Action T1 / Deliverable D1.4 – Life+_ Future scenarios for the recovered wood and rubber sector

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Executive Summary

According to the contingency plan, the aim of new Task 1.4 is to identify and describe realistic future scenarios for the European wood and rubber sectors based on items originally planned to work with through the questionnaires (e.g. legislation, raw materials availability, prices, competitive sectors and their prospects, regional differences, innovation in manufacturing processes, contamination of raw materials, etc.).

The consortium cooperated closely with the European Panel Federation EPF (wood-based panels) and the European Tyre Recycling Association ETRA for the identification of realistic relevant scenarios for the sectors and for the best possible description of every item/ scenario.

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PART A: WOOD

1. Future scenarios for the particleboard sector

1.1. Identification of the scenarios

According to the contingency plan, the aim was to identify realistic future scenarios for the European wood sector, i.e. the particleboard sector as the exclusive user of recovered wood in the industrial manufacturing process, based on the items originally planned to get information from the European companies through the questionnaires: categories of recovered wood materials used, classification systems (legislation, European or national standard, industrial standard, own) for the recovered wood raw materials, legislation and/or certification system for the purchase/use of recovered wood raw materials, origin of recovered wood, prices/quality/availability of recovered wood, production data and share of recovered wood used, future tendency of using recovered wood, treatments and technical limitations in using recovered wood, demand/ sales of recovered wood products, proposals for promoting the utilization of recovered wood.

In order to identify the scenarios the consortium contacted the European Panel Federation (EPF), which is located in Brussels. The contact was established through GLUNZ, which is a member of EPF. The discussions led to the identification of 6 realistic scenarios with the following hierarchical order of significance:

- Competitive sectors and their prospects (e.g. energy)
- Legislation (e.g. recovery and landfilling legislation, rules or classification systems of recovered raw materials)
- Raw materials availability and quality (e.g. origin, quantities available, the role of global commerce, share of recovered wood in products and tendencies)
- Prices (e.g. tendency, taxes related to use of recovered materials)
- Innovation in manufacturing processes (e.g. progress in technology, technical limitations such as variation in quality and highest limit of recovered wood in %)
- Markets (e.g. demand for products from recovered materials)

The above mentioned scenarios were described according to the latest reports, documents, publications, legislation and data at European and global level.

1.2. Description of the scenarios

1.2.1. Competitive sectors and their prospects

The EU has set an important example by its positive lead in recognizing wood as a clean renewable source of energy with considerable potential to meet Europe's future energy needs. Setting targets for renewable energy and drawing up national biomass action plans is a development that is now mirrored in many countries beyond the EU's borders. It has brought the potential of wood as an energy source into sharp focus; and incentives to improve energy efficiency and adopt the latest technologies have encouraged investment across Europe, helping to reduce reliance on fossil fuels. The European Commission with its Renewable Energy Roadmap sees biomass as playing an important role in meeting the 20% share of total energy use to be met by renewable energies by 2020. Therefore, EC has given countries a specific target for 2020 for their share of renewables (EU RES Directive). Wood energy in Europe is expected to almost double in the coming decade (Mantau et al. 2010). Most EU countries have either completed biomass action plans or started the process.

The share of wood in renewable energy varies from country to country, but accounts on average (2004-2007) for slightly more than 50% of the gross inland energy consumption from renewable energy sources in the EU 27. Energy use accounts for a major share of wood fibre consumption. Energy applications account for 42% of the entire wood fibres consumption in the EU 27 (Steierer 2010).
Wood volumes for energy generation are expected to increase by 66% between 2010 and 2020. As it is projected by Steierer (2010) and shown in Figure 1, wood consumption for energy generation is expected to grow from 346 million m³ in 2010 (3.1 EJ) to 573 million m³ (5 EJ) in 2020 and might reach 752 million m³ in 2030 (6.6 EJ). The European Commission and the member states support research and development in other renewable energy technologies, while by comparison technology for wood combustion is relatively mature.

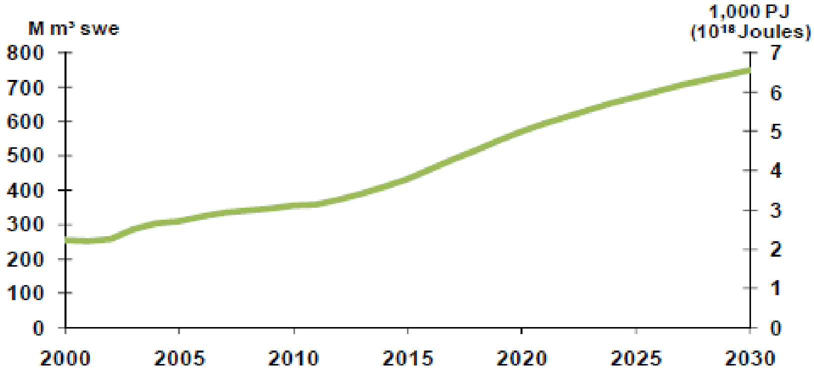

Figure 1: Current and future amounts of wood energy in EU 27 (Steierer 2010)

The wood energy was the only forest related industry sector with steady economic growth in the in the economically difficult period 2008 – 2009. However, wood energy has many facets and differs in it use pattern as well as development from country to country. Steierer (2010) modelled the different sectors separately for households, forest based sector internal use, main activity energy producer and second generation biofuels producer for the period 2010-2030 (Figure 2). Biomass power plants are expected to grow steadily while no major changes will take place to other sectors.

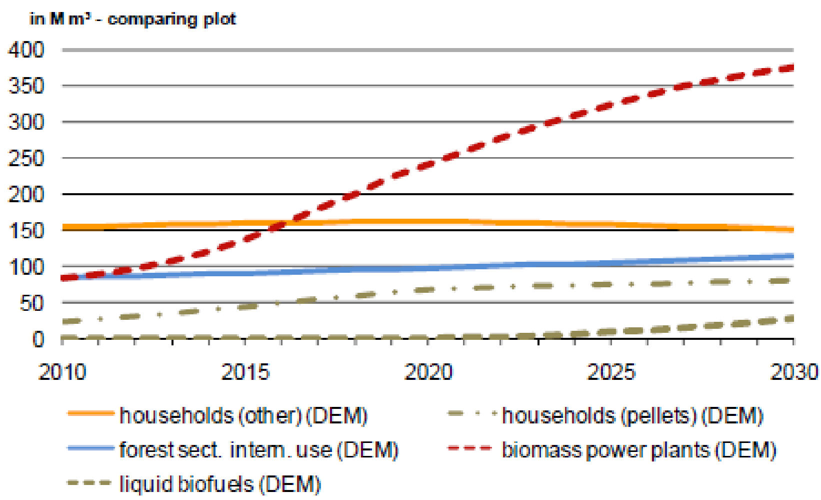

Figure 2: Current and future total amounts of wood energy by consumer in EU 27 (Steierer 2010)

The demand for wood for energy could increase dramatically if countries do not meet energy efficiency targets and expect a maintained strong role of wood energy with 50% share in energy from renewable sources in the future. These framework conditions could increase the demand for wood energy by 205 million m³ in 2020 and in 2030 an even higher additional volume of 297 million m³ would be required at the level of the EU 27. The future demand for wood energy in 2020 and 2030 could be further reduced, if countries successfully implement energy efficiency measures and at the same time if other renewables develop faster than already anticipated. If wood energy decreases its share of the renewable energy portfolio to 75% of its 2010 role (37.4% instead of 50%), wood demand could decrease compared to the above presented results, by another 47 million m³ in 2020 and by 63 million m³ in 2030 Steierer (2010). It also matters, how efficient wood burning facilities make use of the net calorific value of wood. Highly efficient combustion units will decrease the amounts of wood necessary to satisfy the future wood energy needs. According to Steierer (2010), every increase of the combustion efficiency by 1% could save up to 7.5 million m³ at EU 27 level.

The European Committee for Standardization (CEN) published a first draft which harmonizes the definition of residues as distinguished from waste, which is an essential distinction for calculating GHG emissions. They also set out the criteria, verifiers, and templates of data provision lists, as well as methods to assess the sustainability claims of biofuel suppliers. Audit would include the chain of custody, information submitted by economic operators, and implementation of the mass balance method of chain of custody management (CEN 2011).

