Study (UNECE, 2005) and the Workshop “National Wood Resource Balances” (2008). At European level the role of energy policies on forest sector (EU targets to produce 12\% and 20\% of energy from Renewable Energy Sources in 2010 and 2020, respectively) is also analysed in term of the impact on future wood supply and demand. According to the data actually available the EU future scenario highlights a deficit of wood supply in comparison with wood demand (rising from 46 Mm\textsuperscript{3} in 2005 to 134 Mm\textsuperscript{3} and 436 Mm\textsuperscript{3} in 2010 and 2020 respectively), thus suggesting the need to promote strategies able to mobilize additional forest resources in respect of sustainable management practices. However, the need to conduct detailed and realistic studies at national level in order to assess the potential wood supply considering different sources (like woody biomass from outside forest and post-consumer recovered wood) and the goal of developing a comprehensive research approach to cope with the deficit of wood supply, are stressed.

INTRODUCTION

The world land surface is covered by about 30\% with forest ecosystems, corresponding to a total surface of 3.5 Gha (giga hectares, i.e. 10\textsuperscript{9} ha). This figure is approximately half of the forest cover existing in the world when the human population started the agricultural revolution 10,000 years ago; at that time, mainly in the countries of oldest civilizations, as China and Europe, a large portion of the existing forests disappeared or were extensively degraded. Presently, European forest land, excluding Russia and Ukraine, covers a surface area of about 200 Mha corresponding to 35\% of the total surface area of Europe. In Europe and North America the forest cover is presently undergoing an historical change, a true inversion of the shrinking trend that was observable for the last centuries: the European forest surface is finally expanding steadily, since 1950, at an annual rate of circa 0.5\%, because of the abandonment of marginal agricultural farmland, particularly in the mountain and hilly regions of the continent; in the last decade a similar trend has been observed also in countries as China and India, traditionally deprived of forest mantle, clearly demonstrating that it is possible to reverse the curse of increasing deforestation. However, in most of the world, and particularly in the tropical regions,
forest cover is still decreasing at a very fast rate with millions of hectares that every year are degraded to open forests or even bare lands.

Most of the forest land in Europe is presently made up of productive forests, which are managed to produce a variety of goods and services. Among those, production of timber, paper and pulp still represent important objectives of forest management in a large fraction of European forests. They contribute to sustain European wood- and paper-based industries and to supply the European demand for these products. As such, forests are a fundamental part of the European social and economical life.

However, in the last decades the importance of environmental services provided by forests, both natural and planted, has even increased worldwide and it has been estimated to sum up to 70% of their total value (Costanza et al. 1997); the relative role of the different functions varies across Europe: in fact, while wood production and recreation is prominent in Northern and Central Europe, soil protection against erosion and landslides, and landscape improvement have a relevant role in Southern Europe. International Agreements, as those on biodiversity, sustainable development and climate change, have clearly recognised the role of forests at the global scale but have also identified the risk of the impact of environmental changes on forests stability and functions. However, a sound management of natural and man-made forests and the extension of their surface can help counteracting the risks of global change. After the UN Conference on Environment and Development in Rio de Janeiro (1992), the European forestry ministers embraced the principles contained in Agenda 21, i.e., the need and utility of internationally agreed ‘criteria and indicators for the conservation, management and sustainable development of all types of forests’ (Helsinki Conference, 1993): these objectives form the base of the pan-European criteria for sustainable forest management (SFM). These criteria and indicators of SFM were adopted at the Third Ministerial Conference in Lisbon (1998) and now inform the definition and implementation of SFM protocols for all European countries. Also, the ‘maintenance and appropriate enhancement of forest resources and their contribution to global C cycles’ was identified as one and important criterion of the SFM, quite relevant also for the compliance to the Climate Change Convention and to the Kyoto Protocol. This Protocol deserves much consideration, beside its specific role in reducing greenhouse gas (GHG) emissions, also because is one of the first example of assessing and quantifying the economical value of environmental services provided by forest ecosystems.

The international community, by acknowledging forests, both natural and planted, as an increasing source of environmental benefits while providing raw materials such as wood for industrial and non-industrial use, has taken action with multiple initiatives:

• at the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for “sustainable development” to preserve natural forests and to expand planted.
• The Kyoto Protocol acknowledges afforestation and forest management as a means to reduce Greenhouse Gas (GHGs) through the Clean Development Mechanism (CDM), International Emission Trading (IET) and Joint Implementation (JI).
• The United Nations Convention for Biological Diversity (UNCBD) acknowledges forests, if soundly planned and managed, can be positive contributors to preserve natural ecosystems and funding is available through the Global Environment Facility (GEF).
• The United Nations Convention for Combating Desertification (UNCCD) recommends national policies to support the rehabilitation and restoration of degraded ecosystems by planting through the Global Mechanism (GM).

The combined effect of global economic development, of the increasing need of environmental services provided by forest ecosystems, of expanding requirements of renewable raw material for industry and for energy to mitigate climatic change and the growing risk of forest vulnerability to
extreme climatic events, all these factors point to the need to mobilize wood resources by strengthening forest management, forest plantations, agro-forestry and innovative research in these various fields.

GLOBAL OVERVIEW OF FOREST RESOURCES AND WOOD MOBILIZATION

Forest area
At world wide level, total forest area is estimated to be about 4 Gha, or billion of ha, that is 30% of the of total land area. This corresponds to an average of 0,62 ha per capita, with significantly differences among countries in relation to environmental conditions. At regional level, South America is the region with the highest percentage of forest cover followed by North and Central America. Europe (with Russia) accounts for one-quarter of total forest area while Russian federation alone is the country the largest forest area in the world, with about 800 Mha (mega hectares, i.e. $10^6$ ha), or million of hectares.

Despite international efforts and wide debate in the global public opinion and media, deforestation continues at an alarming rate, mainly due to conversion of forests to agricultural lands in the Tropics; the net global change in forest area, measured as the difference between reduction due to deforestation and natural disasters and increase due to afforestation and natural expansion, is estimated to be $-7.3$ Mha per annum in the years 2000-2005, down from $-8.9$ Mha in the period 1990-2000. However, the increase of forest planting, landscape restoration and natural expansion of forests have significantly reduced the net loss of forest area occurring not only in North America, Europe and Japan but also in China and India. Among these countries it’s interesting to note that Italy is one of the ten countries with the largest annual net gain in forest area.

Forest types
In the world, 36% of forest surface is classified as primary forests: forest of native species in which there are no clear visible indications of human activity and ecological processes are not significantly disturbed. The majority of the world’s forests (53%), however, are considered as modified natural forests: forests of naturally regenerated native species in which there are clearly visible indications of human activities, therefore these are the silviculturally managed forests. A smaller percentage (7%) are considered as semi-natural forests that are those forests that include native species established through planting, seeding or assisted natural regeneration. The areas of primary forests and modified natural forests are decreasing because of deforestation and selective logging or other human interventions; Brazil and Indonesia have the highest rate of loss of these forests while European countries and Japan registered a positive rate of change.

The pressure on natural forests could be somehow relieved by increasing the role and extension of planted forests, mostly dedicated to wood and timber production. Forest plantations are those forests established through planting or seeding introduced (non-native) tree species; according to FAO (2005) planted forests account for 4% of global forest surface, covering almost 190 Mha worldwide. The area of forest plantation increased by 14 million ha during the 1990-2000 period; clearly, most of them are established for wood or fibre production.

Growing stocks and Production
In 2005 the total global growing stock of forest ecosystems was estimated at 434 Gm$^3$, of which about 30% is found in South America. The global average growing stock per ha is 110 m$^3$/ha while the countries with the highest growing stock per unit of surface are in Central Europe and in some tropical regions.

Growing stock shows a slightly decreasing trend at the global level, particularly in Africa, Asia and South America while in Europe, North and Central America it shows a slight increase.
About 34% of the global forest area is designated for production (wood and non-wood forest products); however, the total area of productive forests did not show any evident change during the period 1990-2005; on the contrary, productive forest plantations increased during the period 1990-2005, growing from 1.9% to 2.8% of global forest area. This trend varied according to different regions of the world: East Asia (particularly China), Europe (particularly Russian Federation) and North America (particularly United States) reported the greatest change of the area of productive forest plantations: a total increase of 23% compared to the previous time period.

Globally, wood and timber logging in 2005 was about 3 Gm³; 60% of the harvested wood consists of timber for the industry and 40% fuelwood. The countries with the highest wood harvests are USA, Brazil, Canada, Russian Federation and China. During the last 15 years the global wood harvesting showed a relatively stable trend, without significant changes. Only at sub-regional level the FAO Forest Resource Assessment (2005) reported different trends: for example Eastern and Southern African countries increased the harvest of woody products while East Asian countries decreased logging, mostly caused by a significant decrease in China.

The value of harvested woody and non-woody forest products is an indicator of the contribution of forests and woodlands to national economies. This information is used to develop and monitor national policies, set priorities and allocate resources. Globally, the value of wood harvesting in 2005 was 64 billion $, 57 billion $ of industrial roundwood and 7 billion $ of fuelwood. Industrial roundwood represent the main utilization of harvested wood resources in North and Central America; firewood represent the main utilization of wood removal in Asia and Africa where a great number of people still rely on wood for their energy requirements.

Globally, the value of harvested wood shows a slightly increase during the period 1990-2005. This is due to the increase of economic value of industrial roundwood, as the value of fuelwood did not change significantly. The total value increase amounts at about 11% over the last 15 years, but considering the inflation rate the real economic value has decreased at the global level during this period. Particularly interesting the case of Brazil where the wood production shifted from natural forests, obtaining a high price on the market, to forest plantations, characterized by lower prices but greater production.

Understanding the impact of tenure and land ownership issues on sustainable forest management is essential to design and implement effective policies by forest management and governance. In many areas forest ownership is in transition, shifting from state control to local communities and individual households. At global level, 84.4% of forests are public (not only owned by central, regional or local authorities but also owned by groups such as local communities). The highest private forests occurs in Central America (56%) and North America (29%). In Europe, Russia included, private forests represent 10%, although private ownership of forests is increasing. However, this increase involves limited geographical areas and the most relevant one is Central Europe with an increase of 14% during the period 1990-2000, mainly as a consequence of the privatisation of forest lands. In other regions of the world the increment of private ownership is due to the increment of planted forests.

**Energy and environmental functions**

Energy production strategies are playing an increasingly important role within national and international policies. Each countries’ and regions’ economies and societies are affected by the need to produce energy from renewable energy sources (RES) and to reduce the dependence from fossil fuels.

Actually, at EU level, RES account for about 8.5% of energy consumption. Biomass makes up the largest source of RES in EU (66%) and wood is the major source of biomass (89%).


Countries are elaborating different strategies in order to increase the use of RES; in 1997 EU targets were set to produce 12% of energy from RES by 2010, while the EU Biomass Action Plan set the target of a 20% production of energy from RES in 2020. In order to reach these objectives, it is expected that energy policies will have a strong impact on forest-based sector and wood-based industries. It is, thus, important to develop studies and analyses on the forest-based sector in the light of this rapidly changing picture.

Sustainable forest management, as it has been recently defined and structured at regional and global scale, includes among different forest functions and services also environmental change mitigation and greenhouse gas sequestration and storage. It is estimated that the world’s forests store 283 gigatonnes (Gt) of carbon in their biomass alone and 638 Gt of carbon in the ecosystem as a whole. At global level, carbon stocks in forest biomass decrease by 1.1 Gt annually mainly because of deforestation and forest degradation. Carbon in biomass decreased in Africa, Asia and South America; it increased in Europe, North and central America.

Biomass and dead wood account for 44% and 6% of the total forest ecosystem carbon content; while soil, down to 30 cm in depth, and litter account by 46% and 4% respectively.

**Wood resources mobilization**

Recent data from European countries, the 27 EU countries plus Switzerland and Norway (EU/EFTA countries), report an annual wood supply in the 2005 amounting at 775 Mm$^3$; 62% is made of roundwood and fuelwood while the remaining is made of residues from forest operations and of woody biomass from outside forests and supply co-products. Wood from forest and outside forest represents the most important source of wood (71% of the total supply) while post-consumer recovered wood represents a significant secondary wood source (4% of the total supply).

Wood raw material demand in these European countries amounted at 822 Mm$^3$ in the year 2005: 58% of the wood is used to produce goods like sawnwood, pulp and paper, wood-based panels and other products. The remaining 42% is used for energy generation. Sweden, France, Germany and Finland consume more than half (168 Mm$^3$) of the wood utilized to produce energy within the EU/EFTA countries. Most of the wood removals from forest and wood biomass outside forest (71%) finds material application while 29% is utilized to produce energy; also 62% of the secondary wood fibres (recovered wood, co-products) is utilized for energy purposes. In Table 1 the balance between supply and demand in European countries is reported; there are significantly differences among countries depending to the data availability and collection: in five countries the difference between supply and demand is less than 5%; in 22 countries is higher; in 10 countries is more than 25%. Further empirical researches and studies need to be implemented at national level in order to have a more clear data.

<table>
<thead>
<tr>
<th>Year (EU/EFTA 29countries)</th>
<th>Total wood supply [Million m$^3$]</th>
<th>Total use [Million m$^3$]</th>
<th>Difference [Million m$^3$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>775</td>
<td>822</td>
<td>46</td>
</tr>
</tbody>
</table>

The assessment of wood supply and demand for 2010 and 2020 is carried out using the existing European Forest Sector Outlook Study (UNECE/FAO, 2005). The perspectives of long term trends for supply and demand of forest products services is based on the assumption of three different possible scenarios:

- **baseline**: it assumes that long-term historical relationships in forest products markets will remain the same in future (prices and products will not change),
historical trends in the supply and demand of NWFPs and forest services will also continue unchanged in the future;
- **conservative**: it assumes that there will be an increase demand of environmental and conservative forest services in the future; consequently under this scenario forest product prices may increase slightly and economic growth will be slightly slower;
- **integration**: it assumes that there will be more rapid economic integration and market liberalization across Europe and thus an increase of economic growth; consequently the price of forest products will slightly decline.

<table>
<thead>
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<th>Scenario</th>
<th>Average annual rate of economic growth in Europe [%]</th>
<th>Average annual change in the real prices of forest products [%]</th>
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<tr>
<td>Baseline</td>
<td>2.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Conservation</td>
<td>1.5</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Integration</td>
<td>3.5</td>
<td>- 0.5</td>
</tr>
</tbody>
</table>

According to EFSOS, the wood-based industries (sawmills, panel and pulp and paper industry) in EU/EFTA countries will consume 483 m$^3$ in 2010 and will increase their consumption to 523 m$^3$ in 2020.

As for the future wood demand for energy, the analysis is based on national and EU targets for renewable energy; main assumptions are as follows:
- future energy consumption would stay at the level of 2005;
- adopting EU targets;
- the share among different renewable energy sources would be as in 2005;
- the amount of wood need for energy would be as in 2005;
- in the long term (2020) it is expected that other energy sources will be developed and become more competitive than wood; thus, the relative share of wood compared to other renewable energy sources will decrease to 75% of the level in 2005.

Furthermore, the wood supply from forests and forest plantations can be estimated according to Table 3 whose data have to be considered as minimum potential wood supply, based on the EFSOS baseline scenario.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wood supply directly from forests [million m$^3$]</th>
<th>Total wood supply: wood from inside and outside the forests [million m$^3$]</th>
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<tr>
<td>2005</td>
<td>531</td>
<td>775</td>
</tr>
<tr>
<td>2010</td>
<td>536</td>
<td>783</td>
</tr>
<tr>
<td>2020</td>
<td>569</td>
<td>824</td>
</tr>
</tbody>
</table>

Combining wood demand and energy targets an estimation of demand of woody raw material for industry and energy utilizatons can be implemented, as reported in Table 4; values should be considered as probable estimates of an order of magnitude rather than as precise estimates because the scenario has to be developed considering the interactions between the forest based industries and the wood energy demand.
Table 4: Estimates of future wood demand in EU

<table>
<thead>
<tr>
<th>Year</th>
<th>Material use, EFSOS scenario [million m³]</th>
<th>Energy targets [million m³]</th>
<th>Total use [million m³]</th>
</tr>
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<tr>
<td>2005</td>
<td>466</td>
<td>341</td>
<td>807</td>
</tr>
<tr>
<td>2010</td>
<td>483</td>
<td>426</td>
<td>909</td>
</tr>
<tr>
<td>2020</td>
<td>523</td>
<td>696</td>
<td>1219</td>
</tr>
<tr>
<td>2020 “75% scenario”</td>
<td>523</td>
<td>538</td>
<td>1061</td>
</tr>
</tbody>
</table>

According to these data and combining them to analyse the balance between supply and demand in EU/EFTA countries, the future scenario highlights (Table 5) a deficit of wood supply in comparison with wood demand, rising from 46 Mm³ in 2005 to 134 Mm³ and 436 Mm³ in 2010 and 2020 respectively, thus suggesting the need to promote strategies able to mobilize additional forest resources in respect of sustainable management practices.

Table 5: Balancing wood demand and supply

<table>
<thead>
<tr>
<th>Year</th>
<th>Wood supply [million m³]</th>
<th>Wood demand [million m³]</th>
<th>Unbalance [million m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>775</td>
<td>909</td>
<td>134</td>
</tr>
<tr>
<td>2020</td>
<td>783</td>
<td>1219</td>
<td>436</td>
</tr>
<tr>
<td>2020 “75% scenario”</td>
<td>824</td>
<td>1061</td>
<td>237</td>
</tr>
</tbody>
</table>

There is, moreover, the need to develop realistic studies to determine future wood supply on national and international level. One option could be to use the Net Annual Increment (NAI) approach, even though:

- NAI is related only to forests and do not consider that wood can be supplied from other sources (trees outside forest, post-consumer wood, co-products, etc);
- harvesting the NAI in the long term can be un-sustainable because it depends on the age structure of the forests and their potential rotation lengths.

FORESTS, FOREST PLANTATIONS AND AGRO-FORESTRY

Humankind is increasingly facing and challenging environmental degradation: deforestation, land degradation and erosion of biological diversity are major threats for natural forests. Foresters are urgently required to strengthen forest management practices and improve productivity and sustainability of planted forests in an effort to preserve natural forests. In fact, while natural forests suffer from deforestation, the importance of forest plantations is increasing, occupying 190 Mha worldwide with annual establishment rates of 8.5–10.5 Mha, and an annual net gain of 1.96 Mha year⁻¹ between 1965 and 1990 (FAO 2005).

In Europe, a large development of tree plantations is expected to occur mainly in the agricultural land because of the highly developed and structured landscape of this continent; furthermore, planting trees in farms will ensure a sustained, high productivity of woody biomass and an interesting revenue to European farmers.

Current interest in agro-forestry relates mostly to the wider general focus on sustainable agriculture for environmental protection. This focus is often in great contrast to the urgent economic needs of rural people. A partial solution to this problem has come through funding from the European Union for sustainable agriculture and afforestation of arable lands. Trees, mostly valuable broadleaved (hardwood) species like walnut, cherry and ash, were planted back into farmland using public funds and with the aim of producing high quality timber, which is in very short supply on the European market. Afforestation of agricultural land has covered a substantial surface in recent years, in many countries. As an example, more than 100,000 ha of
agricultural lands were afforested in Italy during the ‘90s (Colletti, 2001). However, the appropriate tree species and cultivation techniques should be carefully selected to match the quite different site conditions existing in Europe; the danger is that a significant proportion of those plantations could be unsuccessful. Alternative and new cultural models, such as agro-forestry and mixed models, were studied for replacing hardwood plantation forestry. These studies are in connection with the Mediterranean tradition of mixed cultural systems, which are now marginal. Researches show that both cultural models have numerous advantages in comparison with traditional forestry plantations. Tree growth and timber quality are often improved due to enhanced tree care, better site quality and synergisms among plant/system components. Technical advantages are augmented by ecological ones, such as improved biodiversity, soil erosion control and reduced fire risk; however, farmers’ reactions to innovative agro-forestry systems should also be carefully examined. Eventually, agro-forestry can be more effective than pure cultivation for the restoration of degraded agro-ecosystems and for the preservation of rural landscape, creating biological corridors useful for the reproduction of flora and fauna natural species.

There is also the need to provide appropriate and improved plant genetic material for planting in dedicated woody crops and forest plantations from the forest research institutions. Most of the works on genetic and QTL mapping in forest trees (see Gaudet 2006) conclude with the perspective to provide tools for breeding and marker-assisted selection (MAS). Will molecular tree breeding become a reality in the near future?

Selecting plants that contain appropriate gene combinations in a segregating progeny is a critical component of plant breeding. Moreover, plant breeders typically work with large populations composed by hundreds or even thousands of genotypes. MAS may greatly increase the efficiency of plant breeding compared to conventional breeding methods. Once markers tightly linked to genes or QTLs of interest have been identified, breeders may use specific DNA marker alleles as a diagnostic tool to identify plants carrying the genes or QTLs, prior to field evaluation of a large number of plants. DNA marker technology has been used in commercial plant breeding programs since the early 1990s and has proved to be useful for rapid and efficient transfer of economically interesting traits into agronomically desirable varieties and hybrids. Three main kinds of MAS program are used for early selection of plants to be maintained or used for new crosses. Firstly, there is the simple check for the presence of the allelic form of a gene, which brings a resistance or an economic trait, thanks to the tightly linked markers. Secondly, there is the introgression of a gene or a trans-gene in elite variety by backcross. The plants containing the new gene from the donor parent and the maximum of alleles from the elite recurrent parent are selected. The third MAS program consists in the accumulation in a plant of the alleles with a positive effect for quantitative traits of economic interest. The development of these programs has been possible thanks to the advances in genetics and genomics in crops species: the complete genome sequences of *Oryza* and *Arabidopsis*, the enormous number of ESTs and highly informative markers such as SSRs and SNPs, the genetic maps including QTLs, the physical maps, and the ease of genetic transformation. Today, the genomic resources of some potentially very useful tree species for woody biomass production, as *Populus*, are comparable to those available for crop species: the complete genome sequence of *P. trichocarpa*, the ESTs database available for seven different poplar species, the large number of SSR (more than 4000), the tools to develop SNP markers, the numerous genetic maps including QTLs, and the ease of genetic transformation. However, an important difference between crop species and trees still remains: the generation time to obtain mature plants. On the other hand, poplar improvement programs with traditional breeding methods already exist. The main advantages of MAS are also true for trees: i) time saving from the substitution of complex fields trial with molecular markers; ii) elimination of unreliable phenotypic evaluation associated with fields trials due to environmental effects; iii) selection of genotypes at a seedling stage (less plants to maintain,
space saving). Now the real barrier to MAS in poplar is the economic aspect. As an example, the genus *Populus* makes an important contribution to meeting the global need for paper, timber, and other wood-based products. Besides, new promising opportunities are increasing the interest around cellulosic compounds for the market of energy and biofuels. The role of fast-growing trees, like *Populus*, in carbon mitigation aligned to the Kyoto Protocol is also being quantified and may be considerable. Therefore, molecular tree breeding could really become a reality but the governmental funding agencies and the commercial sector should believe and finance these powerful technologies for poplar improvement with more resources.

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Resource flows in European wood processing industry and future challenges

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Keywords: Wood resource balance, material wood use, energy wood use, sustainability, carbon sequestration in wood products, cascade uses

ABSTRACT

Wood balances have been made since the late fifties. The focus was an overview of all wooden products and the calculation of wood consumption of more or less available statistics. The focus has changed from end-use-products to resources. Furthermore resources like post consumer wood became part of the wood resource market. A wood resource balance is a tool to join all wood resources and uses together in one calculation system. Cascade uses are a typical for the forest sector. In a wood resource balance consumption is calculated directly via field research. Therefore quite often calculated consumption is higher then apparent consumption which relies on official statistics. At EU/EFTA level, the results of the study show a wood consumption of 822 million m³ for 2005. The results indicate that 65% of the EU/EFTA wood fibres supply comes directly from forests, 23% from co-products of the forest based industries (including chips, particles and black liquor), 3% of the woody biomass derives from outside the forest, 4% from post consumer recovered wood and 1% from processed wood fuels (such as pellets and briquettes). 6% of the balance remains undefined. With 58% material use is still higher then energy use of wood fibres (42%) but the latter is much higher then earlier expected.

INTRODUCTION

In the last decades energy wood did not play a major economic role in the wood market. Material use of wood (for paper and wood products) had been the dominating use in most countries of the UNECE region. Since the late 1990s, wood energy came back in the focus of society and policymakers as a renewable energy source to tackle issues of secure energy supply and climate change. In particular the European Union and her Member States have set policy targets for renewable energy (12% by 2010 and 20% by 2020). Since wood energy is currently the major source for renewable energy, these targets are also of high relevance for the forest sector.

METHODS AND DATA BASE

Since 1999 the Centre of Wood Science carried out studies for wood resources. In the beginning it was all about sites of the wood industry. Then the interest in energy uses of wood increased and the tasks were enlarged to resource monitoring. Finally all aspects should be joined together in one system and the wood resource balance was developed. Meanwhile almost the same questions have attained for all of Europe.

Wood balances have been made since the late fifties. The focus was an overview of all wooden products in one calculation system via round wood equivalents. 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.).

In a wood balance the most important statistical source is the import and export statistic. All wooden products like logs and pulpwod semi-finished products and finished products are calculated on the basis of round wood 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 as well. Consumption is finally calculated as the balance gap. This is one of the main targets of a wood balance.

As said before different kind of balances can be calculated, depending on the targets. The focus has changed from end-use-products to resources. To judge the sustainability of the wood consumption, all woody biomass and uses (consumption) must be taken into consideration. Thus a tool is needed for calculating energy consumption. Furthermore, the connections between sectors like distribution channels and the resource mix of consumers become more important and are not covered by traditional statistics. Thus there is a need for empirical research and modified structure of the balance.

Round wood equivalents calculate the input of round wood for an end product. In a system of resources with cascade uses, this is problematic. For example 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 cubic meter equivalents are used, which just calculate the amount of solid cubic meter wood that is transferred from one sector to another.

At this point it should be mentioned that specific resource balances, like one for primary forest wood can be calculated as well. The terms sources and uses are not that common. It may be problematic to use supply and demand, because the data quality is very heterogeneous. They stretch from official statistics via inquiries to expert estimates. In rough, on the side of resources (supply) we have the sectors of industrial round wood and other forest (rest) wood and bark. Sawmill by products and other residues are a valuable proportion of the balance volume. In this rough overview post consumer wood, wood from other then forest land and black liquor is summarised.

On the side of uses (consumption) we have material & energy uses. Because different calculation systems and partly poor data are brought together in this balance, both sides aren’t equal. The balancing adjustment is with 5% in this case relatively small.

The balance in this form includes cascade uses. Wood is a highly versatile material being used and reused in many different processes. The balance in this form presents the sum of all these processes. For example industrial round wood enters a sawmill. From there sawmill by products shift back to the recourse side and delivers to panel industry, pulp industry, and wood fuel industry. Wood fuel industry produces another resource like pellets, which are booked on the resource side and from there pellets are delivered to power and heat and households. Finally the panel industry produces black liquor and this resource is used for internal industrial energy generation. The overall cascade factor of the sawmill industry is in this calculation example 1.54.

Wood balances and wood resource balances are not contradictory to a methodological point of view. The latter fills some important gaps of actual resource issues. On the other hand end–consumer aspects can be included as well e.g. to develop carbon sequestration models.

In contrast to the methodology applied in Germany, the actual study for Europe does not rely as broadly on empirically collected data in new markets, although it is hoped to at least partially remedy this in the follow up to the study. It considers only publicly available information and
data from international databases. Important sources of information on the wood sector are the above mentioned Joint Forest Sector Questionnaire (JFSQ), Joint Wood Energy Enquiry (JWEE), MCPFE enquiry on quantitative indicators of sustainable forest management. Energy information comes from European Commission (Eurostat, DG TREN), World Energy Outlook 2006 (IEA 2007) and the EurObserv’ER. Information on post consumer recovered wood derives from the results of the COST E31 on recovered wood.

**RESULTS OF THE EUROPEAN WOOD RESOURCE BALANCE**

A recently published study of the UNECE on wood resources availability and demands (Part I) assesses in depth current wood supply and consumption in 29 EU/EFTA countries in 2005, using the structure of the wood resource balance developed by Mantau (2005). This methodology calculates independently the wood supply and use of wood fibres, it considers national import and export patterns as well as use and re-use of wood fibres for material and energy purposes.

**Table 1: Wood resource balance for Europe(EU/EFTA) 2005**

<table>
<thead>
<tr>
<th>Sources</th>
<th>[ mio. m³]</th>
<th>%</th>
<th>%</th>
<th>[ mio. m³]</th>
<th>uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>industrial Roundwood – JFSQ</td>
<td>381</td>
<td>46%</td>
<td>26%</td>
<td>217</td>
<td>sawmill industry</td>
</tr>
<tr>
<td>industrial Roundwood - unrep.</td>
<td>16</td>
<td>2%</td>
<td>11%</td>
<td>88</td>
<td>panel industry</td>
</tr>
<tr>
<td>fuelwood – JFS</td>
<td>79</td>
<td>10%</td>
<td>19%</td>
<td>155</td>
<td>pulp industry</td>
</tr>
<tr>
<td>fuelwood – unrep.</td>
<td>6</td>
<td>1%</td>
<td>2%</td>
<td>14</td>
<td>other physical utilization</td>
</tr>
<tr>
<td>Bark</td>
<td>25</td>
<td>3%</td>
<td>1%</td>
<td>7</td>
<td>wood fuel industry</td>
</tr>
<tr>
<td>used logging residues</td>
<td>23</td>
<td>3%</td>
<td>6%</td>
<td>49</td>
<td>power and heat</td>
</tr>
<tr>
<td>woody biomass outside forest</td>
<td>20</td>
<td>2%</td>
<td>8%</td>
<td>65</td>
<td>industrial internal</td>
</tr>
<tr>
<td>chips, particles &amp; residues</td>
<td>118</td>
<td>14%</td>
<td>11%</td>
<td>92</td>
<td>private households</td>
</tr>
<tr>
<td>pulp production co-products</td>
<td>70</td>
<td>9%</td>
<td>16%</td>
<td>135</td>
<td>undifferentiated energy use</td>
</tr>
<tr>
<td>recovered wood</td>
<td>29</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>processed wood fuel</td>
<td>7</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>balance adjustment</td>
<td>47</td>
<td>6%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Mantau / Steierer / Hetsch /Prins (2008): Wood resources availability and demands 2005 – Part I

At EU/EFTA level, the results of the study show a lower wood supply (775 million m³), than wood consumption (822 million m³). This difference comes unevenly forward at countries’ level, and in some cases calculated wood supply is higher than the figure for wood use. The imbalance of 47 million m³ is probably due to by weak and missing data on both sides of the balance (e.g. data on woody biomass supply from outside the forest, supply of post consumer recovered wood, use of logging residues). The study rates data on wood use for energy in private households particularly weak in many countries. Hence the study can not conclude neither on the quality (supply deficit v.s. unknown use), nor size of the difference of balance sheets totals - This can only be done by detailed empiric research at country level.

Despite some data weaknesses, results of the first part are considered as best information available. National correspondents confirmed in a vital review process (response rate: 60%) data to be in the right order of magnitude. Only 6 out of 21 responses proposed changes.

Results of the 2005 indicate that 65% of the EU/EFTA wood fibres supply comes directly from forests, 23% from co-products of the forest based industries (including chips, particles and black liquor), 3% of the woody biomass derives from outside the forest, 4% from post consumer
recovered wood and 1% from processed wood fuels (such as pellets and briquettes). 6% of the balance remains undefined. With 58% material use is still higher then energy use of wood fibres (42%) but the latter is much higher then earlier expected.

**FURTHER METHODOLOGICAL DEVELOPMENT**

Finally some aspects of methodological development shall be discussed. However, this will be done on the basis of German data, because such data are not available on the European level.