In Europe in 2009, around 650 pellet plants produced more than 10 million tonnes of pellets (Sikkema et al. 2011). Total European consumption was about 9.8 million tonnes, 9.2 million of which were consumed within the EU-27. Industrial pellet markets depend on wood pellets imported from outside the EU- 27, mainly from North America and the Russian Federation. Because of their advanced storage facilities and long-term price-setting, industrial pellet markets are relatively mature, compared with non-industrial ones. However, industrial pellet markets remain highly dependent on public support schemes. Prices per tonne of oven-dry sawdust in selected markets have shown high price fluctuation, with a general upward trend in selected regions, e.g. Germany. The average price for sawdust delivered to consumers in Germany has increased at a higher rate than sawdust produced at the sawmill (exmill). This increase in price margins might have been due to increasing transport costs and higher local demand. Sawn-timber production decreased across Europe in 2008-2009 and this, in turn, meant that less feedstock was available for energy. Simultaneously, the pulp and paper sector and the wood based panel sector slashed their input needs, leading to availability of alternative feedstock for the pellet sector from low quality logs and sawmill chips (UNECE 2011).

Industrial pellets still dominate the EU's wood energy trade market, although industry co-products such as chips and sawdust take a large market share for local and regional consumption. Research suggests that extra demand for woody biomass triggered by EU wood energy consumption 2020 targets could reach 305 million tonnes of wood (Sikkema et al., 2011). Additional supplies of woody biomass in Europe could come from 45 million tonnes related to increased harvesting levels and about 400 million tonnes from the recovery of post-harvesting residues from altered forest management, the recovery of post-consumer wood through recycling, from the establishment of woody energy crops, and from agriculture. Any short-term shortages of wood pellets to meet renewable energy targets within the EU-27 could be bridged by imports from nearby areas such as North West Russia. Long-term wood energy deficits could be supplied from North America and the Russian Federation (UNECE 2011).

1.2.2. Legislation

Climate protection is a major normative-regulatory driver on the development of timber industries (Knauf and Frühwald 2011). Sustainability and climate protection used to be a unique characteristic of forestry and wood industry, but not a selling point. Sustainability became a selling point in the last decade; in Europe and North America 30% of the peoples are so called LOHAS (Lifestyle of Health and Sustainability). Sustainability is particularly important for investments in the real estate sector. This is a potential advantage for wooden constructions in the near future. However, more personal aspects (health, wellness, price, energy efficiency) are still most important for consumers and need to be taken into account when new products are being developed.

VOC emissions from wood-based panels and related regulations are still important topics, because health becomes increasingly important for consumers. It seems, however, that wood is increasingly associated with a comfortable room climate, wellness, and "healthy living" (Knauf and Frühwald 2011).

"Energy-efficient buildings PPP", published by the European Commission in 2010, is part of the European Economic Recovery Plan. Extended service life, more efficient use of raw materials, more recycling, as well as greater use of renewables are needed to reduce energy and carbon loads. Lightweight materials and systems can reduce the environmental impact of the construction process, which has the potential to positively benefit wood products (European Commission 2010).

An example of a green policy within European Union concerns the issue of wood waste. Waste from construction and demolition (C&D) accounts for approximately 25% (by volume) of all waste generated within EU and has been targeted as a priority area in the context of the 70% reuse and recycling target set by the Waste Framework Directive for 2020. Although the practices in this area vary greatly between Member States, the European Commission is focusing on identifying the types of construction materials and substances that will comprise the construction and demolition waste category. Wood is one of the waste fractions included in a report on 'Management of construction and demolition waste' which was released in February 2011 by the European Commission, DG Environment. The use of recycled wood for the production of wood-based panels is identified as one of the existing recovery options. However, the competition between material recovery and energy recovery from waste wood is explicitly mentioned as a barrier to re-use and recycling wood waste. A summary of the various green economy initiatives is available in the EPF Annual Report (2011).

According to Prins (2010), in order to increase supply of post-consumer wood specific policy and legislative measures are needed:

- Standardise the classification categories of post-consumer wood, including contamination limits, as a basis for carrying out inventories and to facilitate the use of post-consumer wood. At present the absence of classification schemes for this material in most European countries (or the existence of inconsistent classifications) is hindering the rational development of markets, as all recovered wood may sometimes be treated as "contaminated", thus only possible to burn in expensive and limited waste disposal plants, rather than standard boilers. An objective and widely accepted classification, as exists for recovered paper would help each type of post-consumer wood find the appropriate market
- Accelerate implementation of the Landfill Directive, so that wood waste from demolition, transport etc. is directed to energy use rather than landfill
- Support the formation of efficient recovery and recycling circuits and markets, for instance through increased transparency, and better links between wood users and the recovery circuits

1.2.3. Raw materials availability and quality

Regarding raw materials availability for the wood industries, the trend according to Knauf and Frühwald (2011) will be:

Wood is going to be a scarce resource in the future, especially because wood that has been used for wood-based panels (low quality) is increasingly used to produce energy

Use of alternatives (short rotation plantation, agricultural residues, wood from small, private forests, use of hardwood, etc.) will not be sufficient to supply the increasing demand

Severe competition for high quality wood with the energy sector (e.g. wood is increasingly burned in coal fired power plants)

Production of bio fuel will remain insignificant in the next decade

The scarcity of raw material for the wood based panel industry has several implications (Leissing 2012), such as global purchasing, change in the wood mix (more industrial log wood), optimisation of consumption, used wood/recycling, use of alternative raw materials, geographic relocation of the wood-based material industry, and price management

Wood resource balance results according to EUwood 2010 project

As shown in Figure 3, in 2010 the total supply of all woody resources in the EU 27 was about one billion cubic meters whereof almost 70% come from forest and 30% come from woody biomass from outside the forest. In oven dry tonnes this is about half a billion oven dry tonnes (odt) and equals about 8,500 PJ. The energy consumption in the year 2010 added up to 3,017 PJ (Mantau 2010).

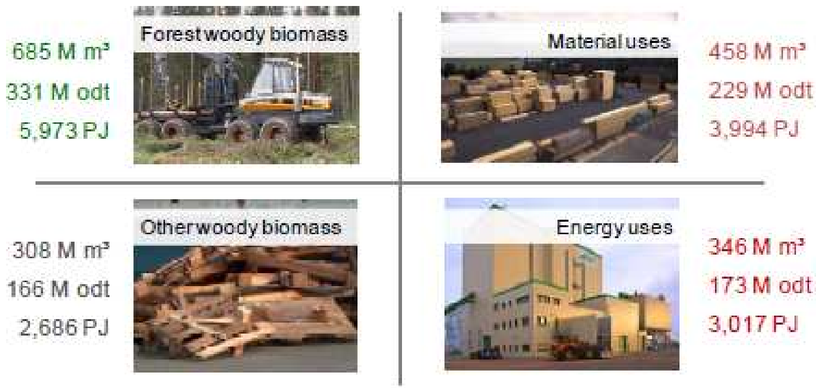

Figure 3: Wood biomass in Europe (EU 27) in the year 2010 (Mantau 2010)

The wood resource balance 2010 and market shares according to the IPCC scenario A1 (Figure 4) is shown below (Mantau 2010):

Potential in M m³	2010	in %	2010	in %	Demand in M m³
Stemwood C, ME	362	36.4	196	23.8	Sawmill industry
Stemwood NC, ME	182	18.3	11	1.3	Veneer plywood industry
Forest residues, ME	118	11.9	143	17.3	Pulp industry
Bark, ME	24	2.4	92	11.1	Panel industry
Landscape c. w. (USE) ME	59	5.9	15	1.8	Other material uses
Short rotation plantation	-	-	21	2.5	Producer solid wood fuels
Sawmill by products	87	8.8	86	10.4	Forest sector intern. use
Other industrial residues	30	3.0	83	10.1	Biomass power plants
Black liquor	60	6.0	23	2.8	Households (pellets)
Solid wood fuels	21	2.1	155	18.8	Households (other)
Post consumer wood	52	5.2	0	0.0	Liquid biofuels
Total	994	100.0	825	100.0	Total