For each resource sector of the balance a flowchart to all consuming sectors is calculated. Therefore it is a bottom up calculation. All material and energetic consumption sectors are filled first. If possible this is done by available statistics, additional inquiries or if both isn’t possible by expert estimates. The data quality is documented in a accompanying report. The sum of all consumption sectors represents the domestic availability of a resource. It is not identical with the use to forest wood since it can come from imports or leaves the system by exports and storage may have some influence as well. Foreign trade is documented in general statistically well. If one knows nothing about storage changes, the sector remains zero. In the case of Germany the result of all calculations is a domestic yield of forest products of 73.2 M m³ for the year 2005. Compared with the registered cutting of 56.9 of M m³, another 16.2 M m³ or 22.2% have been additionally cut. In the time between 1987 and 2005 it was just 14.4 % of all forest wood uses.

*Figure 1: Flowchart of forest woody biomass in Germany 2005*

<table>
<thead>
<tr>
<th>Officially registered cuttings (ORC)</th>
<th>Domestic yield (DY)</th>
<th>Cuttings not registered (CNR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.946 77.8%</td>
<td>73.204 100.0%</td>
<td>16.258 22.2%</td>
</tr>
</tbody>
</table>

| Import (Im) | 2.820 | 3.9% |
| Change in Stock (CiS) | -0.036 | 0.0% |
| Export (Ex) | 6.070 | 8.3% |

| Pulp industry | 6.184 | 8.8% |
| Panel industry | 7.470 | 10.7% |
| Sawmill industry | 37.234 | 53.2% |
| Other material uses *) | 0.585 | 0.8% |
| Domestic availability (DA) | 69.990 | 100.0% |
| Energy plants > 1MW | 0.840 | 1.2% |
| Energy plants < 1MW | 3.463 | 4.9% |
| households | 14.214 | 20.3% |
| Other energy uses | 0.000 | 0.0% |

*Comments: \( DY = DA - Im + Ex + \Delta CI\)S; CNR = DY - ORC*

This effect appears in other sectors as well. E.g. normally post consumer wood is calculated via an inquiry in the disposal system. But post consumer wood is burned in private households or companies buy directly post consumer wood (not contaminated) from other sources (import, industry).
As each resource sector has its typical distribution channels, each consumption sector has its assortment mix. Households do not just burn fuel wood. It is fuel wood from forests, from private gardens or from wood outside forests. Such studies are not available for each year or are not consistent. Thus, there are no time series. The alternative is to stop analyse at this point or find solutions with lower quality but still some information value.

Three household studies (1987, 2002, 2005) have been carried out in Germany. The first two have shown, that not really very much changed in household’s fuel wood consumption. We just assumed a linear yearly increment, calculated on the basis of the difference between the studies. The study in 2005 has shown a huge increase, because of oil price increase. It is always more problematic to model the data when circumstances changes like between 2000 and 2005. Between the need for relevant data and the methodical exactness of the data one cannot really solve the conflict of goals. The transparency of the assumptions is therefore a methodological acceptable way to fill the data gaps.

More studies in other countries will lead to better understanding of the developments and thereby may lead to improve the quality of these estimates. In Germany time series have been calculated back to 1987 because this was the year of the first German inventory and data should be compared with the second inventory in 2002. One of the advantages of time series of all resource and use sectors is a better understanding of wood availability and sustainability which is important for the energy use of wood.

The wood resource balance can lead to a monitoring system of carbon sequestration on the basis of actual statistics. By adding the end-use sector and statistics from the disposal sector it is possible to calculate the amount of wood which is stored in use and how much is used for energy or still is disposed. For Germany in 2002 57,2% of all wooden products were stored in use which added up to 4.5 M t of Carbon (4,5 * 3,67 = 16.5 M CO2). Construction and furniture have with two third a much higher storage potential then packaging with one fifth. However, it is a long way from the actual statistical situation in Europe until valuable calculations of this kind.

If it is true, that we are in a millennium cycle of scarce raw materials and too high carbon dioxide values it is worthwhile to start with all we have. The complexity and dynamics of markets will always be accompanied by data gaps, but the more we know of the unknown, the better we can guess.

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Wood-based panels are important renewable construction products.

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Keywords: Wood-based panels, environment, renewable, construction.

ABSTRACT

The wood-based panels sector has a long history of research and development, with several panel sectors having been in industrial production for nearly a century. The total European production of wood-based panels was approximately 60 million m³ in 2006, the largest proportion of which is attributed to the particleboard industry. Most panel manufacturing processes use non-target forest products (including thinnings and top-end logs), wood chips and sawdust. The particleboard sector alone sources an average 53% of its raw material needs from industrial by-products. It is predicted that by 2020, secondary processed wood products will account for at least 40% of international timber trade. This could provide additional raw material for the panels sector and potentially increase the need for engineered, versatile and fit-for-purpose sheet materials. Wood-based products act as carbon stores and have distinct and inherent environmental advantages over many other construction products. The wood-based panel industry has already reduced its environmental impact by continuous improvements to the manufacturing process, in response to the changing demands of the construction industry and society. However, the challenge still exists to collaborate with allied industries and academia to develop innovative, resource efficient product solutions that extend the life cycle of wood and meet the increasing demand for wood products, without placing additional pressure on the global forest resource.
The importance of innovation for the future of the FWC

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Keywords: forest, wood, chain, wood products industry, innovation, innovation process

ABSTRACT

The on-going globalization means for European wood working industry that we cannot compete by manufacturing old products with old technology. The mature technologies move quickly to global low cost areas or close to the biggest markets. New emerging end uses for renewable and in many ways ecological wood raw-material will keep the price of wood on continuously high level. In these market conditions it can be predicted that the profit margins of industry concentrating on basic products remain very thin. (Absetz 2008)

The value-add to end users and consumers must be the starting point for all development work. A lot of research and development efforts are put to enhancing the properties of wood products and the related services. But the product itself is seldom the source of competitiveness and this is why a new product should be developed with new ever improving manufacturing technologies. This total approach, product technology chain, is often the starting point to new innovation.

The origin and spread of innovations has been researched in business science a lot in recent years. Now it is time to apply this on industrial scale.

Political conclusions in societal and industrial field seem to be that highest level scientific work and industrial cooperation is critical to lead to success.

INTRODUCTION

The wood working industry is dealing with products at different maturity stages. So called basic products like sawn goods, plywood, particle board and different types of joinery products have experienced in recent years quite low market growth. Industry has been concentrating in stream lining their production processes while cost efficiency has been the basic element in strategy. The wide range of standard products has been in the market already a long time and instead of innovations we have been talking of slight improvements.

On wood products field there has been new products introduced like MDF and laminate floorings. These innovative products have experienced remarkable market growth figures with annual percentages well over 10%.

Wood products are in general enjoying of nice tail wind caused by the growth of market share of timber framing and wooden buildings. The brand of ecological, carbon neutral and low energy product will be of great importance for the industry. At the same time the increasing demand for bio-energy and limited potential of forest resources are expected to cause growing volatility in raw-material prices and might have negative influence on the modernizing of the existing industrial capacity.
The market is looking for more ready-to-use, engineered (EWP) and so called system products. There is a great demand for new product and process innovations leading our basic products to more value added ones. New technologies with flexible manufacturing, measuring and optimization technology together with fully integrated on-line manufacturing technologies are options to be used.

Industry has realized that overcoming the traditional weaknesses of wood (like durability and fire) and to move the existing barriers in use of wood we have to cooperate on European level. Roadmap 2010 and Building with Wood processes are examples of new material specific joint cooperation. The need for change and new innovation based growth of industry is expressed also in strategic research agenda of Forest-Based Sector Technology Platform. The change strategy of industry leads to growing demand for European wide joint R&D on highest level.

Enhancing the generation of innovations has been studied widely in business economics. It is a cultural and organizational issue, but also the use of modern tools are important. Product and process development should be based on modelling and simulations together with real life data developed in actual production process. In this respect wood working industry is still in starting phase.

THE NEED FOR INNOVATIONS IN FOREST-WOODWORKING INDUSTRY CHAIN

There is a need for innovations in the whole forest wood products chain in general. Old basic industries are carrying out the logistic tasks from the forest to market value chain. To be living, the chain needs continuous improvements in process efficiency but also higher value output in form of new competitive and improved products. In general we have to get more out of existing raw-material potential.

European forestry and forest industry will meet ever hardening competition from fast growth plantation forests and new producing countries. The way to manage in this hardening competition is to lead the market development and be ahead of low cost competition.

The very cyclical business environment of building is major problem for wood products industry to over-come which leads to valuing of innovativeness of industry.

In the marketing argumentation of wood products to end users we are concentrating on the renew-able material image. But at the same time industry has not fully understood the concept of re-cycling in front of consumers. Wood products industry is using chemicals like preservatives, coatings and adhesives which should be as well recovered before second use of wood (Van Acker 2007). Our total ecologic balance for nature might be even negative. Industry is looking for bio-based solutions and preferably manufactured out of wood material itself. Bio-chemistry is expected to be a new potential source for growth in whole forest industry value chain.

There is always a risk that other competing materials are better in product performance and are equally good in ecological criteria. The risk with wood products may be that certain compromises are needed in balancing ecological image and product performance.
HOW TO PROCESS INNOVATIONS

The management of innovation requires champions or promoters who commit with enthusiasm to the new product or the new process idea. More complex innovations will require more than one promoter. Division of labour becomes an essential success factor. From higher level in organization there is a need for "power" promoter support for the specific innovation. But there is a demand as well for the "technology" promoter as well as for the "process" promoter (Hauschildt 2001).

Ronald A. Mitsch (1990) identified three roads to innovations. The first one is to make sure people know that it is a top priority in company. The second one is that the top management is committed to it. And finally it will not happen without continuing reassessment of the barriers to innovations that tend to develop over time.

Badr Haque and Kulwant S. Pawar from University of Nottingham studied and stated how process modelling and analysis using "light weight" technology supported by focused group discussions and work shops can improve the concurrence and integration within the New Product Development process.

Practical experience in industrial R&D work shows that innovations are borne as a result of good cross-functional team working. This requires full trust and knowledge sharing between team members.

In processing innovations the development of new tools play an important role. Like simulation and optimization tools. The models combining product, raw-material, production and marketing data together are used in industry not only for optimization of production flow but also for designing of new products and processes. I.e. VTT in Finland has developed WoodCIM® software system for wood conversion operations optimization and management covering the entire conversion chain from forest till final product marketing (Usenius 2005)

Models can be scientific ones combining basic material behavior of wood to numerical models and implemented in FE codes to assist standardization, dimensioning and design of buildings. This sort of project has just started as joint R&D project in Building with Wood process, called MechWood.

The efficient use of research and development resources is of key importance also in industrial view. Wide networking and joint activities are needed in the pre-competition phase of totally new issues before the players have own competitive advantages to be sheltered.

CONCLUSIONS

The European forest wood products chain will meet growing competition from global low cost manufacturing areas and fast growing plantation forests. To keep the industry alive we need to lead the market development with new innovations in products and technologies. Joint cooperation of industry and research is needed together with good coordination of the use of resources. Further more we need to develop tools and processes to enhance the innovation process.
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The role of biomass in the world energy system -
A challenge for the forest sector?

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Keywords: Biofuels, bioenergy, biomass, forest

ABSTRACT

Biomass sourced from forest and agricultural residues as well as from dedicated energy crops is an important feedstock for producing heat, electricity and transport biofuels via a range of bioenergy conversion processes. Current markets for the biomass resource are diverse and dominated by traditional biomass used for space heating and cooking (Fig. 1). Excluding these traditional uses, modern biomass equates to around 2% of total global primary energy supply (9.8 EJ/yr), being greater than all other non-hydro renewable energy systems.

Figure 1: World biomass energy flows (EJ/yr) in 2004 and their thermo-chemical and biochemical conversion routes to produce heat, electricity and biofuels for use by the major sectors. Source: IPCC 4th Assessment Report, Working Group III Report "Mitigation of Climate Change", p. 276
The contribution of bioenergy to greenhouse gas mitigation and security of energy supply, employment, industry development, improved health etc. will depend on the future demand for bioenergy services for transport and energy supply. Biomass production and utilization can have negative and positive environmental impacts and there are implications for food security and prices. Project deployment could be constrained in some countries by competition for land use for food, fibre, feed and pastoral crop production; water availability; securing long term contracts for biomass feedstock; transport and storage; obtaining planning approval; and selection of the appropriate conversion plant technology and handling equipment. The future potential for bioenergy remains uncertain, as indicated by the broad ranges assessed in literature. Costs are also very variable depending if the biomass resource is produced on-site as a by-product, requires collection from field or forest, or is purpose-grown.

The prospects for bioenergy in the future world energy system, its expected benefits as well as the relevant potential constraints and issues will be discussed on the basis of the most recent world energy scenarios produced by the International Energy Agency (IEA) and of the work of the IEA Bioenergy Implementing Agreements.

The potential challenges for the forest sector will be presented and discussed.
Wood quality as backbone for a European wood processing strategy

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ABSTRACT

COST Action E44 “Wood Processing Strategy” allowed to collect information and to define strategic options for the future of the Forestry-Wood Industry Chain. The 3 working groups all have been working on this and key issues for each a selection is summarized below:

Working Group 1: Forestry-wood industry chain
Wood supply is not only related to volumes but more important is the fact that tree quality and related wood products are key for sustainable forestry.
An increased impact and development related to broadleaved species is relevant in many countries, while fast growing trees e.g. from plantations should be regarded as essential for established products and also for innovative, but surely not only low quality wood products.

Working Group 2: Solid wood products
Overall it can be concluded that the wood processing strategy has to take into account that a sustainable future for both forestry and wood industry is only guaranteed when primarily based on quality trees and related wood products. Furthermore also on a balanced integrated use of all resources available (veneer, timber, pulp and paper, wood based panels, biomass for energy). The Cost Action E44 working group on ‘Solid wood products’ had many different topics discussed but both (1) the need for quality primary processing and related products as a basis for a sustainable forestry and (2) the option to improve the quality of solid wood products by means of e.g. wood modification are considered critical.

Working Group 3: Wood based panels
Wood based panel industry is not in all countries really present but their role in providing construction products and primary products for the furniture sector makes this sector important for a sustainable future of the FWC. Equally as for the pulp and paper sector there has been an evolution towards some tension on the wood supply. Future will tell how and when this will be decided on strategically with regard to priorities related to material or energy use of woody biomass. A preference toward higher quality transformation was clearly underlined also by this working group and hence plywood is still considered important, but moreover energy transformation is regarded as additional to producing wood products. Data collected and presented in the country reports also reveal the fact that the wood industry is already using a lot of renewable energy originating from forests.

Concluding on these key issues an overall perception is that the production of wood products based on quality forest products will be key in developing a sustainable future for European forestry taking into account a European policy on socio-economic as well as environmental parameters for the forestry-wood industry sector. Nevertheless there is clearly room for national
approaches since regional differences in many aspects will lead to specific emphasis with regard to a wood processing strategy.

INTRODUCTION

The main reasons to launch this COST Action E44 were (1) the missing European dimension of a decision system for the forestry-wood industry chain, (2) the increased importance of sustainable forestry and reliable industrial perspectives and (3) the fact that a better integration of the forestry-wood industry chain is highly desirable.

The following specific topics play an important role in the future development of the forestry-wood industry chain and were integrated in the Memorandum of Understanding of COST Action E44:
- forest utilisation concept
- standards for wood products
- modelling of tree and timber
- trees fit-for-purpose, fast growing trees, plantations
- desired properties determining the wood resource
- increased importance of mixed stand forests
- utilisation of hardwoods like beech, oak, chestnut, ash, maple and cherry
- spruce and pines: variability, potential
- certification of forest and forest products

The COST Action E44 was launched with a kick-off meeting held at the COST Secretariat Avenue Louise 149, Brussels, Belgium on 23/24 June 2004 and will end 22/06/2008. In total 25 countries have signed the Memorandum of Understanding: Austria, Belgium, Bulgaria, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, the Netherlands, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. Relevant additional information on this COST Action E44 “Wood Processing Strategy is available from http://www.cost-e44.be.

WOOD UTILISATION IN THE 21ST CENTURY

Some reflections as summarized below on the wood utilisation in the 21st century constituted the context of this COST Action E44.

Although wood has been a resource for many applications for a long time it is clear that changes in the way we use wood will occur continuously. Since we entered the new millennium, some tendencies for the future are visualised already.

When green timber is harvested it moves through various stages of processing and then on to manufacturing. This production cycle is known as the forestry-wood industry chain. Because it takes raw material through to the end product, the forestry-wood industry chain has an impact on a broad range of issues from forest management to industrial competitiveness. The challenge for forestry is to keep producing high-quality, uniform raw materials to meet the demands of industry. Improvements can be achieved through advances in genetics, silviculture and biomechanical processes. Manufacture of wood products has to be carried out on a sustainable basis, otherwise supply will eventually be exhausted and forests will suffer degradation. Harnessing environmentally friendly and efficient production processes, as well as the latest
recycling technologies will put the forestry industry on a progressive footing in terms of sustainability.

Three aspects will remain important when considering global wood utilisation. The first relates to the resource wood itself, the second deals with process parameters and the third has to do with competition. The future wood resource is linked with forest productions both in quantity and quality. The changes in wood utilisation with regard to processing can be subdivided, firstly in the way wood will be used and secondly the type of wood products that will be involved. With regard to competition, all alternatives for wood and wood products come into consideration.

**Wood supply**

When dealing with aspects of the volume of wood production it is generally accepted that an increase in volume is critical, mainly because of competition with other land uses. It has been pointed out that forest products technology will play a central role in meeting future challenges of wood supply for several reasons. Forest management is and will continue to be necessary to achieve desired forest conditions through forest management that includes wood removal and is a cost-effective way to achieve ecosystem health. Wood technology will help to provide choices for the management and use of the forest, but sustainability must recognise the interdependence of the environment and the economy. Forest products can help forest lands compete economically, thus making their conversion to non-forest uses a much less viable option.

Forests are being squeezed between growing needs and a shrinking resource base. More fast growing species will be part of the total package. Species such as poplar, Sitka spruce and eucalyptus will become more abundant. The shift towards shorter rotation periods is a tendency that has been noticeable for decades. More recent is the increased interest in local species in view of the use of all resources. Currently, there is a focus not only on lesser-known species in tropical regions but a general focus on broad-leaved trees or hardwood in addition to softwood. Species such as chestnut, black locust (robinia) and several Mediterranean species have been highlighted.

Some of the forest production aspects dedicated to quantity have a basic impact on the quality of wood. Shorter rotation periods and a decrease in relative exploitation quantities stemming from virgin forests lead to the fact that larger dimensions are becoming rare. This has and will have an impact on the way wood will be processed. Changes in processing and transformation equipment but also of end products are logical consequences. The fact that more fast growing trees are felled now increases the impact of anomalous wood. A bigger part of the wood volume will contain juvenile wood with a clear impact on dimensional behaviour. Furthermore, both types of reaction wood, tension and compression wood will become more abundant. Finally plantation forestry can lead to a growing impact of wood artefacts such as knots and internal stresses.

Most quality parameters related to the presence of anomalous wood have an impact on wood stability. Dimensional instability of wood is, however, only one of the two main disadvantageous properties. The biological material wood is predestined to be destroyed in a global ecosystem as part of the ecological cycle. Future wood supply will be of such a kind that natural durability of the material will be lower.
Wood processing

Technology for wood processing is rather conservative but shifts in current techniques and the introduction of new methods will be part of the future wood processing sector.

Changes in the sylvicultural management of forests are leading to an increased production of smaller dimensioned logs. Consequently, the growing need for larger dimensions in the building sector as well as the demand for engineered beams requires an intensified application of gluing methods. Traditional laminated products like glulam are now becoming more and more available in other sectors e.g. the production of window frames. The gluing of wood requires a high degree of technical control of performance. Drying wood to exact moisture content is a prerequisite. Meanwhile technology moves towards fast drying, e.g. high temperature drying (HTD). Quality control grading of the material will use, most probably, more modern non-destructive testing. The sector has already started automatisation of assembly in full continuous production using a range of jointing systems such as finger joints.

Lower global natural durability of the wood supply will necessitate the incorporation of wood preservation in order to continue using wood under more hazardous circumstances. Wood preservation uses chemistry to enhance the quality of the renewable wood resource in such a way that the material lasts longer. In this way, a positive impact on the life span of wooden elements is induced. Health and safety aspects, together with ecotoxicological considerations, have shifted the sector from traditional products to new active ingredients. Some older products such as PCP were banned while some others such as CCA and creosote are only tolerated for preservation of the commodities to be used under hazardous conditions. These are mostly related to ground contact. The different modern products and the treating schedules or preservation processes applied now and in the future are related to the hazard class where the wooden product will be used. Together with improved process technology having better penetration and control of fixation, these measures will lead to tailor made wood preservation while avoiding excessive environmental impact.

The lower dimensional stability of new resources due to altered sylvicultural and utilisation patterns increases the need for processes improving this characteristic of wood. Impregnation with resins and densification has been known for decades. For example, instead of phenolic resins more attention is given now to a range of resins, even natural resins, which improve the wood-water relationship or increase hygroscopicity without changing the basic nature of the material. Densification of wood based on thermomechanical modification using heat, vapour and pressure induces also chemical changes. Altered chemical properties not only have an impact on the effects of water but also on natural durability. An even more direct way of reaching this goal is chemical wood modification. The use of chemical reactants makes it possible to modify the hydroxyl groups of the interior surface of the wood cell wall. Processes like acetylation or reactions with other anhydrides and several other new systems like furfurylation may become important upgrading processes for wood in future. It can be expected that the chemical modification will no longer belong only to the wood industry but may be possible in a closed process system at a chemical plant.

The tendency of the coating industry to be more interested in fundamental research regarding the wood substrate and improved interface properties with wood finishes indicates that future impact will be important. The move towards low VOC paints with alterations of solvent-borne and the introduction of waterborne coatings have initiated this change. This diversification also emphasises differences between exterior finishes and interior coatings. In particular, for window
joinery extra attention is given to the maintenance of coatings. Compared to other products such as PVC and aluminium this still remains as one of the disadvantages for wood. Research in this field is mostly related to interface properties like penetration and adhesion but standardisation of weathering methodology is also one of several important topics. Improvements of performance in general are also related to wood surface pre-treatment. Technologies based upon chemical modification or development of specific mechanical surface quality are relevant topics. Extra work on physical parameters like water and water vapour permeability and control of biological degrading systems like blue stain and moulds are topics related to both dimensional stability and biological durability of the future wood resource.

Wood products
Special focus for new developments will be oriented towards load bearing elements and board materials as alternatives for current timber-based applications.

Reflecting on the above-mentioned changes, it can be expected that composite products based on glued smaller wooden elements will become more important. For products where mechanical performance is a major property, the strength and the stiffness of the product have to be detailed in relation to the hazard class in which it will be used. Board materials like plywood and oriented strand board (OSB) will not only face moisture as a physico-mechanical hazard but also biological deterioration. As these panel products tend to be used more as combined structural cladding systems more attention to surface quality is to be expected. When dealing with load bearing beams, engineered products will become more important due to the lack of larger sized elements and increased quality control in construction. Traditional glulam is now facing the future and looking for the incorporation of reinforcement systems. Reconstituted beams such as laminated veneer lumber (LVL) and parallel veneer lumber or strand lumber are newer wooden products enabling material characterisation equivalent to other building components like steel or concrete. End uses requiring the increasingly scarcer high quality solid-sawn lumber in structural applications are creating a market growth for engineered beams.

Just as solid wood is used in many applications where strength properties are not critical, some developments in board materials are also covering this end-use range. Traditional products in this sector are particleboards or chipboards. In particular, with these types of products it seems possible to improve the balance between forest production and wood consumption. Apart from the strategy of total tree utilisation, wood waste recovery is becoming an important issue within this sector. Alternative lignocellulosic materials such as flax, straw, kenaf and many others are waiting at the doorstep of particleboard production and fibreboard pulping. Since the introduction of medium density fibreboard (MDF) there has been a steady increase in interest and use of this material as a homogenised alternative for solid wood. The ultimate challenge to recreate wood still faces the problems of moisture resistance. Improved dimensional stability and biological durability using modified fibre is one of the research topics in this field.

Up to now most people active in the wood processing industry or dealing with wood promotion, consider other materials such as metals and plastics as competitive products. In a defence position, they do not realise that there are overestimated positive properties, claimed for long service life of these other materials. New developments such as life cycle analysis (LCA) and long-term evaluations no longer validate these alternatives under a black/white strategy. Wood is a variable but renewable resource with changing properties. Variability between wood species, origin and even within one tree is very important. Thus, it is very hard to make decisions on the selection of products and the critical use of the resource, e.g. the relationship between
natural durability and the envisaged hazard class. Biological products like wood need a statistical approach. This makes it difficult to defend these products. When looking at new products combining wood with metal, plastics or even concrete it is important to have joint approaches. Using simplifications or copying from the metal or plastic sector will not necessarily enhance the possibilities for wood.

**Conclusions**

Looking to the future is never easy but there is a tendency that there will be a better understanding as how to integrate wood within the total use of natural resources. The next decades will most probably enable man to improve his way of using wood in composites both on the micro and macro levels. There will be a bigger concern about quantity and quality of forest production. Related to quality, the impact of wood preservation and wood modification will deal with lower biological durability and dimensional stability of the available wood resource. Improved wood finishing and better quality of gluing will enhance the utilisation of wood. As the processing of wood will deal more with smaller dimensions, even with wood fibres, it will become common practice to use reconstituted wood. Both for load bearing constructions and for wood products, aiming at being matrix alternatives for solid wood gluing of smaller particles or elements, it will be necessary to provide the market in future with sufficient quality material. Furthermore wood and wood products will no longer be used as an alternative to other materials such as metals or plastics as they will become part of combined products and special wood composites. The simple fact that wood is a very well designed natural composite itself and at the same time a very widely available renewable resource will make future wood products even more competitive.

**COST ACTION E44 ORGANISATION**

The main objective of the COST Action E44 was to increase the knowledge required to create a wood processing strategy in Europe.

A wood processing strategy defines the options and decisions related to forestry and wood industry in order to match the goals and requirements of both (interaction between long term forestry goals and forest products industry initiatives).

Secondary objectives were:

1. To generate the identification of wood processing mechanisms producing solid timber products and wood based panels.

2. To improve insight on forests and the use of the wood produced. Regional typology of forest production and the predicted or estimated future options for wood processing both in volume and quality will be part of this objective.

3. To provide critical information on the future research needs for the forestry–wood industry chain.
Four working themes were defined to work within COST Action E44:

1. Wood as a renewable resource
2. Broad spectrum utilisation of wood
3. New perspectives for wood utilisation
4. End use related properties of wood products

Referring to the frame of Key Area 1 on ‘Wood as a renewable resource’ the following topics should were addressed:

- forestry strategies
- high quality trees
- plantation timber
- ecosystem health
- non-timber forest products (NTFP)
- international trade
- local socio-economic impact

Within the scope of Key Area 2 on ‘Broad spectrum utilisation of wood’ the Action focussed on the following issues:

- primary wood conversion processes
- Integrated processing of forest products
- mixed stand and mixed species processing
- combined processing and total tree use

A great challenge for the Action was Key Area 3 on ‘New perspectives for wood utilisation’ covering the following issues:

- wood fibre utilisation
- non-target forest products
- specifically managed forest
- recycled/recovered wood
- plantation managed forest
- construction timber – grading / design
- long term performance / life cycle analysis
- engineered wood products
- furniture
- biomass for energy

In the frame of Key Area 4 the Action addressed for ‘End use related properties of wood’ in particular the following issues:

- innovative products
- mechanical (long-term) properties
- flammability and fire resistance
- biological durability
- weather resistance
- service life indicators
- wood modification
Each of the 4 working themes was used as topic for a workshop or conference and this was complemented by some specific event related to a more general topic or as interaction with other COST Actions:

*Workshop on State-of the-Art of the Forestry – Wood industry Chain*
31 September – 01 October 2004, Edinburgh, United Kingdom

*Conference – workshop on “Wood as a renewable resource”*
15-17 November 2004, Växjö, Sweden

*Conference – workshop on “Broad spectrum utilisation of wood”*
14-15 June 2005, Vienna, Austria

*Conference – workshop jointly with COST Action E37 on “Wood Modification: Processes, properties and commercialisation”*
06-07 October 2005, Göttingen, Germany.

*Conference – workshop jointly with COST Action E49 on “Wood resources and panel properties”*
12-14 June 2006, Valencia, Spain

*Conference – workshop on “Secure resource supply for the European wood industry”*
23-24 October 2006, Dublin, Ireland

*Workshop on “Regional interactions in the Forestry-Wood industry Chain”*
16-17 April 2007, Ghent, Belgium

17-19 September 2007, Espoo, Finland

*Workshop on “The Forestry-Wood Industry Chain: Regional Differences in Europe”*
14-15 January 2008, Poznan, Poland

During the workshop/conferences, experts active in the 3 Working Groups worked in respect of the topics that are relevant to their sector. Their focus was as described hereafter.

*Working Group 1: Forestry-wood industry chain*

Research outputs and other relevant information were used to discuss the options in the relationship between forestry production and the demand for wood resource by the wood processing industry. Special attention in this Working Group was given to regional differences in Europe on the forest output. Some countries worked already intensively on this topic for their specific region. It was up to this Working Group to combine those activities and to produce a common format and specific answers to the questions raised in this respect. This Working Group worked on defining the constraints that will be implemented through different forestry policy options.
Working Group 2: Solid wood products

This Working Group worked on the relevant topics defined in each working theme in respect of the requirements related to different solid wood products. This takes into account not only quality and quantity but also received major input from research. The research outcomes were also related to the options for innovative wood products as well as the way wood with defect features or with non-standard properties was also integrated. Quantity and quality needed to be considered in the broad sense, including consideration of hardwoods and softwoods as parameters in the analysis.

Working Group 3: Wood based panels

A specific Working Group on wood based panels is important since this sector is clearly differentiated from the sector processing timber into solid wood products. This group inevitably has a different view on most of the topics raised under the 4 working themes but functioned in a similar way to Working Group 2. Unlike the sector of solid wood products, the potential for a growing market is very much present here as well as the issue of competition for access to the wood resource. Therefore this Working Group had a major focus on the quantity needed while defining minimum requirements for quality of the wood. Besides considering the level of integration with industry manufacturing solid wood products, attention was also be given to the interaction with the pulp & paper sector and the biomass & energy sector.

WG1 FORESTRY-WOOD INDUSTRY CHAIN

The working group Forestry-Wood Industry Chain has been active on the interaction between forestry and the wood sector. Focus was of course on the current and future availability of resources, but it was also important to realize that this interaction is not self evident. In many countries seemingly the forestry sector is less involved now than half a century ago in the primary processing and quality requirements of the wood industry. Other keynotes at this Final Conference of COST Action E44 underline this statement (e.g. Leek, 2008; Scarascia and Pisanelli, 2008).

During the conference on “Modelling the Wood chain: forestry – wood industry – wood products markets” in Espoo/Helsinki it was also stated that future forestry in Europe will be depending on the wood processing strategy. Key presentations in this respect were given by Sven-Olof Lundqvist (2007) and Thomas Thörnqvist (2007), both from Sweden. It is important to highlight that the interaction of saw-milling industry alongside the pulp & paper sector is essential for both quality issues as well as sufficient revenue from forest products sales to guarantee sustainability. From the different country reports (Van Acker, 2008) options for specific national wood processing strategies can be identified. Countries like Norway, Sweden and Finland are dealing with large volumes of mainly softwoods as basis for their strategic decisions. Although hardwoods are already or do become more important in those countries than would be expected solely based on volume, the key forestry strategies in many European countries to increase the role and share of broadleaved and mixed forest will have a major impact on future wood processing. Countries like France process traditionally a lot of hardwood. Some other country reports e.g. from Germany, but also Poland revealed that an increased impact of hardwood resource is expected, but that it is not yet obvious what kind of industry will process this adequately. In this respect it was stated that specific hardwood processing industry like plywood industry in Germany has decreased earlier and it is difficult for new companies to establish. Investments are limited and the mainly SME based primary processing industry is not
expanding. Hardwood based innovative products are needed and support to establish new wood flows with adequate quality requirements are key for the transformation of hardwood species. The production of high quality trees is mainly based on the production of quality products like decorative veneer applications and plywood. These types of wood processing are not or no longer part of the national industry in many countries or show a decline. A support for tree quality and/or hardwood based industry (often SME based) should be considered by policy makers caring about the multifunctional role of forests.