Figure 4: Wood resource balance 2010 (Mantau 2010)

Note: (a) Potential supply is the calculated from the theoretical supply under technical and environmental constraints and some socio-economic constraints and according to a medium mobilisation scenario (ME)
(b) Potential demand is calculated on a forecasting model (EFSOS) for wood industry demand and a calculation approach for the energy demand under different assumptions, mainly that policy targets “20 by 2020” will be reached. Two developments of gross national product (GDP) are considered in line with the IPCC scenarios A1 and B2

The potential supply of coniferous stemwood (C) is about twice as much as that of non-coniferous stemwood (NC). The 11.9 % available forest residues of the balance sum correspond to 17.2% of the total forest biomass, including bark. Landscape care wood is about 6% of the available biomass in 2010. The overall contribution of all by-products (sawmill by-products, other industrial wood residues and black liquor) from wood industry and material uses is 17.8%. Industrial wood residues are the most important drivers of cascade uses. They grow with wood industry growth and they are partly a further processed resource. Thus, their overall relevance in the resource provision is higher than the market share expresses. Between the potential of other industrial residues and post-consumer wood some overlapping may occur. This is of course not the case, if other industrial residues are directly consumed at the production site, but may occur when other industrial residues are delivered to the disposal system. Sawmill industry is the biggest consumer. Possibly less well-known, private households are the second biggest consumer group of woody biomass. Other material uses include only traditional other material uses like dissolving pulp, mulch and other round wood (pools, sleepers). The potential in 2010 (994 M m³) was considerably higher than the demand (826 M m³) indicating that the wood supply of Europe is not being over exploited.
In the medium mobilisation scenario potential demand will overtake potential supply between 2015 and 2020 (Figure 5). However, this is only valid in case the possible ecological and technical potential is, in fact, mobilised. Yet, this requires great political and economical efforts. The total demand for woody biomass is estimated to increase from almost 800 M m³ (A1) to nearly 1,400 M m³ in the IPCC A1 scenario and about 100 M m³ less in the B2 scenario. The growth of potential woody biomass supply is highly linked to a prosperous development of wood industry. The most significant change is the higher demand for energy wood to achieve targets “20 by 2020”.

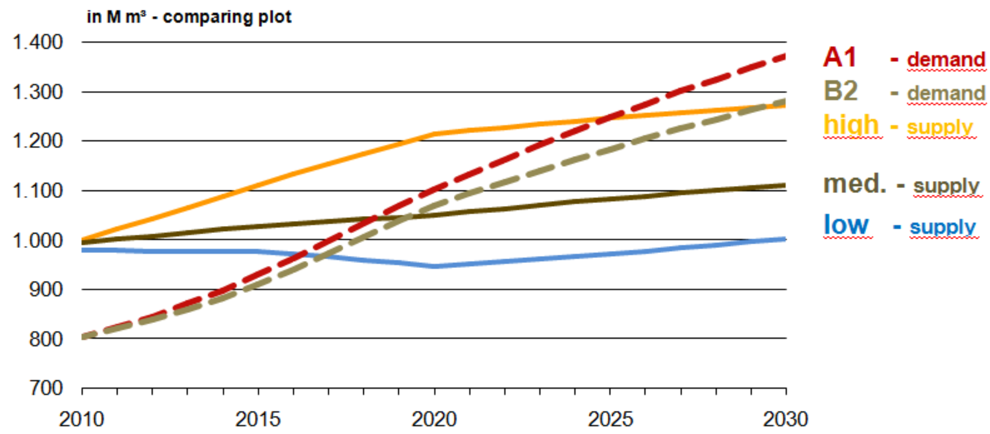

Figure 5: Development woody biomass potential demand and potential supply 2010-2030 (Mantau 2010)

Forest resources represent a relatively stable potential supply of woody biomass in the medium mobilisation scenario (Figure 6). Other woody biomass increases over time because most of these potentials are industrial residues that become larger when the production of the main product increases (scenario A1).

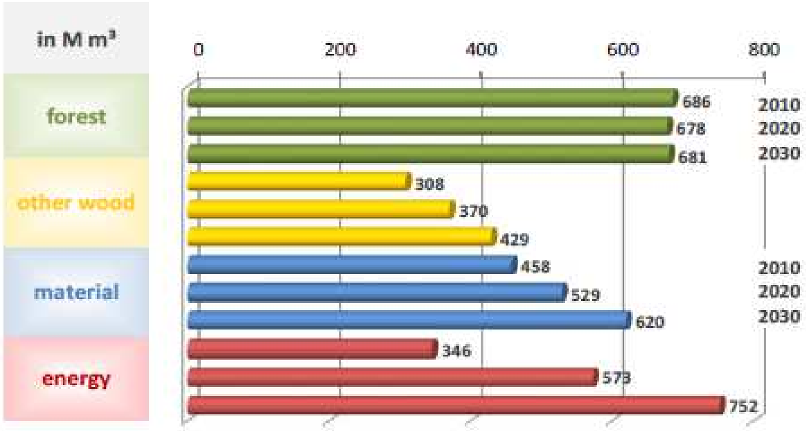

Figure 6: Development of the main sectors of the Wood Resource Balance in M m³ in 2010, 2020 and 2030 (Mantau 2010)

The share of the different segments remains relatively stable. The sawmill industry is with about 40% the biggest user of round wood. However, the saw mill industry also supplies wood to other sectors. About 40% of the cut volume appears on the left hand side of the balance as saw mill by-product. The 2010-2030 projection of wood consumption (Figure 7) of the different material use sectors by market volume and market share are shown below (Mantau and Saal 2010):

material uses	2010		2020		2030	
	in M m³	in %	in M m³	in %	in M m³	in %
saw mill industry	196.4	42.9	218.5	41.3	246.7	39.8
veneer & plywood	11.4	2.5	14.2	2.7	17.3	2.8
pulp industry	143.3	31.3	168.4	31.8	200.3	32.3
panel industry	92.3	20.2	110.1	20.8	135.7	21.9
other material	14.8	3.2	17.6	3.3	19.8	3.2
total	458.2	100.0	528.8	100.0	619.8	100.0

Figure 7: 2010-2030 projection of wood consumption (Mantau and Saal 2010)

As shown in Figure 8, the share of material uses in total wood consumption is expected to decrease from 55.5% in 2010 to 46.5% in 2020 and 43.5% in 2030. The higher rate of growth for energy uses may be attributed to political support for energy demand, and the slower growth for material uses, to the consequences of the financial crises (Mantau and Saal 2010):

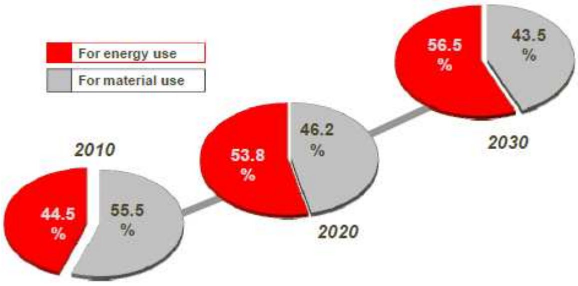

Figure 8: Market share of material and energy uses in 2010-2030 (Mantau and Saal 2010)

The following illustration in Figure 9 compares the developments of the sectors with each other (Mantau and Saal 2010). For a long time the panel industry had a relatively low production volume mainly because it concerned only particle boards. With regard to the growing demand since 1990 and products like e.g. medium density fibreboards (MDF) and oriented strand boards (OSB) achieved strong growth after 1990, which was additionally forwarded by investments in Eastern Europe.