**WG2 SOLID WOOD PRODUCTS**

The Cost Action E44 working group on ‘Solid wood products’ had many different topics discussed but both the need for quality primary processing and products as basis for a sustainable forestry as e.g. stated by Thörnqvist (2007) and the option to improve the quality of solid wood products by means of e.g. wood modification are considered critical. In this respect sawn wood is not only essential for the European construction sector, it is also important for the forestry sector to give priority to such processing and continue looking for integrated approaches with wood industry requiring lower levels of tree quality, like pulp production, wood-based panels and biomass for energy. Although some countries lack the presence of pulp mills and this is one of the parameters differentiating countries within Europe even more today, it is important to underline that an integrated approach of saw mills and pulp mills has proven being very effective. Therefore pulp production was also considered when compiling country reports for this working group. All options to improve the position of wood products on the construction market should be used and optimised. Increased service life (biological, mechanical and in relation to fire) as well as characteristics like dimensional behaviour are important for a sustainable wood industry and a sustainable forestry in Europe.

Cost Action E44 organised two training schools. Besides the one organized on beech (3-6 November 2004) at the University of Göttingen, Germany entitled: “Beech wood: From forestry to end products” a second one was organized in Sopron - Hungary dealing with plantation timber (7-11 May 2007). Both topics underline another two key outcomes of COST Action E44: (1) the difficulties to have a sustainable hardwood processing industry based on quality trees, but also requiring an integrated use of lower quality trees, e.g. red heartwood beech; (2) the increased role of resources from plantations both softwood and hardwood.

Overall it can be concluded that the wood processing strategy has to take into account that a sustainable future for both forestry and wood industry is only guaranteed when primarily based on quality trees and related wood products. Furthermore also on a balanced integrated use of all resources available (veneer, timber, pulp and paper, wood based panels, biomass for energy). The key outcomes presented here will inevitably be part of the future decision making process of the saw milling industry and be defined as such in the frame of CEI-Bois en the Roadmap 2010 activities. Furthermore it can be stated that in a European context the central and more eastern countries will need extra attention since some impact on the development of future wood industry can still be expected and as such also directed towards quality wood products. Clearly many of the 25 country reports (Van Acker, 2008) emphasize an ongoing process of developing new options for the wood industry. Some examples are Latvia, Lithuania and Poland on large volume industry investments. In countries like Hungary, Slovakia and Poland an increased interest on hardwoods has been expressed, but this has also been discussed as a difficult issue for e.g. Bulgaria and Romania. Central European countries with an important focus on softwoods, like Austria, Slovenia are stressing this to a lesser extent.
WG3 WOOD BASED PANELS

When discussing the future wood processing strategy within COST Action E44 the need to address the manifold aspects of wood based panels has been identified. This has been the basis to organize jointly with COST Action E49 ‘Processes and Performance of Wood-based Panels’, a workshop/conference focusing on the properties of wood based panels taking particularly into consideration the quality as well as the quantity of the available wood resources. The joint conference took place in Valencia, Spain (12-14 June 2006) and was entitled ‘Wood resources and panel properties’. Input from scientists and industry identified major topics on the role and quality of the resources for the wood based panel industry. During this conference Chris Van Riet (2006) underlined the expected tension in relation to resources. He expressed this already on several other occasions but in representing EPF, the European Panel Federation, he could show that the raw material resources used for e.g. particleboard production have evolved. Some companies now already use over 70% recovered wood as furnish and the competition or at least interaction with the increased demand for biomass for energy is in this respect eminent. He unfortunately died by the end of 2007 when still active as leader of this working group on ‘Wood-Based Panels’, but his message was carried on by many other experts and is still very valid today.

Wood based panel industry is not in all countries really present but their role in providing construction products and primary products for the furniture sector makes this sector important for a sustainable future of the FWC. Equally as for the pulp and paper sector there has been an evolution towards some tension on the wood supply. Future will tell how and when this will be decided on strategically with regard to priorities related to material or energy use of woody biomass. A preference toward higher quality transformation was clearly underlined also by this working group and hence plywood is still considered important, but moreover energy transformation is regarded as additional to producing wood products. Data collected and presented in the country reports also reveal the fact that the wood industry is already using a lot of renewable energy originating from forests.

In the country reports many national experts explain the specific role of wood-based panels. Plywood has been considered separately and statistics given under this working group on wood based panels are referring solely to chipboard or particleboard, OSB and MDF. The presence of such industry is having a major impact on how the national forestry-wood chain is established. In Belgium the production of particleboard is key and far larger than the presence of forest resources would allow to expect. The use of high amounts of recovered wood based on the presence of a dense population of wood consumers in the region is totally different from countries like Finland or Sweden with limited WBP production. Similarly to Belgium the wood industry in countries like Italy, Spain, but also Ireland is very much based on WBP’s. In Ireland this topic and the interaction with biomass for energy was discussed in more detail during a dedicated workshop on “Secure resource supply for the European wood industry” 23-24 October 2006, Dublin, Ireland. Other major European countries like Germany, France and the United Kingdom are showing also more integration with the saw mill industry, and this contrary to Scandinavia where the pulp and paper sector is clearly more integrated with other primary processing industries. The WBP’s depend partly on the furniture sector which is not necessarily booming with regard of using wood and the construction sector where new innovative products will need to be developed when a continuous growth is expected to be key for this industry.
COUNTRY REPORTS - DISCUSSION TOPICS

Through the structure of Cost Action E44 country reports on the working themes have been provided by the Working Group members and management Committee members. These reports were compiled based on presentations according to a common template but anyhow allowed also to identify some topics of discussion not specified earlier.

Clearly providing data on forest area, wood species and their relative importance, annual increment & harvested amount, ownership and standing volume in m³/ha all need to be harmonised when comparison or integration is envisaged.

This inevitably leads to differences in conversion factors used and assumed yield as well as expressing production in different units like m³, tons and energy output. Standing volume is commonly expressed in over bark values while products refer to volumes under bark.

The presentation of different country reports also showed the differences in approach towards hardwoods. In some countries specific saw milling industry is available and even decorative veneer production. Several national experts also indicated research and interest to use hardwoods for wood-based panels such as chipboard, OSB and MDF. During the 2nd European Conference on Wood Modification (ECWM, 6-7 October 2005) organised in Göttingen together with COST Action E37 many presentations were dedicated to using wood modification to improve the performance of hardwood solid timber products.

Besides wood resource volumes identified by the primary wood processing industry it also became obvious that tops, branches and resources from thinnings can be hard to estimate. This resource may however have an important impact on the biomass from forest. Seemingly in many countries this is already used to a major extent by society but not necessarily registered. Similarly the presence of large coppice forest areas (e.g. Bulgaria) raise question on whether such forest management system is totally irrelevant in relation to options like biomass for energy or supply of fibres or chips for the production of wood based panels. The use of hardwoods from such coppice systems or similar forest management systems is also part of some still unestablished modern wood processing industry or simply forgotten transformations.

This all interrelates very much with the need to produce quality tree for quality wood products. Is this still translated in differences in price? A tendency towards a decreased difference in price between low and high quality logs will anyhow result in less interest from the forest sector to produce according to specific higher quality requirements from some wood processing companies.

In the overall interaction on resource between pulp production, the wood-based panel producers and the bio-energy sector a growing tension may evolve in future in clear assortments and typology for each sub-sector. In company use of bio-energy is an important parameter in the discussion which needs consideration when discussing the role of the wood sector in relation to energy issues. Furthermore during the 4 years COST Action E44 an emerging industry producing wood products specific for energy, e.g. pellets and briquettes has become an important part of the forestry-wood industry chain.

The forestry-wood industry is however not only about the conversion of wood into wood products. Multifunctional forestry is now a common approach but several forest protecting legislation related to conservation identifies more and more forests no longer available for wood production or only to a limited extent.

The discussions within COST Action E44 also indicated that general statistics do not necessary reveal very specific uses of forest products such as utility poles, bark for horticultural application, wood chips and shavings for animal bedding, short rotation forestry for biomass production and standard NFTP like cork.
Finally issues like recycled paper were not discussed by COST Action E44, while also the role of recovered wood was not found uniform on a European level.

**FINAL CONFERENCE OF COST ACTION E44**

The Cost Action E44 Final Conference on the subject “A European wood processing strategy: future resources matching products and innovation” is organized on Friday, May 30th, 2008 at Xylexpo NEW. During the morning session several keynote papers cover a range of subjects of importance for the Forestry – Wood Industry Chain. In the afternoon an open discussion is organized with a panel of expert representatives from the 25 participating countries. This discussion allows both visitors of Xylexpo New (industry represented by manufacturers and service providers, regional planners and both European and national policy makers, general public,...) as well as journalist to get an update on the interactions between forestry and the Wood Industry both now and in future. A compilation of data and discussion on specificity for the countries participating will be available.

COST is the European organization for COoperation on Scientific and Technological research. Within it, the programme of "COST Action E44: Wood Processing Strategy" focused on future wood processing, both related to quality and quantity in order to predict the possibilities to match industry needs with future forestry.

The Final conference is organized by Cost E44 Managing Committee, in cooperation with Acimall, Federlegno and DISTAF (Department of environment forest science and technology) of the University of Florence.

The Cost Action E44 scientific committee is constituted by Joris Van Acker (chairman), Arto Usenius (vice-chairman), Thomas Thörnqvist (WG1 leader), Nico Leek (WG1 deputy), Róbert Németh (WG2 leader), Holger Militz (WG2 deputy), Gus Verhaeghe (WG3 leader), Sergej Medved (WG3 deputy), Marco Fioravanti (University of Florence).

**CONCLUSION ON THE IMPACT OF COST ACTION E44**

The COST Action E44 ‘Wood Processing Strategy’ improved insight on the interactions between forestry and wood industry. As such the main outcome is related to input for decision makers on how to proceed with a common European forestry – wood industry chain strategy. It became obvious that a sustainable future based on a better alignment of forest resources and the production of both traditional and innovative wood products shows regional differences. Not only climate and wood species distribution but also considerable differences in the wood industry present will anyhow require highlighting some specific elements on national level. In general there is an increased competition between the main wood flow systems leading to different wood products. The future of forestry will depend both on volume and quality related products. In short it is important to support all different wood industries being veneer production, saw milling, wood based panels, pulp and paper, bioenergy..., since only an integrated approach of quality and quantity of forest products guarantees a sustainable future for the European forestry – wood industry chain.
The most important achievement of COST Action E44 in this respect is the creation of a format presenting the wood material flows country wise within Europe. The format includes also information about issues which are important for the future of forestry and forest based industry in Europe. An excellent database was collected which will be used in different analyses and in many projects. This is first time really relevant information has been collected on European level.

ACKNOWLEDGEMENT

The author would like to thanks the members of the Management Committee of COST Action E44 for their contributions. As chairman he also appreciated the help from the Steering Committee members: the vice-chairman Arto Usenius as well as the Working group leaders and their deputies: Thomas Thörnqvist, Nico Leek and earlier also Sam Evans for WG1, Róbert Németh and Holger Militz for WG2, Gus Verhaeghe and Sergej Medved as well as José-Vicente Oliver and the former Chris Van Riet who died during this COST Action as WG3 leader. For the practical organisation and scientific challenges encountered it is also important to thank all who helped in organising workshops and conferences as well as the ESF COST organisation and the dedicated COST secretary Günter Siegel and his co-workers.

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www.cost-e44.be
Sawn timber is key for a sustainable FWC

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Keywords: Forest-based sector, sustainability, sawn timber

ABSTRACT

The European Forest-based Sector

- Provides essential products and services contributing to social well-being and sustainable development
- Is an important sector delivering 8% of EU manufacturing added value
- Comprises a renewable and continuously expanding forest resource, covering one third of Europe’s land area
- Incorporate some 16 million forest owners and provide between 3 and 4 million jobs in industry, to a large extent in rural areas and in SME’s.
- Comprises world-leading companies among forest-products producers, suppliers and consultancies.
- Enjoys global technological leadership and occupies leading research position at international level.

A unique position

Our sector is positioned right in the “hot spot” of climate change, energy and raw material related issues, like few other industrial sectors.

Our businesses represent a powerful tool in the work towards a true sustainable development.

We can conclude from this that

- The forest sector is a vital part of a true sustainable development
- The different value chains are in many cases integrated and eventual recycling adds interesting dimensions but brings complexity
- It is important to have a holistic view on the sector when evaluate the “sustainability” performance
Wood material flow between integrated production plants, case Koskisen Oy

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Keywords: Sawn timber, plywood, chipboard, raw material, by-product, bio energy

ABSTRACT

This paper will show the wood material flow between integrated production plants in Koskisen Oy during year 2007. Koskisen Oy is one of biggest family companies in mechanical woodworking industry in Finland and production palette is wider than in any other company. However wood material flow is very alike also on national level in saw industry and plywood industry. Bio energy is hot topic today and it has also more and more important role also in Koskisen Oy. All figures are in cubic meters if not mentioned other units.

WOOD MATERIAL FLOW

Koskisen Oy’s products are; sawn and planed timber, plywood, veneer, chipboard, rooftrusses and houses. Company’s turnover in 2007 was 229 million € and number of employees 1200. (Fig. 1)

Woodprocurement was 1.300.000 million cubic meters. 917.000 cubic meters was used as raw material in sawmills, veneer mill and plywood mill. Own harvesting in Finland was 1.0 million cubic meters and the harvested area about 4000 hectares. 300.000 cubic meters was delivered by
other companies or harvested in Russia. Biofuel from forests was produced from 950 hectares. Theoretically it is possible to produce biofuel from 1500 hectares which would mean 120,000 cubic meters chips. In many areas transportation costs are so high that it is not profitable to collect cutting residues (Fig. 2).

Softwood sawmill used last year 555,000 cubic meters of logs. Production of sawn timber was 245,000 cubic meters of which was planed 69,500. 132,000 cubic meters by-products was used by own integrated plants and 177,000 cubic meters was sold to pulp and paper industry, pellet manufacturers, horse stables and for soil improvement (Fig. 3).

Plywood production used 318,000 cubic meters raw material of which 90 % was birch. 112,000 cubic meters by-products were used in integrated plants and 117,000 cubic meters was sold to pulp and paper industry, as bio fuel and for soil improvement (Fig. 4).
Chipboard mill used sawmills and plywood mills by-products 135,000 cubic meters as raw material. 52,000 cubic meters sawdust was bought from other sawmills. All by-products were used for energy production (Fig. 5).

Heat energy production of plywood mills power plant was 103,000 MWh and generation of electricity only 2757 MWh. (Fig. 6) Total use of electric energy was 70 GWh in 2007 which means that only 4 % is from own production.
Total use of by-products as bio fuel was 123,800 cubic meters which is approximately 13 % of the used raw material. Totally almost 200,000 cubic meters of wood was converted to energy (Fig 7).

The share of bio fuel in heat generation has increased during last ten years from 68 % to 91 %. In year 2009 only 5 % of heat energy will be produced by oil (Fig. 8).
Koskisen Oy

The share of biofuel in heat generation

Koskisen has increased the share of biofuel in heat generation substantially. In 2007 the share of biofuel was 91% of the total heat generation. The estimates for 2008 and 2009 are based on planned actions.

Figure 8: The share of biofuel in heat generation
Forest Products Markets in the North Western European (urbanized) Area; the Dutch experience.

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**Keywords:** demand for natural forests, changing forest management, forest certification, wood harvesting, wood deficit.

**ABSTRACT**

During the last decades the focus in forest management in north Western Europe changed significantly from wood production to nature development. The forest area not available for wood supply is increasing and in the remaining forests the importance of wood production and wood harvesting are losing interest. These developments are illustrated by the experiences in Dutch forestry.

During the same period forest certification was introduced and is gaining victory now. The demand for certified wood products is strongly supported by north western European countries and will increase substantially during the coming years. Forest certification is an effective tool to communicate sustainable wood harvesting as part of sound forest management. Wood consumption will strongly increase, especially by realizing the European RES policy. A significant European deficit of woody biomass is expected. Great efforts are necessary to mobilize more wood from the European forests. Therefore we need new strategies for a more prominent role of wood harvesting in nature oriented forest management.

**INTRODUCTION**

In the north western European urbanized area (see figure 1) forestry is more and more oriented towards nature development. Forest policy is dominated by ‘urban votes’ to increase natural values and biodiversity. During the last decades this development has resulted in significant changes in forest management.

Before 1980 wood production was dominant in Dutch forestry by monocultures and clearcut management in relative young forests. During the eighties in the last century the focus shifted to natural processes to increase natural variety and to improve recreational aspects. This change has resulted in forest areas exclusively managed for nature development and areas with multiple use forests. To deliberately exclude a substantial area from harvesting has an obvious negative effect on the total volume of wood harvested.

Another change with growing impact on the market, more or less during the same period, started with the discussion about the devastation of the tropical rainforests. NGO’s initiated sustainable forest management by introducing FSC. They put sustainable produced timber and the legality question on the international forest agenda. Especially in consumer countries such as UK and The Netherlands the NGO’s have strongly influenced public opinion and their impact is quickly increasing e.g. in Denmark, Germany and Belgium. These countries have developed or will develop national standards for sustainable produced timber, which will be used for the
introduction of public procurement policies for forest products. With this policy governments are stimulating the consumption of certified wood products in their national markets. Forest management and forest products certification has become a useful tool for communication between the forestry sector and the public, especially in relation to wood harvesting.

For some years consumption of wood products is increasing again in the EU, which trend was even stronger in the USA (last year however there was a strong decline, because of reductions in house construction industry) and seems to be exploding in China. The growing demand for timber coupled to a decreased harvest in European forests results in serious problems in wood procurement. Wood prices were rising since 2006 e.g. in the Dutch packaging industry sawn wood prices were already 30 % higher in 2007. Another development is the expected strong increase in the demand for energy wood in the EU. The Biomass Action Plan assesses the EU potential in 2010 for woody biomass from the forest at 220 million m³ round wood equivalents. That is nearly 60 % of the total EU removals in 2004.

These changes in the market for forest products in the north western European region are illustrated in this paper by presenting the Dutch experience.

**THE DUTCH FOREST**

In The Netherlands 13% of the land area is in use for forestry and nature areas. In our very dense populated country infrastructure and buildings occupy also 13%. Agriculture is the dominating land use with still 62% of the area (Fig. 1).
The forest area is approximately 360,000 hectares and is characterized by a great number of very small woodlots and only some big connected forest areas, as you can see in figure 2. There are 55,000 forest plots, of which 83% are smaller than 5 hectares. Less than 1% is bigger than 100 hectares, together these forests represent 30% of the total forest area. The Dutch forests are relatively young and consist of 54% coniferous species and 46% broadleaves.

The forest area per inhabitant in The Netherlands is very low: 0.022 hectare. In comparison UK and Sweden have considerably greater area of forest per citizen: 0.4 and 3.1 hectare.

Figure 3: Scattered forest area in The Netherlands (source State Forest Service).

FOREST MANAGEMENT

As said in the introduction forest management has changed a lot since 1980. Before that time wood production was dominant and the management was characterized by monocultures and clearcuts. Recreational facilities and conservation aspects were part of the local forest managers job. Later on experts for recreation, nature conservation and landscaping were introduced and gave specialized support to the local manager.

After 1980 there was a growing interest for more natural processes in the forest to stimulate natural variety and biodiversity. The “Naturgemässe Waldwirtschaft” in Germany was really inspiring Dutch foresters. It was not only to improve nature but also to make the forest more attractive for the people.

This development to more natural management in the forest resulted in two mainstreams:

- forests which are exclusively managed for nature development (without commercial harvesting) and
- forests managed for multiple-use.

The latest governmental policy paper “Nature for people, people for nature” (2001) strives at 70% of the forest area for multiple-use (including wood harvesting) and 30% exclusively for nature conservation. These two types of forest management are presented in this paper as ‘Integrated Forest Management’ and ‘Nature Forest Management’.
Nature Forest Management
Those managers who were convinced that wood harvesting could not be combined with nature conservation, originally started with non-intervention. In their opinion the forest needed no management at all. Later on most of them got the understanding that interventions are often necessary to stimulate nature development. Management actions were introduced to simulate storms (& wind damage), to increase the number of dead trees, to get more veteran trees and also grazing by cattle was introduced. Basic idea is still not to harvest from a commercial interest.

![Figure 4: Nature Forest Management](image1)

![Figure 5: Stimulating storm damage](image2)

![Figure 6: Grazing by cattle](image3)

Integrated Forest Management
Integrated Forest Management is also nature oriented, but other forest uses are included. Integrated Forest Management was and is driven by foresters, who wanted to transform the Dutch multiple-use forests from even-aged single species plantations into small scale mixed, uneven-aged forests with native species. Wood production became of minor importance, but
wood harvesting is still part of the management. The primary goal is not harvesting the wood, but thinning (=harvesting) is used as a management tool.
Integrated Forest Management is characterized by:
- selective thinnings, no clearcuts, creating gaps,
- natural regeneration,
- un-even aged and mixed stands,
- more native, especially deciduous spp.,
- more dead wood (standing and on the ground),
- large dimensioned trees.

**Figure 7:** Integrated Forest Management: from monocultures to more natural stands

**Figure 8:** More dead wood

**WOOD HARVESTING IN SECUNDARY POSITION**

After 25 years of Integrated Forest Management we can conclude that our forests have an improved ecology and increased nature values. Also the variation in forest structure has considerably increased. The Dutch forests are nicer and have more to offer to their visitors.
But as we already stated earlier wood production and wood harvesting are placed in a secondary position.

If the forest area exclusively managed for nature conservation, without any harvesting, is also taken into account the future for the roundwood working industry in The Netherlands is not very promising. This was the reason why the Dutch Forest Based Industry in 2005 sounded the alarm bell: is there still a future or shall we go direction east?

Together with the Ministry of Agriculture, Nature and Food Quality a Vision on timber harvesting was set up to stimulate the use of wood from Dutch woodlands. To create better opportunities for timber harvesting a set of actions has been formulated. An important issue is how to reduce further increases in harvesting costs and to maintain and enhance a strong position on the international timber market. Mergers and cooperation are necessary in Dutch forestry and wood processing sectors. The sector will stimulate the cooperation between forest owners by coordinating and carrying out timber harvesting operations at a regional level and by offering them so called ‘full service contracts’.

Comparable trends can be seen in Germany and UK. In different German Bundesländer cluster studies show the importance of the Forest-Wood chain for the German economy.

**CERTIFIED WOOD PRODUCTS (CWP)**

The certification process for Sustainable Forest Management (SFM) is an effective instrument to communicate sound forest management, including wood harvesting. Sustainability not only implies care for social and environmental aspects but also for economic profitability. In that way timber harvesting is very crucial for the forest owner.

In The Netherlands FSC is known by 67% of the public! FSC gets strong support from the NGO’s and also from the politicians. FSC and the NGO’s are very successful with their campaigns to promote FSC products in the Dutch market. There is a growing demand for FSC wood. The Dutch Forest Based Industry is active in the FSC chain, but recognizes also other certificates like PEFC and CSA.

The most recent information on CWP on the Dutch market is based on the Probos study for the year 2005. The results are presented in table 1.

| Table 1: Market share of certification schemes as percentage of the total volume of timber consumed in The Netherlands in 2005, differentiated for timber with a certificate and timber without a certificate, but sourced from certified forest (Oldenburger, J.F. and Leek N.A. 2007) |
|---|---|---|
| **Share of total timber market** | **From certified forest** | **Total** |
| **FSC** | 9.3% | 2.9% | 12.2% |
| **PEFC** | 3.9% | 18.1% | 22.0% |
| **MTCC** | 0.0% | 0.3% | 0.3% |
| **CSA** | 0.0% | 0.2% | 0.2% |
| **SFI** | 0.0% | 0.1% | 0.1% |
| **Other** | 0.1% | 1.5% | 1.6% |
| **Total** | 13.3% | 23.1% | 36.4% |

In 2005 13.3% of the total volume of consumed wood in The Netherlands had a certificate. Leading brand is FSC with 9.3%, followed by PEFC with 3.9%. When including wood products originated from certified forests (but without certificate) more than 36% of total wood consumption was sustainable.
Besides the effective campaigns for the promotion of FSC-wood by FSC and the NGO’s more stimuli are given to promote the market for CWP. The Netherlands Timber Traders Association has set very diligent targets in her policy for the coming years:

- In 2009 the origin of all the wood imported by their members is known and
- In 2009 75% of the wood imported by their members is from certified forests.

The Dutch government is also active to increase the share of CWP in the market. For her own procurement policy the government has published recently a set of principles and criteria (the Timber Procurement Assessment System (TPAS)) for FSM and the Chain of Custody. Based on TPAS this year a judgment is expected which certification standards are acceptable for the Dutch public procurement. In 2010 public authorities will buy 100% CWP in their projects, where they act as a client. The Dutch government is also searching for financial incentives to bring more CWP in the market.

In UK, Germany, Denmark and Belgium similar systems have been developed. The countries involved have an exchange of information. Most effective would be if the Commission is setting up a procurement policy for the whole Union.

**HOW TO MOBILIZE MORE WOOD FROM THE FOREST?**

The changes in forest management in the north Western European region towards nature conservation and development and the exclusion of a substantial area from harvesting has an obvious negative effect on the total volume of wood harvested. However, harvesting rates have also been influenced by the rather low wood prices in the past years, the relative high harvesting costs and the fragmented ownership. In most western European countries the wood harvesting volume nowadays has been reduced to a level of 50-70% of the mean annual increment.

Since 2004 consumption of wood products is increasing again in the EU, which trend was even stronger in the USA (last year however there was a strong decline, because of reductions in house building industry) and seems to be exploding in China. The growing demand for timber coupled with a decreased harvest in European forests results in serious problems in wood procurement. Wood prices are rising since 2006, e.g. in the Dutch packaging industry sawn wood prices were already 30 % higher in June 2007. Figure 9 illustrates increasing round wood prices in Germany.

![Figure 9: Development of the price index for round wood in Germany from April 2006 up to February 2007 (Oldenburger 2007)](image-url)
To my opinion there are three issues relevant to increase the mobilization of wood from western European forests:
- The Forest Based Industries should consolidate SFM and legal origin in the market (SFM legitimates wood harvesting).
- Acceptation by managers and forest owners that wood harvesting is an effective tool to enhance biodiversity values.
- Better cooperation between forest owners; offering “full service contracts” for carrying out timber harvesting operations.

WOOD FOR RENEWABLE ENERGY

The expected strong growing demand for energy wood in the EU will certainly contribute to an increased use of wood from the forest. The Biomass Action Plan assesses the EU potential in 2010 for woody biomass from the forest at 220 million m$^3$ roundwood equivalents. That is nearly 60% of the total EU removals in 2004.

Recent studies from UNECE/FAO in cooperation with the University of Hamburg (Mantau 2007) and the study of McKinsey for the European paper industry (CEPI 2007) indicates an immense deficit for woody biomass in 2020: 200 – 260 million m$^3$, that is 25% of the total expected demand in 2020.

To ensure enough supply of biomass, Europe will have to significantly stimulate biomass production and imports. McKinsey recommends to free up land for energy crop production, to maximize mobilization of wood and facilitate overseas supplies. The European RES policy will have great impacts on European agriculture, forestry and environment.

CONCLUSIONS

- North-western European societies demand for more ‘Nature’ in their forests.
- The forest area NOT available for wood harvesting will increase.
- The area of forest that is not producing for the market needs will also increase.
- Forest certification is an effective tool for communication about sound forest management, including wood harvesting.
- Wood consumption will strongly increase, especially by realizing the European RES policy. A significant deficit of woody biomass is expected.
- Concerning The Netherlands:
  - NL is a large importer of wood products,
  - The own forest resource is restricted and limited,
  - BUT 2,5 million m$^3$ annual increment can contribute substantial in improving self sufficiency.
  - HOWEVER increasing wood harvesting under Dutch conditions is very complex because of a strong support for nature.
- We need new strategies for a more prominent role of wood use in Nature Oriented Forest Management.
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Forest Industry Demand and Forest Resources Supply – Challenges and Outlooks in Bulgaria

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Keywords: forest-wood chain, wood raw material, forest resources dynamic, EFISCEN

ABSTRACT

The purpose of the investigation is to create conditions for improvement of the forest-wood chain on the basis of comparison of capacities of wood use by available industrial facilities in Bulgaria with the potentialities of forests in the country to sustainably provide wood raw material.

To achieve the purpose, following methods were used:
- Investigation and prognostication of dynamics of forest resources by means of computer simulation with EFISCEN (European Forest Information and Simulation Scenario Model);
- Collection of information about actual potential (capacity) use by main enterprises of forest industry, by means of the method of interviews and processing of statistical information.

The investigation results represent an attempt at describing the available balance in the modern forest-wood chain and assessing the possibilities for its improvement and development in the long-term.

INTRODUCTION

Forest sector in Bulgaria is not structure-determining in national economy. Only 0.3% of GDP are formed in it. On the other hand, the forest area accounts for 34% of the territory in Bulgaria. It covers 3.68 million ha. The forest stock in Bulgaria preserves over 80% of the protected plants and over 60% of the endangered animal species in the country. 84% of the protected areas of the European environmental Natura 2000 network are forest areas, Bulgarian forests provide about 85% of the water flow in the country or nearly 3.6 billion m³ of clear drinkable water. They play a significant role for reduction of the emissions of greenhouse gases in the atmosphere, accumulating carbon in the biomass through CO₂ absorption. The total absorption capacity is estimated at nearly 142 million tons of carbon, which is about 516 million tons of CO₂ equivalents. Bulgaria’s forests provide employment to about 20 thousand people who are employed in management, security and harvesting of wood and non-wood forest products. The wood processing sector comprises about 4,500 companies in which about 120,000 people are employed (NFB 2006).

The purpose of the investigation is to create conditions for improvement of the forest-wood chain on the basis of comparison of capacities of wood use by available industrial facilities in Bulgaria with the potentialities of forests in the country to sustainably provide wood raw material.
METHODS OF INVESTIGATION

To achieve the purpose, following methods were used:

Investigation and prognostication of dynamics of forest resources by means of computer simulation with EFISCEN (European Forest Information and Simulation Scenario Model v.3.1.3); the model has been described in details - Nabuurs G.J (2001) Schelhaas, M.J and G.J.Nabuurs (2007). The said has been adapted for work with the data about forest resources of Bulgaria (Kostov G, and E. Rafailova 2008). The dynamics of forest resources in the Republic of Bulgaria have been examined, for 22 tree species divided into four groups – coniferous forests, high broad-leaved forests, broad-leaved coppice forests and the so called “forests for reconstruction”, which are low productive forest formations for reforestation. Total data about forests of Bulgaria were used in the paper, regardless of their ownership, with 4 different scenarios formulated by experts: Business as usual – B, Maximum sustainable harvesting – M, Optimistic, handbook – O, and Pessimistic – P. The contents of the scenarios have been described in detail by Kostov G, and E. Rafailova 2008. In this paper, mostly the results simulated under scenarios B and M that were adopted as most probable were taken into consideration.

The collection of information about actual and potential (capacity) use by main enterprises of forest industry, by means of the method of interviews and processing of statistical information was performed by the National Forestry Board as a part of Ministry of Agriculture and Forests during the period 2005-2006 (Trichkov, L. 2006). The data covers 90% of the registered wood processing companies in Bulgaria as shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Registered and operating wood processing companies</th>
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<tbody>
<tr>
<td>Total number of companies according to a list</td>
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<tr>
<td>Companies that do not operate in 2005</td>
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<tr>
<td>Total number of companies operating in 2005</td>
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<tr>
<td>Companies working with sawn wood only</td>
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<tr>
<td>Total number of companies subject of summarisation</td>
</tr>
<tr>
<td>Number of companies that have submitted summarised data for 2005</td>
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<tr>
<td>Percentage of companies covered</td>
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RESULTS

The main data from the simulations with EFISCEN for wood use from thinnings and fellings totally and by groups of forests until 2050 are shown in Fig. 1 (Kostov G., Mihailova J. And Trichkov N. – COST 44 – Ghent 2007).

The data shown, as well as the details by tree species (Kostov G, and Rafailova E. 2008) show the following:

The potential use of wood from coniferous forests may be increased from the present 4.7 million m³ of standing volume to 8 million m³ per year. The increase is more significant in the thinnings, and lower in thefellings (Fig. 2). According to the same source, there is no potential for increase of fellings in the case of Norway spruce and European fir. The Scots pine stands and plantations are the only significant reservoir for potential increasing the domestic conifer round wood supply.
Figure 1: Removals standing volume total

Figure 2: Removals standing volume coniferous
The potential use of wood from high broad-leaved forests may be increased from the present 2.4 million m³ of standing volume to 4.2 million m³. The increase is both in the thinnings and in the fellings (Fig. 3). In the latter, however, there is almost no resource to increase the harvest from fellings in the case of main species, such as oaks and beech (Kostov G, and Rafailova E. 2008).

![Figure 3: Removals standing volume high deciduous](image)

Significant is the potential for increase of the harvest of wood from coppice forests, irrespective of the general tendencies of decrease of their area, because of their conversion into high ones. The potential acceleration is mainly based on an increase of the fellings by about 1 million m³ per year (Fig. 4).

As a whole, it is possible and expedient to increase the timber standing volume harvest in the country from the present 7.2 million m³ to about 11 million m³ per year (Fig. 1). Similar levels of harvesting of wood volume are mainly related to an increase in the thinnings and fellings from the coppice forests in which timber suitable for technological processing and energy purposes is harvested. The increase of the volume of wood harvest for sawing, veneer and veneered plywood is with a low potential with respect to present levels. The main species, such as Norway spruce, European fir, high-stem oaks and beech, have no resource to increase the harvest of large-sized round wood from old (mature) stands (Kostov G, and E. Rafailova 2008).

Data about roundwood used and ordered by the merchants and consumers interviewed is shown in Fig. 5 (after Trichkov L. 2006). The main that is established from the data shown in Fig 5 is:

- The amounts of round wood ordered for 2006 by processors and merchants are considerably greater than the previous year, with the demand for coniferous round wood being for 48% more. The increase of demand for large-sized wood is for 56% more.
Figure 4: Removals standing volume coppice

Figure 5: Total demand and supply of different categories of round wood (2005)
In the case of the broad-leaved wood, the demand is again considerably higher for the large-sized wood – 39% increase, at a total of 15% more broad-leaved round wood ordered. Striking also is the higher supply of broad-leaved firewood than the existing demand.

Fig. 6 illustrates that almost ¾ of the round wood ordered are used in the forest processing industry. 17% are used for the needs of the local population, which mainly are firewood, and the export also in the form of mainly firewood and technological wood is about 8% of the total amount of round wood.

**CONCLUSIONS**

About 7 million m$^3$ of standing volume are cut from Bulgaria’s forests annually, which as a round wood are about 6 million m$^3$.

The condition of the forests in Bulgaria allows increasing the use to about 11 million m$^3$ of standing volume per year, which means about 9.5 million m$^3$ of round wood.

Within the framework of such use, the additional round timber from thinnings and from fellings in coppice forests coming into the market has no sufficient demand under the present structure of the wood processing industry in Bulgaria.

Intensification of the shortage of large-sized wood for sawing, veneer and veneered plywood made of oak, beech, Norway spruce and fir is expected. The Scots pine will have a relatively
higher share in the provision with large-sized wood in future, mostly at the expense of the artificial forests created in the past.

The free potential resource of about 3 million m$^3$ per year of round wood that is suitable for technological processing and energy purposes is a basis for a serious change in the existing forest-wood chain in Bulgaria.

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The effect of steaming parameters on colour change of some hardwoods

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Keywords: hardwood, steaming, colour modification, red heartwood, colour homogenisation

ABSTRACT

The colour of some durable hardwoods are not met the taste of most consumers, and it is unstable as colour changes are taking place with time under influence of air humidity and light. Some others have inhomogeneous colour. Both problems can be solved by steaming. Black locust wood is highly sensitive to the steaming temperature. Its greenish brown colour can be modified in a large scale up to chocolate brown. By steaming with a temperature above 100°C, black locust color can be modified to a very dark brown resembling that of some tropical timbers. By steaming the extremely hard timber of back locust growing in Europe can substitute some tropical timber.

In contrast, beech and turkey oak are much less sensitive to the steaming temperature. These timbers often have red heartwood. Side by side the white sapwood and the dark red or brown heartwood are non attractive. This colour disharmony can be homogenised by steaming. The colour of white sapwood turns to worm light brown and the heartwood becomes also worm brown close to the colour of the steamed sapwood.

INTRODUCTION

In practice, steaming of wood for colour change was started in the second half of the last century. But systematic research to determine the specific effects of the steaming parameters was carried out only during the last 10 years. Most relevant publications concerned the steaming behaviour of black locust are: Molnár 1998, Tolvaj and Faix 1996, Tolvaj et al. 2000, Horváth 2000, Horváth and Varga 2000. Horváth created an exponential function presenting the steaming temperature dependence and time dependence of the lightness change of black locust (Horváth 2000). Varga and Zee compared the steaming properties of two European and two tropical hardwoods (Varga and See 2008) Mostly black locust and beech timbers are steamed. It is sad, steaming of beech is easy but steaming of black locust is difficult. The reproduction of the same color for black locust by steaming is problematic. There is no answer in the literature why the steaming behaviors of these two species are extremely different.

These days are coming up a new promising color modification method, which is a combination of ultraviolet irradiation and thermal treatment. Mitsui and his co-workers discovered that UV treatment before steaming amplifies the darkening effect of steaming (Mitsui et al 2001, 2004, Mitsui 2004).
The objective colour measurement in wood research was widely applied only in the recent past (Bekhta and Niemz 2003, Hapla and Militz 2004, Mitsui et al. 2001, 2004, Mitsui 2004) This objective color measurement helped the researchers to find out the steaming behaviours of wood species.

EXPERIMENTAL METHODS

For laboratory steaming wet (25-30%) black locust (*Robinia pseudoacacia* L.), wet (47%), semidry (28%) and dry (8%) beech (*Fagus silvatica* L.) and wet (55%) Turkey oak (*Quercus cerris* L.) samples were prepared from heartwood and from sapwood (black locust only from heartwood) with the size of 300 x 40 x 22 mm and only those were used for the tests, which have not any wood defects. The treatment was carried out at atmospheric pressure (below 100°C) in a steam chest at 100% relative humidity. Above 100°C an autoclave was used. The steaming process started with a six hours heating process. The temperature was regulated automatically around the set value with ±0.5°C. The heating was switched off after finishing the steaming and the temperature decreased without cooling up to the laboratory temperature. Before color measurements, the steamed wood specimens were subsequently conditioned for one month at room temperature. The specimens were then cut with a sharp circular saw through the center parallel to the longer side and the newly prepared surfaces were used for color measurements. For the color measurements a MINOLTA 2002 colorimeter was used. The reflection spectrum was measured in the 400-700 nm regions. From these data, the L*, a*, b* color co-ordinates were calculated based on the D65 light source. On each specimen, color measurement was taken at 10 randomly chosen spots and the results were used for further analyses.

RESULTS AND DISCUSSION

The effect of chemical changes induced by steaming can be observed with the naked eye already after a few hours treatment. The color of specimens becomes visibly darker and browner as the original color. Black locust changes its color from the unattractive greenish yellow to a relatively more pleasant reddish hue. The visual observations described above can be confirmed by the objective color measurement. The lightness change of black locust samples is presented in Fig. 1. The lightness decreased continuously at any steaming temperatures. This decrease was more pronounced with increasing temperature, demonstrating that the value of lightness change correlates exponentially to the steaming temperature (Horváth 2000).

This lightness decrease was proportionally more effective in the first days in agreement with a previous study (Molnár 1998) and more or less leveling off around 10 to 4 day. The trend lines (belonging to different steaming temperatures) are fare from each other. That means the color change of black locust is highly sensitive to the steaming temperature. This finding can be the reason why it is difficult to reproduce the same color in a series of steaming. If the steaming temperature has not been kept constant the result will be quite different color. Old steaming chambers are usually not able to keep the temperature in a constant level, and the final color can not be repeated in those chambers.

Above 100°C the lightness trend lines go to the same lightness value. This value is half of the original lightness of black locust. It represents that a wide range of color can be created altering the steaming temperature and time. Color of black locust can be modified to a very dark brown resembling that of some tropical timbers such as the African wengé (*Millettia laurentii*) or the South American supupira (*Bowdichia spp.*) frequently used for solid wood and prefab flooring components.
The change of red color component as a function of steaming time is presented in Fig. 2. The red color of black locust represented by $a^*$ co-ordinate increased rapidly at the beginning of steaming. This tendency was accelerated with rising temperature. Above 90°C the curves have a maximum value. (Probably at lower temperatures the curves also have maximum, but they are out at the examined steaming time range.) The place of maximum sifted towards shorter steaming time with rising temperature. This finding is important for industrial steaming. This maximum can be an upper limit of the effective steaming time at the indicated temperature.

During steaming new chemical components are created containing conjugated double band system. These structures are created during the degradation of the extractives being in black locust wood. In comparison the poplar wood, which hardly have extractives, charges its color only in limited value towards red (Tolvaj and Faix 1996). These newly created colored molecules are extractable and the heat steam leaches them out decreasing the values of the $a^*$ co-ordinate. These leached components can be found in the wastewater.

Kollmann et al. (1951) concluded that the value of color change depends on the temperature and requires high moisture content in wood. Mainly this conclusion is the reason of those believes.
that only the living wet wood can be steamed properly. Our experimental results (not presented here) demonstrate that dry black locust wood can be steamed properly if the steaming temperature is higher than 100°C.

The main colour co-ordinate, the lightness ($L^*$) of beech samples changed in a different way comparing to the change of black locust (Fig. 3). Here the trend lines are almost in the same position below 100°C and within one day steaming time. It represents that steaming of beech is not sensitive to the steaming temperature if it is below 100°C. That is why beech wood can be steamed easily.

The lightness of white part decreased more than the lightness of red part. This phenomenon gives the possibility of colour homogenisation. The difference between the lightness decrease of white and red heartwood was significant during the first 18 hours of steaming. After this time the trends were the same. It means the colour homogenisation time was about 18 hours at any temperature. It is well visible in Fig. 3 where the lightness changes of white and red heartwood are presented together at different temperatures.

Figure 3: Lightness change of white (a) and red (b) heartwood of beech ($U= 47\%$)

The change of the red colour co-ordinate ($a^*$) was opposite to the change of lightness co-ordinate (Fig. 4). The curves of red colour have a maximum. The increase of the $a^*$ values before the maximum was extremely intensive, but the decrease after the maximum was moderate. These maxima sifted towards shorter steaming time with rising temperature. The intensity of the maxima was almost the same at white and at red heartwood. In the viewpoint of red colour the homogenisation time was the steaming time belonging to the maximum. These time values were longer below 100°C and sorter above 100°C than the values calculated according to the lightness change.

Figure 4: Red colour change of white (a) and red (b) heartwood of beech ($U= 47\%$)
The effect of the initial moisture content was also examined. The investigation of this parameter is important because in some cases there is long time passed between felling the trees and the steaming. The sawn timber can dry fast. It can happen that semidry boards have to be steamed. For this purpose semidry (U=28%) and dry (U=8%) samples were investigated beside the wet (U=47%) samples. The results are presented in Fig. 5-6 represented by steaming at 80°C. The figures show, the color change of initially wet and semi dry samples are similar.

The only difference was that the red colour increase was faster at wet samples than at semidry samples during the first 6 hours of steaming if the temperature was higher at 100°C. The lightness change of initially dry samples was slower than the change of wet samples below 100°C. Above 100°C there was no difference among the examined series. The red colour change was more sensitive against the initial moisture content (Fig. 6). This change was less intensive at dry samples and below 100°C the difference was visible in the whole examined time interval. Above 100°C the increase of red colour did not stopped after one day but continued in the whole examined region, so the change was able to reach the change of wet samples. This finding gives the information that beech wood can be steamed properly if the moisture content is above the fibre saturation point. If the moisture content is below the fibre saturation point steaming temperature should be above 100°C.

Turkey oak has nice white but wide sapwood, and many trees have dark reddish-grey heartwood. The border between the dark and white portions is usually very sharp. This great colour
difference can be diminished by steaming. The colour changes caused by steaming are presented in Fig. 7. Most of the colour change happened during the first 12 hours of steaming. There was no difference among the effects of various temperatures below 100°C. With increasing temperature the darkening of sapwood was greater during the first day of steaming. At 110°C the colour change was rapid in the first one days of steaming, and then the decrease became moderate parallel with the levels of the other temperatures. The treatment caused a little darkening of heartwood. This change was less intensive than the darkening of sapwood. The changes between sapwood and heartwood created a degree of colour homogenisation, thus giving the wood a more uniform appealing appearance. Much of the homogenisation happened during the first day of steaming.

Before steaming the dark heartwood was almost twice as red as the sapwood. During steaming the trend changed. The red colour component of white sapwood increased more rapidly than the change of heartwood. The trend lines crossed each other a little before 12 hours of steaming at 110°C. At 80°C, this point was at 24 hours steaming time. The curves for colour change reach a maximum at one day of steaming for 110°C. At longer steaming times, the steam started leaching out the newly created chromophors, as it was also observed during steaming of black locust. More chromophors were removed from the heartwood than from the sapwood. The optimal colour homogenisation time (in viewpoint of red hue) was found at 12 hours for 110°C, and 24 hours for 80°C and for 95°C. The created colour hues of both sapwood and heartwood were even redder than the hue of non-steamed heartwood. These newly created warm brown colours are visually more attractive than the original colour of heartwood. Based on the technical properties, steamed Turkey oak can be utilized for some indoor applications (e.g. parquet flooring, furniture components and front panels) after colour homogenisation.

CONCLUSIONS

The color change of black locust is fast at the beginning of the steaming. This tendency decreases with time and goes to a constant level. By steaming with a temperature above 100°C, black locust color can be modified to a very dark brown resembling that of some tropical timbers such as the African wengé (*Millettia laurentii*) or the South American supupira (*Bowdichia spp.*) frequently used for solid wood and prefab flooring components. If a specific color is desired, the proper process parameters controlling the steaming process have to be set accordingly and monitored closely.

All temperatures in the examined 80-120°C range are suitable to homogenise the colour of white and red heartwood of beech. The colour change was similar below 100°C independently on the
temperature. Most part of colour change has happened during the first 18 hours of steaming. The initial moisture content has not effected the colour change above the fibre saturation moisten content. At initially dry samples the colour change was slower than at wet samples.

Based on the technical properties, Turkey oak can be utilized for some indoor applications (e.g. parquet flooring, furniture components and front panels) after colour homoginisation. The colour difference between sapwood and heartwood can be reduced effectively by steaming in the 80-110°C temperature range. The new appearance created is a visually more attractive brown colour than the natural colour of heartwood. Steaming above 100°C can be recommended if a special dark brown colour is needed.

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Drivers of the Polish forestry-wood sector

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ABSTRACT

A characteristic feature of the Polish forestry-wood sector is its dependence on national timber resources and namely on one main supplier of wood – the State Forests. Lately, Polish demand for wood has been greater than the given supply and this deficit amounts to 5 M m³. An interesting issue which arises, is whether this deficit is really a hindrance for the development of the Polish wood industry? On the one hand, there are Polish companies who claim they could increase their production if only they were allowed to buy more roundwood, on the other hand however, is it not the case that a restriction on the amount of raw material stimulates a more balanced use of it? Another interesting aspect is the tendency to increase timber harvest not only for energy, but also for processing use, gaining importance all around Europe, including Poland. What measures should be taken to support this process? Considering the above, this paper will focus on presenting key driving forces behind the development of the Polish forestry-wood sector.

Among key stimuli of the Polish wood industry’s development one must distinguish the creation of a more effective system of selling wood in Poland. Tools allowing for the activation of SMEs, which are dominant in the Polish wood industry, are also significant. These include: reaching for funds from the EU budget, choosing most efficient ways of financing, the formation of clusters, the creation of more effective management systems, enhancing knowledge transfer. With regard to the last tool, the significance of the Forest-Based Sector Technology Platform and its daughter-platform, i.e. Polish Technology Platform for the Forestry and Wood Sector should be stressed. Additionally, the Polish forestry-wood sector is affected by external factors, such as the growing potential of China or the financial crisis in the US. All these factors influence the economic performance of the Polish wood industry, which has been relatively good recently, as will additionally be shown in this paper. The Polish wood industry is relatively competitive; however, the entrepreneurs see significant barriers of innovation implementation which will be presented.

INTRODUCTION

The aim of this paper is to present potential drivers of the Polish forestry-wood sector development. This sector in Poland experiences similar challenges as those faced by the whole European sector: wood raw material deficit, problems with mobilising wood resources, flood of cheap wood products from China, decrease in supplies to the USA etc. However, it also has the potential to grow which has to be activated by various means which to a great extend have to be addressed to the entrepreneurs who for their most part are small and medium-sized enterprises. There is also a need to integrate the sector and make all the stakeholders see that its well operation depends on value chains and creating value added not by price but by making the most of the advantages that Polish producers can offer the customers. And the said advantage stems from knowledge transfer which is realized by bridging the gap between science and industry through such initiatives like for example technology platforms. However, we cannot forget about
the implementation of gained know-how and that is conditioned by the availability of funding which can pose a huge problem for SMEs. Therefore it is important to point some of effective ways of financing the operation of companies of the forestry-wood sector. Another aspect are external influences on the sector, i.e. China conquering the European market in wood products and the slump in demand from the USA which resulted in increased sale of German and Scandinavian sawnwood on the Polish market and brought about a reduction in Polish sawmill production. This highlights the need for defining the factors which are key stimuli of the Polish forestry-wood sector and focusing on actions which would lead to gaining a relatively sustainable competitive advantage allowing further development of the sector.

CONDITION OF THE SECTOR

Characteristics of the Polish forestry-wood sector
Poland plays an important role in the European forestry-wood chain. With timber harvest amounting to 33 M m$^3$, the country is the fifth largest supplier of roundwood in the European Union. Production of wood-based panels gives Poland the second place in the EU, floorings – third place, furniture – sixth place and sawnwood – seventh place. The Polish forestry-wood sector has also a significant meaning for the Polish economy. It has a 3.5% share in the global production, a 2.4% share in the gross value added, and a 13% share in Polish exports. Wood and wood products increase the positive foreign trade balance and furniture is one of the main export commodity groups in Poland. Moreover, the sector employs 350 thousand people, thus taking into account the families of those employed, it provides a living for about 2 million people. As far as the structure of the wood sector is concerned the furniture production dominates with a 41% share in sold production. The pulp-and-paper and paper-processing industries are also of significance with a 26% share.

One of the main characteristic features of the Polish forestry-wood sector is the fact that forests are mainly publicly owned (82%). Mostly (78%) these are forests managed by the State Forests National Forest Holding (PGL Lasy Państwowe) which is responsible for 95% of the total timber harvest. Prices of roundwood are currently determined by a new system of wood sale based on a forestry-wood portal which is available for all clients on equal terms. This system has been designed with the aim of delivering benefits for the suppliers as well as recipients of wood. It should be emphasized that Polish national timber resources are relatively highly self-sufficient and only about 6% of roundwood is imported.

Another distinctive feature of the Polish wood and furniture industries is the domination of small and medium-sized enterprises, especially micro enterprises (93%). Consequently, the development of the entire sector can be stimulated by increasing these companies competitiveness. The issue is particularly complex as SMEs often face barriers of increasing their effectiveness, such as: problems with financing, insolvency, lack of funds for new technologies, lack of effective management systems, lack of will to cooperate with R&D’s etc. Generally, companies with a significant share of foreign capital are the most competitive in the Polish wood sector but still it is price competition which dominates over “quality-innovation” competition.

Recent trends have led to difficulties in domestic raw material supply on the Polish wood market. The deficit of roundwood is currently estimated to be about 5 M m$^3$. As a result, competition for wood among companies, branches and even sectors is growing. For many companies, especially of the sawmill industry, this deficit is a hindrance to the full use of their economic capacity. If the deficit tendency is to be maintained in the long-term, it could lead to liquidation of some companies, mainly small and medium-sized, and worsening of other companies’ economic performance, including a lower profitability index. The recent deficit has led in the short-term to an increase in wood prices in Poland and a plunge of the sawmill
industry’s profitability. On the other hand however, lack of roundwood on the market may to some extent influence more effective use of it. This could in consequence stimulate a more balanced development of the Polish forestry-wood sector. Furthermore, it is important to analyze the Polish roundwood deficit in the global perspective. Given the recently decreasing global demand for sawnwood, due to the surplus of sawnwood on the American as well as European market, it can be predicted that the difficulties in Polish raw material supply will become a less important development barrier for the sector. An inflow of sawnwood from Germany and Scandinavia to Poland has already been observed.

Another interesting aspect is competition for roundwood between the wood and energy sectors in Poland. Although the country’s priority is to use wood for processing purposes there is growing demand for wood as a biomass for energy purposes. This is a consequence of Poland’s obligation towards the European Union to increase the share of energy derived from renewables, the source of which is mainly biomass, as alternatives such as wind or water are not frequently used in Poland. In order to increase Poland’s domestic raw material supply an effective system of using wood waste as well as post-consumer wood should be created. For the moment there is no system of managing post-consumer wood in Poland and its creation could be a significant driver for the Polish forestry-wood chain.

It is noteworthy that Polish wood companies keep increasing their presence on foreign markets. In case of furniture, circa 90% of total Polish production is exported. This makes Poland the world’s fourth largest exporter of furniture and the third largest in the EU. This openness is especially vital in the context of Poland’s membership in the European Monetary Union. As for now it is planned that Poland will adopt the euro in 2012. Until then Polish exporters of furniture have to deal with significant barriers of development, such as exchange rate fluctuations and transaction costs. Recently, due to the fact that the Polish national currency has been gaining value in relation to the euro, these entrepreneurs have been making less profit. In this light, the sooner Poland joins the euro zone, the better for the Polish wood industry (Pikul, Ratajczak, 2006). Finally, being part of the global forestry-wood sector, Poland’s wood industry is strongly influenced by external factors such as the growing economic potential of China. The country has become one of the world’s biggest producers, consumers and importers of particular wood products. Chinese expansion poses some threat for Polish wood companies but on the other hand it can also be a driver for the Polish forestry-wood sector as will be shown further along in this paper.

**Economic performance of the Polish forestry-wood sector**

Lately the economic performance of the Polish wood sector has been relatively better than of other processing sectors. The wood sector has achieved better financial and economic results, has a higher share of value added in production and experiences high and growing dynamics of exports. Moreover it can be observed that profitability indices have been improving, particularly when it comes to the production of wood-based panels (net profitability in 2002 – 2.7%, whereas in 2006 – 6.5%), pulp, paper and paperboard (in 2002 – 9.2%; in 2006 – 10%) and furniture (2002 – 2.9%; 2006 – 4.2%).

In 2006 the sold production of the furniture industry rose by 13%, whereas the production of wood products by 7%, and pulp and paper production only by 5%. The share of the wood sector in the sold production of industry is more than 8%. The dynamics of sold production of the wood industries is currently higher than the Polish industry average and this tendency is predicted to continue at least in the short term. It is worthwhile to mention that the wood industry is one of the industries in which the use of production capacities has been growing at the fastest rate.

As far as foreign trade is concerned, roundwood and products of its processing account for over 11% of the Polish exports and their share in imports is almost 5%. It is of significance that furniture is one of the most important product groups in Polish exports, with a share of 6%. More than 85% of the value of Polish furniture exports is directed to the European Union countries,
mainly Germany (41%), France (8%) and the UK (7%). Contrary to the overall situation in the Polish foreign trade wood products generate a positive balance of exports and imports.

**Barriers to the entrepreneurship as perceived by the Polish entrepreneurs**

Having presented the current situation of the sector it is worthwhile to mention also the barriers faced by Polish business generally as perceived by the entrepreneurs. It stems from Fig. 1 that complicated and fast changing legislation as well as bureaucracy and difficulty in obtaining EU funding are among the greatest obstacles. The lack of employees is another often raised issue hindering development of Polish companies in general and at the same time it is a noticeable problem in the forestry-wood sector, especially when it comes to finding skilled workers. The situation is also unsatisfactory when it comes to financial liquidity and financial resources for investments. Also competition of foreign companies, including Chinese, is perceived as a barrier to development.

Fig. 2 confirms observations made hereinbefore but at the same time gives more general overview of the Polish economy presented by the entrepreneurs. In addition to the above-mentioned barriers high interest rates and tax burdens are also hindrances in running a business and Polish economy is not free from corruption and dishonesty.

Looking at the presented picture of the Polish forestry-wood sector it is clearly visible that there is a need to determine key stimuli of the sector development in order to maintain its competitiveness in the future characterized by growing competition for the raw material as well as more and more aggressive competition on the wood product market. If the barriers are to be overcome then there is a need to find ways to conquer difficulties like lack of funds for investments, complicated law, troublesome access to the EU funding, competition of foreign companies, and deficit of skilled employees. The last issue is especially important to the Polish forestry-wood sector which is suffering from outflow of qualified workforce to great extent caused by opening West European labour markets to employees from Poland.
KEY DRIVERS

New wood sale system
The wood trade system has been evolving for a longer time and went through few stages. In 1990s there was a rule of customer negotiations with forest managers, directors of Regional Directorates of State Forests or General Director of State Forests. In the period 1998-2001 the sale form were tenders and auctions (Söstak 2001). In the following years there was a come back to contracts concluded with customers. However the system which was operated till 2006 was criticized for the lack of transparency of negotiations and various criteria assumed by different Regional Directorates of State Forests. From 2007 new rules of wood sale have been effective in Poland. The new system was introduced by Regulation No. 52 of General Director of State Forests of 23 October 2006 and is based on following principles (Kwiecień 2006): 1) sale rules are the same for all buyers; 2) there is equal access to the raw material; 3) rules comply to the law. According to the Regulation the State Forests activities are:
- preparing agreements stating that if in a given calendar year there is a sale contract concluded between State Forests and customer then a minimum wood raw material quantity is guaranteed in the contract (so-called raw material promissory document);
- preparing a wood sale offer by State Forests (the sale offer refers to the whole calendar year and to particular periods);
- determining future buyers (taking into account the interest of the Treasury if future buyers withdraw from contract conclusion);
- emergency wood sale;
- sale of wood raw material to State Forests plants and use of these plants and other business entities in the scope of wood shipping and disposal.
This new wood sale system is based on the forestry-wood portal which gives equal opportunities to all its clients as well as allows for common, simultaneous and open examination of submitted demand and selection of best offers and their proportional reduction on the basis of assessment criteria which are known and accepted by certain bodies (Lis 2007). The system is still evolving and some of the criteria used by the portal need to be discussed as they are more favourable to big customers (e.g. production capacity criterion). The system was to neutralize the supply monopoly of the State Forests but has not been successful in that and also has not gained the full commercial law regulations are complicated and unclear
acceptance of the industry; therefore most likely it will have to be modified in the future. Nevertheless introduction of the new system was a pioneer and modern solution striving at optimization of the sale process and one of the drivers of the sector facing raw material deficit.

**EU funding**
European Union creates many possibilities for the sector to gain funding for various activities including scientific advance (supported by numerous initiatives within 7FP) and development of companies which can find necessary support in the EU regional policy, environmental policy and Regional Innovation Strategies (RIS). It is expected that in the period 2007-2013 the Polish forestry-wood sector should benefit from the regional policy programmes in following ways (Bidzińska, Ratajczak, Szostak 2007):
- increase in the companies competitiveness through: increased effectiveness and quality of work; higher innovation level of the sector enterprises (as a result of initialising innovation activities, intensification of scientific research, better operation of R&D institutions, stimulating knowledge transfer); promotion of business links (e.g. creation of clusters); improvement of employments structure and workforce qualifications; support for starting-up companies;
- increased potential of the sector;
- adjustment of the companies to the requirements of the European Union legislation;
- support for SMEs operating in the sector;
- rational use of biomass for energy purposes.

**Effective management systems**
Effective management systems are another factor stimulating enterprise competitiveness in the market. They allow for attainment of company strategic goals including achievement of measurable economic effect. A management system can be considered effective if a certain economic entity achieves better results that the average for a particular group of companies. A management system is made up of various components, such as the management of: human resources, quality, innovation, promotion, product, safety, environment etc.

It is obvious that a management system which is “perfect” and suitable for each and every company of any branch does not exist. Enterprises differ as far as their size, legal status, economic condition, technological potential etc. are concerned. It should be emphasized that a well chosen and organized management system allows companies to gain market advantage due to many benefits it brings. These include: an improvement of the corporate image, greater motivation of employees, a reduction of economic losses. For instance if employees are regularly informed about the company goals, if they are being trained through various programs, given regular feedback, evaluated together with being gratified, they will be more likely to “help” the company to achieve best possible results.

A popular nowadays model of management comprises the usage of outsourcing, which in practice means that companies commission part of their production to firms which specialize in the required activity and will perform it more effectively. This model is still however more common among wood companies from Western Europe than in Poland. A similar situation exists in the case of clusters, a relatively new way of organizing company structures in Poland, worth mentioning however due to substantial benefits it can bring to wood companies. Furthermore, Polish wood companies could profit from implementing the concept of lean management, which allows for a reduction of costs together with creating a more comfortable working environment. Another possibility is to train staff in Total Quality Management, which is aimed at providing product quality together with client satisfaction (Bidzińska et al. 2007). In the context of value chains more common use of vertical integration model by the forestry-wood sector enterprises seems another worthwhile idea.
Well organized management systems are most common in big companies, however, use of such systems in SMEs would contribute to an increase in their efficiency thus in their competitiveness in the market which is no longer local but global and in consequence more demanding.

Clusters – a driver for competitiveness
Although clusters are still a relatively new organizational structure in Poland, there are a few initiatives of this kind undertaken within the wood sector; however their presence in the market is too short to evaluate potential benefits. Lately the idea of clusters has been becoming more and more popular, partly due to the fact that their creation is supported by projects funded from the EU budget. It should be emphasized that the formation of clusters could bring Polish wood companies the following benefits:
- better conditions of negotiating prices and terms of sale (this has significant meaning on a market where there is one dominant supplier of wood),
- reduction of costs due to: common financial services for members of clusters; common infrastructure (e.g. costs of heating); common outsourcing of parts of production (e.g. parts of furniture made in China); creation of common exports products and a common search for new areas of sale, often abroad; buying consulting services together; training employees together; common transport; common marketing policy; common fair expositions;
- knowledge transfer (cooperation with the research provider community) etc.