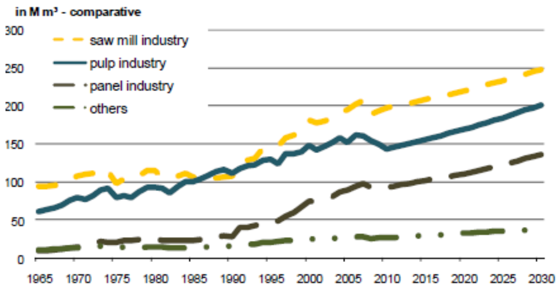

Figure 9: Comparative development of material uses 2010-2030 (Mantau and Saal 2010)

According to estimations (Mantau 2010), if the energy demand develops approximately according to the policy targets then, the demand for energy wood will more than double by 2020. With 750 M m³ the data already exceeds the wood supply potential of the forest with current utilisation intensity (medium mobilisation) of ca. 680 M m³. While the demand for energy wood more than doubles, the wood consumption for material uses rises only from 458 M m³ to 620 M m³. The energy demand would exceed the material demand at some point between 2015 and 2020 (Figure 10).

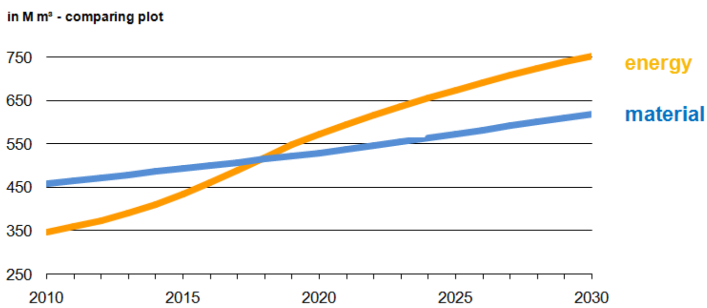

Figure 10: Development of material and energy uses of wood (IPCC A1 scenario) according to Mantau (2010)

The forest biomass potential remains in principle stable over the period considered. Major changes are dependent on which mobilisation scenario is being used. Presuming the medium mobilisation scenario, it is likely that the percentage of biomass not arising in the forest increases over time. In IPCC A1 scenario the percentage of non-forest biomass goes up from 31% to 41%. If greater efforts are undertaken to lift forest management systems to a higher mobilisation scenario, however, the percentage of non-forest biomass will increase less or even decline (Figure 11).

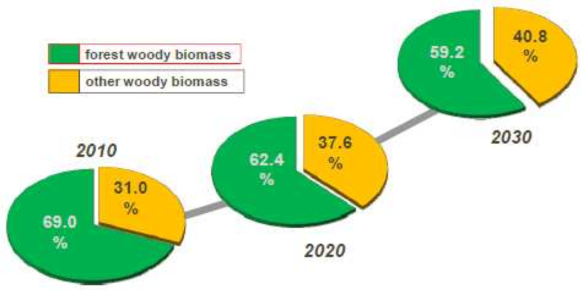

Figure 11: Share of forest and other woody biomass in potential supply (medium mobilisation, IPCC A1 scenario) according to Mantau (2010)

The wood resource balance reflects all sectors in detail for the years 2010, 2020 and 2030. Below it is shown the comparison of the medium mobilisation scenario on the potential side of the balance with demand according to the A1 scenario and the central assumption regarding the renewable energy targets. The demand side reflects the scenario A1 with growth rates of the gross national product (GDP) between 2.0% and 2.5% for Europe. The raw material 2010-2030 situation and structure in the EU 27 total (Figure 12) is as follows (Mantau 2010):

Wood Resource Balance							
Region		EU27		IPCC Scenario:			A1
potential	2010	2020 M m³	2030	2010	2020 M m³	2030	demand
stemwood C, ME	361,8	356,8	355,7	196,4	218,5	246,7	sawmill industry
stemwood NC, ME	182,3	178,1	181,0	11,4	14,2	17,3	veneer plywood
forest residues C+NC, ME	118,0	119,8	120,3	143,3	168,4	200,3	pulp industry
bark, C+NC, ME	23,7	23,3	23,4	92,3	110,1	135,7	panel industry
landsc. care wood (USE) ME	58,5	66,0	73,5	14,8	17,6	19,8	other material uses
				20,9	43,5	53,6	producer of wood fuels
sawmill by-products (POT)	86,6	96,0	107,8	85,5	98,3	113,9	forest sect. intern. use
other ind. res. reduced (POT)	29,7	34,9	41,7	83,2	242,0	377,1	biomass power plants
black liquor (POT)	60,4	71,3	84,9	23,2	68,8	81,5	households (pellets)
solid wood fuels (POT)	20,9	43,5	53,6	154,5	163,2	150,6	households (other)
post-consumer wood (POT)	52,0	58,7	67,3	0,0	0,8	29,0	liquid biofuels
total	993,9	1.048,4	1.109,4	825,5	1.145,4	1.425,4	total

Wood Resource Balance (without solid wood fuels)							
Region		EU27		IPCC Scenario:			A1
potential	2010	2020 M m³	2030	2010	2020 M m³	2030	demand
forest woody biomass	686	678	680	458	529	620	material uses
other woody biomass	287	327	375	346	573	752	energy uses
total	973	1.005	1.056	805	1.102	1.372	total

Figure 12: Raw material 2010-2030 situation and structure in the EU 27 (Mantau 2010)

Note: ME Medium – refers to medium mobilisation scenario; POT Potential – refers to "real" availability under given constraints; USE Use – refers to potential that is or will be used; C Coniferous – softwood; NC Non-coniferous - hardwood

Projection of volumes of post-consumer wood 2010-2030

Leek (2010) used the relation between the solid wood consumption per capita and the share of post-consumer wood (packaging materials, demolition wood, timber from building sites, and fractions of used wood from residential (municipal waste), industrial and commercial activities) in the total national solid wood consumption in 2007 for the prediction of the future post-consumer wood supply in the EU 27 countries. The total supply of post-consumer wood for the EU 27 in 2030 was estimated for the IPCC A1 scenario at 67.3 M m^3 and for scenario B2 at 58.6 M m^3. Compared to the supply of post-consumer wood in 2010 this equals a growth of 29% for the period up to 2030 for A1 and 12.7 % growth for B2. Half of the post-consumer wood is to be generated in the western region (Figure 13).

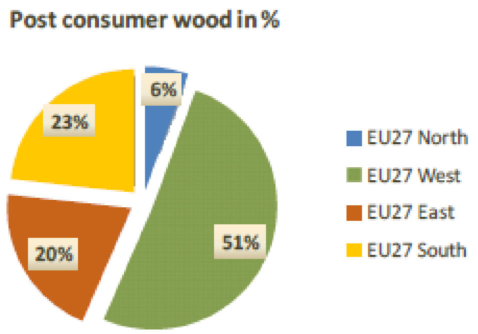

Figure 13: Projected shares of the EU regions of the total post-consumer wood volume in 2030 – scenario A1 (Leek (2010)

The growth of the post-consumer wood volume from 2010 to 2030 according to Leek (2010) is illustrated in Figure 14. The graph shows the development of post-consumer wood in total (=POT), of post-consumer wood recovered (=USE) and post-consumer wood landfilled or incinerated (=DIS). The volume of post-consumer wood which is landfilled will decrease strongly in the coming years. The EU Landfill Directive 1999 set targets for the quantity of biodegradable municipal waste (BMW) that each EU member state can send to landfill. As a consequence of this EU Landfill Directive the quantity of wood waste that is recycled will increase in the future, but the generated total volume of wood waste is not influenced by it. The targets in the Landfill Directive seem to be very promising, but the process has been delayed and some countries are only now starting the process of reducing their share of land filled waste.

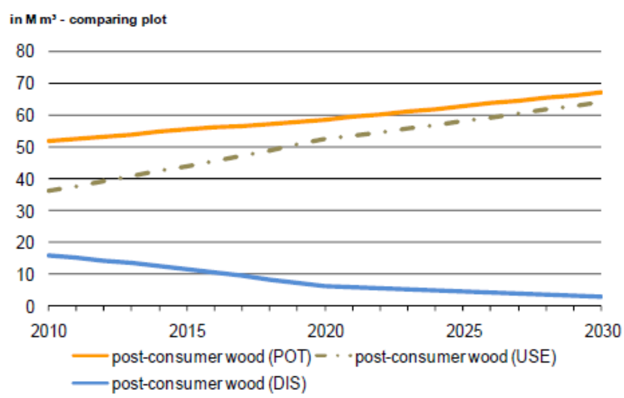

Figure 14: Potential, use and disposal of post-consumer wood for the EU 27 countries– scenario A1 (Leek (2010)

Projection of volumes of industrial wood residues 2010-2030

The resource of industrial wood residues becomes available and grows with production. This resource is dependent on the material recovered and thus, dependent on the efficient use of the raw material. The projection of potential volumes of industrial wood residue segments 2010-2030 is displayed in Figure 15 (Saal 2010). In this Figure the segments of industrial wood residues can be compared within the total volume of industrial wood residues.