Financing – putting ideas into practice
Since a high share of SMEs is a characteristic feature of the Polish forestry-wood sector and they are in general characterized by low capital and additionally by low creditworthiness, the lack of financial resources is a substantial obstacle hampering investments and innovation in the sector. Therefore various techniques of financing operation and above all development of these companies should be mentioned among other drivers of the sector development. Although SMEs to great extent finance their investments using profit they make and resources from depreciation deductions these may be not enough to make considerable advance in terms of innovation. Various types of loans and leasing are not the only answer. Factoring, whose history reaches back to antiquity, is cession of receivables to a factor thus a way of obtaining financing and also through the improvement of company’s financial liquidity it facilitates credit accessibility. Whereas factoring concerns domestic transactions, forfeiting is a similar method but allowing for selling receivables connected with contracts for services, sale and delivery in international trade. And last but not least financing technique which seems potentially interesting and worth popularization in terms of the sector development is venture capital addressed to companies wanting to make “a great leap” implementing a truly innovative solution. And what is important venture capital financing may take seven forms covering various stages of a company development (ed. Targalski 1999): seed-financing, start-up-financing, first-stage-financing, second-stage-financing, third-stage-financing, bridge-financing, and buy-outs.

Knowledge transfer – choosing the development direction and supporting implementation
Knowledge transfer plays an important role in development of any sector including forestry-wood sector. Unfortunately over half of Polish entrepreneurs do not the need of cooperation with research institutions and around 40% of companies are not aware how to reach these institutions which on the other hand are interested in commercialization of their services (Łącka 2007). This situation is also encountered in the forestry-wood sector. Therefore stimulation of knowledge transfer by various initiatives at national and European scale can be considered a vital driving force of the sector. Among the undertaken initiatives are actions addressed to all the economy sectors like (Ratajczak 2007): Innovation Supporting Act (in force since December 2005), actions of the Polish Ministry of Science and Higher Education such as Innovative Economy Programme (aimed at promotion of science and business cooperation, academic entrepreneurship
support, financing of new technological solutions etc.), Technological Initiative Programme (created to support new products and technologies development based on achievements of Polish technological science), Foresight “Poland 2020” or B2Europe West Poland project (whose objective is to support business and innovation through information, feedback, cooperation, technology and knowledge transfer, and encouraging SMEs to benefit from EU 7FP; the project covers 5 provinces of Poland: Zachodniopomorskie, Lubuskie, Wielkopolskie, Dolnośląskie, and Opolskie, and has 6 key partners and 3 local partners), and initiatives concerning specifically forestry-wood sector such as virtual network “Forests” (focused on facilitating participation in EU FP, integration with EU research, dissemination of knowledge, and increasing the role of research in forestry), WOODISM SSA (striving at stimulation of science and industry international cooperation in the wood sector), and Polish Technology Platform for the Forestry-Wood Sector (PPTSL-D). PPTSL-D is one of the National Support Groups (NSG) of the European Forest-Based Sector Technology Platforms and as such delivered its national input to the European Strategic Research Agenda (SRA) which comprises of 5 Strategic Objectives combined with 5 Value Chains (FTP SRA 2006). As a result a matrix of possible lines of the sector development was created. Additionally every NSG produces a National Research Agenda (NRA) mirroring the structure of the SRA and stressing national specificity of the sector in a given country. Polish NRA is still under preparation but it is expected to be a driver of the sector as it is a valuable tool of defining lines of development based on knowledge transfer and intra-sectoral collaboration.

Another initiative enhancing collaboration in the field of knowledge and skills transfer was “InnovaWood SSA – An Innovation Strategy to Integrate Industry Needs and Research capability in the European Forestry-Wood Chain”, funded under the EU “Global change and ecosystems” research activity of the Sixth framework Programme whose deliverable is a free-of-charge interactive database allowing companies to find research providers from all over Europe which offer services in chosen topics of wood science and technology. The aim of the database is to bridge the gap between industry needs and research capabilities. An expected result is stimulation of the competitiveness of the European Forestry-Wood Chain. The issue is particularly important for Poland where the industry is rather sceptical about collaboration with knowledge and skill suppliers.

**New business model due to Chinese expansion**

One of the main driving forces for the development of the Polish wood market is the increasing activity of East-European and Asian markets. Among emerging players in the global wood market one can distinguish: China, India, Brazil, Indonesia, Russia, Malaysia, and Chile. The role of China should be emphasized since, as stated in the Forest Products Annual Market Review, “…China is now the hottest forest products market in the world…” (Forest Products Market 2005-2006). A very significant trend is that China imports low value raw materials used in manufacturing of higher value-added products which are later exported. Integration of the Chinese market with the global economy is on the one hand a threat and on the other an opportunity for Polish furniture companies. The threat consists in the necessity to compete in the market where cheaper, i.e. more competitive, products appear. In 2006 for example, the share of furniture imported to Poland from China in total Polish imports of furniture rose to 13%, while in 2000 it was only 1%. From the other perspective however a chance for making structural changes in Polish companies has appeared. Polish wood enterprises can commission parts of their production to companies in China, i.e. benefit from outsourcing. Polish producers would still be dealing with activities which give the product greatest added value, such as marketing, price policy, distribution, market analysis, competition, creating relationships with clients etc. If Polish producers do not switch to such a business model soon, they may find companies from Western Europe commissioning their production to China instead of Poland, as it is today.
Another interesting aspect is the increasing standard of living of some social groups in China, resulting in a rise of imports from the West, as it is for instance taking place in the case of furniture. Polish furniture producers could take advantage of this trend by directing their exports to China and securing their position on the Chinese absorptive market. So far Polish export of furniture to China is not significant.

An obvious barrier of choosing Chinese producers as business partners is geographical distance. Costs of transport may however be reduced if this business model would be based on DIY furniture, in packages, often made of MDF, relatively light and taking up less space (Kalupa 2004). Another interesting aspect is that in West European countries, the idea of outsourcing production to countries with cheaper labour force is most common among big enterprises. Taking into account the dominance of SMEs in the Polish wood and furniture industries it seems worthwhile searching for benefits from collaboration between companies which are natural competitors and this can be done for example through the creation of clusters.

**CONCLUSIONS**

The Polish forestry-wood sector demonstrates well economic performance and has its established position in the national as well as European market. However, globalization requires constant development in order to keep up with changing market conditions. Among the problems which the sector has to cope with at present are internal factors such as the deficit of roundwood, requirement for a better wood sale system or barriers to raising the competitiveness of wood companies, which for their most part are SMEs. These barriers include entangled and unstable legislation, bureaucracy, hampered access to EU funds as well as lack of human resources. Additionally external factors, such as the growing potential of China, influence the Polish forestry-wood. Therefore use of the drivers discussed above is necessary to create a sector which will face the 21st century challenges. Creation of a post-consumer wood managing system, development of consumer-tailored wood sales system, and preparation of NRA are among tools to accept the challenge. Furthermore, implementation of some of the drivers, like adoption of most appropriate thus most efficient management systems, use of various financing and funding methods or cooperating with R&D units and creating clusters, are dependent on the companies. They need to see the benefits instead of hindrances, for instance entrepreneurs still perceive EU funding hard to get and so the possible benefits are neglected, venture capital is a solution which means partial loss of control over the company but for qualified managers who can be of help in running the business, and implementation of the most suitable management system, though it sometimes seems complicated, is another way of gaining market advantage by the company. Cooperation with R&D institutions is also a sphere that has to be improved as research providers must be perceived as a way to gain competitive advantage. Other drives, like expansion of Chinese companies or planned accessing the euro zone in 2012, do not depend on the companies but they need to know how make the most of these.

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Wood Technology Road Map – Austria

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Keywords: Technology road map, wood innovation, technology foresight, wood technology

ABSTRACT

A technology road map (TRM) is the result of a needs-driven technology planning process by a team of experts in order to identify, select, and develop technology alternatives so as to satisfy a set of needs. TRM can be considered a foresight method, however, it is based on the assumption that the future can and should be created, and that this should be done in a collective process. Technology road mapping can be done at either of two levels – industry branches (or other groups of companies) or individual corporations – applying the same structure such as: needs, critical system requirements and targets, technology areas, technology drivers and targets, technology alternatives and emerging technologies, recommended alternatives or paths, and a road map report. The main benefit of technology road mapping is that it provides information so as to make better technology investment decisions by identifying critical technologies and technology gaps and identifying ways to leverage R&D investments etc., based on a jointly defined 'image' of the future.

INTRODUCTION

A technology road map (TRM) is the result of a needs-driven technology planning process by a team of experts in order to identify, select, and develop technology alternatives so as to satisfy a set of needs. TRM can be considered a foresight method, however, it is based on the assumption that the future can and should be created, and that this should be done in a collective process. Technology road mapping can be done at either of two levels – industry branches (or other groups of companies) or individual corporations – applying the same structure such as: needs, critical system requirements and targets, technology areas, technology drivers and targets, technology alternatives and emerging technologies, recommended alternatives or paths, and a road map report. The main benefit of technology road mapping is that it provides information so as to make better technology investment decisions by identifying critical technologies and technology gaps and identifying ways to leverage R&D investments etc., based on a jointly defined 'image' of the future.

Wood industries have already taken advantage of technology road mapping and several road maps have been initiated (Anon. 2003, Anon. 2005, Anon. 2006 etc.). Currently an innovation road map for wood is to be implemented in Switzerland (Anon. 2007).

Supported by the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) the authors are currently managing a technology road mapping process for the Austrian wood industries. The main targets of the TRM wood Austria are: economic guarantee of any further development of the forest-based sector in Austria, strengthening and facilitating innovation in the
forest-based sector, and providing basic knowledge for planning and decision making in research, provide a framework for efficient research planning, development and education.

METHODS

There is no standard method for developing a TRM. One of the main ideas of a TRM is a proactive procedure and starts from the idea that the future can and should be created (“one had better create the future than predict it”). A comprehensive analysis of Technology Road Mapping (TRM) techniques and the key elements of a TRM are provided by de Laat et al. (2002) and Laube et al. (2006). Generally the development of a TRM consists of three phases: preliminary activities, development of the technology road map, and follow-up activities. The project is in now in the second phase, the development of the road map, primarily through workshops with wood industry experts. The scope of the process will be presented in the poster.

During the preliminary activities, which included discussions with experts from BMVIT and the wood industries as well as a survey of current activities on the international level (various TRMs concerning wood, Forest Sector Technology Platform, COST Action E44 etc.), the scope and the boundaries for the actual road map have been developed. The overall objective of the TRM project is the creation of an action plan for the forestry – wood value chain with various supporting measures concerning research, development, education and training, structural policy etc. The following specific issues have been identified and will be discussed in the workshops (Fig. 1):

- Forest based industries – data on structure, relevance, supply and demand projections
- Resource efficient technologies (adjustment, optimization and radical changes)
- Intelligent and new applications of wood (multifunctional wood-based materials, cascadic use of wood, wood refinery concept etc.)
- External and internal management and logistics along the value chain
- Innovation process, standardization and technology transfer
- Measures for keeping industrial sites and headquarters (resources, technologies, structures etc.)

Each workshop is led by an expert for the specific issue who provides the state of the art (e.g. data on long-term supply and demand projections for wood industries or wood resources in short supply – a challenge for technology and innovation etc.). An impulse presentation to the workshop topic forms the beginning of each workshop.

In order to keep the stakeholders (forest-based industries) as well as the ministries involved, interested in and informed of this project, separate high level groups from the industry and the ministries have been established. These high level groups are invited to regular discussions by the project management.

RESULTS AND DISCUSSION

As the various workshops are still ongoing and the final document has to be elaborated in an iterative process, no results are available at the moment. The results will be presented in an Action plan 2015 – the Wood Technology Road Map in autumn 2008.

At first glance the Austrian forest products industry is based on the industry's inherent strength: stewardship of a renewable and sustainable raw material base, a manufacturing infrastructure that can process wood resources into a wide variety of consumer products. The industry is also
uniquely positioned to move into new growth markets centred around bio-based “green” products.

Based on the TRM workshops and accompanying workshops concerning the future of wood industries, one of the most challenging developments will be a more resource efficient wood technology, improved functionality of wood based materials and products, optimized wood products design, and new product-service models. Competition between wood for material use (including pulp and paper) and as an energy carrier is increasing, which forces the whole forestry wood chain to reorganize (e.g. cascadic use of wood and increased use of recovered wood etc.). Demographic changes will lead to new living scenarios which will also have an enormous impact on wood products.

Fig. 1: Structure of the project management of the Technology Roadmap Wood Austria and the various workshops including the workshop experts, people and institutions involved

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Wood resource allocation has become one of the key issues for the wood industries and mobilization of the forest resources will have an important role in the future. The challenge of keeping Austria as an industrial site (especially for the pulp and paper industries due to the rigid CO2 regulations) has already been announced in public by various entrepreneurs.

In a long-term perspective a changing forest resource (increase of mixed species, especially hardwoods) due to changing silvicultural measures and climate change has to be taken into account.

Note: Currently the project is in the state of finalizing the workshop series. As the final document (and results) will have to be evaluated and discussed by all persons involved (compare Fig 1.), no detailed results can be presented to the public at the moment.
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Wood Material Flows Currently Present in the Slovak Republic

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Keywords: wood processing industry, wood material flows, Slovak Republic

ABSTRACT

The Slovak economy is simultaneously a small and remarkably open economy, in which the national contribution of wood processing industry is considerable. Nevertheless, the application of sectoral programs is considered to help the industry that needs to undergo certain restructuring. Such an instrument is used now in strict compliance with the EU rules on granting state aid and the competition protection rules. A gradual adaptation of industrial structure in wood based sector to the EU accession conditions is under the process, and the Slovak Republic has expressed it in accordance with the economic criteria contained in the programs of the acquis communautaire. The detailed knowledge of the wood material flows from the forest to the last burned particle is the basic condition to understand and to control the national system. This paper presents the results of wood flow investigation in Slovakia through the forestry and wood-based sector. Forests outcomes support the development of wood processing industry and are used as tools to demonstrate the potentials of wood as an industrial raw material as well as an energy source.

INTRODUCTION

The wood material flow strongly depends on available resources and structure of wood processing industry and related industry in a country or a region.

The macroeconomic of the forest – wood industry chain contributed by 4.0 % of gross domestic product in 2005. Forest industry covers 0.6% of GDP, wood processing industry 2.4% and there is also public beneficial function of the forest representing 1.0% of GDP (Green report 2006, SO_SR 2008).

Ownership of the Slovak forests is diverse. 41% of the forest land is owned by state, 25% by association of private owners and 14% is private. Municipalities and church possess 10% and 3%, respectively. The rest of the forest land belongs to unknown proprietress due to unfinished restitution process in Slovak republic. Despite the ownership, more than 50% of the forest land is maintained by State forest enterprise.

The forest in Slovak republic consists of coniferous (41%) and broadleaves species (59%). Among major species belong beech (31%) spruce (26%) and oak (11%). Pine, Larch and Fir species appertain to less common species (7.2%, 5.5% and 4.2%, respectively). Other species take place in less than 2% each.

The wood processing industry (WPI) rates among medium-sized industries of the Slovak Republic with a 9.6% share in the total industrial output of the Slovak Republic. The recorded number of employees in companies with 20 and more employees stands at approximately 30,000. Revenues from their own goods and services represent an annual volume of
approximately SKK 85 billion, export stands at SKK 67 billion, acquired investments in 2005 represented SKK 9.4 billion.

The total Slovak annual wood consumption including the entire product range and all classes stands at the level of approximately 6.5 million m³. The export of raw timber represents approximately 1 million m³, of which sawmill and veneer products represent a substantial portion. The WPI development possibilities lie in the use of reserves in wood utilisation and in the relatively high export of raw timber and high export of semi-finished wood products with a low degree of finalization.

The most stable wood processing industry branch is pulp and paper industry. Most of them are controlled by multinational companies with success tradition in the field (Mondi from South African group AngloAmerican, Dutch Kappa Packing, Irish Jefferson Smurfit). Saw mills and panel product industries have had rapid improvement over the last 5 year. This was done especially due to large investments of established foreign investors (such as German sawmill owner Rettenmeier). The major investor of wood panel industry is Kronospan who managed to produce 36% of Slovakian wood panels in 2005 and later expanded his activities in the 3rd largest panel production company Bucina Zvolen. Among main contributors to furniture making industry belong Swedish Swedwood, Lind Mobler and successful Slovak owned Decodom and Ecoltech.

### EXPERIMENTAL METHOD

The data for the analyses were taken from three reliable references available in Slovak Republic (SR), namely Green report 2006, the Statistical Office of the SR and Report of wood processing industry development from the Ministry of Economy of the SR (ME_SR 2006). The sources cover databases of wood processing enterprises with over 20 employees.

Because of complexity and data availability, the wood flow analysis was analyzed for the reference year of 2005 only. Four areas of the forest-wood industry chain were of concern, namely, forest industry contribution to the wood industry, sawn wood industry, wood base panel industry, pulp and paper industry and new developed renewable energy industry. More deeply into the wood processing scatter and less reliable data we have found. Therefore wood flow in furniture or wooden buildings industries were not quantified in this study as well as export volumes flow of high value added wood products such as pulp and paper, wood base panels or plywood.

The main goal was to collect data of wood material flow through the forestry and wood-based sector and to show how this information is useful for further development and expanding of the industry. Roundwood under bark was used as a reference unit. Fuel wood chips and fuel wood listed in the references in tones was recalculated to reference unit using average wet roundwood density of 710 kg.m⁻³. A yield factor of 55% was used for conversion of roundwood volume to sawn timber processed in saw mills. A yield factor of 70% was used for conversion of roundwood volume to panel product volume.

### RESULTS AND DISCUSSION

#### Forest industry contribution to wood industry

In 2005, the total growing stock was 438 Mm³ (Green report 2006)¹. Reported annual increment was 11.6 Mm³ of wood (under bark with dbh > 7cm). Due to wind calamity in 2004, the total harvested volume was in 2005 10.2 Mm³ (Fig. 1) and in 2006 8.3 Mm³, respectively. During the typical year (such as in 2004), the harvested volume was 7.3 Mm³.

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¹ Mm³ will stand for million (10⁶) cubic meters of roundwood under bark unless it is stated differently.
The import of the wood resources was rather low. In 2005, 67 thousand m$^3$ was imported as roundwood and wood for energy industry. Stabilizing relations at the domestic market caused the subsequent decrease in export during the years 2000 to 2004. Timber export started to drop after 2000. An increase in the year 2005 to 1,815 thousand m$^3$ is the consequence of an urgent need to process windthrown calamity timber (Palus et al. 2007).

The majority of the roundwood is processed in sawn mills and pulp mills (Fig. 2). There is small amount of 1$^{st}$ and 2$^{nd}$ class roundwood which is used in veneer production. Probably the best quality roundwood in Slovakia is sold as stumpage or raw stems.

**Figure 1: Wood resources flow in forest–wood industry chain.**

**Figure 2: Assortment structure of the round wood in 2005.**

**Sawn wood industry**

European sawn wood industry tends to be concentrated in the large mills (capacity of 0.2 – 0.4 Mm$^3$ per year) and large enterprises (capacity above 1 Mm$^3$) (Parobek 2006). In Slovakia we have similar approach. Sawn wood industry consists of thousands SME’s with less than 5 employees and of several large mills with capacity up to 0.5 Mm$^3$. Nowadays, this is a well developed sector of wood processing industry. After large support of Skipper Investments fund from Luxembourg in P.F.A. s.r.o. Lozorno, Amico Drevo s.r.o. and Slovincom, the production of the mentioned companies doubled to 0.3 Mm$^3$ in 2006 (Trend
2007). Moreover, the biggest enterprises Rettenmeier Tatra Timber s.r.o announced expanding his capacity up to 0.8 Mm³ in 2008 (rettenmeier.com 2008).

In 2005, sawn wood industry processed approximately 4.04 Mm³ of industrial roundwood and produced 2.630 Mm³ of sawn wood. Since there is no data about remaining waste distribution, based on expert estimation (supported by few unpublished data) there is an assumption that the flow of wood waste from this industry splits into three parts: a) waste used for production of heat energy partially covering technology energy needs (0.142 Mm³), b) waste used in panel industry (0.566 Mm³) and c) waste used in pulp and paper industry (0.566 Mm³). In 2005 there was no report of marketing excess energy to public grid, but this activity is recently expanded in Slovakia (Rettenmeier Tatra Timber s.r.o, Bukoza a.s.).

**Wood based panel industry**
In 2005, the wood panel base industry produced 0.583 Mm³ of panel boards. The main contributors (68% of production) were Kronospan Presov s.r.o., Bucina DDD s.r.o. and Tatra timber s.r.o. The industry has two main sources: industrial roundwood (app. 0.364 Mm³) and waste from sawn industry (app. 0.566 Mm³). Kronospan Slovakia states that his production is from residues of sawn wood industry only (Trend 2007). Approximately 0.202 Mm³ of wood was used as own energy source. At that time, some plans in using energy for commercial purposes were made by Smrecina Hofatex a.s.. On the other hand, Bukoza Zvolen a.s. skipped from particle board program and becomes suppliers of fuel chips for energy industry. Their production line was bought and renewed by Austrian Kronospan and the company was renamed to Bucina DDD. After that the capacity of particle boards rapidly increased. The Smrecina Hofatex should be also mentioned as one of the expanding healthy company. Over the last 7 years their triple production of insulated boards to 0.14 Mm³ and become one of the top leader companies in the field of bio-isolated materials in Europe. The company is also investing in energy production plant.

**Veneer and plywood industry**
The veneer and plywood industry in Slovakia has minor part of wood processing industry in terms of processing volume. Despite of that, the sector processed the highest quality roundwood, mostly from domestic sources (0.086 Mm³) and small amount was imported (0.001 Mm³). Although old former Slovak companies have suffered on the market, new investments from Spain and Italy opened new enterprises (Onte Slovakia s.r.o. or Eurotranciaty)

**Pulp and paper industry**
As other European pulp and paper industries, for the last years also Slovakian ones had gone through economical recession. The price of paper and paper products went down and companies tried to overcame the problem by expanding capacities. Unfortunately, this brought oversupply and even lower prices (Trend 2007). After expanding Mondi Business Paper SCP and enlargement of wood base panel industry (the main wood resource competitor), the available wood supply has decreased. The pulp and paper industry has become more depended on imports. Together with an increasing of wood and energy prices, the industry went through rough time. Slovakian pulp and paper industry produced 1.469 Mt of products in 2005 (0.610 Mt pulp and 0.859 Mt of paper and paperboards, respectively). Forest owners as the main supplier insert to this industry 2.302 Mm³. Approximately 0.055 Mm³ of wood was imported and the rest was most probably taken from the sawn mill industry (approximately 0.556 Mm³). The wood resource is commonly used by pulp mills as a cheap source of heat energy and it can reduce cost of the technological process. It is estimated that pulp and paper industry used approximately 0.4 Mm³ for heat production. It should be stated that the input and output data are officially published statistical data, but they do not coincide. It is assumed that the input volume for pulp and paper industry is underestimated.
**Renewable energy industry**

This is a new developing industry in Slovakia. Green report (2006) stated that 0.76 million tons (Mt) of dendromass from the forest was used for energy purpose (0.12 Mt as forest chips and 0.64 Mt as fuel wood and wood from cutting and snags). It is only 17% of the potential from the forest, but there is no production capacity on the Slovakia market. Almost half of the forest chips were exported to Hungary. Nevertheless, the tendency of using “energy” wood is growing. In 2006, the consumption rose up to 0.81 Mt and the assumption for 2007 was 0.85 Mt.

In 2006, there were 18 companies focusing on briquette production with production of 0.06 Mt. Among the biggest producers belongs Bioterm Liptovska Porubka, Faba Banska Stiavnica, Norba Novaky, Drevodom Rajec, etc. (Soos 2006). More than 14 enterprises made 0.04 Mt of wooden pellets, but their total capacity was 0.08 Mt per year. It is exponentially grown industry sector and recently is heading for 0.15 Mt in 2008. Most of the production is exported to Austria, Italy and Hungary. Main pellets producers are Drevomax Oravska Podzamok, Pali-Energy Sladkovicovo, Amico Drevo Oravsky Podzamok and Biomasa Kysucky Lieskovec. Moreover, new investment in Martin and Polomka expands pellet production capacity to more than 0.09 Mt.

Another newcomers in renewable energy industry are heat production plants in Banska Bystrica (Smrecina Hofatex) and Zvolen (Zvolenska teploarenska a.s. supplied by Bucina Zvolen a.s.). Since 2005, another “birds” – local heat energy plants for residential areas have started activities based on wood renewable resources. In 2006, seven of those units across Slovakia were fully functional and plants for others already exist (Green report 2007). The motivation for building such units mainly dwells in cheaper heat production compared to standard fossil fuels commonly used in Slovakia.

**CONCLUSION**

The demand for wood resources in Slovak republic is growing. New investment in every sector of wood processing industry and expanded capacities created a significant impact on wood trade market in Slovakia. Since harvesting politics of foresters is based on the forest annual increment, the supply is limited. Some wood processing sectors started to import more and more wood resources from abroad. On the other side, there is a capacity for energy produced from wood resource and in utilization of recycled wood. Another possibilities for development of wood processing industry lie in the use of reserves in wood utilization and in the relatively high export of raw timber and semi-finished wood products with a low degree of finalization.

From the wood harvested in 2005 (10.2 Mm³), majority went to sawn wood industry (4.046 Mm³ of roundwood under bark) who is also a main supplier of residues for panel board industry. Pulp and paper industry consumed probably more than 2.9 Mm³ and panel wood industry 0.93 Mm³. For the energy purposes 1.1 Mm³ was used. Smaller amount of wood went to veneer and plywood industry (0.08 Mm³) and the remaining part (0.5 Mm³) is associated with other utilization of wood resources (for example used by foresters or other industrial sectors). The export represented 18% of harvested volume in 2005 (1.8 Mm³).

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Modelling of wood and wood products flow in the Slovak Republic

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Keywords: wood flow, modelling, forest industry

ABSTRACT

There is a discussion about paradox of sustainability which concerns have led to efforts to reduce consumption. On the other side, consumption is a key driver of an economy. The economic growth requires permanent increasing consumption that is why; it is complicated to find reasonable way how to use resources. Current production structures require large amounts of primary materials and are not likely to be sustained without large implications for the environment. The paper deal with Material flow analysis (MFA) intends to support this understanding by providing insight in material flows. The method is applied to analyze the wood and wood products flow through the economic system of The Slovak Republic. The method provides detailed information about the final consumption of wood and wood products. This will make the construction of material flow analyses like this one more difficult in the future. Mentioned analysed factors can be viewed as main driving forces affecting efficiency of supply chain, therefore their development and current status is examined in the paper.

INTRODUCTION

Forests in Slovakia are managed as renewable natural resource. They provide on sustainable products and services that contribute to the improvement of the life quality in the whole country. During last period a lot of challenges and opportunities have been accrued in the forestry sector according to, political, economical and social changes, while new conditions also brought new threats and risks. However, new occasions didn’t change main proposal of Slovakian forestry. Slovakian forests represent an important domestic natural source of renewable wood raw material, non-timber forest products and public services as well.

Forest resources in Slovakia

The Slovak Republic is located in Central Europe with total area 49 thousand km² and a population of 5,4 mil. people. Wood represents a significant renewable raw material for the relatively well-developed forest products industries, which are represented by a large scale of wood processing companies to small firms. The share of forest industries in the creation of Slovak GDP is about 3 % according to national statistic office in 2006. (forestry 0,6%, forest product industry 1,4%, public beneficial forest functions 1,0%) The share of the GDP is not so significant, but on the other hand Slovakia belongs to the most Forested countries in Europe. Forest cover is about 42 % of territory (2 mil. ha). Broadleaved forests represent 57 % (Beech 31%, Hornbeam 5,5%, Oak 11%) and coniferous forests 43 % (Spruce 26%, Pine 7,2%, Fir 4,2%) with a good wood quality of total growing stock more than 439 million m³. The average growing stock per hectare is more than 220 m³, which highly overtops the European average. All these facts deal with wood resources are important base for forestry sector and wood processing industry. In Slovakia forest industry is divided to two sectors as forestry and wood processing
industry. Many times lacks and risks can represent important problems. For instance close dependence among forestry and wood-processing industry and communication problem between them. Over mention facts have consequences on forest products flow. Both sectors have passed through a transformation. Wood-processing industry has been totally privatised. Stock companies have been created or other private companies without a participation of the state. Ownership of forest resources vary among different European countries. In Slovakia, state owned 41.8% of forests, associations of owners cover 24.9%, private have about 14.2% of forests, municipalities 9.7% and churches owned 3.4% of forests.

The high share of forest cover and rich raw wood resources as well as importance of the wood-processing industry in the Slovak economy are the reasons why forestry sector should to an even greater extent stimulate the country’s economic development. Similar situation can be found in many different European countries. That’s why it is necessary to encourage wood processing industry in changing the character from cost-price type to qualitative and innovative one. Changing market environment and traditional socio-economic factors influence relations between supply and demand sides of the market. Globalisation trends, free market economy and open trade possibilities determine to a great extent territorial structure of roundwood deliveries in Europe and form business relations between timber sellers and buyers. (Palus, Sulek, Parobek, 2007)

Slovak economy is characterized by their massive throughput of materials and energy. Present structures of production require large value of primary wood materials which are processed into products, transported, consumed and on the end discarded as waste. Anyway value of wood harvesting (10,2 Mm³) is still less (about 88 %) than total wood increment (11,6 Mm³). In Hekkert et al. (2000), for understanding of wood flows and material metabolism is likely to contribute to more sustainable production and consumption. For wood processing industry same as for company it is able to use Material flow analysis (MFA), which intends to support understanding by providing insight into the volume, the structure, and the regulating mechanisms of anthropogenic material flows.

In general there are many various hypotheses about wood and wood products flows. One of these methods is sketched on the fig.1. A diagram shows possibility of utilisation of forest, wood flows of all forests products (wood and non wood forest products) as well as all services of forest. Different final consumers are mentioned in this diagram beginning in individuals crossing families till industry.

This analyses refers to accounts in units (usually in terms of meter cubic or ton) comprising the extraction, production, transformation, consumption, recycling and disposal of materials. Various methods exist which cover approaches such as substance flow analysis, product flow accounts, material balancing and bulk material accounts. MFA has been used for wood processing industry in different countries. According to Mr. Hekkert, who done this research for paper and wood flow in The Netherlands, MFA is able to use in wood processing sector same as for any other industry sector. MFA is a fairly new and rapidly growing research field. Accounting of material flows at firm level have been established in many places but similar efforts on the European, national and regional level are still at the beginning.
Material Flow Analysis -MFA

The emphasis of the method is at providing detailed information about the final consumption of material flows, especially those material flows that are normally hard to trace like some special wood products as packaging material and product parts from wood. But not only final productions could be problematic, but also semi products as well as wood waste, which could be use for next processing. This is valuable information forasmuch as final consumption data of products and materials are very hard to find. Often, apparent consumption data are used as an estimate of the final consumption. However, this estimate is only reliable for final products that are not processed any further. For materials and intermediate products, apparent consumption rather means ‘the use in industry’ which is not a very good estimate for final consumption. Especially for market economy, the difference between imports and exports of materials and products made out of these materials influence the reliability using apparent consumption data as final consumption data.

The aim of this study is to describe the method on wood and wood products flows in Slovakia. For analyzing wood flow has been chosen as an important material flow in Slovakia in terms of value and the final consumption is widely spread over many final consumers.

These flows are defined in mass units per time period. In the special case of individual need oriented MFA, the system under study is additionally related to an individual need (e.g. wood resources). Main field of application is evaluation of environmental policies ranging from emission control, promotion of technological changes up to consumer information. For this purpose, a number of indicators are chosen to describe the environmental problem as well as the relevant characteristics of the system under study. MFA describes such subsystems as networks of technical or economic processes, which are linked by material flows (Baccini and Brunner 1991). It applies a general mathematical description of the process network based on the wood flow. Beyond this definition, it is a generally defined method allowing for a large variety of
system’s definitions as well as an integration of various modelling approaches. Several different model approaches were introduced to describe the development of material stocks. Economic parameters can be included into this general model by adding financial flows (expenses, income and value added) and financial stocks (financial assets).

To ensure a comparable forestry industry we analyze annual wood flows in a Slovakia with common regulations. The method applied consists of the following steps:

a) Systems analysis - it includes the definition of system boundaries, processes and wood products and the choice of indicators.

b) Measurement/assessment - the analysis can be based on data of technical processes (bottom-up approach) as well as on national statistics (top-down-approach).

c) Mathematical description and calculation of the material flows - the mathematical description of MFA describes the system with variables given by the systems analysis. It is used for data simulation (e.g. calculating the best estimates of wood supply) and modelling. MFA systems are fully described in time and space with the following system variables:

- \( M(j)(t) \) : amount of material in \( V_j \) (wood harvesting)
- \( A_{rj}(t) \) : material flow from \( V_r \) to \( V_j \) (wood products and semi products)
- \( V_j \) : selected balance volume (process)

Balance equations describe the general interactions (scheme 1). Regarding materials, elements and energy, the input flows equal the output flows plus net accumulation. Each balance volume can be described by the following general equation:

\[
\frac{dM(j)}{dt} = \sum_r A_{rj} - \sum_s A_{js}
\]

The balance equation is generally also valid for financial flows. For processes with financial assets we can either model financial flows equivalent to cost calculation or neglect financial assets and net accumulation in the mathematical description by estimating expenses and incomes.

d) Schematic presentation and interpretation of the results - the results are presented in flow diagrams.

e) Evaluation of future resource management strategies - the method aims at evaluating future management strategies. For this purpose, we choose a suitable model specification and establish a set of model equations.

The analysis has been done for wood and wood products flows in Slovakia. The Main comparison between production and consumption has been done for all important mechanical and chemical wood products in Slovak conditions. For this case Consumption (\( C \)) is estimated as a value according to Production (\( P \)), Import (\( I \)) and Export (\( E \)). As we know this scheme 2 is very relative, however for this case is acceptable.

\[
C = P + I - E
\]

Calculation of the final consumption is a complicated process. Starting with the physical supply and use tables a lot of matrix multiplication has to be carried out; different cross-cuttings of tables have to be used as starting point for other calculations etc.
For all wood products in the supply and use figures it is estimated whether they are used as material, product component or as final product.

On the Fig. 2 is comparison between production and consumption of different wood assortments. More than 90% of harvesting wood in Slovakia is consumed as an industrial wood. In last years, the production of coniferous wood is little bit higher than broadleaves. This paradox is results of accidental cut. This figure show still higher production of raw wood compare with consumption, especially in case of softwood. Very similar trends are presented in some wood products as sawnwood (fig. 3), were consumption is little bit more than one half of production. The same results are for some special types of paper (as Paperboard, Paper-Board Ex newsprint and printing and writing paper, wrapg. and packg. paperboard etc.). The high export value of coniferous sawnwood as many other wood products is reason. The high export is affected of different prise on domestic and foreign market as well as much higher production as consumption.
Legend: P – production, C - consumption

Fig. 4 MFA of raw wood and different wood assortments in 2006

As has been noted, a changing environmental situation and transition of all sector of Slovakia economy to a market economy consequently increase the importance of forestry industry. This is a guarantee of the ecological and balanced multi-functionality of the forest and emphasis on its public welfare functions, conservation, wood and non wood production.

In the diagram (Fig.4) is slighted simple wood flow in primary forest industry. Only wood and different wood assortments are declared. The share between coniferous and non coniferous roundwood harvested in Slovakia is changed every year according to occasion cut. In general consumption is always smaller than production, which means higher value of export compare with import. Them main wood assortment is logs and pulpwood, which represent more than 80% of all production. As we can see on fig. 3 the most important product is represented by sawnwood. Production of sawnwood is more than 2, 44 mil. m³, this amount is mostly represented by coniferous sawnwood. For this case little bit less than one half of over mention product is exported mostly in EU countries. However it is important to mention, that this trend is vary in dependence on type of products.

CONCLUSION

Bookkeeping MFA is a method that puts together existing data, which enables comparison of flows, their size and uncertainty connected with these flows. Also when data uncertainties are considered MFA contributes to knowledge about “hot spots”, i.e. which flows are the dominating ones, and which flows have the largest level of uncertainty. However, the usefulness of MFA depends not solely on which results (numbers) is yielded, but also on how the MFA is performed. The result, the numbers from an MFA study, can always be questioned simply because other input data, other system boundaries etc. could have been chosen. There is another reason MFA cannot be seen as a decision-supporting tool in the sense that when you are done with your analysis you have only one possible answer. Even if the numerical result from an MFA study was absolutely certain down to last decimal, there is another aspect to consider. The final decision is always based on more or less personal values and is thus nothing a scientist should concern himself with (Stirling, 1999).

In Slovakia forestry tradition has old historical background. It is necessary to find mode for implementation new ideas and find the way between traditional forestry and new management trends, technologies, wood supply following sustainable development of forestry as well as environmental standards.

In accordance with above-mentioned facts about forest industry in Slovakia, the most important challenges are aimed especially at following tasks:
• Utilisation of forest potential and wood forest products and services aimed at sustainable rural development and still increasing.
• The development of forest industry by better utilisation of different wood assortments (increasing of value higher quality of assortment in primary processing and recycling of wood). There is still low value of wood recycling in wood processing industry.
• Possibility to add value for wood products in domestic conditions and increase of economic effectiveness of forest industry. It is mean to support restructuring of domestic wood processing industry to create preconditions for domestic utilisation of all available timber assortments.
• New concept of financial policy in forestry sector that considers economic and production specifics of forest sector, based particularly on the integration of public-beneficial functions provided by forestry into market process.

Over mention activities connected to efficient and modern utilisation of wood can contribute to the sustainable development of natural resources in the Slovak Republic.

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Wood Quality and Product Properties of Grand Fir Timber

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Key words: wood quality, wood products, Abies grandis, investigation objectives

ABSTRACT

As a part of a joint-project, wood quality and utilisation-orientated investigations will be carried out on beech (Fagus sylvatica) and Grand fir (Abies grandis) from sustainable managed mixed forests for the manufacture of innovative and prospective wood products and wood-based materials. The wood product properties of Grand fir timber will be investigated at the Burckhardt Institute, Wood Biology and Wood Products Section, University of Göttingen.

Unfortunately, there is very little information about the technological properties of Grand fir grown in European forests; therefore, it is necessary to provide potential future wood products customers with research results on wood properties and possible uses of Grand fir timber. Such relevant data is important to demonstrate homogeneity with regard to workability and timber improvement processes while at the same time contributing to the development of a timber market for Grand fir. Moreover, from the point of view of wood quality, an optimal forest management strategy for this fast growing tree species needs to be established. The ecologically based silvicultural objectives of forest management as well as the results of the second German forest inventory clearly show that in the future the mixed forests areas in Germany will increase. To optimise the yield of high quality wood for the production of sawn timber, target diameters play an important role in the management of Grand fir.

Looking ahead, it is given that the forestry-wood-chain in Germany should be ecologically amicable as well as industrially profitable; therefore, tree species with a promising future should be given our full attention with respect to sustainable forest management as well as to innovative wood utilisation. Grand fir appears to be a tree species which could meet the demand of the wood industry; in addition, as an accompanying tree species in mixed forest ecosystems, Grand fir is very suitable in combination with beech in most of the forest sites in Northern Germany.

INTRODUCTION

The principal objective of this joint project is to develop a managing strategy for fast growing Grand fir as an accompanying tree species within almost natural beech stands. An additional objective is to achieve a higher volume of sales of small-sized beech timber as well as of Grand fir timber. A necessary precondition is the development of new innovative wood products and their end-use applications. Grand fir has already demonstrated its ecological compliance in several forest areas in Germany. A profitable yield within a relatively short rotation period can, therefore, be expected in the future, especially for private forest owners. This joint project is sponsored by the Federal Ministry of Education and Research (BMBF; FKZ 0330551) and is divided into eight subprojects.
RESEARCH OBJECTIVES

Unfortunately, there is very little information about the wood technological properties of Grand fir grown in European forest areas which have been carried out in research project using representative investigation material (HAPLA & WELLHAUSEN 2003). Preliminary investigation results of wood density show a high variability within Grand fir trees as well as between dominant and co-dominant trees (HAPLA & KUBALEK 2004); therefore, it is necessary to investigate both wood product properties as well as on their end-use applications. This task (Subproject 2) is the responsibility of the Wood Biology and Wood Products Section, University of Göttingen. The objectives of Subproject 2 are:

To compare several sample size collectives of differently treated Grand fir trees from mixed forest stands. In addition, a reference collective from an all Grand fir stand will also be investigated. At least ten sample trees per collective are required to maintain the level of accuracy necessary for the statistical data analysis. Furthermore, careful use will be made of labour and time.

To produce several products from Grand fir timber of significantly different growth ring structure, using the bottom 12 m stem section. Some of the wood product properties will be investigated in cooperation with the wood industry.

To provide forest owners as well as the wood industry with the investigation results. Furthermore, the investigation results should be used for establishment of silvicultural measurements with the aim of achieving an optimal utilisation-orientated quality of the Grand fir timber.

RESEARCH PROGRAM

- Drying behaviour of sawn-timber and kiln schedule;
- Machining and surface treatment;
- Strength grading of sawn-timber using a non-destructive technique;
- Testing strength properties of full-size timber;
- Modification of wood product properties;
- Testing of biological, physical and mechanical wood product properties after modification processes;
- Gluing and finger-jointing of wood products;
- Testing of wood product properties in cooperation with the wood industry;
- Structural timber and glue-laminated beams.

The research paper introduced here is intended to promote information about sawn timber characteristics of the Abies grandis and to gather data with regard to possible uses of the sawn timber. This will make it possible to establish future uses of the sawn timber and to ascertain to what degree the broad spectrum of sawn timber can be complemented with this fast growing variety. To this end bending tests are carried out on small specimens so that the interplay between longitudinal and cross sections and tensile strength can be measured. Using approximately 1000 samples visual sorting according to DIN 4074 was done. A comparison with results obtained by sorting with the aid of the “Timber Grader” manufactured by Brookhuis Micro Electronics and then performing a destructive bending test according to DIN 408 showed that the visual sorting greatly underestimated the load capacity potential of the wood.
As gluing is one of the central technologies in producing high quality sawn timber products, tests were carried out and with respect to the MPA (Institute of Material Testing) certified glues for support structures. Hereby close attention was paid to the tensile shear strength, tensile stress strength and determinations after extreme aging conditions. The tests were based on procedures of the norm series EN 302 and revealed an excellent usability of all gluing systems applied (HOF & HAPLA 2006).

The thermal wood modification of coniferous sawn timber has established itself in various forms as an accepted procedure. It was for this reason that thermal modification technology was selected and the treated wood of the *Abies grandis* examined. Particular attention was paid hereby to the biological durability. An increase of the durability can be reached at certain process temperatures without negatively affecting the compression and bending strength. In addition to examining important technological characteristics the research continues for uses for which the typical characteristics of this light wood are advantage and which lead to its independent uses.

**CONCLUSION**

Because spruce (*Picea abies* (L.) Karst.) is the most important coniferous timber species for the German wood industry, the investigation results obtained will be compared to spruce wood properties. This should facilitate the assessment of possible uses for Grand fir timber. An important objective within this joint project is the dissemination of the research data base not only to forest owners and the wood industry but also to potential end-users. Therefore, a knowledge-transfer should take place at different levels. End-users, representatives of wood industry enterprises, planners and architects should be approached and informed by means of publications, congresses and wood fairs. The successful dissemination of the investigation results by means of technology-transfer and further educational activities is regarded as an important part of the joint project management. In forest enterprises, the silvicultural treatment of the stands is the main strategic decision. The investigation results are also required for a decision support system for forest owners for the optimal management of Grand fir mixed stands.

Research will also be needed to manage the complex effects of silvicultural measurements as well as abiotic and biotic factors on growth dynamics and wood quality of Grand fir (HAPLA 2006). A key element in achieving this goal involves developing strategies on how to optimally utilise Grand fir trees grown in mixed forest ecosystems under various conditions. Future wood production must be based on efficiency and quality as much as on volume. Improved forest management models will be required to generate high quality wood products.

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Separating sap- and heartwood in the primary breakdown of Scots pine

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Keywords: economic revenue, log scanning, quality prediction, sawn timber

ABSTRACT

Pine (Pinus sylvestris) heartwood and pine sapwood can, in several respects, be considered two different timber products. Sapwood demonstrates open structures that easily adsorb moisture and is vulnerable to bio-chemical disintegration, but also more easily painted, glued or impregnated. Heartwood, on the other hand, is less disposed to moisture fluctuations, hence, more dimensionally stable, and durable. Heartwood content is closely related to cambial age and to the progress of annual ring width. It is also the nature of pine is to grow timber of quite varying quality along the stem. Resins are more abundant near the base, and the knottiness is shifting, following certain patterns from the base upwards. Several of those traits can be identified prior to breakdown, applying specific wood technology knowledge, recent research and standard log scanner equipment. Even with this potential for producing more homogeneous board quality by including heartwood in the breakdown decision basis, one should not forget the practical implications for the sawmill. The cost of keeping separate heartwood quality classes and the risk of mistakes might easily exceed the price gain.

INTRODUCTION

Softwood timber is an excellent material used for a variety of applications. Within one and the same species, heart- and sapwood can, in some respects, be considered two different timber products. Generally, sapwood is light in colour, easily painted, impregnated or otherwise treated. Heartwood is less disposed to moisture fluctuations, thus more dimensionally stable and usually more durable. In old buildings and artefacts it is well known that the sapwood might be corroded while heartwood persists. This variation in properties causes divergent uses, which generates a need for knowledge how to distinguish the two for optimal utilisation of the timber and to adapt silvicultural practice to influence the production of one or the other. In every tree, the wooden tissue - xylem - is always fabricated as sapwood to transfer sap between the root and the crown. The wood must therefore, at least in fresh condition, be open and penetrable to liquids and gasses. In due time, after some years, the innermost rings are irreversibly inactivated and transformed to heart. The physiological activity in the parenchyma and epithelial cells is terminated, moisture content is reduced, pits are aspirated and the wood is impregnated with resinous and phenolic components. This is considered a part of the natural aging of the tree (Wagenführ 1989).

Heartwood takes various appearances depending on the species in question. Most softwood species contain a heart without physiological activity, with low moisture content and dark colour caused by phenols. In some species like the Norwegian spruce (Picea abies), the constituents producing the dark colour is missing. Nevertheless, in all other respects, the spruce heartwood is equivalent to the readily visible heart of e.g. the pines (Wagenführ 1989). For Scots pine, a
straightforward correspondence denoted the ‘pine heartwood age rule’ has been reported (Gjerdrum 2003): The number of rings in the heartwood equals the square root of the cambial age less a constant parameter, to the second power. The same rule applied to any height levels in any tree, irrespective of site, silvicultural practice etc. In the case of Scots pine of Scandinavian origin, the parameter evaluated to 3.0. This model was later augmented to other conifers (Gjerdrum 2006): European larch (Larix decidua), stone pine (Pinus cembra) and European yew (Taxus baccata) - all with different parameters. The model was found to be valid for trees of largely varying origin and vigour, and along the stem in single trees, inside and outside the living crown. This model implies cambial age as driving force: A tree with a tiny crown has low capacity to fabricate wooden tissue, thus producing narrow rings and - the number of sapwood rings unaltered - narrow sapwood, and vice versa.

When present, heartwood is always located in the central (older) part of the stem, more or less symmetrically around the pith. Even if heartwood, under favourable conditions, might be readily separated from the heart by visual means, the colour gradients are often seriously influenced by moisture disturbances and by weathering of the surface. Heartwood contains less water than sapwood, resulting in a lower green density. The two, heart- and sapwood, might be separated in an x-ray scanner (Oja et al. 2001). Even if efficient, the technical equipment is quite expensive and has until recently not gained much hold in the Scandinavian sawmill industry. Another approach has been to investigate temperature gradients caused by moisture evaporation from log crosscuts. Such temperature observations might be detected by a heat sensitive infrared (IR) camera and, in conjunction with a traditional scanner, used for an automated calculation of heartwood diameter (Gjerdrum and Høibø 2004).

APPLICATION AND DISCUSSION

By Scandinavian tradition, the main yield, i.e. the square inscribed in the small end diameter, has been the most valuable part of the timber, usually with only slight variation between the inner and outer part of the main yield. If present, knots will be larger in the outer part, and more compression wood and juvenile wood near the pith. Such logs will be sawn “from inside outwards” to optimise the most valuable central part. However, for a small fraction of the best quality pine trees, the outer part of the first log will yield highly esteemed clear boards; such logs will regularly be sawn “from outside inwards” (in an approach much similar to veneer peeling).
The wide variation in heartwood content in pine sawlogs is easily acknowledged (Fig. 1). In some applications it would be feasible to take this variation into consideration while planning the most profitable breakdown pattern. The heartwood variation might be observed by x-ray scanning (Oja et al 2001, RemaControl 2008) or by IR imaging (Fig. 2) in a way that can be easily included in the log assessment/sorting procedure.

![Figure 2: IR image (left) and temperature profile (right) from pine crosscut (Gjerdrum and Høibø 2004)](image)

In Scots pine, the number of rings in the heartwood is directly linked to the cambial age by the Heartwood Age Rule: Heartwood age equals the square root of cambial age less 3.0, to the second power (Gjerdrum 2003). The rule is valid at all levels along the stem, in particular for all small end sawlog crosscuts. Consequently, with two logs of equal diameter, the one with most heartwood also reveals the highest number of rings. Indeed, for a given log diameter, mean annual ring width can be directly estimated with heartwood fraction as predictor (Gjerdrum 2003). As ring width is an important quality trait per se, x-ray or IR technology can be applied for indirect estimation of ring width, alone or in combination with heartwood fraction.

Usually, the breakdown decision is based on
- a combination of board and log dimension
- estimated log quality (other than heartwood, e.g. knottiness, distance from stem base, ring width)
- (potentially) heartwood amount

Even if a potential for producing more homogeneous board quality by including heartwood in the breakdown decision basis, one should not forget the practical implications for the sawmill. The cost of keeping separate heartwood quality classes and the risk of mistakes might easily exceed the price gain.
It should be noted that the outcome of main yield, expressed as a ratio of sawlog volume, is extremely dependent of choosing the right combination of board dimension and log diameter. Any adjustment to just saw "narrow centre boards" to achieve more heartwood will therefore inevitably fail in economic revenue. A full adaption of the sawing pattern based on sound economic calculation will be necessary before venturing into such projects (Fig. 3). This might well result in producing boards with in radically new patterns for untraditional applications, e.g. one visible, clear sapwood face in combination with a durable, knotty heartwood face. A fair price gain in merchandising such products must be the main and only motivation. And such practice would be tailored to each sawmill, rather than applicable on a general basis.

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Juvenile wood of Hardwoods - differences to mature wood

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Keywords: hardwood, juvenile wood, mature wood, Quercus petraea, Quercus cerris, Robinia pseudoacacia, Fagus silvatica, Populus x euramericana “I 214”

ABSTRACT

As one of the main result of the research work it was found that the fibre length, the thickness of the fibre walls, the vessel-diameter are increasing from the pith towards the bark, and reach a maximum value in the mature wood. This phenomenon was observed at all investigated wood species (ring porous: Sessile oak - Quercus petraea, Turkey oak - Quercus cerris L., Robinia - Robinia pseudoacacia L.; diffuse porous: Beech - Fagus silvatica L., and Poplar “I214”– Populus x euramericana “I 214”), however the curves showed different profiles by different wood species. The boundary between the juvenile wood and the mature wood was determined at the age of 10-14 years (4 years transition zone), except of the beech where the corresponding age was 18-20 years. The share of different cell types (vessels, parenchyma, and fibres) in a single annual ring did not show any correlation with the radial position (juvenile age). The density around the pit was definitely below the values determined in the mature wood by all investigated wood species but poplar, where a contrary tendency could be observed. The differences between the juvenile and the mature wood by hardwoods shown in this paper predict differences in behaviour (during drying, mechanical processing, and surface finishing).

INTRODUCTION

The rotation time of the forests nowadays is considerable shorter compared to the period some decades before. In addition timber grown on plantations managed with short rotation time is becoming more and more important, as its share on the wood market is increasing. It means that the wood industry has to face to smaller diameter logs with higher share on juvenile wood. Recognizing this lack of knowledge, and the scientific challenge, several authors started to investigate the juvenile wood of hardwoods. Without aiming at completeness the most recent publications dealing with hardwood’s juvenile wood are: Gatto DA, Haselein CR, Buligon EA, et al (2007), Medzegue MJ, Grelier S, M’Batchi B, et al. (2007), Adamopoulos S, et al (2007), Csoka L, Zhu JJ, Takata K (2005), Klasnja B, et al (2003), Bhat KM, et al (2001), Evans JW, et al, (2000), Klevinska V, Bikova T, (1999), Sandberg D, (1996), Helinskaraczkowska L (1994), Fukazawa K (1984). The authors suggest different indicators for age demarcation between juvenile and mature wood, although maturation age often varies among the properties, growth rate, individual tree and site. This paper should contribute to the knowledge gained on the field of juvenile wood in hardwoods.
EXPERIMENTAL METHODS

Anatomical investigations
From each investigated wood species one trunk was selected, which was free from visible defects. 20mm thick discs with were cut at breast height, and strips containing the pith were sawn out of the discs. The investigated properties were:
- annual ring width,
- early wood – late wood ratio (ring porous wood species),
- fibre length,
- diameter of vessels,
- cell wall thickness of fibres,
- ratio of vessels, ray and axial parenchyma, and fibres on a unite cross section area (Fig. 1.) (microscopic slides),

![Figure 1: Image analysis of the cross section for vessel’s area (Robinia)](image)

The specimens for fibre length measurements were taken from every 2\textsuperscript{nd} year up to the age of 30 years, and from the rest every 5\textsuperscript{th} annual ring was investigated.

Density investigations
The trunks were cut into boards, and the boards were dried to 12% dry based moisture content. The specimens to the density investigations were cut into sticks as shown on Fig. 2. The dimensions of the sticks were: 10mm x 10mm x 1000mm (R x T x L). The sticks were cut into specimen showing the dimension 10mm x 10mm x 15mm (R x T x L).
The oven dry density was determined by the equation:

$$\rho_0 = \frac{m_0}{V_0} \left[ \frac{g}{cm^3} \right],$$

where

- $m_0$: oven dry mass [g]
- $V_0$: oven dry volume (105 °C, until constant mass) [cm$^3$]

**RESULTS AND DISCUSSION**

**Anatomical investigations**

**Annual ring width (data are not shown here in detail)**
The ring widths were analysed for all investigated wood species. The dimension of the ring width was measured at the average diameter of the disc, from the pith towards the bark. According to this property, the boundary between juvenile and mature wood could be determined as it follows:

- Robinia: suitability not proved
- Sessile Oak: 15-17 years
- Turkey oak: 15-17 years
- Beech: suitability not proved
- Poplar: suitability not proved
The annual ring width is a week predictor for determination of the juvenile age, because it varies very high upon the silvicultural management, amount and distribution of precipitation, etc.

**Early wood – late wood ratio (ring porous wood species) (data are not shown here in detail)**

The early wood / latewood (EW, LW) ratio was determined for the ring porous wood species. The variation of the early wood’s width was lower compared to the late wood.

- Robinia: EW: 0.45-1.15 mm, LW: 0.80-4.60 mm, suitability not proved
- Sessile Oak: EW: 0.45-1.15 mm, LW: 0.70-4.60 mm, 15-17 years
- Turkey oak: EW: 0.30-0.70 mm, LW: 0.70-4.60 mm, 15-17 years

As the late wood widths followed the total annual ring widths, the respective ages corresponded to those of the annual ring widths.

**Fibre length**

The results for fibre length are presented on Fig. 3. Analysing the figure it is noticeable that the fibre length is increasing with the cambial age. By visual investigation of the curve the following ages can be determined for the segregation of juvenile and mature wood:

- Robinia: 12-14 years
- Sessile Oak: 10-12 years
- Turkey oak: 12-14 years
- Beech: 18-20 years
- Poplar: 10-12 years

![Figure 3: Fibre length vs. cambial age by different wood species](image)

**Diameter of vessels**

The vessels’ diameters are shown on Fig. 4. A distinctly visible growing tendency can be observed by the ring porous species, while the diffuse porous ones show practically constant values. Analysing the data, the following boundary ranges can be determined for the juvenile age:
Robinia 12-13 years  
Sessile Oak 9-10 years  
Turkey oak 8-10 years  
Beech suitability not proved (slight increase)  
Poplar suitability not proved

![Figure 4: Vessel diameter vs. cambial age by different wood species](image)

**Fibre wall thickness**

The thicknesses of the fibre walls are shown on Fig. 5. Beech and Turkey oak show a definite growing tendency over the cambial age, while the other three species do not show any correlation to the cambial age. Investigating the curves visually, the following ages can be determined for the segregation of juvenile and mature wood:

Robinia suitability not proved (slight increase)  
Sessile Oak suitability not proved (slight increase)  
Turkey oak 12-14 years  
Beech 20-22 years  
Poplar suitability not proved

![Figure 5: Fibre wall thickness vs. cambial age by different wood species](image)
Ratio of vessels, ray and axial parenchyma, and fibres (area percentage on cross section)

The areas of different cell types on the cross sections did not show any tendency to the cambial age. Typical distribution of cells is shown on Fig. 6. The conclusion is, that vessel’s, ray and axial parenchyma’s, and fibre’s percentage cloud not be proved as suitable anatomical indicators of age demarcation between juvenile and mature wood.

Figure 6: Percentage of area cover on cross section by different cell types (Robinia)

Density investigations

The corresponding density maps are shown on Fig. 7a–e for all investigated wood species.

Figure 7a: Density (oven dry) map of Sessile Oak [g/cm³]
Figure 7b: Density (oven dry) map of Turkey Oak [g/cm³]

Figure 7c: Density (oven dry) map of Robinia [g/cm³]
In case of ring porous species the density is proportional influenced by the ring width. Therefore the density can not be a predictor for juvenile age, as the annual ring width is influenced by many other factors (see above). Studying the Figures 7a-e some zones and stripes can be observed, were the density reaches more or less homogeneous values. On the density map of the beech disc (Fig. 7d) eccentricity can be observed, which corresponds to the eccentric position of the pith.
Other investigated properties were: Shrinking, Compression strength, MOR, MOE, Tensile strength and Impact bending. Regarding these predictors no tendencies could be observed yet. Further tests are planned on larger scale, to prove the suitability of these properties to determine the juvenile age of hardwoods.

CONCLUSIONS

Fibre length could be proved as a good predictor for juvenile and mature wood boundary among the investigated anatomical characteristics. The suitability of other investigated anatomical predictors could be partially proved only. Based on the fibre length the following juvenile ages could be defined for the investigated wood species: Robinia: 12-14 years, Sessile Oak: 10-12 years, Turkey Oak: 12-14 years, Beech: 18-20 years, Poplar: 10-12 years. The vessel’s diameter was proved as good predictor for ring porous wood species: Robinia: 12-13 years, Sessile Oak: 9-10 years, Turkey oak: 8-10 years. The thickness of the fibre wall could be proved as good predictor for two wood species: Turkey oak: 12-14 years, Beech: 20-22 years. The ratio of vessel’s, ray and axial parenchyma’s’, and fibre’s (area percentage on cross section) and the oven dry density did not show any tendentious differences in the juvenile and the mature wood. Further investigations, such as, different mechanical properties, are under investigation. In order to show differences in drying and dimensional stability, wood samples in product dimensions are going to be tested in the future.

AKNOWLEDGEMENT

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Fast growing tree species within the European Forestry-Wood-Chain:
Volume versus Quality and Use

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**Keywords:** wood streams, wood quantity and quality, fast growing timber, plantation timber

**ABSTRACT**

It is clear that due to many influencing factors the European Forestry-Wood-Chain is rapidly evolving. For several decades, the amount of harvested wood from Europe’s forests has been significantly lower than the theoretical sustainable yield level. However, the rapid increase in wood demand is profoundly changing the balance of the sector and its new players (bio-energy). Some fact and figures concerning the European Forestry-Wood-Chain were brought together to feed the discussion on future strategies. It is a fact that factors as new plantation timber, mobilizing currently underused forest areas, environmental issues, price settings and wood quality discussions will have there influence in the more complex Forestry-Wood-Chain.

In filling the gap between demand and supply of wood resources, plantations will become important. Plantations today provide up to 25\% of the world industrial fibre and it is still rapidly increasing. The planted area is mostly growing in Asia and actually very little in the northern hemisphere. Questions must be raised in how Europe will provide the industry with raw material, especially the new emerging bio-energy producing sector.

Accurate and up to date data on the whole Forestry-Wood-Chain is essential to identify needs for adopted policy. The combined country reports produced by COST E44 is a tool in assessing these goals.

**INTRODUCTION**

In spite of the fact that the European Forestry-Wood-Chain is currently still missing accurate statistics, it is clear to its members (foresters as well as wood processing companies) that due to many influencing factors the chain is rapidly evolving. Especially on the supply side of the chain a lot of new challenges occur.

For several decades, the amount of harvested wood from Europe’s forests has been significantly lower than the theoretical sustainable yield level. However, the rapid increase in wood demand is profoundly changing the balance of the sector. New players as bio-energy producers are competing for the same raw materials. The question arises if an imbalance has been developed between supply and demand of wood.

In the next part some facts and figures are brought together concerning the European Forestry-Wood-Chain to evaluate the supply-demand balance for classical industrial round wood processing as well as for the emerging energy sector. In the discussion part both must be linked to understand the new wood flows and to assess the outlook for wood supply for both players in the future. It must be kept in mind that industrial round wood and wood for energy can be to some extend substituted. All wood can be burned, but on the other hand due to technological improvement lower quality material can be upgraded to higher value added products with a
longer service life. In the overall discussion special emphasis is given to the fast growing tree species which can generate large wood resources in short time spans.

SOME FACTS AND FIGURES OF THE EUROPEAN FORESTRY-WOOD-CHAIN

Forests are an important resource, accounting for almost 30% of the Earth’s total land area. Although European forests (excluding Russia) only account for 5% of that area, they are the most intensively managed in the world. They provide 12% of the current global round wood fellings and up to 23% of the industrial round wood. The European wood processing sector produces up to 30% of all wood-based panels, paper and paperboards. Despite the increasing demand for wood and wood products, the EU has become a net exporter of forest resources.

Overall, Europe counts over 1 000 million ha of forest area, equivalent to 1.42 ha per capita. Most of the forest cover (80%) is accounted for by the Russian Federation (Fig. 1).

Of Europe’s forests, 70% can be classified as semi-natural while only 8% is categorized as plantation forests. The average European forest owner (EU25) holds around 13 ha accounting for an overall private ownership of 63% of the forest cover.

At an annual rate of 500 000 ha, Europe’s forests are expanding. The total standing volume is currently about 20 000 million cubic meters, producing an estimated 350 million cubic meters of industrial round wood a year. In practice about 65% of the net annual increment is harvested.
Fig. 2 gives more detailed information per country on forest cover and standing volumes.

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<th>Country</th>
<th>Land area (x 1000 ha)</th>
<th>Forest area (x 1000 ha)</th>
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<th>Population (x 1000)</th>
<th>Forest cover per capita</th>
<th>Volume (x 1000 cubic metres)</th>
<th>Growing stock (x 1000 cubic metres)</th>
<th>Industrial roundwood production (x 1000 cubic metres)</th>
<th>Harvest roundwood production (x 1000 cubic metres)</th>
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**Figure 2:** Detailed numbers concerning land area, forest area, standing volume and harvested quantities per country.

**DISCUSSION:**

**THE FUTURE FORESTRY-WOOD-CHAIN AND THE POSITION OF FAST GROWING TREE SPECIES.**

The main points of discussion that influence the Forestry-Wood-Chain can be summarized as follows.