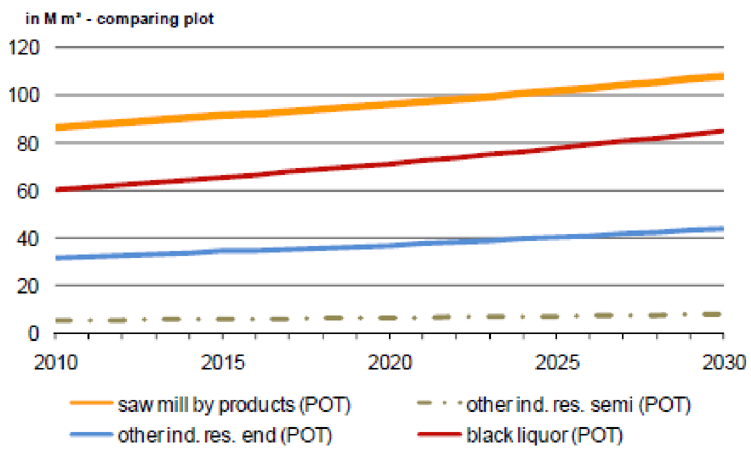

Figure 15: Projection of total potential wood residue volumes 2010-2030 (Saal 2010)

Figure 16 shows the relevance of industrial wood residues related to the potential available stemwood as well as in comparison to potential volumes of other woody biomass from landscape care activities and post-consumer wood (Saal 2010).

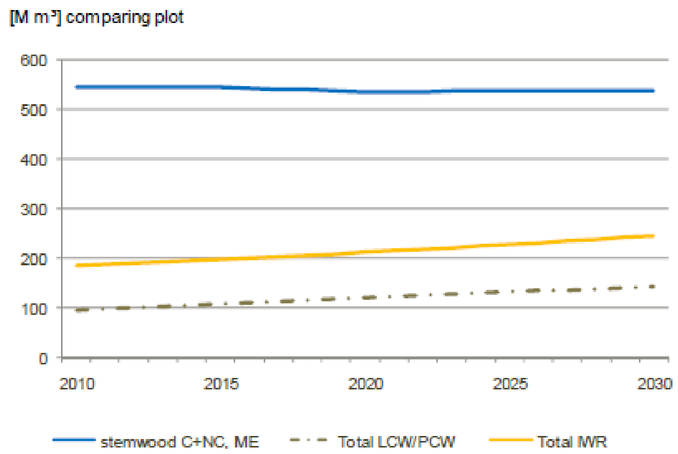

Figure 16: Comparison of industrial wood residues (IWR) shares with post-consumer (PCW) and landscape care wood (LSW) (Saal 2010)

1.2.4. Prices

Nowadays there is an increasing utilization of wood (material and energy) and other lignocelluloses. According to (Knauf and Frühwald 2011), for the wood industry as a whole, increasing prices for wood will not be a competitive disadvantage, because price of energy also increases, which makes the production of alternative materials more expensive. However, producers of wood based panels will have problems, because wood accounts for a high percentage of total production costs and the price for (basic) particle board is unlikely to increase.

New (augmented) products need to be developed. A new commodity-cash-cow like laminate (flooring) is not in sight. A key topic for the wood industry sector is the development of new products made of hardwood.

Panel prices in the EU bottomed out during the first half of 2009 but they recovered strongly throughout 2010, and by early 2011 panel prices had largely recovered back to their 2008 levels. The largest increases were observed for particle board prices which improved by more than 35% compared to 2009, although mark-ups obviously differ according to the type of boards, their previous price level and their country of origin. Interestingly, particle board producers had planned for even higher price increases to compensate for a continuous rise in production costs, notably wood and resins. However, given the general market conditions in the EU, they were unable to fully implement the price hikes as planned. This partly reflects the fact that, while the demand for particle board increased slightly, it remained at a relatively low level because demand within the furniture and construction sectors was weak (UNECE 2011).

The EU has set a target to meet at least 20% of its total energy consumption by 2020 from renewable energy sources. In an effort to reach the target, many EU countries have increased consumption of woody biomass in the form of wood chips and pellets over the past few years. In 2010, over 11 million tonnes of wood pellets were consumed, which was about 7% higher than the previous year. Demand for wood pellets in some European countries has outpaced domestic production over the past few years. This has resulted not only in increased imports from neighbouring countries but also from North America. Increased demand for wood chips, sawdust and smaller logs from pellet manufacturers and energy companies has started to have an impact on wood-fibre prices in some markets in both Europe and the North America. In general, higher raw material prices were recorded throughout Europe in 2011 (UNECE 2011).

1.2.5. Innovation in manufacturing processes

Climate protection and efficient use of resources are the most important fields of innovation. According to Knauf and Frühwald (2011), there are six trends at the moment regarding innovation in the wood-based industry:

Standardisation: Wood becomes an industrial product

Selling “all-in-one solutions” instead of intermediate products or commodities. This requires cooperation within the (wood) sector or with other sectors and a high degree of prefabrication)

Composite materials

Lightweight design: While in 2004 the major advantage of lightweight products was considered to be its in-use-properties (easier handling => people are more mobile), in 2009 the efficient use of wood was considered more important

“Convenience wood”: “Fast-smart products”, meaning selling more do-it-alone products instead of custom built products

Products with added value

Up to now considerable attention in the research activities for the wood-based panel industry has been given to the different environmental issues. In the past the main research work was devoted to the crucial issue of formaldehyde release. Future research work to find new binder systems or new binder combinations with less release of formaldehyde and application of suitable after-treatment methods of wood-based panels to decrease their emission potential will be needed (Roffael 2006). For certain types of products increasing attention could be also paid to the use of natural binders alone or in combination with synthetic binders to further mitigate emission and to develop new alternative composites (Vidal 2011).

According to Potter (2011), the wood panel sector has a bright future. This is despite the doom and gloom that has often plagued the industry leaders in the last few years. Particular focus will be put on the necessity to balance the R&D efforts between wood products, new fibre-based products, and the emerging bio-products from wood.

Innovation is needed in techniques and procedures for classification and separation of waste wood (spectroscopy, mechanical, chemical, other). The procedures provide recycling options of foreign bodies (metal, plastic, stones, etc.) and wood particles. To effectively use waste wood, new concepts of waste wood sorting and new techniques have to be investigated for a more efficient and save recycling. First tests using NIR spectroscopy as well as Ion mobility spectrometry (IMS) show the feasibility of both techniques to detect different contaminations within the surrounding wood. To detect also paint and coating as undesired surface layer use of X-ray fluorescence spectroscopy (XRF) seems possible (Meinlschmidt et al. 2012).

1.2.6. Markets

Recent changes of European markets and structures in the broad wood industry sector should be considered (Knauf and Frühwald 2011):

Wood based composites are increasingly used for construction, while use for furniture decreases. This is probably because much of furniture is industrially produced outside Europe (e.g. China)

Engineered wood products substitute massive wood

Maintenance will be more important than new construction. That is why non-industrial users (carpenters) become more important. However, the type of work carpenters do changes; they just assemble pre-fabricated products from industry instead of building the whole construction

The vertical range of manufacture increases (in both main sectors: saw milling and wood based composites)

Internationalisation of markets. In the past, the US market was more important. The development of this market in the future is unclear. This means that in the near future the international trade of products will increase (as well as trade of raw material), but it is expected large scale shift of production sites

Following the fierce economic downturn, the European wood-based panel industry is slowly but surely returning towards better market conditions and improved capacity utilization. The European wood-based panels industry will continue to face considerable challenges, including rising production costs, partly the result of competition for wood with the renewable energy sector as well as higher costs of resin and chemicals which reflect rising oil prices. The overall European particle board production capacity continued to drop to 41.5 million m^3 in 2010 and to 40.3 million m^3 in 2011 (Figure 17). EU imports of particle board increased in 2010 while exports decreased, resulting in a weakened exporting position for the European particle board industry. Particle board production increased by 5.6% in Europe in 2010; the furniture industry was the main driver behind this recovery as the construction sector continues to encounter difficulties in many European countries. Despite showing signs of recovery, the situation for wood-based panel producers remains complicated by the fact that consumers and end-users in many countries are worried about the future, causing them to postpone spending on new construction, renovation and new furniture (UNECE 2011). However, it was seen a 3.7% increase of real particleboard consumption in 2011 in Europe corresponding to 28.4 million m^3 as compared to the 2010 data (EPF 2011).

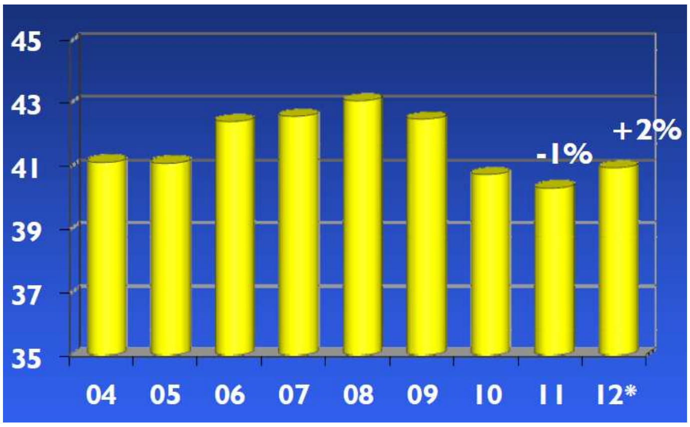

Figure 17: Evolution of particleboard production capacity in Europe (EPF 2011). Estimation (*) for 2012

According to (Leissing 2012), the European debt crisis has a clear impact on the wood-based material industry and markets. Specifically, there the general economic situation affects consumer behaviour and unemployment. The wood-based material industry is driven by (a) new residential construction and renovation, and (b) long-term consumption (material assets). At least at the moment, the debt crisis is not having a negative impact on the real estate sector/renovation but long-term consumption may be affected. Wealth in Europe is expected to decline over the long term with further consolidation among equipment suppliers, raw material suppliers (e.g. paper, glue), logistics, furniture industry, wood distribution, and wood-based material producers. Other phenomena due to crisis affecting the markets include a difficult refinancing situation (long-term bank financing no longer possible rising risk premiums, higher information requirements, new forms of financing) and an extreme, on-going volatility in the wood-based material industry (flexible working models, variable cost structure as far as possible).

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PART B: RUBBER

2. Future scenarios for the rubber sector

2.1. Identification of the scenarios

As for the wood sector, once again the aim for the future scenarios was the same for the rubber sector as well. This time, the consortium contacted with European Tyre Recycling Association (ETRA), which is located in Brussels.

The 6 scenarios that later will be analyzed (in hierarchical order) are:

- Markets (e.g. demand for products from recycled tyres)
- Raw materials availability (e.g. origin, quantities available, the role of global commerce)
- Competitive sectors and their prospects (e.g. energy)
- Innovation in manufacturing processes (e.g. progress in technology, technical limitations such as variation in quality and highest limit of recovered rubber in %)
- Legislation (e.g. recovery and landfilling legislation, rules or classification systems of recovered raw materials)
- Prices (e.g. tendency, taxes related to use of recovered materials)

2.2. Description of the scenarios

2.2.1. Markets

So far, the main applications using recycled tyres were sports surfaces and safety floors. It also had multiple civil engineering uses. Artificial reefs, coastal defence, landfilling engineering, construction bales, noise barriers, rubberised asphalt mixtures, insulation are some of these uses.

During the past decade, EU had considered that the use of rubberized asphalt mixtures as a great opportunity in this area. Over a million kilometres of regional road networks in the EU require periodic repair and resurfacing and over half a million kilometres will be constructed in the EU states during the next decade. Rubberized asphalt mixtures could be used for them because they fulfil the requirement for noise reduction. Furthermore, they also can elongate the life of the road.

Giving the availability of ELT's and that during the past 20 years plants that produces granulated rubber in EU were multiplied, the potential of this market is more than obvious. It can absorb the majority of the recycled ELTs. Of course there is competition with other materials than can be used for the same utility, but still the benefits of using rubberized asphalt mixtures gives to them high potential.

The development of plastic products is also growing. Shred tyre with binder thermoplastic or polyurethane can produce different materials and objects such as shoe soles, casings, insulating sheets, backs, motorcycle helmets, etc. New products from recycled rubber are a great opportunity for new applications emerging in the market for ELTs rubber. The biggest objection may come to doubt the quality and durability of the resulting materials, but it can be solved with the development of manuals and quality certificates.

In addition to surfacing materials, many new roadbeds will require fill, lining material, expansion joints and drainage systems, each of which can be produced from recycled tyres. Sound barriers for noise reduction also could be manufactured by recycled tyres. It is estimated that more than 45500 Km of major highways and more than 150000 Km of inhabited areas could use that.

Of course, the economical crisis from 2007 to nowadays has affected the current situation. In Greece, 5 recycling facilities have suspended their operation during the last 5 years. Talking with numbers, from 2000 to 2006 the number of recycled ELTs raised from 460 kT to 1105 kT (increase of 140%), but from 2007 to 2011 thenumber of the recycled tyres was almost constant, with a slight raise from 1105 kT to 1315 kT (increase of 19%) It is important though to mention that even in times of recession, there was some (albeit small) increase. It is expected though that this stagnation is going to end soon and that in the following years the sector of tyre recycling will start to expand once again. It is quite convenient that nearby Europe there are two growing markets (Middle East and Russia) that are in need of recycled tyres and Europe can cover the lack of know-how that they have.

2.2.2. Raw materials availability

Due to the limited lifetime that the tyres have, it is clear that they can be considered as a raw material in abundance for the recycling sector and this doesn't seem likely to change in the near future.

The following figure demonstrates the evolution of car parc on world major markets and it includes a projection until 2025. In 2019 it is expected that the Chinese car parc will overtake the NAFTA's (North America) one and that in the same year the rest of the world will take over Europe. The European car parc will have an increase of approx. 32 % (from 289 million in 2007 to 381 million to 2025), while NAFTA's will have an increase of 17 % (from 168 million car in 2007 to 197 million in 2025). On the other hand, the most impressive increases will be for China (1100%, from 25 million in 2007 to 299 million in 2025) and for India (which is represented in the rest of the world) (600% from 15 million in 2007 to 104 million in 2025).

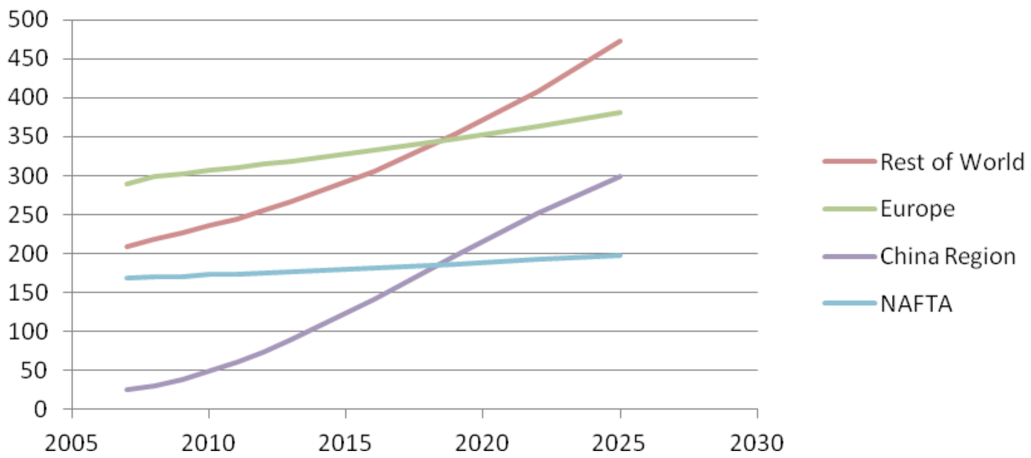

Figure 2.1: World car parc in million (projected to 2030) [source: ETRA, JATMA, NAFTA]

These data indicates that Europe could be self-sufficient by recycling the used tyres that are generated in it's territories. Of course car parc is not indicating directly the amounts of generated used tyres for the same regions and that is because tyres have different specifications for each one. For example, the chart that represents the Rest of World shows that the car parc of this region is going to be the world leader from 2019 and on. But on the other hand, in this region the average life of tyres is quite longer than Europe, North America or Japan.