- Supply from natural forests or more man-made plantations?
- Quantity does not imply poor quality! Forest management to have wood fit for purpose.
- Environmental discussion will lead to “Save the environment, use wood!”
- New players on the market for the same kind of raw material.
- Narrowing price settings. High quality stems are getting cheaper, lower quality material is getting more expensive.

**Fast growing (plantation) timber**

Globally, the forest cover is still declining at a rate of 10 to 16 million ha. On the other hand, increasing population and rising incomes stimulate the wood demand. Solutions must be found to prevent further deforestation to secure a continued wood supply in the future. On the supply side this can be done by the mobilization of wood from underused forests or by establishing more plantation grown timber. Otherwise a significant gap between the wood demand and supply from only “natural” forest will occur (Fig. 3).
Current industrial round wood harvests from plantations count for about 635 million cubic meters or 40% of the global industrial wood supply. This reliability on timber grown in man made plantation systems is still increasing in an attempt to fill this emerging gap (Fig. 3 and 4).
Fig. 5 gives an overview of the amount of planted forest in relation with the natural forest cover. Worldwide these plantations only account for about 3.5% of the total forest area. Due to the intensive management and shorter rotation periods they do account for almost 35% of all industrial round wood supply. In Europe these 28 million hectares supply yearly around 172 million cubic meters of raw wood material.

The most important tree species used in plantation forestry in Europe today are Douglas and Sitka spruce as softwood species and Poplar, Eucalypt, Robinia (black locust) and Birch as hardwoods.

To fill in the gap between demand and supply two strategies can be followed. Mobilization of wood from currently underused forest areas or establishing more plantation grown material.

To mobilize more wood from underused forest areas, four elements are considered to be key elements for successful implementation. First of all accurate information is needed concerning current forest status and about ownership and legal constraints. Information is also needed on the motivation of the forest owners to what extent they are (un)willing to cut there forest. Furthermore you need a legal framework of property rights and several technical (logistic) instruments.

On the other hand, establishing new tree plantations is more easily realised in practise. Due to the rapid growth rates, lower amount of land area is needed for the same outcome. Plantations can assure some critical demands and market supplies. Economically these forest show high investment returns. They do “conserve” natural forest through substitution of intensive management (first strategy).

**Quantity versus quality**

We have to keep in mind that production of large wood volumes to fill the existing gap between demand and supply should not only focus on the quantity. It is necessary that all different elements of the whole Forestry-Wood-Chain are considered. The production both high value added products and low value added commodities guarantee a more stable and sustainable wood chain.

Adopted forest management in these fast growing stands should lead as such to at least a minimum of higher quality logs. Herby, options of technological improvement become more important in order to use lower quality material in higher value added products as well.

Unfortunately, in a lot of European countries the management towards quality stems of fast growing species in “natural” stands such as birch in Belgium has been lost or even never been developed.

**Environmental concerns**

This paper does not address in detail all related environmental concerns, but it is clear that this factor will play a role in the overall discussion.

The most important fact is the recognition that wooden products do account as carbon sinks, even when in use as a wood product. Replacing other more energy consuming materials as plastics, concrete and steel by wood will have positive effect on achieving Kyoto goals. It could be summarized as “save the environment, use wood”.

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Energy from woody biomass
The outlook for wood used for energy production has at least three key elements to take into account.
- Wood volumes and especially the types of wood resources currently used are not accurately measured (lack of reliable statistics).
- Which factors will influence the future trends?
- Factors determining long-term trends appear to change. Increased prices of fossil fuels, new policies for climate change and renewable energies, all tend to encourage the consumption of wood for energy.

The development of energy out of woody biomass will be influenced by a large number of factors. The changes concern policies on wood energy in relation to the fossil energy prices. How will the competition for the same resource of raw wood material evolve, especially in the traditional wood using industries? The behaviour of forest owners and their willingness to harvest will influence the extent to which new wood resources are mobilized.

Price politics
Within the Forestry-Wood-Chain a remarkable trend is developing of narrowing prices, leaning that higher quality logs are getting cheaper while lower quality material is getting more and more expensive. This means that wood resources for different end products are become more and more substitutable.

This leads to structural problems already occurring in Europe. Several countries (Belgium, Germany, ...) are having difficulties of selling large dimension timber or getting it processed. If higher value processing can be obtained without forest management (thinning, pruning, ...) foresters tend to become more “lazy”.

The biggest influence comes from the energy sector that is in such a high need for raw material and this in competition with panel producers and pulp and paper industry. As such new European strategies are necessary to find additional wood supply (even outside the forest area) and on the other hand new emerging technologies should be implemented to upgrade material to higher value end products with longer service life. At the end of this life span wood still remains an energy source! Taking up recovered wood in the wood chain of the future is key.

The new more complex Forestry-Wood-Chain
Fig. 6 gives a very schematic overview of the Forestry-Wood-Chain. It clearly shows the new influencing factors of bio-energy, new wood resources and the need of recovering wood at the end of the life span.

Especially on the side of new wood supplies (i.e. fast growing tree species) a lot remains to be done. Research is needed in upgrading this material to the higher quality side of the wood chain.
CONCLUSIONS

Of the global forest cover of 3.9 billion ha still 10-15 million is lost yearly. In filling the gap between demand and supply of wood resources, planted stands will take an important role. Plantations today provide up to 25% of the world industrial fibre and it is still rapidly increasing. The planted area is mostly growing in Asia and actually very little in the northern hemisphere. Questions must be raised in how Europe will provide the industry with raw material, especially the new emerging bio-energy producing sector. Accurate and up to date data on the whole Forestry-Wood-Chain is essential to identify needs for adopted policy. The combined country report produced by COST E44 is a first tool is assessing these goals.

REFERENCES


In this paper also all country reports were used which were produced as a core document by COST Action E44.
Wood based products and climate changes

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Keywords: wood based products, climate changes, energy, energy efficiency

ABSTRACT

Wood is our only naturally renewable raw material. From the environmental point of view wood plays important role. During its growth it absorbs CO₂, which is later stored in the products. The CO₂ stored in the wood is during combustion released into the climate, but because no additional CO₂ is created the combustion of wood is a CO₂ neutral operation. But to tackle the climate changes combustion of wood is not the only approach. One of the possible or one could say even one of the best approach would be to emphasize the use of wood and products out of wood. One cubic meter of wood can reduce the CO₂ emissions from fossils fuels up to 1 tone, not only via replacement of fossil fuels, but also by using it. For wood production less energy is required for manufacturing, and also a lot of energy needed by wood working industry is generated from its own resources (wood residues/waste wood, bark, etc). Wood based panels as widely used material is mostly out of wood, especially from wood residues so one can say that this industry contributes to the sustainable use of natural resources. And since they are made mostly out of wood, they also store CO₂. And this is not their only advantage. Second very important advantage is also its thermal properties. Like wood, they have good isolation properties (especially low density fibrous materials), hence contributing to lower energy consumption when used as a building material (wooden houses, prefabricated houses, passive houses, etc). The aim of this paper is to show the possibilities that wood based products offer to us as a material that reduces the emission of CO₂.

INTRODUCTION

Over the last decade we witnessed rapid changes in our climate. Global warming due to the green gas emissions left evident marks: warm winters with almost no snow, warmer summers, less rain, greater number of hurricanes, rapid temperature changes, and warmer see, etc. All those changes are the consequence of our interference into nature. We now produce more, we live "faster", high energy demands not just in industry but also in our everyday's life (air conditioning devices, TV, computers), transportation needs (Fig. 1). All those goods that we take for granted are influencing our environment and climate with green house gas emissions.

Greenhouse gases are the gases present in the atmosphere which reduce the loss of heat into space and therefore contribute to global temperatures through the greenhouse effect. Greenhouse gases are essential to maintaining the temperature of the Earth; without them the planet would be so cold as to be uninhabitable. However, an excess of greenhouse gases can raise the temperature of a planet to lethal levels.
The most powerful greenhouse gases are

- Water vapour, which causes about 36–70% of the greenhouse effect on Earth. (Note clouds typically affect climate differently from other forms of atmospheric water.)
- Carbon dioxide, which causes 9–26%
- Methane, which causes 4–9%
- Ozone, which causes 3–7%

Our battle against global warming started with searching for alternative energy sources, especially renewable sources like water, wind, solar, geothermal and biomass, but with this search we didn’t solve the original sin, our need for energy.

If we are talking about the biomass the first material that comes to our mind is wood. Wood is fascinating material, it's renewable, usable in many forms and we can even recycle it from the products that we made (not chemically treated wood). And from the first time that man "discovered" fire, we now that wood burns, and with that in mind we can see that it can easily be used as an alternative energy source. But with burning of wood we destroy it and soon we can realize that such material is not in unlimited amount. So the questions that arise are:

- Is the wood good material as an alternative energy source
- Can we do more out of wood and
- Can wood and wood based products contribute to lowering the greenhouse gas emission

## WOOD AS ENERGY

From our history we know that we can use wood for heating and fuel, hence we can get energy from wood. Wood as energy source has several environmental advantages over fossil fuel. The main advantage is that wood is a renewable resource, offering a sustainable, but dependable supply. Other advantages include the fact that the amount of carbon dioxide (CO₂) emitted during the burning process is typically 90% less than when burning fossil fuel. With CO₂ in mind we can't claim that this process is carbon sinking process. The fact is that burning wood is carbon neutral process; that means that so many CO₂ that tree absorbed by the photosynthesis, so much it is released/emitted into atmosphere when wood is burned (Fig. 2).
As we can see wood can play important role in reducing the danger of global warming. One cubic metre of wood absorbs almost one tone of CO₂.

Since, it only returns the CO₂ that has been absorbed; wood combustion does not contribute to the global warming. And since wood contains little sulphur or nitrogen, the combustion of wood don’t contribute to the acid rain, and since little ash is produce we can claim that energy from wood is clean energy.

"Wood energy" can be obtained from many different sources: chips, bark, sawmill and shaving residues, residues from furniture manufacturing, recovered wood, forest residues after harvesting and/or thinning.

Wood as energy is used in several forms. It can be used in form of:

- Chips (800 kWh/m³)
- Pellets (4,9 kWh/kg)
- Firewood (4,0 kWh/kg)
- Spruce (2178 kWh/m³)
- Pine (2196 kWh/m³)
- Beech (3078 kWh/m³)

If we calculate the yearly amount of wood needed for heat in one household that previously used around 3000 l of oil, it would need 30...45 m³ of chips.

But at using wood for energy we must be cautious. It's true that the amount of wood that is harvested is lower than the amount that could be harvested (CEI – Bois, 2205), but on the other hand, to achieve the full size tree needs to grow at least 15 years, some species 30 years or more.

**WOOD AS MATERIAL**

Until 19th century wood was the most important material, not just for heating and as fuel, but also as a raw material for construction, crafts, shipbuilding, etc. Shortage of wood leaded to the development and introduction of wood saving techniques and alternative materials and energy sources. New materials that are now mostly used like wood based panels were developed.

Wood is high – performance material. Related to other construction materials it is low in weight and in some cases high in density. It has very good load – bearing characteristics.

During the production of wood and wood based products very little waste is generated, since all by–products are used as a raw material or as an energy source. Between 50 and 60% of energy needed for the manufacturing of wood based products is generated by combustion of wood waste (saw dust, bark, etc.), so the companies are getting energy from their own resources. And manufacturing of wood based products requires less energy (Table 1), than other materials; hence less CO₂ is emitted into atmosphere (Fig. 3).
Table 1: Energy for production

<table>
<thead>
<tr>
<th>Material</th>
<th>Energy kWh/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>240</td>
</tr>
<tr>
<td>Brick</td>
<td>580</td>
</tr>
<tr>
<td>Concrete</td>
<td>500</td>
</tr>
<tr>
<td>Iron</td>
<td>25,000</td>
</tr>
<tr>
<td>Steel</td>
<td>63,000</td>
</tr>
<tr>
<td>Aluminium</td>
<td>195,000</td>
</tr>
</tbody>
</table>

From the data above we can see that wood, not just less energy is needed for its production, but also that CO₂ is stored in the product.

As we mentioned before wood is not usable only in its solid/natural state but also in the form of wood based products like LVL, plywood, OSB, particleboard and fibreboard (Fig. 4).

Figure 5: CO₂ lifecycle emissions of building materials during the lifecycle (CEI – Bois, 2005)

Figure 6: Wood based panels
All mentioned materials found their place in our everyday life. In North America OSB and plywood are the most used material for house building, particleboards and fibreboards are the most used material for furniture, plywood is also used for boat building (Fig. 5).

Figure 7: Use of wood and wood based products

The advantage of those materials is among their good mechanical and physical properties also in the usage of low quality wood and recovered wood (particleboard). Those materials therefore also help us to save forest – the lungs of every city and World in general. And at the end of the life cycle products made from wood and wood based products can be recycled or reused for products like particleboards or combusted and use for energy. Average lifetime of wood and wood based products depends mainly on the type of products, but we can easily say that such products can be used for decades, in some cases even centuries (Fig. 6).

Figure 8: Hayrack (photography: Zgonc, I. 2007)

But the benefit of using wood and wood based products isn't related only to the storage of carbon but also to the more, let's say, tangible effect – thermal insulation effect or heating costs. Wood
is natural thermal efficient material, and its thermal conductivity is much lower than thermal conductivity of concrete, steel, etc (Table 2).

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal conductivity Wm⁻¹K⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>0,08...0,17</td>
</tr>
<tr>
<td>WBP</td>
<td>0,08...0,17</td>
</tr>
<tr>
<td>Concrete</td>
<td>0,8...1,2</td>
</tr>
<tr>
<td>Steel</td>
<td>14...16,3</td>
</tr>
<tr>
<td>Brick</td>
<td>0,8...1,3</td>
</tr>
<tr>
<td>Aluminium</td>
<td>205...237</td>
</tr>
</tbody>
</table>

Timber systems can be more cost – effective in constructing energy efficient buildings than cement block, brick or alternative materials; triple–glazed windows can be more easily produced from wood than from other materials and wooden floors will provide better thermal insulation than concrete floors. It is especially favoured in cold climates, where, with careful design and considered use of insulating materials, low energy consumption reduces heating costs whilst providing comfortable living conditions, often in very low external temperatures. Houses made from wood (timber framed houses, prefabricated houses from wood and wood based products) can be more energy efficient, less energy is needed for heating purposes, hence less CO₂ is going to be emitted into atmosphere by fossil fuels (if used). Smaller heating system hence less heating costs and less CO₂ emissions. Wooden houses namely, set the standard for the heat insulation. Wooden cell structure gives to wood natural thermal insulation that is superior to any other material. If properly build wooden houses easily meet the thermal insulation regulation, and if additional insulation is added than low or even zero energy wooden houses can be build.

Nowadays there are many different products, materials and solutions to choose from. That choice can have a significant effect on CO₂ emissions. Concerning the above mentioned fact one can conclude that using wood and products from wood can in fact have greater – better impact on the global warming. If we would substitute concrete, bricks and other construction materials with cubic metre of wood or wood – based products that we would save in average of 0,75...1,0 t CO₂ in other words 12...30 t of carbon can be stored in average timber house. (Fruehwald, et al., 2003).

A Swedish study undertaken in 2001 compared the embodied energy² and CO₂ emissions from the construction of two similar houses, one made from timber, the other from steel and concrete. The difference of 2.300 MJ/m² energy used in the materials and construction of the houses is enough to heat one of the houses for 6 years, while the 370 kg/m² difference in CO₂ emissions is equivalent to the emissions from 27 years’ heating.

It has been also reported (CEI – Bois, 2004) that an annual 4% increase to 2010 in Europe’s wood consumption would sequester an additional 150 million tonnes of CO₂ per year.

CONCLUSION

Wood is very fascinating material. It comes in various sizes and shapes and it can be used for many purposes, from packaging, transport application, furniture to construction usage and for energy. Wood follows us from our birth till our death.

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² The energy used in the extraction and production of a material or product
If we consider the CO₂ emissions wood and wood based products stores CO₂, hence not contributing to the global warming effect. And since we know that average life cycle could be several decades we know that we stored carbon for longer period.

When wood and wood based products are at the end of life cycle or wood can't be used for any type of products, than from the environment and energy point of view it should be used for energy (Fig. 7), and not like some would like to present, that the most useful way of using wood in the environmental and global warming sense is to burn it and use it for energy.

![Figure 9: Life cycle of wood and wood based products (EPF, 2004)](image)

With global warming in mind we must state our priorities. Or first priority has to be lowering the amount of greenhouse gasses that are emitted into atmosphere. Lowering of those gasses can be achieve by several means, but the most efficient mean would be to lower our energy demands, and that we can easily achieve by using wood and wood based products.

Use of wood and wood based products for building has to be the future standard for energy efficient building. Such building will show advantages in several aspects:

* Less energy needed for production
* Thinner walls
* Flexibility
* More comfortable living conditions
* Higher heat insulation hence less energy needed for heating
* Good sound insulation
* Durability
* Predictable behaviour in fire

Wood and wood based products offers us many ways for affecting the global warming, not just by burning it. When using wood and wood based products we can contribute more to lowering the greenhouse gas emission, especially in the longer period. We mentioned already that wood is carbon warehouse, and since wood is a good thermal insulating material, less energy is needed for heating hence less energy costs and less CO₂ is emitted into atmosphere (even if fossil fuel is used).

Wood therefore is and must be at first the substitute for carbon intensive materials, not just as construction material, but also in furniture and other fields.

Use wood and wood based products to tackle the climate changes. The wood working industry gives value to the forest and respects the carbon cycle. (CEI – Bois, 2005 & EPF 2007)
REFERENCES

Potential annual amount of cutting residues, suitable for fuel, in Lithuanian State forests

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Keywords: Bioenergy, forest fuel, cutting residues, forestry

ABSTRACT

The paper presents the analyses of potential amount and use of cutting residues in Lithuanian State forests in 2006. The total forest area was 2218 thou. ha, covering 32.5% of the Lithuania territory in 2006. Total growing stock volume was 401.1 mln. m³. State forest enterprises and other state forest managers harvested 3.5 million m³ in 2006.

The potential use of forest biofuel from cutting residues could be expanded in Lithuania, though due to many reasons only the small amount of logging residues are used. According the Lithuanian forests enterprises data, the estimated amount of the potential cutting residues in state forest in 2006 was 850 thou. m³. Theoretical calculation data shows that during 2006 in Lithuanian State forests was 1084 thou. m³ potential cutting residues. Potential amount of cutting residues in Lithuanian state forest according the growing conditions reduced to 336 thou. m³.

The sale of cutting residues in 2006 included about 76 thou. m³. However the amount composed only approximately 9% from total potential cutting residues in Lithuanian state forest.

INTRODUCTION

Production and use of biofuel is promising type of renewable energetic in EU countries. Lithuania has very limited local source of fossil fuel and considerable part of fuel is importing from foreign countries, such as Russia, Kazakhstan, Ukraine and Poland. Wood as fuel is used long time ago. At this time the part of wood fuel isn’t great in the energy production, but use of wood fuel for energy production is increasing each year.

Cutting residues is the main biofuel recourse which still is used in very small amount. The main problem is that taking of cutting residues from the stall is expensive and low productive. Potential of cutting residues valuated not less than 600000 m³ per year either about 1.3 TWh. There are about 200 boilers, which using biofuel, and the total power exceeds 450 MW in Lithuania. The biggest bio-boilers are established in Vilnius (60 MW), Marijampolė (16 MW) and Tauragė (12+8 MW). They are using about 0.8 mln. m³ wood per year.

The state importance forestland was 1.05 mln. ha according data obtained from the last forest assessment in 2007. The biggest growing stock volume accumulated in Vilnius council forests is 84.2 mln. m³. The total growing stock increased from 401.1 mln. m³ till 404.7 mln. m³. The average growing stock volume remained at 199 m³ ha⁻¹ (Lithuanian Statistical Yearbook 2007).

In Lithuania timber harvesting volumes were decreasing during three years. States forest enterprises and other state forest managers harvested 3.5 mln. m³ merchantable roundwood in 2006.
Resource of cutting residues depends on timber harvesting volumes. It is foreseen that it will increase in the period 2001-2010 till 6.3 mln. m³, 2011–2020 – 7.5 mln. m³ and 2021–2030 – 8.3 mln. m³, respectively (Kuliešis, Petrauskas 2000).

**EXPERIMENTAL METHODS**

The data about cutting residues in Lithuania states forest was collected from forest enterprises. It was received data of 2006 on wood volumes from final and intermediate felling and amount of cutting residues, there with on not merchantable branches in each forest enterprises.

At first the lost of cutting residues, related with stand site types while estimated all lost of forest cutting residues, was assessed. The use of potential cutting residues in some forest types is limited. In some of forest sites types such as Na (normal humidity, very poor fertility), Ša (slopes, very poor fertility), La (temporarily overmoistured humidity, very poor fertility) and Ua (overmoistured humidity, very poor fertility) it is not aloud to bring away the cutting residues. In the more humid forest sites cutting residues are used to reinforce the gutter road.

There are not exact data about amount of cutting residues that it is needed to reinforce the gutter road, therefore according similar researches and guidelines (Mikšys, 2006, Tebėra, 2005) we used the following values: (1) in the Na, Ša, Šae, La and U forest soil types it is not aloud to bring away cutting residues; (2) in the other Š and N forest types - 90 percent of cutting residues are available as biofuel, and (3) in the L (except La) and Pn forest soil types - 50 percent cutting residues are available as biofuel.

The amount of potential cutting residues can decrease not only because of growing conditions but also of technological process. The cutting residues consist of above ground stump part, bark from industrial roundwood, tree top, industrial roundwood overlap, cutting and branches. There is not such practice to barking the logs in the forest, thought the bark and industrial roundwood overlap with the logs are removed in to sawmills. So, the amount of cutting residues that is staying in the forest is decreasing. The stumps are left in the forest as well. The biomass of stump, bark, branches and stem estimated as percentage from total tree volume using the models, designed by Usoltsev, Hakkila, Alakangas for particular tree species and was adopted in Lithuanian stands (Usoltsev, 2001, Hakkila, 2005, Alakangas, 2005).

**RESULTS AND DISCUSSION**

Table 1: Potential amount of cutting residues in Lithuanian counties, thou. m³

<table>
<thead>
<tr>
<th>County</th>
<th>Final felling</th>
<th>Intermediate felling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alytus county</td>
<td>28.1</td>
<td>29.4</td>
<td>57.5</td>
</tr>
<tr>
<td>Kaunas County</td>
<td>92.8</td>
<td>58.0</td>
<td>150.6</td>
</tr>
<tr>
<td>Klaipėda county</td>
<td>26.8</td>
<td>13.1</td>
<td>39.8</td>
</tr>
<tr>
<td>Marijampolė county</td>
<td>42.5</td>
<td>15.1</td>
<td>57.6</td>
</tr>
<tr>
<td>Panevėžys county</td>
<td>64.2</td>
<td>50.3</td>
<td>114.4</td>
</tr>
<tr>
<td>Šiauliai county</td>
<td>71.0</td>
<td>43.7</td>
<td>114.8</td>
</tr>
<tr>
<td>Tauragė county</td>
<td>39.4</td>
<td>21.2</td>
<td>60.6</td>
</tr>
<tr>
<td>Telšiai county</td>
<td>44.1</td>
<td>34.2</td>
<td>78.2</td>
</tr>
<tr>
<td>Utena county</td>
<td>21.5</td>
<td>17.5</td>
<td>39.0</td>
</tr>
<tr>
<td>Vilnius county</td>
<td>82.8</td>
<td>55.2</td>
<td>137.9</td>
</tr>
<tr>
<td><strong>Total in Lithuania</strong></td>
<td><strong>513.2</strong></td>
<td><strong>337.7</strong></td>
<td><strong>850.4</strong></td>
</tr>
</tbody>
</table>

According the Lithuanian state forests enterprises data, the estimated amount of the potential cutting residues in state forest in 2006 was 850.4 thou. m³. The biggest amount of cutting residues was in Kaunas (150.6 thou. m³) and Vilnius (137.9 thou. m³) counties.
In these counties states forest enterprises had the highest protective and exploitable forest group plots and there were the felling mostly of broadleaves. The lowest amount of cutting residues was in Klaipėda (39.8 thou. m³) and Utena (39.0 thou. m³) counties. It was determined what total amount of cutting residues from final felling was higher approximately twice than the total amount of cutting residues from intermediate felling.

The potential amount of cutting residues according the growing conditions was estimated by the rules as it was mentioned, and summarized in Table 2.

### Table 2: Potential amount of logging residues in Lithuanian counties according the growing conditions, thou. m³

<table>
<thead>
<tr>
<th>County</th>
<th>Cutting residues</th>
<th>Percent from potential amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alytus county</td>
<td>36.7</td>
<td>63.83</td>
</tr>
<tr>
<td>Kaunas County</td>
<td>87.1</td>
<td>57.84</td>
</tr>
<tr>
<td>Klaipėda county</td>
<td>21.5</td>
<td>54.02</td>
</tr>
<tr>
<td>Marijampolė county</td>
<td>31.4</td>
<td>54.51</td>
</tr>
<tr>
<td>Panevežys county</td>
<td>52.5</td>
<td>45.89</td>
</tr>
<tr>
<td>Šiauliai county</td>
<td>66.3</td>
<td>57.75</td>
</tr>
<tr>
<td>Tauragė county</td>
<td>32.6</td>
<td>53.80</td>
</tr>
<tr>
<td>Telšiai county</td>
<td>38.8</td>
<td>49.62</td>
</tr>
<tr>
<td>Utena county</td>
<td>30.2</td>
<td>77.44</td>
</tr>
<tr>
<td>Vilnius county</td>
<td>93.</td>
<td>67.44</td>
</tr>
<tr>
<td><strong>Total in Lithuania</strong></td>
<td><strong>490.1</strong></td>
<td></td>
</tr>
</tbody>
</table>

It was estimated, that the highest lost of cutting residues was in Panevėžys (54.11 %) and Telšiai (50.38 %) counties. There were determined forest soil types with index of humidity \( L \) (temporally overmoistured) in large area. Such area covered about 70 percent of forest areas in these counties. The lowest lost of cutting residues was in Utena (22.56 %) and Vilnius (32.56 %) counties. In this counties forest soils types with index of humidity \( N \) (normal) were dominant.

It is necessary to mention that determined cutting residues lost are not stable. It depends on meteorology conditions. If the year will be humid then to fortiy of gutter road require more cutting residues. If the year will be waterless then amount of cutting residues, suitable to fuel, increases. Amount of cutting residues also depends on felling stands location. Either, the felling volume is changing every year. As it was mentioned the felling volume increase: 2001-2010 – 6.3 mln m³, 2011 – 2020 – 7.5 mln m³ and 2021 – 2030 – 8.3 mln m³, therefore the amount of cutting residues will increase too.

Potential amount of calculated cutting residues in Lithuanian counties are presented in Table 3.

While calculated the potential amount of cutting residues according the methodology, it was determined that there was 1084 thou. m³ of cutting residues in Lithuanian states forests. It was 1.27 times higher than data given by forest enterprises in 2006 years. The difference of the estimated amount of cutting residues could be because the different models of the biomass of tree estimation are applied in the country.

As it is shown in the table 1, the higher amount of cutting residues was in Kaunas (173.8 thou. m³) and Vilnius (166.4 thou. m³) counties. The smallest amount of cutting residues was in Klaipėda (54.2 thou. m³) and Utena (65.6 thou. m³) counties.
Table 3. Potential amount of calculated logging residues in Lithuanian counties, thou. m³

<table>
<thead>
<tr>
<th>County</th>
<th>Final felling</th>
<th>Intermediate felling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alytus county</td>
<td>44.9</td>
<td>33.1</td>
<td>77.8</td>
</tr>
<tr>
<td>Kaunas County</td>
<td>104.8</td>
<td>68.9</td>
<td>173.8</td>
</tr>
<tr>
<td>Klaipėda county</td>
<td>36.2</td>
<td>18.1</td>
<td>54.2</td>
</tr>
<tr>
<td>Marijampolė county</td>
<td>60.2</td>
<td>19.5</td>
<td>79.7</td>
</tr>
<tr>
<td>Panevėžys county</td>
<td>102.9</td>
<td>52.5</td>
<td>155.3</td>
</tr>
<tr>
<td>Šiauliai county</td>
<td>83.7</td>
<td>52.2</td>
<td>135.9</td>
</tr>
<tr>
<td>Tauragė county</td>
<td>50.2</td>
<td>22.6</td>
<td>72.8</td>
</tr>
<tr>
<td>Telšiai county</td>
<td>54.8</td>
<td>37.2</td>
<td>91.9</td>
</tr>
<tr>
<td>Utena county</td>
<td>45.9</td>
<td>19.7</td>
<td>65.6</td>
</tr>
<tr>
<td>Vilnius county</td>
<td>120.1</td>
<td>46.4</td>
<td>166.4</td>
</tr>
<tr>
<td><strong>Total in Lithuania</strong></td>
<td><strong>703.7</strong></td>
<td><strong>370.2</strong></td>
<td><strong>1073.4</strong></td>
</tr>
</tbody>
</table>

However, further, the amount of cutting residues was recalculated according the growing conditions (Table 4).

Table 4. Calculated potential amount of logging residues in Lithuanian counties according the growing conditions

<table>
<thead>
<tr>
<th>County</th>
<th>Cutting residues, thou. m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alytus county</td>
<td>36.1</td>
</tr>
<tr>
<td>Kaunas County</td>
<td>59.3</td>
</tr>
<tr>
<td>Klaipėda county</td>
<td>58.8</td>
</tr>
<tr>
<td>Marijampolė county</td>
<td>32.5</td>
</tr>
<tr>
<td>Panevėžys county</td>
<td>38.3</td>
</tr>
<tr>
<td>Šiauliai county</td>
<td>37.7</td>
</tr>
<tr>
<td>Tauragė county</td>
<td>96.6</td>
</tr>
<tr>
<td>Telšiai county</td>
<td>51.1</td>
</tr>
<tr>
<td>Utena county</td>
<td>36.1</td>
</tr>
<tr>
<td>Vilnius county</td>
<td>59.3</td>
</tr>
<tr>
<td><strong>Total in Lithuania</strong></td>
<td><strong>511.3</strong></td>
</tr>
</tbody>
</table>

There is the considerable potential amount of cutting residues in Lithuania states forests but only 9 percent of these resources are used by this time. The realization of cutting residues in Lithuanian counties presented in Table 5. The main reason for not intense realization of cutting residues is that the production cost of forest fuel is higher than product cost.

Table 5. Realisation of cutting residues in Lithuanian counties (2006)

<table>
<thead>
<tr>
<th>County</th>
<th>Cutting residues, thou. m³</th>
<th>a*</th>
<th>b**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alytus county</td>
<td>2.4</td>
<td>4.2</td>
<td>8.5</td>
</tr>
<tr>
<td>Kaunas County</td>
<td>12.7</td>
<td>8.4</td>
<td>13.7</td>
</tr>
<tr>
<td>Klaipėda county</td>
<td>3.4</td>
<td>8.5</td>
<td>12.7</td>
</tr>
<tr>
<td>Marijampolė county</td>
<td>9.3</td>
<td>16.1</td>
<td>21.9</td>
</tr>
<tr>
<td>Panevėžys county</td>
<td>12.3</td>
<td>10.8</td>
<td>19.2</td>
</tr>
<tr>
<td>Šiauliai county</td>
<td>9.0</td>
<td>7.8</td>
<td>12.7</td>
</tr>
<tr>
<td>Tauragė county</td>
<td>2.3</td>
<td>3.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Telšiai county</td>
<td>8.4</td>
<td>10.7</td>
<td>19.0</td>
</tr>
<tr>
<td>Utena county</td>
<td>2.10</td>
<td>5.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Vilnius county</td>
<td>13.7</td>
<td>9.9</td>
<td>16.5</td>
</tr>
<tr>
<td><strong>Total in Lithuania</strong></td>
<td><strong>75.6</strong></td>
<td></td>
<td></td>
</tr>
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* - the percent of cutting residues from the total amount.
** - the percent of cutting residues according the growth condition.

It was evaluated, that forest enterprises realized 75.6 thou. m³ cutting residues in 2006 year. It is only 8.9 percent from total potential amount of cutting residues in 2006. Marijampolė (16.1 %)
Panevėžys (10.8 %) counties realized the higher amount of cutting residues, while Tauragė (3.8 %) and Alytus (4.2 %) - the lowest amount of cutting residues.

It was found, that amount of cutting residues, which forest enterprises realizing to retailers was two times higher than amount, which was realized to wholesalers.

The price of cutting residues depends on point of sale. The cutting residues price in the stall is lower than price in the wood yard and it vary from 2 (0.27 €) to 7 (2.01 €) Lt m$^{-3}$ (not including VAT) and in the wood yard the cutting residues prices vary from 17 (4.9 €) to 48 (13.9 €) Lt m$^{-3}$ (not including VAT).

**CONCLUSIONS**

1. According the Lithuanian state forests data, the estimated amount of the potential cutting residues in state forest in 2006 was 850 thou. m$^3$, while the calculated amount of cutting residues is 1084 thou. m$^3$.
2. the higher lost of cutting residues is in Panevėžys and Telšiai counties. The lowest - in Utena and Vilnius counties.
3. The sale of cutting residues in 2006 included about 76 thou. m$^3$. However the amount composed only approximately 9 % from total cutting residues in Lithuanian state forests.

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Poplar cultivation in Italy: history, state of the art, perspectives

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ABSTRACT

Specialized poplar plantations have existed in Italy for more than a century and remain a characteristic feature of large areas of both the plains and hills. The timber produced forms an important raw material, in particular for the local first processing timber industry with a preferential destination towards the plywood sector. Even if the area under poplar cultivation is only 83,000 hectares, equivalent to less than 1 % of that under forest in general, it contributes to more than a third of the annual national production of industrial round wood, with a total volume of about 1Mt of timber collected.

This article provides a general overview of this industrial chain, much appreciated and taken as an example on an international level, describing its peculiarities and its development over time in reference to the economic factors which it is composed of, i.e. the poplar growers, the harvesting companies and the industries which process the timber obtained.

In particular we also analyse the principal technological and economic aspects, the harvesting methods, the final destinations and derived products, and report on recent trends and their prospects in the medium term.

INTRODUCTION

Due to increasing legal obligations and economic constraints the management of natural forests aims towards optimising non-speculative and environmentally friendly functions, in the interest of the public. The economic-productive function therefore is fulfilled by wood plantations established in order to provide a source of raw material destined for the first processing industry. Such plantations provide a positive response to the need for fast production (with a growth rate not achievable in forests) and for better planning, and to the need for homogeneity in terms of size and technological characteristics of the assortments obtained. Presently, on a world scale, only a little more than 10 % of the industrial supply is provided by these plants but it is forecast that this figure could reach 50 % by 2050 (Sedjo 2001).

In this context poplar cultivation could represent a valid alternative for conventional forestry resources contributing greatly to the annual production of roundwood to be processed.

In Italy, in contrast to most other countries (where it is generally grown on marginal land and managed according to a “naturalistic” model), poplar is grown on the fertile soils of the plains often in competition with arable or other specialised crops, which are often subsidised. Poplar trees are cultivated in a decidedly agricultural context, with the temporary occupation of soil subject to rotation and in competition with other crops. Also machinery and equipment are used which are not typically forestry related.
As a consequence, in order to increase production and achieve the greatest volume of the most profitable kind of timber certain kinds of agronomical practices have to be undertaken such as working the land, pruning, fertilising, irrigation and treatments for pest and disease control. Poplar cultivation, be it on specialised plantations or in rows (windbreaks etc.) has also had a fundamental influence in modelling the agricultural landscape of the Po Valley to the extent that now it has become a traditional characteristic element together with the cultivation of cereals and rice. Depending on the geographical context poplar cultivation is often seen in a concentrated form (above all along the Po river and other principal waterways on sandy or silted soil subject to flooding), with uninterrupted groups of plantations or fragmented.

A substantial amount of poplar cultivation serves a secondary role, particularly in many farms in hill or plain areas with a low level of specialisation, often as a means of extra income achieved without much effort but to the detriment of the wood quality. Land fragmentation, limited size of single cultivations and the absence of good planning are the main reasons for the negative and unstable market trends, where the disadvantageous contract position of the weaker components i.e. the poplar growers and the harvesting companies, constitutes an important factor of its periodical structural crisis. Nevertheless the case of poplar cultivation for Italy is the closest to the concept of an industrial wood chain, in which economic interdependence between subjects at opposite parts of the system is brought about, even if, as seen on a more accentuated level in the forestry sector, there is a lack of vertical integration between the wood processing industries and the producers of the raw material. Only a few wood industries are the actual owners of the plantations whereas most of them satisfy their supply needs on the local open market or with imports of round wood and semi-finished products.

Right from the beginning Italian poplar cultivation has not only been characterised by its wide range of final wood products (paper industry, match production, furniture etc.) but above all by its suitability to the plywood industry which requires material of the highest quality with precise technological requirements i.e. an even trunk free from defects and with wide diameters. The logs for rotary cutting constitute the most valuable assortment and the main objective of the traditional cultivation model, so much so that still today this type of usage is the only one that can guarantee its survival. This is achieved by integration with other industrial sectors such as particle board, packaging, pallets and pulp production, which altogether consent a complete exploitation of the plant and to which minor varieties and discards from the harvest and first stage of processing are destined.

AREAS, COMPANIES AND PRODUCTION

Already from the 1930’s poplar cultivation in Italy had assumed characteristics of a specialised cultivation, essentially to respond to the supply requirements of industry, and covering an area of around 10,000 hectares. Immediately after the Second World War this area went up to 35,000 hectares and continued to increase until finally reaching its peak of 175,000 hectares at the end of the 1960’s, the period in which the positive economic trend and intensive economic development helped maintain high levels of demand and high prices for wood. Expansion would have been even greater if some conditions, primarily entrance to the EEC, had not adversely affected the dynamics of the wood market by favouring importation and the decision of many companies in the agricultural sector to change, given that other kinds of cultivation were more profitable (thanks to specific subsidies) and less risky in relation to the length of time of the growing cycle.
Also in this period there was a sharp upturn in the amount of felling, from around 320,000 m³/year in 1960 to 1,600,000 m³ at the end of the decade.

At the beginning of the 1970’s the insecure economic climate and high inflation, as a result of the serious oil crisis, in turn helped to increase the price of poplar wood. This caused an uphill trend in poplar cultivation which reached an area of around 135,000 hectares in 1982.

Moving on to the early 1980’s there followed a crisis resulting from the reorganisation of the plywood industry and the new restrictions dictated by environmental laws relating to river areas, more suitable to poplar cultivation. At this point many farmers abandoned their activities in this sector causing a significant reduction in the amount of surface under poplar so much so that at the end of the decade it was only about 106,000 hectares.

In the 1990’s the above mentioned difficulties become more accentuated with a tendency towards the use of recycled products, more in line with waste legislation, rather than the various assortments used in the particle board industry.

Moving on to the beginning of the 21st century the land under cultivation decreased even more. Based on data from the last General Agricultural Census (ISTAT 2001), specialised poplar farms occupy little more than 80,000 hectares, 88 % of which are located in the four northern Regions around the Po river and in Friuli.

This enormous reduction in land area, equivalent to more than 40 % from the 1970’s to today has also caused a serious decrease in the number of poplar farms, from 60,000 to 25,000 to date. For the most part (80%) these are private farms involved also in other types of cultivation and run and worked on by the families themselves. This also brought about an increasing pulverisation of the land. The average surface area covered by poplar trees for each enterprise is around little more than 3 hectares, with a few farms growing large scale plantations (tens of hectares) and many others with plantations hardly reaching one hectare.

In the last decade domestic poplar utilization were about 1,5 Mt/year, while at the beginning of the new century, after a further reduction, they have stabilised at around 1Mt/year (ISTAT 1950-2007).

**CULTIVATION**

The reference model for traditional poplar cultivation in Italy is that of industrial tree cultivation. Although the not OGM, selected for the cultivation and registered in the N.R.C.F., are more than 40, ‘I-214’ is the one nearly always chosen by the plywood industry (mainly because of its very low density) and consequently it has a more convenient price (by 10 €/t) compared to the other clones. This produces a negative effect on the diffusion of other clones, often more productive, of better shape and resistant to diseases.

The cultivation model suggests planting 1 to 2 years old sets, with spacing between 5 x 6 m and 6 x 7 m (density between 260 and 330 trees per hectare, without thinning). In the first five years the area is subject to various kinds of treatments including weeding, fertilisation of the soil, spraying to eliminate parasites affecting the leaves and the wood, pruning and sometimes irrigation.

In the following period the treatments are reduced to mechanical weed control and localised spraying for woodworm. Maturity is reached depending on the site conditions, the density of the plantation and the expectations of the owner, after 9 to 12 years when each tree has a commercial volume, i.e. up to 10 cm diameter, of between 0,7 and 0,9 m³, equivalent to a fresh weight of between 0,56 and 0,72 t. However it is not uncommon to find plantations with trees between 15 and 18 years old and volumes of up to 1 - 1,2 m³.

As far as the economic aspects are concerned, the cultivation practices involved require a manpower commitment which vary between 12 and 18 h/ha/year, with costs of production
between 8,000 and 11,000 €/ha, which are mostly costs of establishment, of irrigation works and of the various phytosanitary treatments necessary.

![Figure 1: Typical mature poplar stand from the traditional industrial plantation in Italy (photo by A. Giorcelli)](image)

The economic success of poplar cultivation is strongly influenced by the characteristics of the assortments obtained at the end of the production cycle, the percentage of which can vary considerably depending on the plantation and the kinds of cultural practices carried out (most importantly pruning and pest treatment). The main product, that is the round wood to be rotary cut for the production of plywood panels, makes up for 50 - 60% of the trunk, while the rest is divided into assortments for packaging and for chipping for use in paper production or particle board (Zanuttini and Cielo 1998).

It is most important to be able to produce the greatest possible volume of wood of the highest quality, in that it has to cover the costs related to the use of that of lesser quality which is also more commercially difficult to manage. Where such an objective becomes impossible to reach, added to the fact that the financial commitments involved are considerable and the waiting time for financial gain long, it may result in the decision to not continue to cultivate, particularly in times of uncertainty in the market place. There is also a clear lack of planning plantations with regards to industrial consumption. This in cycles determines, on a vast scale, periods of lack of supply of round wood resulting in higher wood prices which, in turn, act as an incentive to increase the number of plantations. This phenomena tends to repeat itself at regular intervals more or less similar to the length of poplar rotation (IPC 2005).

**SALE**

The methods of sale of the mature poplar plantation are of different types but in the majority of cases consist of the transfer of the trees from the owner to the harvesting enterprise or directly to the wood processing industry.

The buyer then assesses the volume and offers a price for the entire amount or, less likely, a unit price for the timber divided into the main assortments. If the wood is sold by weight the agreed price is applied only to the assortments with a diameter of more than 15-20 cm.

If the plantation is bought by a factory then logging could be carried out by the factory’s own logging team or entrusted to a harvesting enterprise, after having sent an inspector for the selection of the different assortments and the vehicles to be used for transportation. However, if
it is bought by a harvesting company they themselves together with the industrial customer define the criteria for utilization.

Table 1 shows the dimensions of the main assortments based on the needs of the principal types of usage and their corresponding market value.

**Table 1: Main features and prices (at march 2008) for poplar assortments destined to the industrial processing**

<table>
<thead>
<tr>
<th>Wood assortments (logs or small trunks)</th>
<th>Dimensional requirements</th>
<th>Indicative ex factory price (€/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>for plywood</td>
<td>min. ø: 22 cm</td>
<td>I quality (for faces):</td>
</tr>
<tr>
<td></td>
<td>length: 310; 260; 220; 190; 180; 160; 130 cm</td>
<td>130 - 180</td>
</tr>
<tr>
<td></td>
<td></td>
<td>II quality (for inner plies):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70 - 110</td>
</tr>
<tr>
<td>for small packaging</td>
<td>min ø: 20 cm</td>
<td>50 - 90</td>
</tr>
<tr>
<td>(wooden box for vegetables &amp; fruits)</td>
<td>various lengths, starting from 110 cm</td>
<td></td>
</tr>
<tr>
<td>for sawing (blockboards cores)</td>
<td>min ø: 16 cm</td>
<td>50 - 90</td>
</tr>
<tr>
<td></td>
<td>various lengths, mainly 190 cm</td>
<td></td>
</tr>
<tr>
<td>for sawing (pallets)</td>
<td>ø between 18 and 25 cm</td>
<td>40 - 70</td>
</tr>
<tr>
<td></td>
<td>length &gt; 250 (generally 400) cm</td>
<td></td>
</tr>
<tr>
<td>for paper</td>
<td>ø between 10 and 18 cm</td>
<td>30 – 50</td>
</tr>
<tr>
<td></td>
<td>length: 200 cm</td>
<td></td>
</tr>
<tr>
<td>for chipping</td>
<td>ø between 3 and 10 cm;</td>
<td>15 – 35</td>
</tr>
<tr>
<td></td>
<td>length: 220 cm</td>
<td></td>
</tr>
</tbody>
</table>

The price of the standing tree fluctuates between 35 and 50 €/t. To this must be added the cost of utilization (20-25 €/t) and transportation (10-15 €/t, depending on the distance).

A mature poplar plantation can yield from 150 to 170 t/ha of assortments with an average commercial value of 60 €/t. It follows that the revenue can be less than the costs incurred, so much so that with the recent market situation traditional poplar cultivation is at the limit of economic sustainability and only an increased production in the assortments of a higher quality will allow for a gain on the original investment by the owner.

**HARVESTING**

Harvesting of mature poplar plantations can be carried out using two alternative methods, at opposite ends of a scale based on different levels of mechanization.

The traditional method, currently adopted by the majority of companies, consists of the use of multi-purpose agricultural machinery, supported by equipment of a more specialised nature, such as hydraulic cranes, log clippers etc. Felling is carried out manually by a specialised operator with a chainsaw, generally backed up by a tractor equipped with an arm to push the trunks. This is followed by the “processing” stage, subdivided into “selection and measuring”, “debranching” and “cross cutting” (with a worker at the base of the trunk and another at the top for cross-cutting and debranching at the same time”. The top-ends and the larger branchwood is put in small piles to be collected and loaded on the trucks; the thinner branchwood (less than 3-4 cm diameter) is left on the ground and subsequently crushed or burnt.

The wood assortments are then loaded onto a lorry with a trailer or an articulated lorry using a mechanical arm positioned at the back of a tractor or self-propelled vehicle with a revolving motorised arm.
A possible improvement to the traditional method is using a self-propelled vehicle (generally a caterpillar type) with clippers and chainsaw for the preparation of the branches. Such a method doesn’t entail exaggerated costs, regardless of the size of the lot, but if it is efficient as far as the main product (industrial roundwood) is concerned it can’t be so for the assortments with lower diameters. Other negative aspects include manual handling, fatigue and dangerousness of the work, beside the difficulty of finding qualified labour.

At the other end of the scale there is a highly mechanized harvesting method, involving the use of specialised harvesters which can carry out the felling process and the preparation of the wood material up to a diameter of 4-5 cm.

![Image: The use of modern machinery starts to be quite diffuse also in Italy, specially for the harvesting of poplar plantations where it finds more favourable conditions than in the forest sector.]

A specialised articulated tractor (forwarder) capable of taking heavy loads is often used in the bunching, extraction and loading processes.

This method is advantageous in terms of productivity, however the much higher purchasing and running costs of the harvester will make the activity economically efficient only if it used in the crosscutting of the industrial roundwood, something which finds a lot of resistance from traditionalists rooted in the old system of manual preparation. There are also advantages attached to combining a chipper to the harvester particularly for the preparation of smaller assortments. This represents an important development in the mechanisation and labour organisation in the poplar plantation and constitutes an increase in daily productivity to 35 t/d/worker compared to 12 t/d/worker of the traditional system. (Cielo and Zanuttini 2004; 2007).

The unit labour costs incurred when using a highly mechanised method are inferior to those incurred with the conventional system (approximately 14-15 €/t instead of 19-21). Moreover a team which adopts this method can work up to 100 hectares per year compared to 12-15 hectares per year utilized with traditional techniques.

Given the rise in demand for biomass and the prospect of finding an opening into the energy sector, the production of poplar wood chips could substitute other forms of commercialisation of smaller assortments, although with the necessary machinery available for transport and a stable market. The use of the harvester for preparing the smaller branchwood however, cannot be economically justified neither in terms of productivity or labour costs.
In addition, utilising combined machinery becomes advantageous only if the technical, logistic and commercial organisation of the enterprise is equally advanced and allows for the complete exploitation of the potential of such equipment, i.e. working all day and all year round. This is seen in the areas more suitable for poplar cultivation, such as the plains where the plantations are of a larger average dimension and the enterprises more professional.

The use of the harvester in poplar cultivation in Italy is hindered by two factors: on one hand the huge investment necessary for its purchase, with relation to the relatively small size of the plantation itself, and on the other hand by a presumed decrease in the wood quality. In fact according to some industrial operators highly mechanized harvesting methods compromise quality, the dimensions of the logs are less accurate and damage is caused to the bark and the wood.

However a step up in the level of mechanisation often represents a necessary way forward into modernisation.

More modern working techniques can also contribute to maintaining a favourable value of the standing tree and consequently to disincentive the abandon of poplar cultivation and avoid the risk of compromising the competitiveness of the entire production chain.

THE PROCESSING INDUSTRY

Poplar wood is suitable for many kinds of uses, in continuous evolution in relation to the market dynamism and to the development of industrial technology. The main uses are shown in figure 2 below where they are grouped according to different portions of the tree they are obtained from (in relation to the diameter of the wood and number of defects).
The success of poplar wood is mainly due to its homogeneity (it comes from monoclonal plantations) its low basic density, its light colour hardly to be found in other species and its easiness to process, glue and paint. The semi-finished products are able to satisfy functional, aesthetic and decorative needs required by the wood industry and in particular the furniture sector.

**History and evolution**

In Italy the use of poplar wood in the wood panel industry has its origins in the sanctions decreed by the League of Nations, associated with expansionistic colonising aims (the Ethiopian campaign 1935-36): the supplies of wood raw material for rotary cutting (at the time based on birch, okoume and beach) were interrupted which made some factories try to rotary cut large poplar trees planted in amongst the crops. The result was positive and very soon after almost all Italian factories passed over to the poplar, determining, upon modification of the cultivation model, the diffusion of a dedicated cultivation (Giordano 1983).

Industrial recontraction and the development of the economy started in the 1950’s, brought about a large expansion in the plywood industry, as a result of an increased demand in furniture, at that time seen as an important possession for the Italian family. There was also an upturn in demand for poplar wood for the fruit and vegetable packaging industry run by hundreds of family businesses, situated along the whole length of the Po river, involved in sawing and handmade production of wooden crates. Also at this time the first factories producing particleboard were built, supplied for the most part by poplar branchwood: a new and important use for residuals of utilizations.

*Figure 4: Scheme of the possible uses for the different tree portions.*
In the 1970’s the chipboard industry developed on a massive scale to the extent that at the end of the decade there were around 50 sites, with a production capacity of more than 2 Mm³ panels. Many factories were set up manufacturing thin particleboard destined to compete with plywood (at that time the plywood industry numbered more than 200 plants, with an overall production of 750,000 m³) to produce hollow core boards for doors and the furniture industry.

In the 1980’s the extensive use of particleboard in the furniture sector caused a reduction of plywood production to 400,000 m³/year with the number of production outlets halved (106 in 1982). At the same time the wood pallet industry makes itself known.

At the end of the decade Italian industry became interested in the import of poplar roundwood and semi-finished products from other European countries (Brun and Gianola 1995).

In the 1990’s a great change was brought about by a new opportunity, offered by waste legislation, to allow use of wood discards in the production of chipboard. This reduced the value of poplar branchwood to practically nothing. Pallet production continued to grow however, using mostly imported conifer sawn wood.

In the new century the wood panel industry has seen a rise in the concentration of the productive capacity and a simultaneous drastic reduction in the number of companies. Plywood and blockwood factories number only 23, with a production of 450,000 m³/year. Particleboard companies number total 21 (organised into 4 large industrial groups and 7 smaller groups which carry out the production of chipboard alongside that of the more important plywood) with an overall productive capacity of more than 5 Mm³/year, mostly originating from the use of reclaimed woody material.

Presently, some companies, principally those producing plywood, have relocated production to other European countries (above all Hungary and Romania) where the raw material is abundant and less expensive and the labour costs are inferior to those of the Italian market. In some cases these companies carry out several of the phases of the production process abroad while others, for example, completing the procedure and organising the commercialisation of the finished products, are performed in Italy.

Present situation and main products
The production sector involved in the first processing of poplar wood today is mainly made up of small and medium sized companies, many of which are located in the main poplar area (Po valley) and often in industrial districts.

Their modest size allows for, on one hand, a greater production flexibility, a capacity to differentiate the production plus a speedy response to the changing market. However, on the other hand they lack suitable structures, the professionalism required for successful management or to undertake research activity.

In Italy poplar wood is one of the most important raw materials for the plywood industry, which managed to expand on the international markets, right from its beginnings, thanks to the use of the best assortments of this species, which make up for 90 % of the needs of the whole sector. These companies use around 500,000 t/year of Italian poplar wood, have an average of 70 employees and an annual production of about 20,000 m³ of panels each. They are often family run, well structured and responsive to the international market. Some are larger and characterized by an integrated production system (plywood, blockboard or chipboard) which permits complete usage of the raw material.

Poplar plywood however has reached a certain maturity in terms of its development (in particular for its high level of efficiency and productivity) and market destination (mainly the furniture and caravan industry).

Possible margins of improvement could be reached through economies of scale and marketing, while concerning the technical aspects, possible innovation appears to be related to diversification. This means the ability to identify alternative uses in untraditional sectors (sailing,
building and transport, through the improvement of some technical properties of the panel) and create products with a greater value able to optimise the technical characteristics of this wood (Zanuttini 2003; Zanuttini et al. 2003; AA.VV.1995).

In terms of packaging the uses of poplar wood come under two types, those made with sawn wood (industrial packaging and pallets) and those for the fruit and vegetable market (boxes, baskets, trays and other kinds of containers) created by means of small-size peeling machines. The latter takes up a reasonable amount of the roundwood from mature poplar plantations, competing with the plywood industry. For the former however, poplar wood is only used if it can guarantee supply costs inferior to those proposed by alternative sources i.e. imported conifer roundwood and semi-finished products. This sector for the most part made up of small enterprises (10 to 15 workers) with equipment not always very up to date, today has a limited influence on the consumption of poplar wood.

The paper industry, which in the past was closely dependent on poplar, has gradually abandoned this species. This sector is controlled by huge industrial groups who have anticipated the process of globalisation of commercial import-export by purchasing (for a long time now) logs of other wood species on the overseas markets where these products are guaranteed in enormous quantities and in constant supply. Given that the importation of conifer pulp is cheaper the use of poplar timber from national production comes about only in times of unfavourable economic circumstances. For this reason, at national level, there are only very few plants which produce pulp using poplar wood. The demand is further diminishing even if the relative assortments maintain their price at a potentially interesting level (although often reappraised by the costs of selection, loading and transport), with a total volume of 200.000 t/year (equivalent to a little less than 1/4 of the timber consumption of the sector).

In this field poplar wood is appreciated for its positive qualitative characteristics (suitable for obtaining white odourless paper) and for the professionalism of the industrial chain which in recent years has re-evolved with the implementation of the latest machinery. In addition, the development of modern technology in the production of chemi-thermo-mechanical pulp (CTM) could offer new opportunities, on the basis that there is adequate availability of the raw material.

The particleboard sector, generally made up of large heavily mechanised factories, is traditionally depending on the use of poplar wood assortments of a lesser quality (top ends, branchwood or portions of defective plants otherwise unusable) the low cost of which is of fundamental importance. Recently however, this sector, in response to recent developments in waste legislation (which foresees a system to divide waste collection and its disposal) has reorganised itself to reuse the discards from production and recycle woody material of different types (packaging, second hand furniture, wooden material reclaimed from buildings and demolitions, some products from green maintenance etc.) So, in the light of this, the use of poplar wood assortments for chipping is continually declining, though amounting to about 200.000 t/year.

This situation, moreover is causing problems to the production of poplar wood; in fact if the assortments are not sold or under-priced, this will reflect negatively on the value of the standing trees, since all the timber has to be either removed or otherwise eliminated to leave the terrain in a condition to be used for further cultivations.

Other industrial destinations for poplar roundwood, i.e. sawn timber for carpentry, matches and ice cream sticks, quite relevant in the past, are now marginal. One case in particular still having certain relevance is that of wooden/wool inorganic-bonded panels for the building sector. The fibre panel sector is only marginally interested in wood from this species. Products in which the
use of poplar wood have shown an increase, are dyed veneers, multi-laminar wood (Castro and Zanuttini 2004) and ultra light mdf panels made using a particular dry process.

In relation to the introduction of innovative products, a possibility of a future use for poplar wood is in the glue-lam (Castro and Paganini 1997; 2003) and engineered panels sectors. In the latter field, some products would need only a limited modernisation of the technology already in existence- as in the case of LVL (Baldassino et al. 1996) or plywood for special uses – while others would need more complex modifications, as for example OSB (Oriented Strand Board) (Zhou 1990), which is gaining an increased quote of the market also on a European scale.

NEW SCENARIOS

Certification
Problems of environmental sustainability, particularly regarding the salvation of tropical rainforests, have brought about a growing diffusion of certificated wood products on the market. Even poplar cultivation has had to deal with the necessity to obtain such recognition.

The first step towards the certification of poplar cultivation was the preparation, by means of a pilot project, of an appropriate disciplinary for cultivation, agreed among the interested parties, which foresees a limited use of chemical products and a reduction of soil working, to be put into action in environmentally sensitive areas. Its integration into the national PEFC and FSC standards for sustainable management of poplar cultivation favoured the adoption of this system as a technical operating reference, facilitating monitoring and inspection from the certification body.

Such standards have in common the necessity to reduce negative environmental impact of the cultivation, accurate company planning, attention to employee training and work place safety. The FSC standard is however more restrictive regarding the obligation to reserve land for the sole purpose of the growth of the native vegetation, for a stricter threshold for clone differentiation, for the prohibition to use dithiocarbamates and to establish plantations homogenous for age and clone composition larger than 10 hectares.

The PEFC standard, which is better suited to the problems of poplar cultivation, shows a greater degree of relevance as regards the traditional practices, appearing to be able to direct poplar growers more successfully in the management of plantations (AA.VV. 2008a).

Both standards have however generated positive feedback. On one hand the possibility of turning to a group certification has brought about a new form of association aimed at economies of scale otherwise unthinkable. On the other they may become a keystone for facilitating the introduction of new poplar clones, which even though not sought after by the plywood industry, still have advantages for productivity and the environment (requiring fewer cultural practices).

At the moment in Italy there are 586 FSC-certified hectares, all privately owned and generally destined to meet the demand for plywood production for the foreign market, and 2696 PEFC-certified hectares, belonging to four different groups of owners.

As far as the processing industries that use poplar wood are concerned, given that there is no mutual recognition between the two schemes, many have resorted to the double implementation of their Chain of Custody (CoC). In this field certification is more frequent and concerns dozens of companies for each scheme.

The market, however, is young and a well structured and planned demand does not yet exist. The processing industry, moreover, notwithstanding the higher costs incurred by the poplar growers are not willing to accept a premium price for certified wood. The poplar growers which decide to obtain certification therefore aim to maintain their market quota and to be visible in wider contexts, improving in the meantime their relationship with local stakeholders. At the moment
the interest for certification of poplar cultivation is therefore destined to spread in relation to the public subsidies which will be made available (AA.VV. 2008a).

**Energy and environmental uses**

At present new agricultural models are becoming known, mainly connected to the necessity to increase the use of renewable energy sources (to respond to the Kyoto protocol) and to a greater attention to the environment.

Regarding bio-energy, poplar cultivation based on Short Rotation Forestry- SRF models (2-5 years rotations for repeated cycles) is becoming more widespread in recent years thanks to, above all, specific financial regional subsidies. However, these cultivation models are not yet sufficiently tested, they are hardly economically sustainable (with an average production of dried biomass around 15 t/ha/year in the most favourable cases) also due to the present low quotation of chipwood, and require the implementation of specific techniques (above all, as regards mechanisation). In answer to this the possibility of adopting longer rotations (up to 5 years) to produce woody material suitable also for the packaging industry is being valued, trying at the same time to get round the potential problems of such an intensive mono-cultivation.

The use of poplar for biomass production is altering the stability of consolidated markets, provoking a certain preoccupation among some industrial operators: plywood producers fear that poplar growers may shift towards such models and the relative financial support involved, while producers of chipboard are afraid of its influence on the price and the supplies of the raw material, also as a result of unfavourable competition because of the financial support previously mentioned. In any case the industries of the sector are directly or indirectly involved in this development and in the consequences entailed (AA.VV. 2007).

As regards the environmental functions, in Italy, like in other countries, expectations are increasing towards this type of cultivation. For example it has become clear how important “green corridors” made up of poplar plantations are for the fauna in riparian areas and how poplar trees can slow down the process of erosion in areas subject to flooding. Besides, poplar plantations make a significant contribution in terms of biodiversity, carbon sink and in general for naturalistic aspects. To this can be added the phytodepuration action through the absorption of nitrates and heavy metals for the restoration of contaminated soils, for which specific plantations are at an experimental stage.

**Polycyclic plantations**

Recently some experimental models have been studies of polycyclic plantations, where poplar is mixed with valuable hardwoods (for example walnut and cherry). These main species, are also mixed with secondary shrub species, added to obtain growth synergies, better conformation of the trunk, multifunctional objectives and the reduction of the risks of single-species cultivation. In these kind of plantations poplar provides an income at an early stage of the overall rotation. The first results appear encouraging, even if it is early to form a general judgement (Buresti Lattes et al. 2008).

**CONCLUSIONS**

Traditional poplar cultivation in Italy has been undergoing a period of uncertainty for some years now which has resulted in an economic instability and a notable reduction in the surface area under cultivation and in the number of workers. It would therefore seem necessary to intervene at various levels in the poplar chain, restructuring it in a more integrated and modern manner, with the objective of overcoming the abounding difficulties and obstacles which characterise it and developing a real and true “poplar system”.
Other than the classic supporting initiatives (such as research and technological developments aimed at improving efficiency of the cultivation process, harvesting and industrial production) and the remedies considered in specific fields, from confrontation between the public and private stakeholders involved some proposals have emerged on which future efforts can be based. Between which are:

- the acquisition of detailed and continuous information (starting from an inventory of plantations and comprehensive researches on operators and companies)
- actions aimed at improving the image of the sector and the desirability of the professions involved, to overcome the difficulties related to the generational turnover.
- planning of the production and consumption of poplar wood, by overcoming the problems of interaction between the different economic subjects (which at present don’t allow the development of inter-professional contracts in the industry chain);
- the improvement of communication and marketing, also through actions aimed at showing the positive effects of plantations on the environment and enhancing their ecological value (above all in comparison with alternative agricultural crops);
- improved awareness and greater involvement of the administrative and political bodies in the problems of the sector.

Concerning the industrial sector, it is possible to foresee a scenario in which some traditional or particular uses will remain valid only if they are upheld by further innovations, paying the due attention to the price of the raw material, to qualitative conformity, reliability and eco-compatibility of the finished and semi-finished products obtained.

It is evident in any case that only with willingness and the effective contribution of all the active parts will it be possible to discourage the abandoning of poplar cultivation, with a loss of knowledge which makes up for an excellence of the “made in Italy”, and make sure that it is attributed a strategic role also from the viewpoint of a greater attention to energy politics and environmental questions.

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