2.2.3. Competitive sectors and their prospects

- **Current situation**

There are five routes for the End of Life Tyres (ELT). These are:

- Reuse/export
- Retread
- Recycling
- Energy recovery
- Landfill

EU considers material recovery as their main priority, thus recycling and energy recovery were promoted in the last two decades in comparison with the rest routes. As it is demonstrated in the following graph, in the early 90's landfilling was the main option (62 % of the total ELT). At that time, material recovery was at a preliminary stage (5 % of the total ELT) and energy recovery covered just a small percent (14 % of the total ELT). Later in the same decade, the concepts of recycling and sustainability were emerged and that led to the rapid decline of the landfilling option. Eventually, in 1999 the 1999/31/EC directive has completely forbidden the tyres landfilling. This directive anticipated that by the end of 2006 the tyres landfilling percent would be eliminated. Nevertheless, while the landfilling percent is still declining, there is still a small percent (for 2011 it is 5 % of the total ELT) and this is due the reformation of the EU composition.

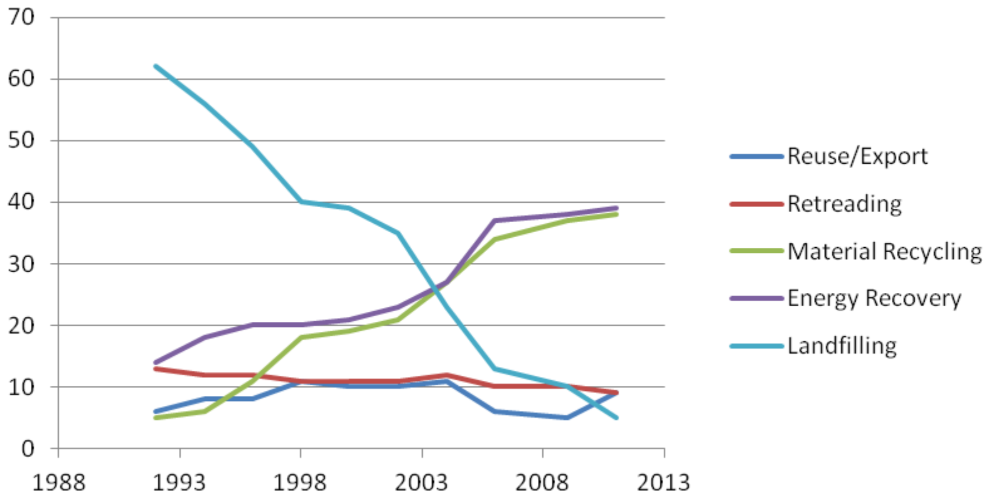

Figure 2.2: Routes of ELT's in EU (% percent/year) [source ETRA]

The analysis of these data leads in two future scenarios regarding the projection of these five routes for ELT. In both scenarios, it was assumed that landfilling will not be an option by 2025.

- **First scenario**

As it is demonstrated on figure 2.2, there is a constant growth rate for recycling and energy recovery from the beginning of the global economical crisis in 2007. Until that year these routes were constantly growing (for recycling from 5 % in 1992 to 34 % and for energy recovery from 14 % in 1992 to 37 %), but since then the increase is quite smaller (for recycling from 34 % to 38 % in 2011 and for energy recovery from 37 % in 2007 to 39 % in 2011). In this scenario the hypothesis that the economical crisis will affect these rates is adopted. So, the rates of recycling and energy recovery remain still for the next decade. At the same time the slight increase of these rates is covered by the corresponding decrease of the rates of reuse/export and retreading.

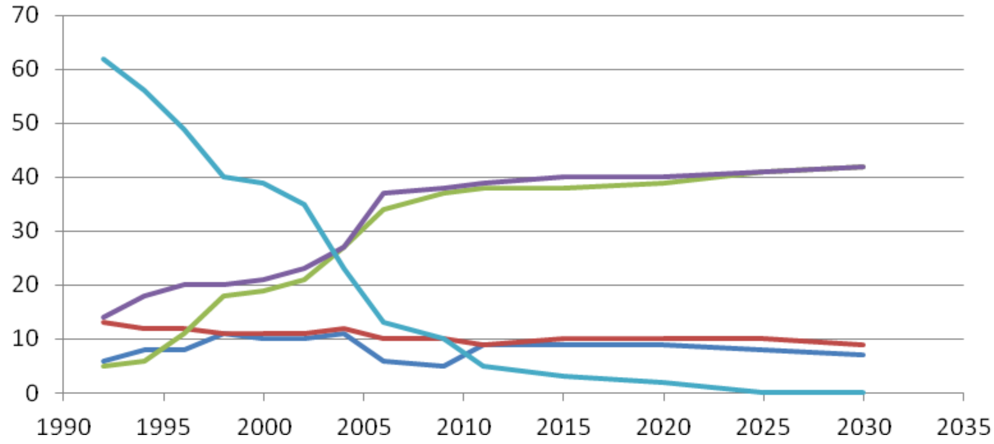

Figure 2.3: Routes of ELT's projected to 2030 according to scenario A (% percent/year) [source ETRA]

- **Second scenario**

This time it is assumed that recycling will recover and that it will start to grow, due to fact that EU considers recycling as the first option (50 % of total ELT in 2030). Energy recovery on the other hand will have almost the same constant growth with the previous scenario (39 % of total ELT in 2030). The recycling increase will be covered from a slight decrease of reuse/export (4 % in 2030) and retreading (6 % in 2030).

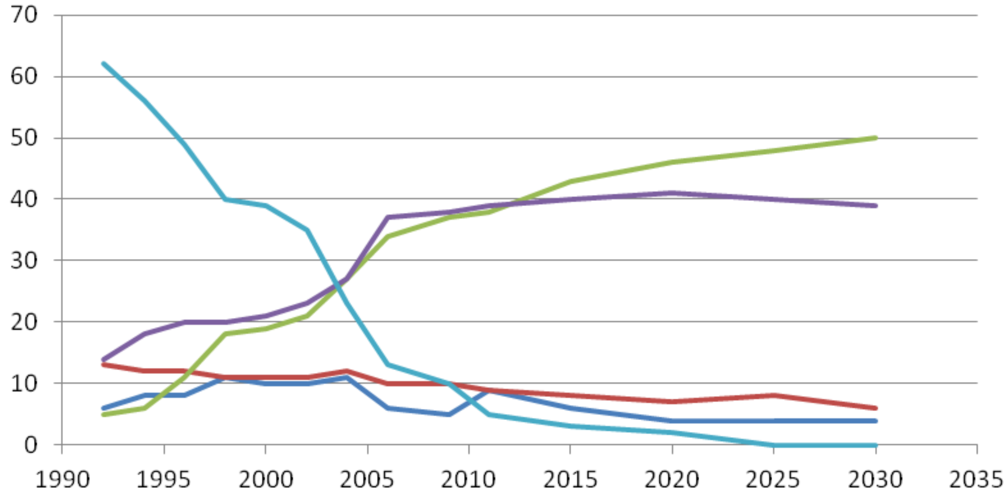

Figure 2.4: Routes of ELT's projected to 2030 according to scenario B(source ETRA)

This scenario is considered more realistic. Tyre recycling was a breakthrough during 90s and early 00s in EU and it is expected that the market will be cautious only for a limited period.

2.2.4. Innovation in manufacturing processes

So far the technology that absorbs the vast majority of the recycled used tyres is shredding. In this process the whole tyre are shredded to the desired for each utility fraction.

Besides that, there is a series of emerging technologies that could be used instead. These are:

- **Devulcanization**

It is a process of decomposition that allows the recycling of rubber from ELTs based on chemical bond breaking cross monosulfide, disulfide and polysulfide (carbon-sulfur and sulfur-sulfur bonds) of vulcanized rubber. The aim of the devulcanization of rubber is a product with properties similar to virgin rubber to return to revulcanize with or without the use of other compounds, and then to produce rubber mould applications. The devulcanization is an expensive technology but some applications have been developed and the investigation continues. Some of the existing processes are devulcanization chemical, bacterial, thermal, microwave, mechanical, ultrasonic, chemical-mechanical, thermo-mechanical and thermo-chemical and other. They are only a small number of operating systems but with small capacity. The greatest potential for productive areas of research is to reduce processing costs and obtaining rubbers with properties identical to virgin rubber.

- **Pyrolysis**

Pyrolysis is the thermal degradation process of shred or granulated tire in intermediate substances such as gas, oil, solid residue (char or carbonaceous solid residue) and steel. In the pyrolysis process, shred tire (1 - 3 cm), or granulated tire (0.5 - 4 mm) free from steel and textiles are heated at a moderate temperature (400 - 800 ℃) in the absence of oxygen or a limited amount.

Despite the scientific research, there are few industrial plants in operation. At present, researchers focus their efforts on studying the kinetics of pyrolysis with ELTs under different conditions of temperature (300 - 850 ℃) and different proportion s of oxygen (5 - 21 %) or nitrogen atmosphere, and to achieve cost-effective through different strategies for recovery.

The main advantage of pyrolysis technologies is to obtain products capable of recovery and a gas fraction that can be used as fuel in the process, as fuel in cement kilns or co-generation; tyre-derived oils have characteristics similar to a gas-oil trade being able to use as fuel in conventional furnaces and combustion engines, and the pyrolytic carbon black has great potential because it can enhance fuel substitution (when mixed with coal), absorbing light, the manufacture of polymeric materials, or as feedstock in the manufacture of charcoal and tyres.

- **Gasification**

This is another thermal treatment technology which can use ELTs also. The thermal degradation of organic matter is carried out in the reactor under low-oxygen atmosphere (1/3 - 1/5 stoichiometric for complete combustion) and a temperature about 600 ℃. The result is a synthesis gas or syngas with an approximate yield of 63 % by weight, and a solid phase representing about 37 % about total weight. Yield gasification process varies depending on the technology, fuel and gasifying agent used.

The solid fraction is composed of carbon black and steel. These are easily separated for material recycling.

There are two technologies:

- Entrained bed reactor, is subdivided depending on the relative sense of the flow fuel and gasification agent in “downdraft” where the streams are parallel, and “updraft” when travelling in the opposite direction.
- Fluidized bed reactor , a gasification agent has an inert and waste in suspension until the particles of ELTs is gasified, becoming flying ash and then, these are washed away from the syngas.

The biomass gasification such as agricultural and forest waste is a highly developed technology and is currently having a great success in the world, but in the case of ELTs is yet in its development. Spain has installed the first tire gasification plant in Europe in La Coruña (Garanesa) in 2003 by Guascor S.L. The company is the leader in this technology with FBLD series motors for recovery of the produced syngas. These motors have been specifically developed to operate with poor gas up to 4.5 MJ Nm-3 in which fuel components are mainly carbon monoxide (CO) and hydrogen (H2).

This treatment obtains products capable of recovery and can be used as fuel for electrical or thermal energy, and in addition, Spain has an active national technology. The disadvantages, the difficulty of predicting the composition of the gas due to the variation of parameters and low-electrical yield of 25 % compared with about 50 % that can be achieved with biomass waste such as agricultural or forest.

2.2.5. Legislation

The Directive 1999/31/EC on the landfill of Waste banned the landfill of tyres (whole or shredded) totally, by the end of 2006. Still this target is not yet achieved, due to the reformation that happened in the meanwhile in EU. Of course, in the past two decades, tyres landfilling is almost eliminated (from 62% of the total used tyres arising in 1992, to 5% in 2010) and this result is considered as satisfactory as it is expected that eventually during the next decade landfilling will stop being an option for the used tyres.

In the same time, End of life Vehicle Directive (2000/53/EC) had set a target of 95% recovery for vehicles below 3,5 tonnes by 2015 and indirectly setting targets for a minor part of ELT in the EU (it is estimated that ELT coming from ELV as defined by 2000/53/EC represent a tonnage below 10% of total EU ELT). Recently the European Union (EU) adopted Directive 2008/98/EC in waste policy. This repealed Directives 75/439/EEC, 91/689/EEC and 2006/12/EC as of December 12, 2010, becoming the new framework law on waste of European Community, to which all Member countries must adapt.

Finally, Directive 2005/69/EC restricts the marketing of tyres containing hazardous substances such as PAHs.

In Europe there are three systems for collection and management of used tyres, the free market system, the producer’s responsibility system and the tax system. In the first one, a legal framework sets the objectives to be met but does not designate those responsible. All the operators in the chain of collection and recovery of used tyres are thus in competition with one another. They are also free to cooperate with each other to promote recovery practices at optimal cost. In the tax system, the State sets the amount of a tax that is used to finance the recovery of end-of-life tyres. This tax is levied on tyre manufacturers, and is generally passed on to the customer. The

State is thus responsible for processing the tyres and remunerates the operators in the recovery chain. Finally, in the producer’s responsibility system, the State defines the regulatory framework for recovering end-of-life tyres and obliges the manufacturers of new tyres to take responsibility for collecting, recovering and recycling them. In each country that has opted for this system, manufacturers have thus created a sector of activity specializing in recovering used tyres, and this sector is represented by one or more ecoorganizations.

The debate on the balance between them is still open. During the last decade, there have been several changes to the EU map, regarding on which of these three systems each country adopts. The following figure, presents the present situation. Many countries are using the producer’s responsibility system, but the major European markets of Germany and England are using the free market system. Thus, it is obvious that it is very difficult to adopt one policy regarding this issue, because it is generating various conflicts.

Figure 2.5: The three different management systems of used tyres in EU (source: ETRA)

Regarding technical aspects, there is no European Standards for the applications of used tyres. The only European Standard related to the use of ELTs is he recently approved CEN/TS 14243:2010: 'Materials produced from end of life tyres - Specification of categories based on their dimension(s) and impurities and methods for determining their dimension(s) and impurities'. This was a major step for the sector of tyre recycling. It is expected that this European Standard will contribute to a significant increase in the level of quality of tyre-derived products while opening the market to new applications, promoting technology exchanges and access to know-how and innovation, and protecting the environment. In 2011, a new CEN Technical Committee was set up (TC366), replacing the previous Project Committee which had completed its mandate. A new Business Plan was adopted in May 2012 with the main aim of validating and converting CEN TS14243 into an EN standard. Beyond the present characterization of the different materials derived from end of life tyres in terms of dimensions (ELT cuts, shreds, chips, granulates and powders) and impurities (steel & textile) using harmonized methods of sampling and testing, further ELT properties will be standardized, such as physical characteristics and chemical composition.

2.2.6. Prices

The three different management systems for the ELTs are very crucial for the determination of the product's price. Both in the tax and the producer's responsibility systems, there is a small amount added on the price of every new tyre that it is sold. This tax is levied on tyre manufacturers, and is generally passed on to the customer. In the first case this amount is determined by the State, while in the second case it is determined by the manufacturers under the supervision of the State. In the free market system all the operators in the chain of collection and recovery of used tyres are in competition with one another, but of course there is always a legal framework set by the State. The coexistence of these three systems has so far managed to keep the prices at a constant level and it should be considered that as long as legislation protects the prices of ELTs, the most likely prediction is that there is not going to be any significant price fluctuation.

Apart from the question of logistics, a decisive factor in that choice will be the gate fee applicable to these options. Companies that produce rubber granulate will therefore be forced to compete on price with cement kiln operators. This will continue to be the case since legislation does not prescribe a minimum quota for material recycling.

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